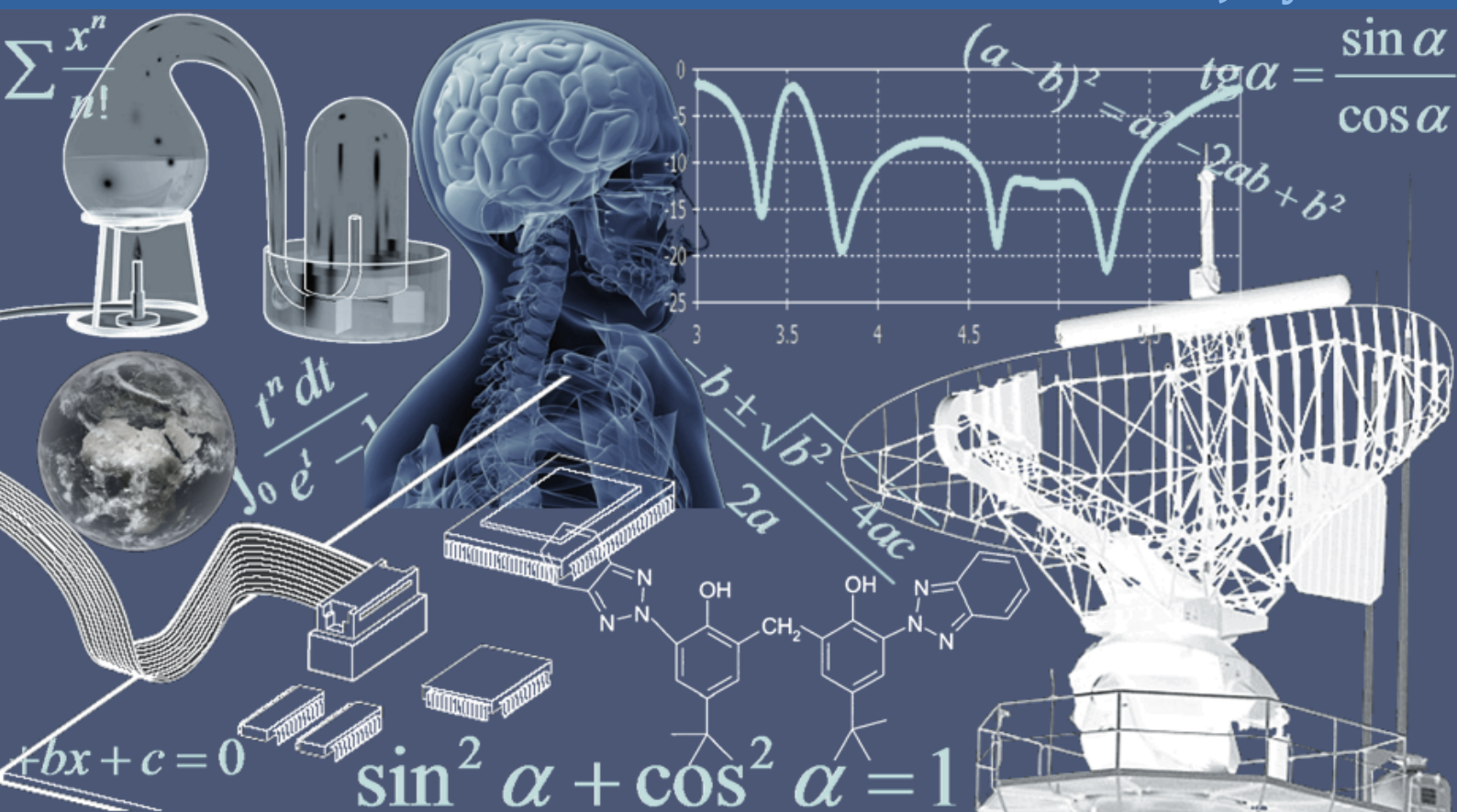


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Bio-inspired and Bio-inspiration: a Disruptive Innovation Opportunity or a Matter of “Semantic”?

A Review of a “stronger than logic” Creative Path based on Curiosity and Confidence (4C²2C[©])

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ABSTRACT: “Innovation is not the idea, but what you do with it”. Can ideation be engendered by artificial means? Can it come from bio-inspiration?

In this third review centered on innovation, open innovation, and now disruptive innovation, the authors have reviewed and re-contextualized various bio-inspired technologies ranking from pharmaceutical developments, medical treatments, software and hardware, energy, materials and natural polymers.

This after a refreshing introduction associated with 1- the skills of the “bio-inspired” business engineer, 2- the open innovation process path and discipline therewith and 3- the patent value of the pioneering, possibly disruptive inventions in the typical patent portfolio.

A knowledge flow pattern, from sharing, integration, search, generation, classification, dissemination, to application, is proposed to outline the necessary understanding of bio-inspiration to yield application of innovative value; still nurturing the proposed knowledge “life cycle”.

The necessary creative confidence can be gained, reinforced by the bio-observation and inspiration; nonetheless a larger set of functions may need to take part to the innovation process with their own recognized and valued creative potential and phobia elimination.

When performed by enlarged teams comprising the engineer, scientist, IP strategist, business model expert, sales and marketing teams, accountant, executive and operating teams, the ATA[©], adjacent technology analysis – covered in previous reviews - is one way to further challenge the imperfect patent tools when dealing with open disruptive innovation. Semantic is, in the present study, shown as an improvement, lacking motion and pictures.

KEYWORDS: Innovation, open innovation, disruptive innovation, collaborative, Collaboratory™, adjacent technology analysis, ATA[©], IP strategy, semantic analysis, bio-inspired, bio-inspiration, pharmaceutical, medical, software, hardware, energy, materials, natural polymers, bio-mimicry, biotechnology, DNA, confidence, curiosity.

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Some assessments are intended to educate and raise awareness of some of the complex issues that surround the intellectual property in the field of knowledge extraction from the about 80 million patent documents available, and to assist in the development of practical skills for dealing with inventions in the context of innovation. It does not seek to provide legal, managerial or technical advice on intellectual property related law as such. For any guidance, legal or any other, seek advice from the appropriate professionals; this study can by no mean substitute for expert legal, technical and managerial advice.

The opinions expressed by the writers in this article do not necessarily represent the viewpoints of the companies the author are employed by.

1 INTRODUCTION

Confidence and Curiosity, part of the broader Creativity

As a continuation “chapter III” of an on-going innovation series appearing in IJIAS, Int. J. Innov. Appl. Stud., [1], [2] (Rebouillat & Lapray, 2014; Rebouillat, 2013), and prior to introducing this subject in the context of bio-inspired matters, it is probably desirable to remind the reader of some prerequisites; such as the skills generally anticipated to take an active part in the process of innovation, which is outlined within an R&D path from ideation to product launch. It is also equally important to position the intellectual property (IP), and more specifically the patent dynamics in these pre-introductory refreshing fundamentals.

After adding the Collaborative/Collaboratory[®] dimension to each and every 4C[©] skill descriptor introduced by Rebouillat back in 1998 [1], [2] (Rebouillat & Lapray, 2014; Rebouillat, 2013), two extra criteria revealed especially useful in the present study.

The business engineer, now unavoidably part of multiple networks, called most of the time the open innovation networks, such as many other partners in the process of innovation, will best perform his task if Curiosity and Confidence are promoted and stimulated by this process. There are many ways to avoid lack or loss of Curiosity and Confidence, which generally occurs out of personal experience, back sometime in the childhood and education journey, or which is inherently unavoidable due to an excessive standardization of the business/technology & science functions; splitting the creative from the non-creative people.

Kelleys (2013) [3] have authored one of the most astonishing essay on the matter of confidence in the creative course, involving a very large and diverse population and functions therewith. No doubt that although well-known hindrance circumstances, such as phobias, tend to annihilate creativity, the authors found ways to successfully develop and put in place methods to change the creative records of small to large organisations once the need is well recognized; sometime at the upper CEO&CTO levels to start with.

The word Curiosity tends to be subject to interpretation, pending on the context and multilingual semantic; in the present study its original meaning from the classic Latin language, *curiositas*, is favoured since it is associated with the care, i.e. special attention, and search, i.e. discovery, dual roots.

Mankind tends to “trust” nature and bio-events and therefore to gain confidence from the observation of nature and bio-systems; as long as sufficient curiosity is placed into the comprehension of these in order to limit usual phobias or to avoid leaning towards inhibiting ineluctability.

Bio-inspiration fits well with the addition of the 2C, coming from Curiosity and Confidence, to the 4C²© equation, becoming 4C²2C[©], as depicted on figure 1.

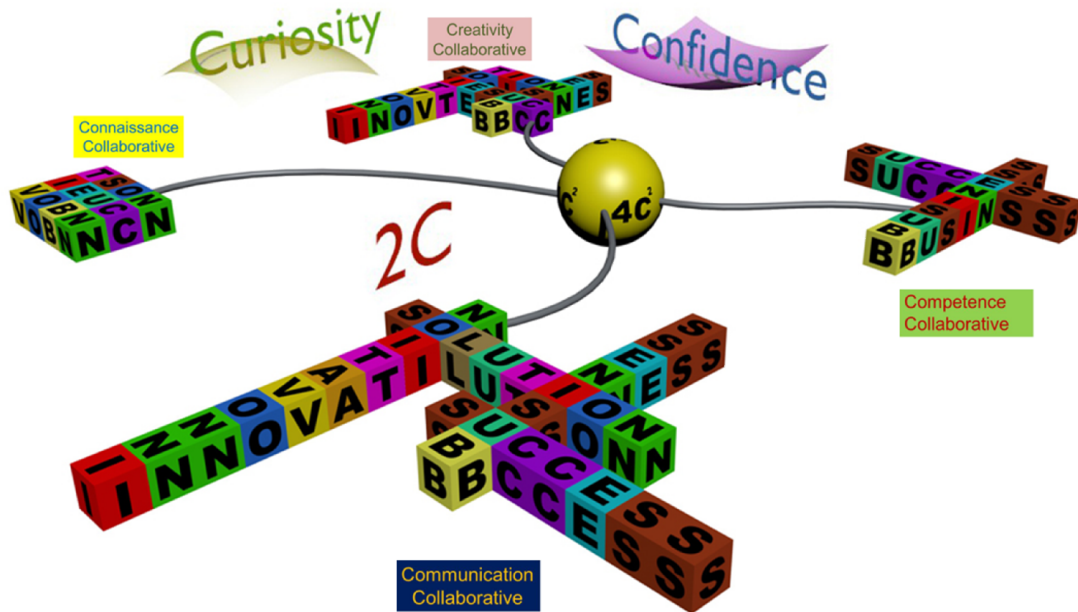


Figure 1. Curiosity and Confidence now part of the $4C^2$ equation becoming $4C^22C$

“Management Processes” are part of a broader Creativity too

There are several processes which may be used to safeguard creative developments and to help establish a multigenerational product roadmap with secured IP and business models therewith.

The House-of-Quality, the Quality Function deployment (QFD), the Voice-of-Customer (VOC), the Theory-of-Constraints (TOC), the integrated Theory of Inventive Problem Solving (TRIZ), Six Sigma, etc. have paved the way to promote best practices, to boost and to secure the innovation processes and routes to market of multigenerational products and processes [1], [2] (Rebouillat & Lapray, 2014; Rebouillat, 2013).

Most of these approaches, individually or integrated in innovation management processes, have now got Wall Street’s attention and became prerequisites to a good design of a portfolio of products. Although not so long ago Business Models were missing or developed as an after the fact “justification” or became the “most natural” way to proceed without being truly engineered for it.

An innovation pathway, for defining and meeting customer desires in an open innovation frame, was adapted and named by Rebouillat the “Z-process” back in the 90’s.

Figure 2 provides the sequences of this process which are self-explanatory. Additional rather common acronyms appear on this flow chart:

- CTQ: Critical To Quality, key measurable characteristics of a product or process
- SWOT: a structured planning method used to evaluate the Strengths, Weaknesses, Opportunities, and Threats
- ATA©: Adjacent Technology Analysis, [1], [2] (Rebouillat & Lapray, 2014; Rebouillat, 2013)
- DOE: Design Of Experiments
- RVA: Rapid Value Assessment complements VOC
- SHEA: Safety Health and Environment Awareness

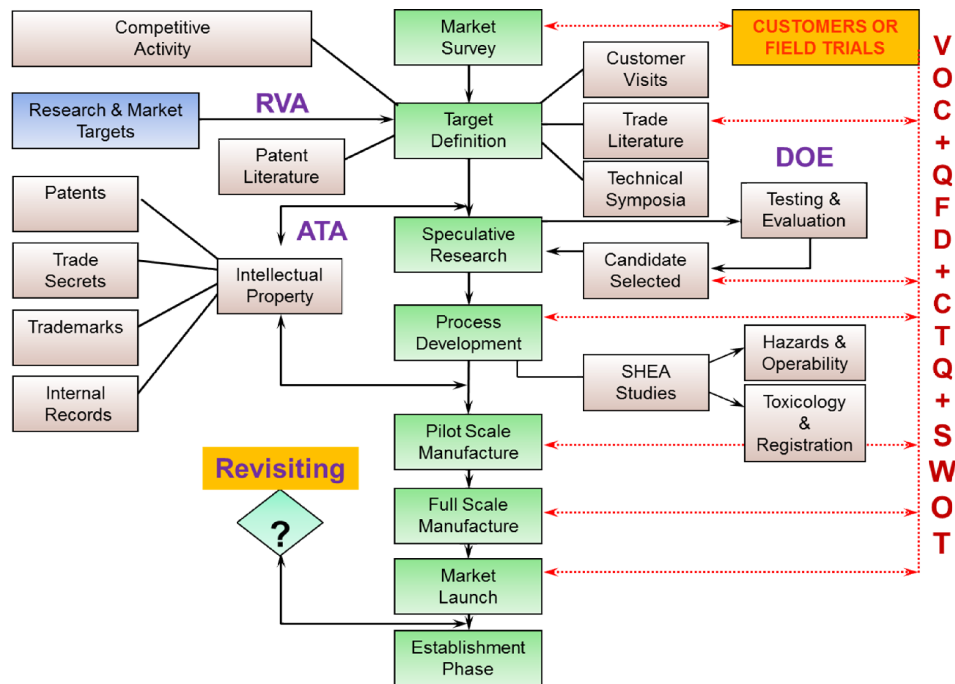


Figure 2. The Z-Process combines multiple business and technology management processes

Patent Quality to “feed” or replace Patent Quantity: a disrupting challenge

According to “Updating TRIZ: 2006-2008 Patent Research Findings” and adapted figure 3, minor and continuous improvements constitutes about 60% of the average patent portfolio while only 5% are of pioneering/new nature which in turn accounts for more than 70% of the portfolio overall value. Then the majority of the patents accounts for less than 25% of the value of the given portfolio.

The design of figure 3 is disruptive by nature and tough to put in place practically; nonetheless almost paradoxically, quality, emerging from pioneering, has to replace quantity for a broader creativity to happen. This without, at least temporally, hardening the “cash cow” securing cushion, coming from the bulk of the portfolio; that bulk generates a steady profits return that far exceeds the cash needed to purchase or to start it.

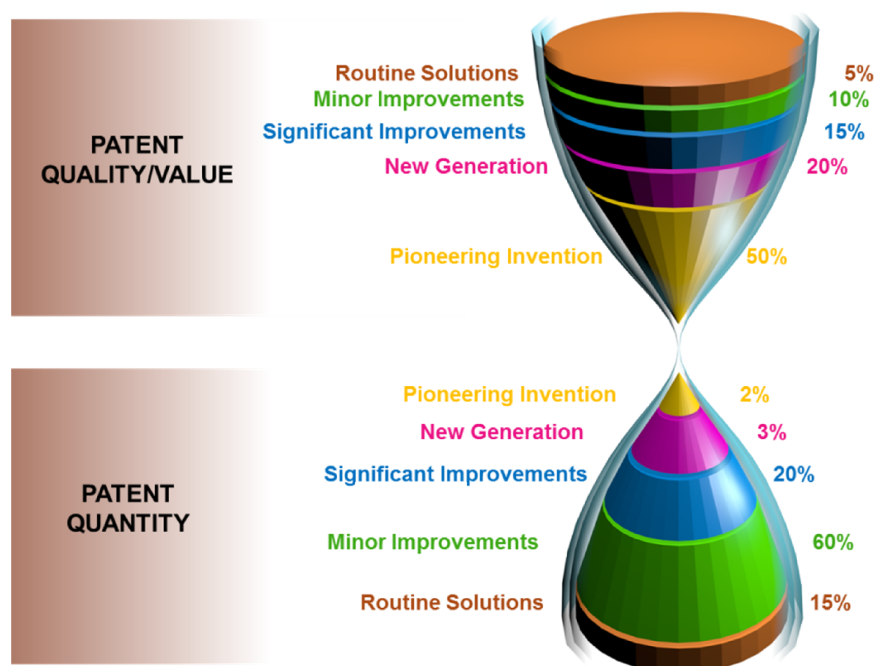


Figure 3. Electing for Quality maintaining a broad patent “coverage” remains a disruptive challenge

Disruptively?

A disruptive innovation can be a key for the company to prosper and last [4] (Christensen, 1997). The term “disruptive technology” has been commonly used as a substitute of “disruptive innovation”. So far, several of such technologies have been inspired by natural environment. In an age of rapidly growing understanding of nature’s secret design and concepts we have yet another chapter to add in the story of our joint venture.

Bio-mimicry vs Biotechnology

Humanity is continuously inspired by nature and has learned how to use its resources in every domain of life. To do that we often use means of biotechnology. It is the action of using living organisms to develop desired products, using derivatives thereof and modification of organisms (like breeding or genetic manipulation) [5], [6] (Dove, 2000; Thieman & Palladino, 2013).

In addition, in nature we found an inspiration to build planes and fins with capabilities exceeding living creatures. Sometimes, we boldly copy nature solutions, like structure of honeycomb that can be found in, to give just a few examples, LED technology, mirror structure of Hubble telescope, loudspeaker, or various aircraft applications. This is qualitatively different from biotechnology and began the field of bio-mimicry or bio-mimetics (also called biomimesis, bionics or biognosis).

Wealth of ideas that produce platform of solutions

The retrieval of all the patents from the US Patent and Trademark Office (USPTO) that contains the keyword “bio-inspired” yields 236 results. Using a recently developed interface to the USPTO to map patent portfolios [7] (Leydesdorff, Kushnir, & Rafols, 2012), we have noticed that documents were clustered around two main areas, namely medical and computational sciences (figure 4). The authors choose then to primarily give an overview of the range of solutions in these two areas. At the same time we do not attempt to describe in depth the underlying technologies, neither to provide an exhaustive list of them. Delivered examples come from all range of categories from those that are in commercial use, ready to be implemented patents and scientific projects that, although promising, still require a great deal of research.

Mimicking nature does not only mean creating a synthetic copy of its solutions. Equally, it can mean that one can look at the solutions that nature provides and be inspired by it. Therefore, in this review terms bio-inspired and bio-mimicking are used interchangeably.

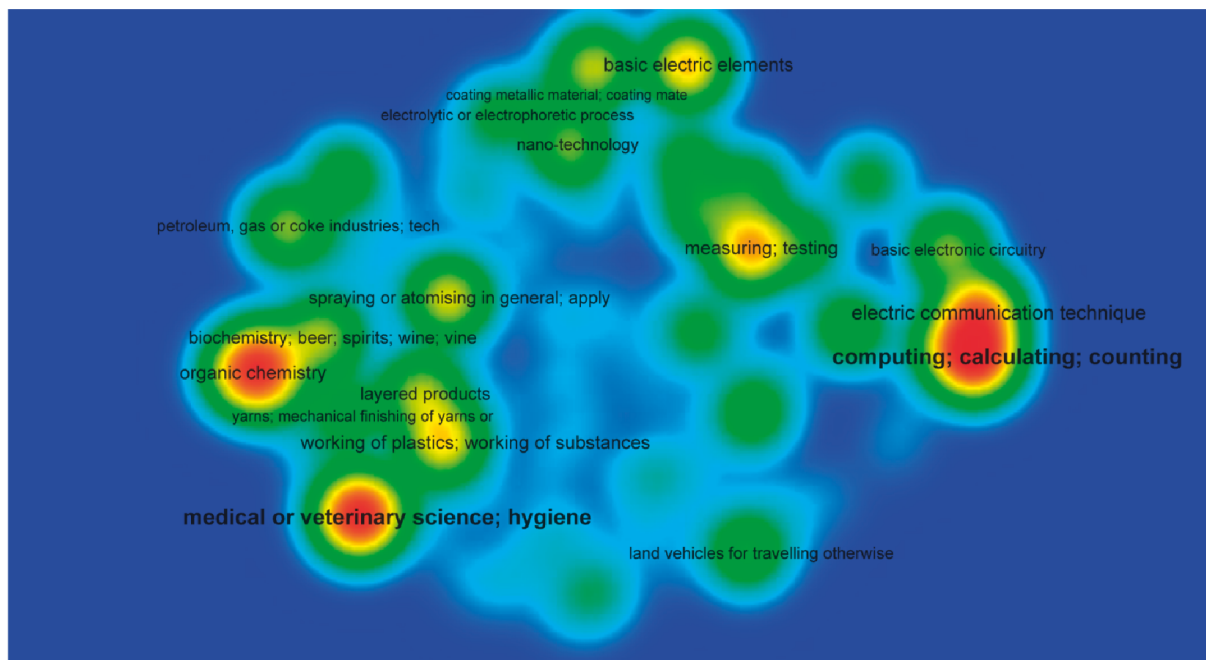


Figure 4. Mapping of “bio-inspired” USPTO patent portfolios

Nature mimicking is done on any conceptual level. It can mean rather a straightforward copy of the solution like in the case of Velcro (hook-and-loop fastener) that copies burrs of burdock. Or, can adapt a concept such as behavioural phenomena of animals to create problem solving techniques used in computing [8] (Chakravarthy, Bachan, Roshini, & Chandrasekharan, 2012). Nature “brand” comes with firm promise of solutions that resisted the durability test, have optimal energy consumption and can be simple to implement (provided we sufficiently understand them). It would be unwise to assume though that we can find all the best solutions in Earth environment. Nevertheless, it’s a pool of ideas that one cannot neglect.

The solutions provided by nature are applicable to the -nano, -micro, -macro and -mega scale. Moreover, one problem can find several solutions (figure 5). Let’s examine the mechanosensing to illustrate that concept by examining nature’s product portfolio. The range of possibilities is broad, starting from bacteria and ending in mammals. Let’s turn first to plants, such as the *Mimosa pudica* (common name: touch-me-not) that can react to environmental changes by closing its leaves in less than 0.1s. The basics of that response are simple and relay on a change of inner pressure, so called turgor [9] (Allen, 1969). On the other end of the solutions spectrum we encounter mammalian skin packed with mechanoreceptors connected to neurons. This system allows converting mechanical stimulus (touch, pressure) into an electrical signal further processed by the brain. This ensures great precision of sensation and is crucial to execute fine task of object manipulation [10] (Johansson & Flanagan, 2009). This proposition, although brilliant, is very complex to fully comprehend and therefore mimic. Nevertheless, engineers strive to design prototypes of “sensitive skin” [11] (Lumelsky, Shur, & Wagner, 2001). Perhaps it is satisfactory for one’s purpose to look at solutions with less multipart organisation found in insects or spiders, where the majority of sensory information is analysed locally without involving the brain. Sensing vibration is a vital task for spiders as it signals the presence of a prey on the web or a prospective mate. To perform the task, at a level far better than humans, they use “sensory hairs” or so called lyriform slit organs. This system uses deceptive simplicity of sensing changes in air or relevant cuticular strains such as mentioned vibrations [12] (Fratzl & Barth, 2009). Only recently, in-depth analysis of properties of available resources combined with new materials and micro fabrication techniques allowed starting to think about producing synthetic sensors [13] (Johnson, Bonser, & Jeronimidis, 2009).

In a similar manner, it is important to grasp, that many solutions and patents are not applicable to only one described situation as presented below. Many of them comprise rather a platform of solutions that can be used according to one's needs. One example is a technology of self-healing, slippery liquid-infused porous surfaces, abbreviated as SLIPS [14] (Wyss Institute, SLIPS: Slippery Liquid-Infused Porous Surfaces); a material that repels both liquids and solids, which can be used to coat medical devices (as described below) as well as in a range of different applications. Due to the specification of SLIPS, that can include: (1) transport of crude oil and biofuels; (2) economical heating/cooling systems; (3) ice resistant coatings for devices/instruments operating in refrigerated and polar environments; (4) stain resistant coatings on optical surfaces, such as solar cells, lenses, sensors, and night vision devices; (5) anti-biofouling coatings for medical devices and instruments, and marine vessels, also for deep sea exploration [15] (Wong et al., 2011).

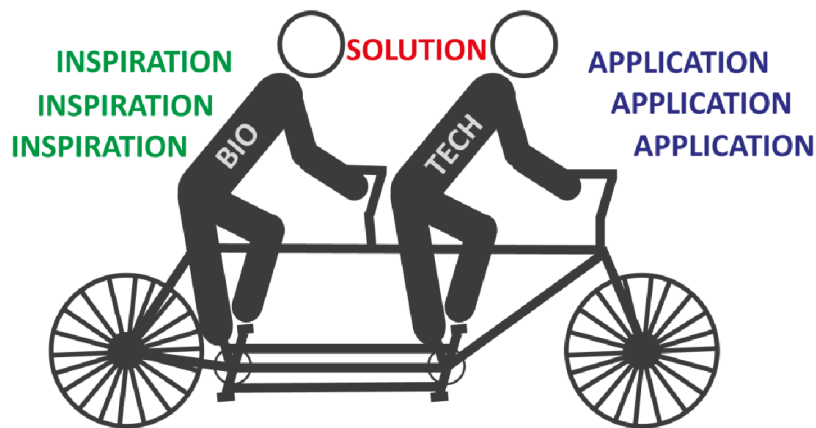


Figure 5. Platform of bio-inspired solution

Biologically inspired technology innovation process and methodology

The bio-inspired solutions are the result of a meeting, broadly speaking, between biologists and engineers (figure 5). As presented above, the result of such collaboration can produce outcomes beyond our expectations. Nature has uncountable patents, many of them difficult for us to identify straight away. This necessitates novel interdisciplinary approaches starting from the education and training plans that build a bridge between biology and engineering fields. Some efforts in that domain has been already made, an example is the Center for Biologically Inspired Design, a research unit at Georgia Institute of Technology [16] (cbid.gatech.edu). The task of cross domain knowledge translation is not straightforward. The researchers analysed the approach to solve the problem taken by the students with different backgrounds during the course on biologically inspired designs [17] (Vattam, Helms, & Goel, 2007). The study pointed out that biologists and engineers differ in (1) the language they use, (2) the objectives of their work (understanding of the process vs creating applicable solution), (3) the complexity of the systems in questions (living organism with variety of simultaneous functions vs technical development to master one task), (4) the resources to use (cellulose vs steel for reinforcement of high structures) [17] (Vattam et al., 2007). All of those differences were visible during the execution of the projects and resulted in frequent cognitive errors such as issues in defining the problem with appropriate level of specificity and not being able to create correct analogies [17] (Vattam et al., 2007). The authors proposed to use interactive computational tools to facilitate the process of innovation by retrieving the relevant biological information for given technical problems [17] (Vattam et al., 2007). It seems that creating a library and tools that could create appropriate analogies to link biology and technology is a promising approach. Some propose to take into account the complexity of living organisms in question and focus not only on physical properties but also on environment, the cause and purpose of action, available resources and auxiliary systems involved [18] (J. F. V. Vincent, Bogatyreva, Pahl, Bogatyrev, & Bowyer, 2005). Nevertheless, we must remember that we need to reach a deeper understanding of differences in the approach between man and nature to solve similar issues, and some initial data point that they are substantial [19] (J. F. V. Vincent, 2005). In addition, there is a key challenge in front of us of how to make the process of bio-inspired innovation more systematic, and not of retrospective in approach.

In essence, an algorithm to structure methodology in technical innovation exists (like one known as TRIZ) and some think that, if transformed to match a bio-setting, may prove to be a useful procedure. Russian inventor Genrich Altshuller analysed hundreds of thousands of patents and that allowed uncovering patterns of evolution for technical inventions. This set of observation was a foundation to develop rules describing a systematic process to solving technical problems, known as TRIZ (acronym from Russian name) or referred as “the theory of inventive problem solving” [20] (Altshuller, 1999). TRIZ algorithm became worldwide recognised tool and many Fortune 500 companies successfully use its methodology [21]¹. The general TRIZ principles of transfer of functions, mechanisms and principles from one field to another are very similar to the process of bio-mimetic. Therefore, some tried to examine its usefulness in a new field. The problem in TRIZ terminology is defined as a conflict between two contradictory elements, e.g. when the product needs to be stronger but can’t be heavier. Based on patent analysis, all contradictions were classified in a form of 40 Inventive Principles. Every conflicting element was next considered according to a list of 39 factors, which in addition could impact on each other. The result of such combination generates a contradiction matrix of functional problems. It helps to identify and narrow the problem and in a next step can provide a method for resolution based on ways in which similar problems have been resolved by other people, often in other areas of science and technology. The key is to sufficiently generalize the conflict to allow insights from a variety of disciplines, that in turn increases the possibility to generate more innovative solutions [20] (Altshuller, 1999). Since, it is difficult to apply a common “language” applicable for both biology and technology, the first step was to examine a few case study examples from nature trying to recognise solutions to contradiction-like problems and examine whether the 40 Inventive Principles apply [22] (Mann, 1999). From the gathered data, mostly from macro-scale cases, it appears that Inventive Principles could be used but the ability of the current Matrix to mimic natural inventions is small [22] (Mann, 1999). Analysis of arthropod cuticle is another example of thorough attempt to translate biological functional design in terms of standard TRIZ Inventive Principles [19] (J. F. V. Vincent, 2005). The authors identified the functional conflicts and looked at the solutions proposed by nature and technology, it turned out they were overlaying in about 20% [19] (J. F. V. Vincent, 2005). Authors suggested that this mismatch may be a derivative of several factors. Firstly, it is essential to consider a living system in a context of its environment, and not, as in the case of technology, in isolation. It is necessary to identify what are the components that create the system under consideration, as well as to what higher in hierarchy system it belongs to. In case of a specific tissue, taken as an example, it is helpful to recognise what cell types it is built of and what organ it will create. In turn, it will help us to understand the purpose of action, causes, limits and effects of a system. This initial consideration and definition of the system can help to identify if such a function is even described in the TRIZ system or needs to be added as another possibility. Next, we must carefully consider what resources were available when the biological system was created as it is a key determinant of its development. Finally, since the living systems are embedded in hierarchical structures, several auxiliary elements can be involved in execution of its function. Complex interaction between units of natural ensemble will most likely cause unpredictable effects. Further studies, by the same group, confirmed and further demonstrated that technology and biology employ different strategies to solve the same problem and that we can benefit from looking into nature’s design to uncover a surprising result [23], [24] (Bogatyrev & Bogatyreva; J. F. V Vincent, Bogatyreva, Bogatyrev, Bowyer, & Pahl, 2006).

Having an indication that biologically inspired technology carries uncovered potential it would be unwise to abandon this new engineering domain. Although we are still struggling to design a systemic approach to generate innovation in bionics domain we should keep up our efforts as even in the current environment they bring measurable results. At the moment, the development of bio-inspired-technology is powered by knowledge generation lead by inter-disciplinary studies and continuous dialog between engineers and biologists. The growth of innovation inspired by nature is a derivative of gathered knowledge described in a common for all interested parties language (figure 6).

¹ www.aitriz.org/triz

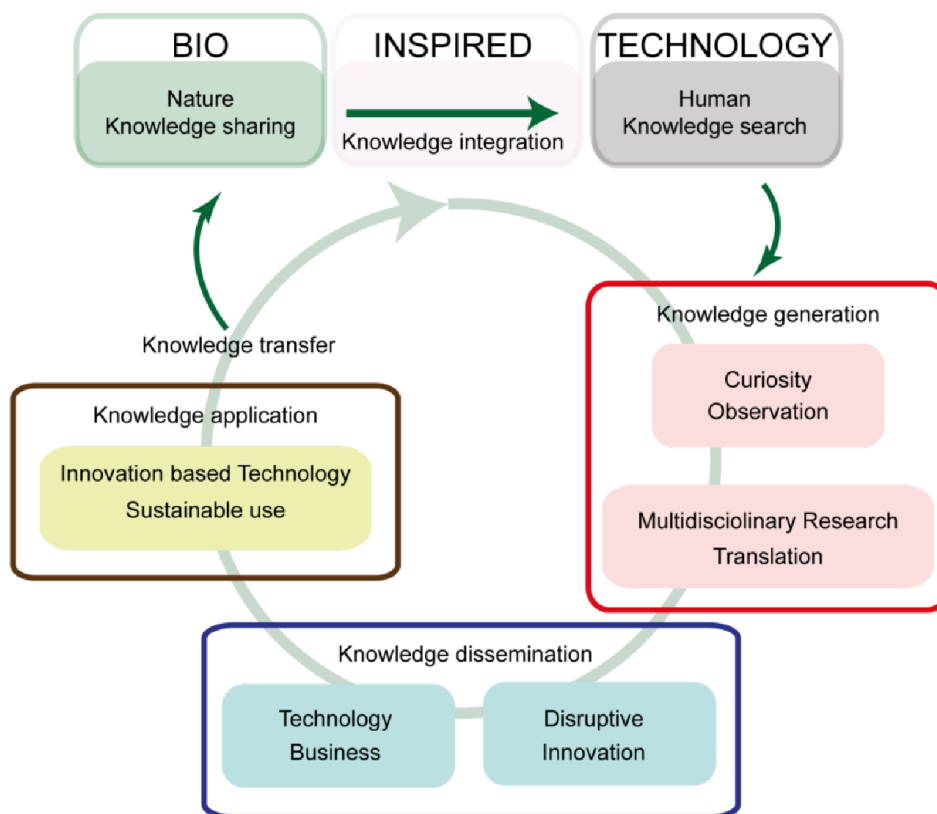


Figure 6. Knowledge flow

2 BIO-MIMICKING - FUTURE INNOVATION DRIVE FOR PHARMACEUTICAL INDUSTRY?

The pharmaceutical industry is clearly one of the most innovation demanding ones [25] (IFPMA, 2013) and as such can clearly benefit from a bio-mimicking approach. It became extremely important since the rate of truly new drugs being launched is decreasing in recent years [26] (Pammolli, Magazzini, & Riccaboni, 2011). We present below some of the new developments that may become disruptive innovation for the industry.

DNA-based nanostructures as targeted drug delivery systems

DNA is a biological material that stores, codes and transfers information. Due to its properties of self-recognition and self-assembling it has been used to create nanostructures that can serve different functions. It is an interesting example of bio-mimicry where scientists are deliberately taking advantage of the properties of natural polymer to create structures with purposes not foreseen in organisms but desired by bioengineers.

The area of structural DNA nanotechnology uses a technique called DNA origami, where a long piece of DNA strand is folded into a desired shape with hundreds of short staple strands [27], [28] (Rothmund, 2006; Yan, Labean, Feng, & Reif, 2003). This relatively new technique (pioneered in 2006) allowed creating three-dimensional and polyhedral structures with desired, pre-defined shapes and dimensions in nano-scale not achievable beforehand.

The DNA nanostructures possess a combination of features that allows us to consider them as system for drug delivery. Firstly, and somehow obviously, they are bio-molecules and as such they are compatible with bio-systems [29] (Ko, Liu, Chen, & Mao, 2008). Therefore, there are little associated threats of its accumulation and/or toxicity like in the case of inorganic or artificial nano-materials, however certain shapes may have some immuncity [30] (Origami et al., 2011).

Crucially, unlike nucleic acids they can cross cells membrane [29], [31]–[33] (Hamblin, Carneiro, Fakhoury, Bujold, & Sleiman, 2012; Ko et al., 2008; Li et al., 2011; Walsh et al., 2011). It has been suggested that just certain geometry could be sufficient for the nano-structure to be internalized by a cell [31], [32] (Hamblin et al., 2012; Li et al., 2011). In that context

being able to produce specific shape is fundamental. Lastly, they prove to be stable in physiological conditions after internalization [31], [32] (Hamblin et al., 2012; Li et al., 2011). In addition, there are several methods that allow the coupling of DNA nano-structures with active compounds, these include small molecules, nucleic acid, proteins and other nanoparticles [34] (Li, Fan, Pei, Shi, & Huang, 2013).

Influenced by these advances Douglas and colleagues designed a DNA nanorobot capable of delivering signalling molecules to selective cell population [35] (Douglas, Bachelet, & Church, 2012). It is an important point as currently we are designing drugs (ligands) to act on their selective targets. The latter are most likely present in many places of biological systems and activated cause widespread, additional to therapeutic, unwanted side effects.

The designed nanorobot has a form of hexagonal barrel that consist of two domains attached to each other. Next, they designed two “lock” mechanisms that open when binding to “keys”; they were added in front of the barrel, on left and right side. When both locks recognise their target they open (dissociate) and initiate a reconfiguration of the barrel (it halves). This exposes previously hidden surface with attached cargo (that can carry up to 12 payloads). Only when the robot simultaneously encounter a correct combination of keys it will become active, and there is no competitive mechanism that could open it. In inactive state (closed barrel) the cargo cannot interact with cells. The authors showed that several cell lines could selectively activate the robots, up to the single-cell level. Importantly, the nanorobot was shown to discriminate target cell types (derived from granular lymphocytic leukaemia, aggressive natural killer cell type) in a mixture with healthy leucocytes. Finally, activated nanorobots induced growth arrest in the above cell line [35] (Douglas et al., 2012).

To sum up all of the above, it opens up a possibility of a new era of effective, cell population oriented drug delivery system with possible low side effects, and creates wealth of possible interactions of inorganic particles with biological systems.

In a similar manner, the self-assembly properties of DNA was used to create complex structures that coat inorganic nanoparticles (used as therapeutics, contrast agents and integrated systems for treatment and diagnosis of disease). As mentioned beforehand, such a strategy was designed because, despite their effectiveness [36], [37] (Park et al., 2010; Perrault, Walkey, Jennings, Fischer, & Chan, 2009) they are not well cleared from the body and such a persistent presence in the system may lead to a variety of toxic effects. Therefore, to counteract that unwanted effect several studies tried to improve the process of drug delivery and elimination by combining inorganic particles with organic molecules. The recently proposed structure consists of a central (core) nanoparticle surrounded by DNA with a possibility to add several layers of additional particles surrounded by DNA with different sequences that insert themselves into the previous layer [38] (Chou, Zagorovsky, & Chan, 2014). The final DNA coat is covered with additional ligands that enable interaction with biological systems. It has been shown that superstructures after entering the system can specifically accumulate in tumours (without non-tolerable side effects) and be effectively eliminated by kidneys [38] (Chou et al., 2014). Altogether this allows designing diversity of colloidal superstructures that can serve as a drug delivery platform with desired biological stability, low and non-specific interactions with biomolecules and cells and favourable pharmacokinetics.

Both examples open doors to a whole class of novel enabling technologies that uses DNA as building material, with potentially very big impacts.

Bio-inspired solutions for R&D cost saving

The cost and time of successfully launching a new drug on the market is ever growing, reaching USD 1.3 billion and lasting over 14 years [25] (IFPMA, 2013). In that process the numbers bluntly point out that more and more substances do not reach or pass subsequent clinical trials that translate to higher costs. Some of that can be reduced by more rigorous fundamental and pre-clinical research of new molecular entity that subsequently have higher chances of success and launch [39] (Paul et al., 2010). Can some of the bio-inspired technologies contribute to investments saving during the R&D process?

We are not yet able to simulate the complex physiology of an organism; therefore the use of animals during final elucidation of an impact of tested new molecule on biological networks cannot be replaced. Unfortunately, in addition to other disadvantages, we have very few reliable animal models of disease and the results of such studies not necessarily translate to human. At the moment, initial data collection concerning the action of new molecules is performed in living cell cultures. This gives rather limited insights as concerns single cells type and a result excludes further tissue, organ and system level interactions. Both issues can be overcome with the possible use of “organs-on-chips” that can both give insights into system levels actions of tested molecules and reduce the use of animals [40] (Huh et al., 2013). The idea is to culture living cells in micro-channels (polymeric or glass) that express and maintain tissue specific functions. Examples include most of human cells from brain, kidney, liver, heart, skeletal muscle and intestine. Recently improved systems mimic chemical and

mechanical environment of human organs and allow tissue to tissue interfaces. With the use of these systems one can truly mimic physical and chemical environment and thus organ level function [40] (Huh et al., 2013). As a proof of concept lung-on-chips have been used to predict efficacy and toxicity of new therapeutics against pulmonary edema [41] (Huh et al., 2012). This can become a future approach to test drug efficacy and safety in pharmaceutical as well as fundamental research context.

Finally, one could think of increasing the effectiveness of producing biopharmaceuticals taking a closer look on natural systems self-regulation. Mimicking of the ecosystems provides a proposition of bio-supportive medium with at least one nutritional and bio-limiting agent [42] (Guritza, 2003). Specific configuration of such an artificial environment can enhance production of active pharmaceutical compounds. Bio-inspired medium is also another example of multiple application of one technology solution (figure 5). It could be used to limiting growth of unwanted bio-mass on materials exposed to aquatic environments. It is an alternative to currently used coatings that prevents bio-fouling and corrosion, but often includes toxins, therefore their use is limited.

The above section 2 related to the pharmaceutical industry has been subject to semantic analysis performed by two different search engines, and then clustering. The study was performed on the first 1000 most relevant patent references for the sake of processing ease. Obviously the two searches converge as per comparison of the left and the right gearwheels clusters on figure 7.

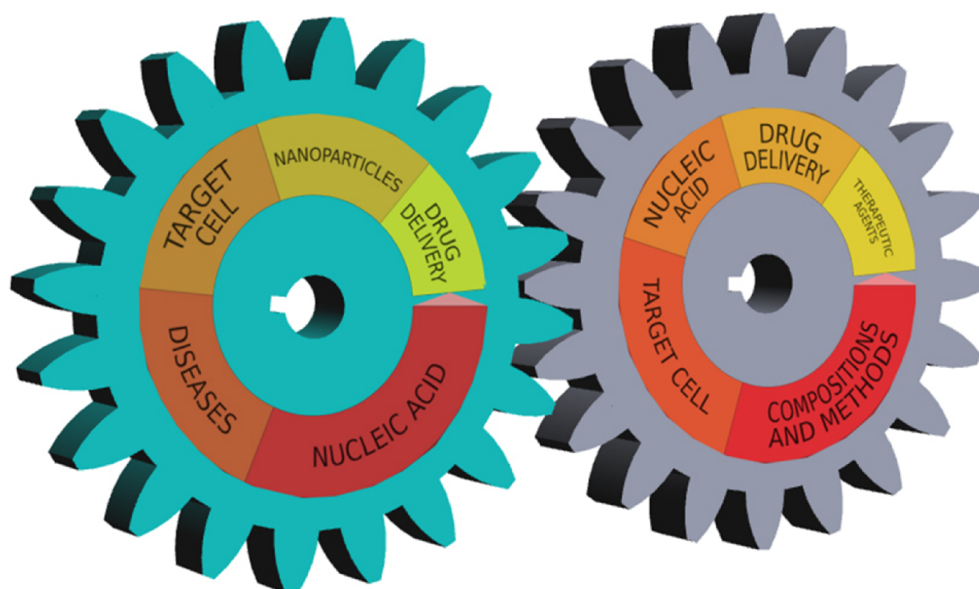


Figure 7. Semantic analysis and clustering of section 2 – “Pharmaceutical Industry”

3 BIO-INSPIRED MATERIALS, TECHNIQUES AND TREATMENTS IN MEDICINE

Similar to pharmaceutical industry, biologically inspired solutions in the area of materials, technical devices or treatments have the capability of pushing the frontiers of medicine as we know it. Several examples presented below, although apparently not related to each other, will help to shape a bigger picture.

We will not be soon capable of mimicking the precise hands movement of a surgeon. In fact, even manipulating delicate materials, including human tissue, by machines is a challenging task. Engineers found an inspiration in a simple feeding apparatus mechanism of molluscs (like California sea slug). It is a muscular structure that is able to grasp and move food into the animal’s body. The invention is mimicking this specific muscular arrangement and its capability of gripping and manipulating fragile, irregular materials in the lumen. It can be complemented by sensors to detect local environment changes e.g. in pressure and can be manipulated *via* external control systems. The above technology therefore could be used in, among many, medical applications such as removing plaque from blood vessels [43] (Hillel, Beer, Mangan, Quinn, & Sutton, 2010).

Deposit of plaques (cholesterol) obstructs arterial blood flow, and will most likely lead to the development of cardiovascular diseases. These are the most common causes of death and in the same time become a financial burden for the society [44] (American Heart Association, 2013). To keep arteries open, surgeons insert bare metal mesh tubes, called stents. This solution is not perfect and patients can suffer from re-closure of the artery. It can be initiated by stents themselves that penetrates into the vessel wall. The interior surface of blood and lymphatic vessels consist of thin layer of cells called endothelium. It forms an interface between circulating blood or lymph in the lumen and the rest of the vessel wall. Its function is far more complex than just a barrier and includes control over blood pressure, inflammation, release of agents against blood clotting and supporting formation of new vessels, as well as repair of damaged organs. Disruption of the endothelium function can lead to the cascade of events resulting in serious complication. Therefore, stents have been equipped with drug eluting coats; sadly they did not manage to solve the entire problem. Alternatively, one could think of mimicking original endothelium cell layer to avoid the above problems. Recently, a natural endothelium mimicking nanomatrix that could be used to coat medical devices such as vascular stents has been patented [45] (Jun, Kushwaha, Brott, & Anderson, 2010). It uses peptide-based molecules that self-assemble into nanofibers, so called peptide amphiphiles, which host endothelial cells [45] (Jun et al., 2010). The aim is to simulate natural cells environment, so called extracellular matrix (ECM). Extracellular matrix, although variable in types, can be described as surrounding of the cells that provides multiple functions. This includes structural support, cell-to-cell communication, adhesion and complex signalling involved in cell growth or healing. Another example approach to mimic such conditions is the use of cellulose acetate porous membrane (that can also comprise carbon nanotubes) [46] (Gouma, 2007). In this case, artificial scaffolding from natural polymers could be used in the process of tissue bioengineering for therapeutic purposes such as custom-made skin implants. Which of the two patented approaches can prove to be more compatible with our organism is yet to be determined.

In our imagination, hospital is associated with an almost sterile place. It is self-explanatory why maintaining a clean medical environment and tolls is a necessity. Novel materials can help with achieving this labours task. Engineers were inspired by the Nepenthes pitcher plant that has very slippery surface crucial for catching a prey. The rim of the plant has a microstructure that locks-in liquids and then acts as a repellent surface. Insects with drops of water on their feet that step on it then slide straight to the digestive juices of the plant. This idea led to the design of a synthetic material called: self-healing, slippery liquid-infused porous surfaces, or SLIPS [15], [47] (Aizenberg, Hatton, Ingberg, Super, & Wong, 2012; Wong et al., 2011). SLIPS are able to repel a broad range of liquids such as oil or blood making it the perfect coating for a variety of applications.

Prevention is better than treatment in every aspect under consideration. In everyday life it proves to be challenging to maintain good posture while sitting on an office chair and working for long hours. Engineers patented a system that employs mimicking of human body posture to help keeping a healthy position during work as well as during correlated discrete movements [48] (Tholkes & Hockenberry, 2004).

Finally, an example of a futuristic treatment for impaired vision inspired by primitive water organisms. This story is about a multi-layer example of bio-inspired technology and concepts and will slowly reveal its potential in the next paragraphs.

The green alga (*Chlamydomonas reinhardtii*) is a well-known organism in the biopharmaceuticals and the biofuel field as a source of hydrogen. However we are particularly interested here in how this single cell organism is able to move in response to, and towards light. The light is detected by a family of proteins that serves as sensory photoreceptors, so called channelrhodopsins (ChR; figure 8). In practice, they form a passage (channel) connecting the inside of the cell to the external environment. It can be either open, when it absorbs light, or close. ChR absorbs blue light that results in a change in the anatomy of the protein that opens up and allows the free flow of ions (cations such as H⁺, Na⁺, K⁺, and Ca²⁺). In turn, movement of electrically charge ions changes a cell's potential across the membrane leading to its activation or inhibition. In other words, one could say that ChR forms light-gated ion channels [49] (Kato et al., 2012).

Ion channels are present in all cells and they shape electrical signals by gating the flow of ions across the membrane. This is no different to specialised brain cells, neurons. However, they are a key component of neurons physiology as information in the brain is processed and transmitted through electrical and chemical signals. It is not surprising that the voltage gradients across neuron membrane are maintained by a combination of ion pumps and ion channels. Together, this led to the idea of controlling activity of brain cells by inserting into their membrane the green algae ChRs and manipulating them with light (figure 8). Now the last task at hand is how to insert them and gain full control of ChRs and therefore neurons?

With the current techniques it is rather a straightforward task. Scientists have at hand a variety of transfection techniques (viral transfection, electroporation, gene gun) that force neurons to express and integrate ChRs into their membrane. Important to note that such cell modification, in principle, does not lead to any signs of toxicity.

One needs to add, that we can not only activate neurons with the blue-light sensitive ChR but also silence them with yellow light-activated chloride pump halorhodopsin, from *Halobacteria*. The field of controlling genetically modified cells with light has been termed optogenetics [50] (Deisseroth, 2010).

The repertoire of multiple-colour optical activation with millisecond precision is heavily used to probe the function of nervous system [51] (Deisseroth, 2011). However, first efforts have been made to use it as a therapeutically valid tool.

These bring us back to our main point of applying optogenetics to a problem of vision degeneration. The inner surface of the eye is a light-sensitive layer of tissue, and its degeneration leads to blindness [52] (Lagali et al., 2008). The photosensitivity is ensured by photoreceptors coupled to neurons that relay the information to the cortex of the brain that will “analyse” the image. In the situation when photoreceptors have been lost inserting ChR2 to retinal neurons could lead to their excitement by light (figure 8). Indeed, inserting light sensitive channels to specific cell types (called ON bipolar cells) in a mouse model of disease restored some signalling towards the visual cortex and was sufficient for the animal to perform given tasks [52] (Lagali et al., 2008). These results hold a promise that this technique will be applicable to the treatment of other neurological diseases that necessitate cell-specific modulation.

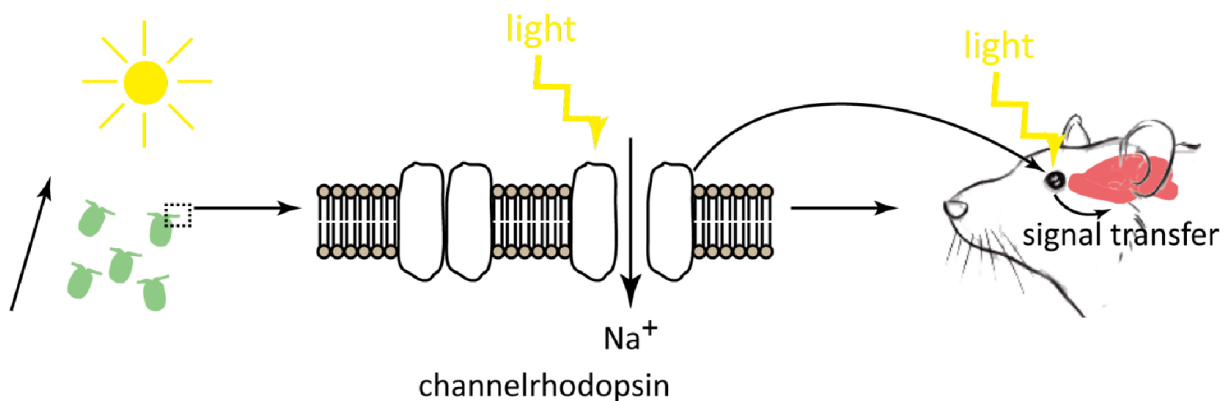


Figure 8. Optogenetic-based treatment vision degeneration

4 HOW WE PATENT SOLUTIONS PROVIDED BY NATURE FOR PHARMA/MEDICAL TECHNOLOGIES?

Currently solutions developed by nature are (mostly) not protected by patents. One can have easy web access to genome database of several animals e.g. bacteria *E. Coli* [53]² and human [54]³. The above was re-enforced by a decision of U.S. Supreme Court (on June 13, 2013, in *Association for Molecular Pathology v. Myriad Genetics*, No. 12-398), that unanimously ruled that, a naturally occurring DNA segment is a product of nature and not patent eligible merely because it has been isolated [55] (Ledford, 2013). It is an important decision because since 1980, the USPTO granted patents on more than 35,000 gene sequences (20% of human genome). This decision invalidates Myriad's patents on the markers for breast and ovarian cancer: BRCA1 and BRCA2 genes. In practice it means that other companies will be able to propose the test detecting mutation of the above genes, which will most likely result in a cheaper price for this service and will become more accessible to women. On the other hand, removing the protection of intellectual property, crucial for commercial investment, can slow down the development of new products or may push companies to protect inventions as undisclosed trade secrets. Importantly, the court also held that manipulation of a gene to create synthetically-produced complementary DNA could still be eligible for patent protection. This statement has already caused confusion as there is no further guidance to determine how much modification is sufficient to justify a patent. The same question is currently under revision considering the stem

² www.genome.wisc.edu

³ www.doegenomes.org

cells research [56] (Marshall, 2014). An advocacy group (Consumer Watchdog) aims to invalidate a patent from 2006 awarded to biologist James Thomson, who was the first to isolate and culture stem cells from human embryos [57] (Thomas, 2006). The implications of withdrawing a patent, both for public sector research institution and commercial technology transfer are not straightforward to predict [58] (Bergman & Graff, 2007). Clearly, this uneasy and vital discussion has just been opened.

5 BIOLOGICALLY INSPIRED SOFTWARE AND HARDWARE – A WAY TO SOLVE EVERY COMPLEX PROBLEM?

Some problem cannot be simply solved using rule-based software code. This is when we turned to nature to look for ideas to develop algorithms to help us. Insights into how biology manages complex matters of structure, behaviour and operation of systems and organisms have proven to be a fruitful source of stimulation. Depending on the specific source of inspiration, algorithms can be further divided into several categories: (1) artificial neural networks inspired by animals' central nervous systems; (2) evolutionary algorithms (EA; including genetic algorithms, GA) that use mechanisms inspired by evolution; (3) swarm intelligence (SI) that attempts to mimic the behaviour of a group of independent organisms such as ant or bee colonies, bird flocking, wolf group hierarchy, bacterial growth, etc.; (4) others. It is virtually impossible to discuss here in depth all available tools, their structure and application, and it's not our primary goal. It is nevertheless important to emphasise that all of them can be used to solve a variety of problems in fields such as financial modelling [59] (Brabazon & O'Neil, 2010) or computer networking [60] (Meisel, Pappas, & Zhang, 2010).

Human brains are highly plastic, process information in parallel, learn easily, use semantic interpretation of speech, process image and solve many more conceptual problems. It is therefore our ultimate inspiration to design some of those desirable characteristics. It seems that the key element allowing a brain to outperform computers in many tasks lies in their system architecture build from a variety of extremely interconnected processing units [61] (Buzsaki, 2006). The basic hardware unit of the brain super computer is the single nerve cell, called neuron (figure 9) [62] (Hammond, 2008). These are excitable cells. When they receive relevant information they generate electrical signals and propagate them along their processes (called axons and dendrites). This capacity is due to the presence of proteins in their membranes which allow the selective passage of ions, called simply the ion channels. These are similar to channelrhodopsins, mentioned in a previous chapter, with the difference that they are activated by a change in membrane voltage, not a light. Neurons generate only one type of electrical signal called an action potential (AP) or a spike. Moreover it is “all or nothing”, 0 or 1 type of signal, it can simply occur or not. The details of information it carries are therefore coded in the frequency of neuronal discharge. Neurons are not (mostly) connected by membranes, so that electrical signal cannot freely propagate from one to another. Instead they communicate by specialised zones of contact formed between cells that are called synapses. They are specialised in the transmission of information in chemical form and although slower, they contain a myriad of information compared to an electrical signal. Such a communication is possible because neurons are also secretory cells. The product that they release is called neurotransmitter, and can be any small molecule like amino acids, peptides, or monoamines. After an AP reaches the restricted membrane part of the neuron (synapse) it signals the release of neurotransmitters to the extracellular space. Next, the chemicals bind to and subsequently activate ion channels present on the membrane of the receiving neuron. In turn, opening of channels may initiate AP and signal transmission in the receiving neuron [62] (Hammond, 2008).

Based on those principles, an artificial neural network can be already modelled. It uses artificial nodes, equivalents of neurons, that are connected together to form a network (figure 9). The artificial synapse is assigned a strength or amplitude of a connection between two nodes, and is known as synaptic weight. Artificial neurons are simplified, mathematical models of biological equivalents described above [63] (McCulloch & Pitts, 1943). McCulloch-Pitts model of neuron has many inputs (i.e., analogue of dendrites, post-synaptic site of network) with attributed weight (w) and one output (analogue of axon, pre-synaptic site of network) [63] (McCulloch & Pitts, 1943). Similar to its natural counterpart, the output vector value (of 1 or 0) next propagates to the input of the next artificial neuron, through a synapse. Similar to its natural process, the weight of artificial synapse, and hence the connection between units is changing during learning. This simplistic analogy is sufficient to give artificial network biological properties such as the ability to acquire knowledge through learning and storing information within inter-neuron connections. The artificial neurons can be connected in series; in so-called feed-forward networks (figure 9). If nodes have internal loops (or feedback connections) then their architecture is referred as recurrent network. The objective of every neural network is to transform the inputs into meaningful outputs. And again, the key factor to determine signal processing is the architecture of the network. The most common neural network, belonging to feed-forward family type, is the multilayer perceptron. The multilayer perceptron can produce only one set of output values because artificial neurons are organised into layers that are nonreciprocally connected (this is a so-called static system). On the other hand, the recurrent network is equipped with feedback paths that allow a modification of subsequent inputs to the nodes (this is a so-called dynamic system) [64] (Jain, Mao, & Mohiuddin, 1996). The true power and advantage of neural networks lies in

their ability to learn. Briefly, the network is adjusting the weight between nodes during the training process. It is able to derive them directly from the given examples and improve them after several repetitions [64] (Jain et al., 1996).

Generally speaking, this is a point where analogies with biology to create software's based on artificial neural networks has been replaced by methods of statistics and signal processing. Let's examine the next step that would be interesting to model and add to artificial neural network – that is considering two types of neuron. Depending on the action of neurotransmitters, released by a synaptic ending, we can divide them into one that will excite/activate the receiving (post-synaptic) neuron or will inhibit/stop the generation of spike. Differentiation between excitatory (E) and inhibitory (I) neurons is a crucial point. Natural networks composed of only excitatory units (as it is the case for artificial neuron) is extremely unstable and produces simple and predictable results. Excitation will lead to excitation at every step, resulting in ever-growing increase of activity, exhaustion and shut down of the network (figure 9). It implies that the network requires a control system to be able to carry out useful information. In contrast, when you introduce inhibitory units into the chain, its activation will suppress the discharge of its target neuron [65] (Pouille & Scanziani, 2001). Depending on the target type it will inversely influence the network. These differences in the behaviour of two types of chains of neurons are further illustrated on figure 5. In the second configuration, resembling natural system, it is more difficult to predict the spread of the input and activity of every unit as it strongly relies on the details of the connections. In other words, this network generates nonlinear effects and complex behaviours [66], [67] (Dupret, O'Neill, & Csicsvari, 2013; Lapray et al., 2012).

To sum up, the true complexity of the brain's operations emerges from the relationship of interacting elements, and the activity that can be transmitted in both bottom-up and top-down directions. Modelling such complex network and its behaviour with the use of software tools has its limits. Therefore, some researchers are trying to build hardware realisations of spiking neurons models and networks. To build a silicon analogue of a biological neuron, one needs to mimic the behaviour of a cell determined by, described above, voltage-, ion-, and neurotransmitter triggered conductances. It can be done by representing neuronal membrane as electrical circuit's equivalent. In electrical circuit, a membrane is a capacitor and ion flows are represented as leak conductance. It has been manufactured by using a combination of complementary metal-oxide-semiconductors circuits. Importantly, a silicon neuron, modelled on a cortical principal cell, would respond to applied stimulus in a similar way as its biological counterpart [68] (Mahowald & Douglas, 1991). This approach truly mimics the properties of a biological tissue rather than interpreting its principles to create artificial networks. This qualitative difference may bring us closer to create machines more suitable to solve real world problems. An example to support that notion comes from a neuromorphic hardware [69]⁴, which successfully executed algorithms that classify data with different features [70] (Schmuker, Pfeil, & Nawrot, 2014). Importantly, this approach takes into account the natural variability in morphology and function of the brain and includes processes such as lateral inhibition [70] (Schmuker et al., 2014).

⁴ www.kip.uniheidelberg.de/cms/vision/projects/facets/neuromorphic_hardware/single_chip_system/the_spikey_chip/

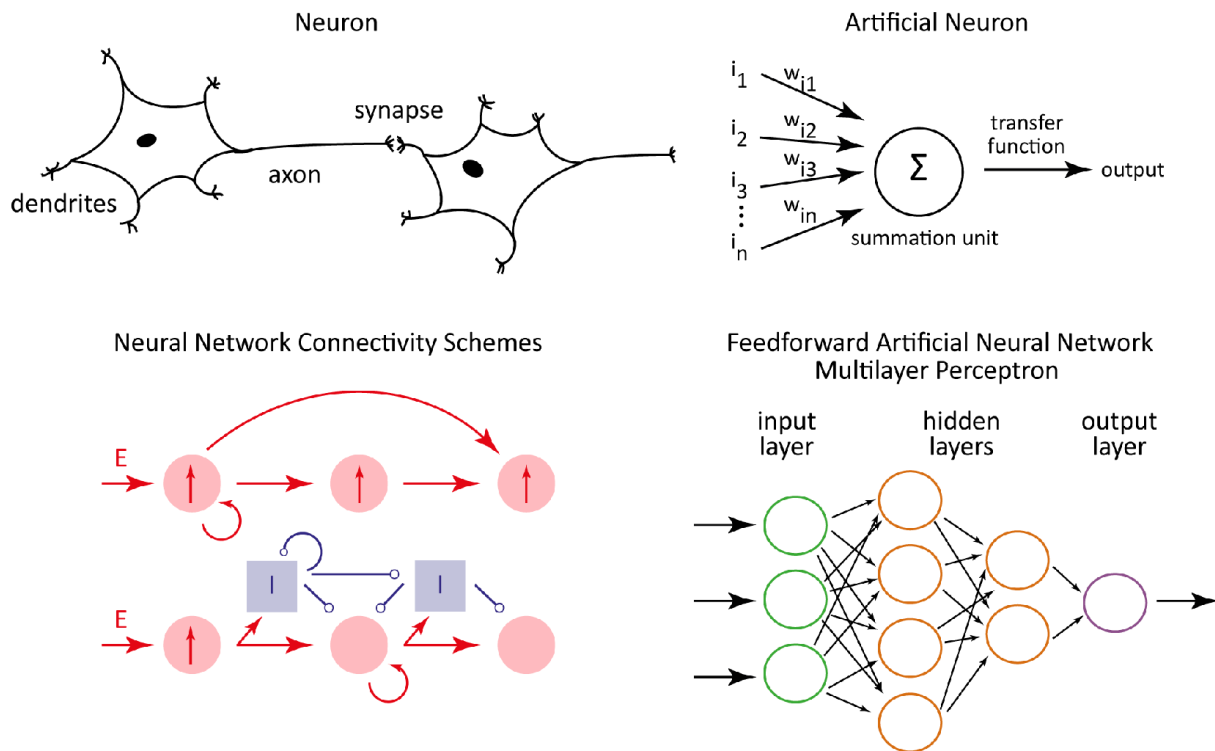


Figure 9. Natural vs artificial neuronal networks

6 WILL BIO-INSPIRED INNOVATIONS CHANGE OUR FUTURE ENERGY SOURCE?

We are facing an increase in demand for energy accompanied by higher emission of CO₂ and fast depletion of fossil fuels reservoir [71]⁵. There is an immense need for improvement in harvesting, transformation, delivery and the use of energy today. In nature we found several models that could help us in that challenge. In the centre of attention is the process of photosynthesis. It is an immensely important one for our ecosystem chain of reaction that converts sunlight into chemical fuels in the form of chemical bonds (as a storage system). The prospect of using free and enormous resources of solar energy that every day reaches Earth seems to be a perfect solution. However, the natural photosynthetic process is characterised by a low efficiency of 0.1% to 8% and as such can't be used directly. It applies both to photovoltaic electricity (solar cells) and the production of biofuels from biomass. One of the plausible strategies for producing sustainable fuels would be to create an artificial process of photosynthesis. The goal being to mimic the process of translating bioenergy to fuel with the use of much more efficient and simpler technologies than nature's, as well as to be able to scale it up at reasonable cost to meet our demands. There are growing efforts to bring interdisciplinary scientists to encounter the challenge [72]⁶ and raise awareness among industry and policymakers of benefits of solar fuel use [73] (Royal Society of Chemistry, 2012).

Before turning to specific examples, the reader can benefit from going a bit more in detail of how the process of photosynthesis works in green parts of plants, algae and some bacteria. It will facilitate our understanding of which elements we need to reproduce. In the big picture a plant simply uptakes water through its roots and carbon dioxide (CO₂) through leaves and with the use of light it produces glucose (substrate for respiration and building material) and oxygen (O₂), see figure 10. Behind the curtain a complex process of converting light energy to chemical energy takes place in specialised organelles called chloroplasts. This is where the main player, one of few known photosynthetic pigments called chlorophyll

⁵ www.worldenergyoutlook.org

⁶ www.lbl.gov/LBL-Programs/helios-serc/html/overview.html

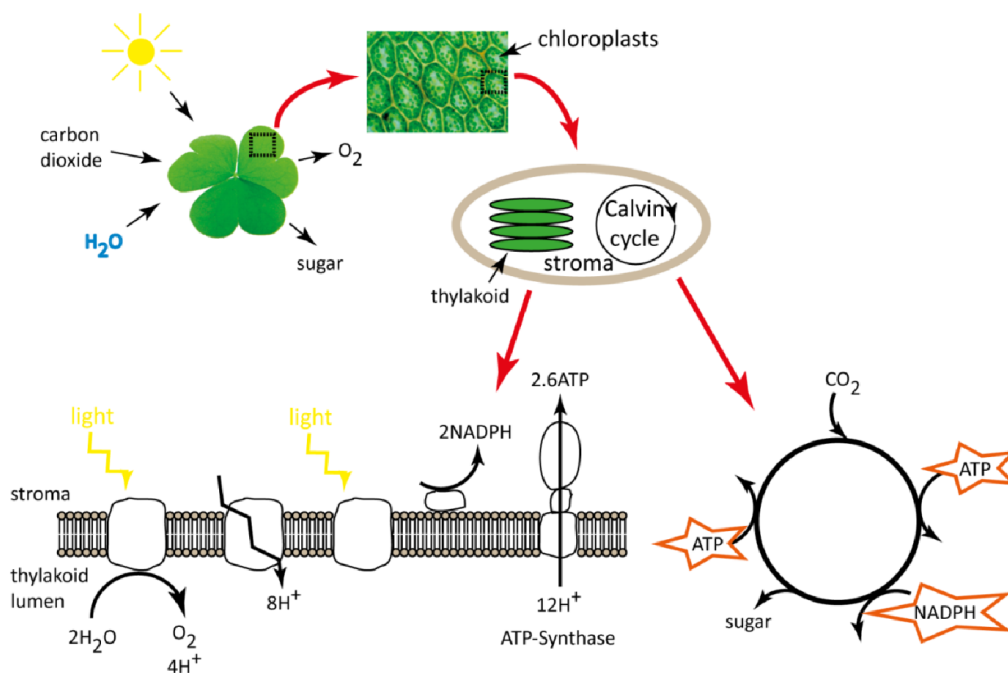
captures the energy from the sunlight. Chlorophyll absorbs light in the blue and red portion of the electromagnetic spectrum, and reflects green and near-green portions of the spectrum; therefore the leaves of the plants (chlorophyll-containing tissues) appear to be green. All chloroplasts have at least three membrane systems; one of them is the thylakoid system, that floats in a semi-gel-like fluid called stroma. The energy conversion takes place on that membrane as it is enriched in green chlorophyll molecules arranged in and around photosystems. As the term photosynthesis itself suggests the process has two steps. The first part, -photo, necessitates light and takes place on the membrane of thylakoids and the second part, -synthesis, is light independent and takes place in the stroma, and is called the Calvin cycle. In the broad view, during the photo- part light delivers energy necessary to split the water and that will eventually lead to producing NADPH and ATP (high energy biological fuel) and O₂ (considered here as waste product and responsible for the Earth's atmosphere). Light is powering the movement of electrons, extracted from water, through the electron transport chain. This movement causes the protons to go inside the thylakoid and creates a positive charge. The protons move out through one available channel created by a protein called ATP-synthase. As a result NADPH and ATP are now in the stroma and are ready to be incorporated in the next Calvin cycle. Their role is to supply energy that will allow incorporating carbon from CO₂ and synthesising various sugars such as glucose.

Our aim is to target two reactions: the light driven splitting of water into its component parts hydrogen and oxygen, and the light-driven reduction of CO₂ by water to give CO, oxygenates or hydrocarbons. The successful design of a chemical strategy to deliver the latter is a grand challenge which has not yet been effectively prosecuted. The process of artificial photosynthesis can terminate with the formation of H₂ or carbon-based products (e.g. methanol or methane). The stoichiometry of water splitting into molecular oxygen, protons, and electrons is deceptively simple; achieving it by chemical catalysis has proven remarkably difficult. Many approaches have been adopted with variable success [74] (Andreiadis, Chavarot-Kerlidou, Fontecave, & Artero, 2011). For instance in 2011 Andreiadis and co-workers created a triad assembly that could mimic the three steps of the natural photosynthetic process [74] (Andreiadis et al., 2011). In this strategy a photosensitizer molecule to power the system (P; figure 10), is linked to a water oxidation catalyst and a hydrogen evolving catalyst. This mimics the first step of photosynthesis, when a light-harvesting complex captures photons and transduces them into electrons. The electrons are next transferred to hydrogen catalyst (A; figure 10). When the photosensitizer is hit by light it undergoes oxidation and this drives the water splitting catalyst to donate electrons to the photosensitizer, hence referred to as a donor (D; figure 10). The oxidized donor is able to oxidize (split) water to H⁺ (utilized for dihydrogen production) and O₂ [74] (Andreiadis et al., 2011).

There are many possibilities as to how to create an ideal triad assembly that could efficiently perform artificial photosynthesis [75]–[77] (Hammarström & Styring, 2008; Kalyanasundaram & Graetzel, 2010; Megiatto Jr et al., 2014). One example involves the utilization of a silica material that can serve as a platform to assemble and couple photocatalytic components for the direct conversion of water and CO₂. In this case two functional units were used, a light-absorbing electron pump (Cr centre) coupled to a multielectron-transfer catalyst for water oxidation (Ir oxide nanocluster). The trials demonstrated that no O₂ was formed in the dark and that water oxidation is driven by the charge-transfer-excited Cr complex coupled to Ir oxide cluster. This suggests that covalently anchored metal centres could be used as charge-transfer chromophores for coupling the oxygen-evolving site to a reducing metal-to-metal charge-transfer unit in the nanoporous solid [78] (Nakamura & Frei, 2006). Alternatively, one could use a liposomal membrane with artificial triad coupled to the natural ATP- synthase [79] (Steinberg-Yfrach et al., 1998). This approach indicates yet another possibility of bio-synergy - that is assimilating technology and biology.

Multiple approaches can contribute to solar fuels future. None of them prove to be a definite answer and all of them are still on the basic research side. Using an interface to the USPTO to map 78 available patent portfolios related to artificial photosynthesis [7] (Leydesdorff, Kushnir, & Rafols, 2012), we have noticed that no definite “cluster” appeared. This further illustrates that multiple lines of research exists and shows that the comprehension of translation process is growing and will sooner or later yield commercial results. The key areas that can contribute to the ultimate solutions are: architectures (for controlling of electron transfer), catalysis (catalysts for water oxidation, or CO₂ splitting), devices (e.g. improving the efficiency of water splitting), photocatalysis, mechanisms and theory. The overview of progress in mentioned areas can be found in [80] (Concepcion, House, Papanikolas, & Meyer, 2012).

Natural Photosynthesis



Artificial Photosynthesis

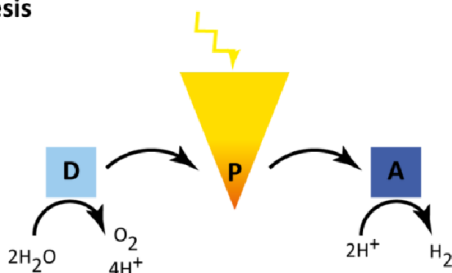


Figure 10. Natural vs artificial photosynthesis

The above section 6 related to future energy source has been subject to semantic analysis performed by two different search engines then clustering. The study was performed on the first 1000 most relevant patent references for the sake of processing ease. Obviously the two searches converge as per comparison of the left and the right gearwheels clusters on figure 11.

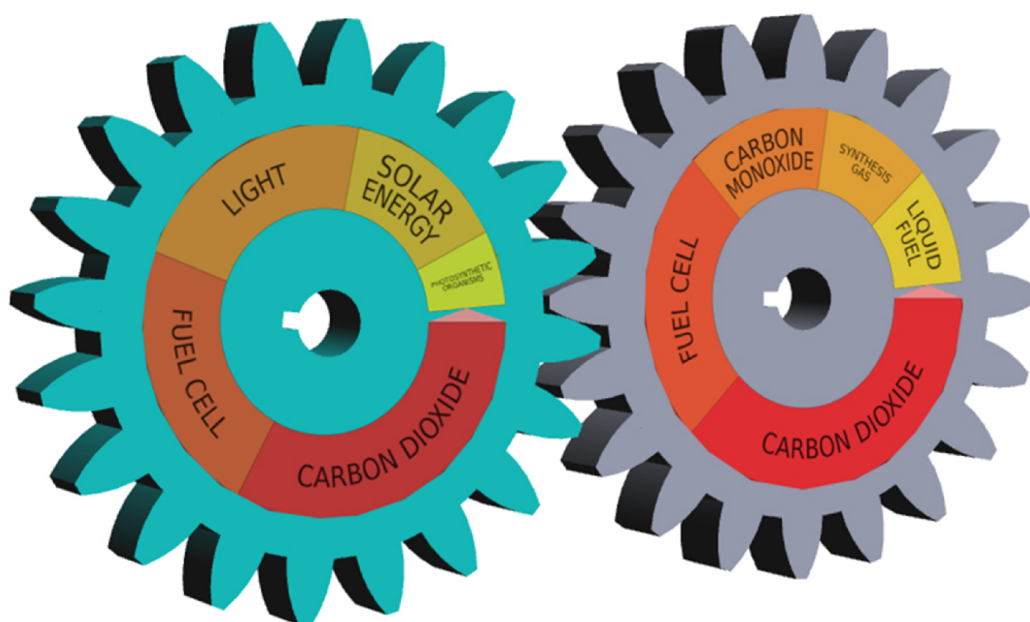


Figure 11. Semantic analysis and clustering of section 6 – “Future Energy Source”

7 HOW TO TACKLE THE PERFECT DESIGN AND PRODUCTION OF NATURAL POLYMERS?

The observation of nature boosted the increase amount of innovative materials that come to life such as previously mentioned Velcro, honeycomb-like structures or SLIPS [47] (Aizenberg et al., 2012), to name a few. In the case of material innovation, the mimicry approach is not always as straightforward and easy as imitating lotus leaves surface because strategies for design differs between engineers and nature. The biggest obstacle is to transfer concepts and procedures used in natural settings, simply because we yet lack insight into those processes. These are however, the core causes that decide about properties of materials. Development of material is constructed in an opposite way, engineers first choose the material and then create it (top-down approach), and nature would start with material at hand that will self-assemble (bottom-up approach). The resulting hierarchical structure of natural structures gives certain advantages that we desire to imitate, including resistance, multifunctional or adaptive properties and self-healing capacity. A simple and imaginative example is a design of material modelled on shark skin. The surface of the shark’s skin is very rough, under closer inspection it turns out to have little structures, described as V shaped or tooth like, and called dermal denticles [81]⁷. They are aligned parallel to the flow of water; producing vertical spirals of water that ultimately reduce surface drag. Engineers were inspired by the microtopography of shark’s skin that, in the same time, acts as an anti-fouling and anti-bacterial material that does not necessitate the addition of toxic agents [82] (Carman et al., 2006). A material with this set of properties can be used on any surface that needs to be kept clean such as medical devices [83]⁸.

Materials that belong to a group of polymers are everywhere in our surroundings. They can have either natural origin (such as DNA, wool, silk or cellulose) or be synthetic ones (including nylon, polyvinyl chloride, silicone, and many more). Polymers, in their simplest form, are chains of bonded small molecules (monomers) with multiple applications. One method to produce them is a process known as radical polymerisation. It uses very reactive molecules with unpaired electrons (free radicals) that initiate a chain growth by adding to monomer unit. In turn, it will generate a new radical and repeat the process. However, this process often yields various structures, molecular weights, and lengths of polymers. To gain more control on the procedure of polymerisation scientists were inspired by the natural approach of polymer synthesis. Organisms are using templating synthesis, such as transcription of nuclear DNA into messenger RNA, followed by peptides creation. In

⁷ ocean.si.edu/ocean-photos/biomimicry-shark-denticles

⁸ sharklet.com

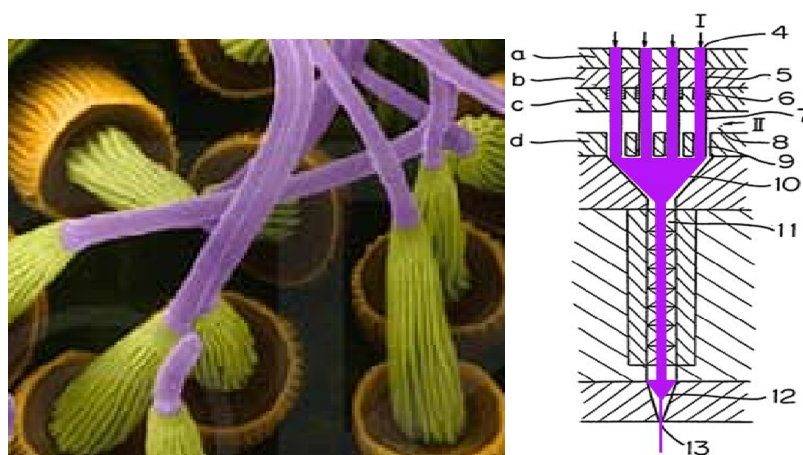
addition, to avoid the undesirable interactions between elements, reactions are carried out in separate cell compartments. Scientists specifically mimic a combination of segregation and templating seen in cells to gain precise control over the organisation of polymers during radical polymerisation [84] (McHale, Patterson, Zetterlund, & Reilly, 2012). This is a great example to illustrate an earlier point that inspiration provided by nature can be purely on conceptual level and doesn't mean we have to use bio-materials to achieve it. The next paragraphs further illustrate this point.

Silk is an exceptional natural polymer with a unique set of mechanical properties and efforts have been made to produce a material with similar characteristics. The idea being to copy spiders and insects several types of silk designed to achieve a range of functions from prey capturing and immobilization to reproduction. Technically, silk types consist of repetitive blocks of crystalline domains (beta sheets; made mainly by two types of alanine rich regions) and so-called amorphous matrix (consisting of helical and beta turn structures glycine) with the addition of various compounds other than protein that enhance the fibre's properties [85] (Simmons et al., 2014). Nature's high - performance fibre exhibits a unique combination of high tensile strength and extensibility so that the energy required to break spider silk (toughness) can be 10 times greater than for any other biological materials (cellulose, collagen, chitin).

Spider vs other macromolecular materials: Strength (N/m²)-mid vs Energy to Break (J/kg)-right [86] (Lewis, 1992)

Dragline silk	1×10^9	1×10^5
Kevlar [®]	4×10^9	3×10^4
Rubber	1×10^6	8×10^4
Tendon	1×10^9	5×10^3

A commonly proposed structural model for the silk fiber, “with highly oriented alanine-rich crystals, and with weakly oriented "protocrystals" contributing to the unusually high compressive strength of spider silk”, is generally proposed after Jelinski and co-workers. In this model, “glutamine and other bulky residues limit the growth of 3 sheets and force the formation of loops and tie chains that link crystals to one another and to the surrounding amorphous matrix. This picture is consistent with a theoretical model of spider silk elasticity developed recently by Termonia at DuPont [87] (Termonia, 1994), in which the fiber is represented by small crystallites embedded in a rubbery amorphous phase. A key feature of the Termonia model, which reproduces the stress-strain behavior of the fiber very nicely, is the presence of a thin layer within the amorphous matrix with a modulus higher than that of the bulk amorphous phase. Small crystallite size is advantageous in this description, as it allows the high-modulus "interphase" to occupy a large volume fraction in the semicrystalline fiber”.



**Figure 12. A spider spinneret with silk spinning spigots. Copyright & Credit [88] (Dennis Kunkel Microscopy, Inc.)
 And a spinneret assembly analogue (right) from [89] (Hiroyasu et al., 1983)**

Spiders' silk is a protein rubber, it means that at room temperature it is stiff; however upon immersion in water it will absorb it and contract to half of its length. It is the interplay between the hard crystalline segments, and the strained elastic semi-amorphous regions that gives spider silk its extraordinary properties [90] (Gasline, Denny, & DeMont, 1984). To mimic and perfect the process of natural silk production we need to combine both the feedstock proteins from which the silk is produced, its post-translational changes along with the spinning process itself [91] (Vollrath & Knight, 2001).

Back in 1996, in the Science News, Vol. 149 No. 10 p. 152, one could read the following:

“- “Cloning the entire silk protein is not necessary, agrees John P. O'Brien, a chemist at DuPont Co. in Wilmington, Del. “We think we can mimic most of natural silk's properties with much simpler polymers and produce them large-scale.”

“Silk has a lot in common with reinforced rubber,” he adds. “This allows us to use theories of rubber elasticity to design the synthetic fiber's architecture.”

To reduce the length and complexity of the synthetic protein, DuPont Life Sciences chemist Stephen R. Fahnestock says his group has homed in on four short amino acid sequences from one of the two major proteins. By implanting a synthetic gene for those sequences, his team has coaxed bacteria and yeast into producing a novel protein, which DuPont is spinning like conventional polymers into fibers.

“They're not quite like natural spider silk,” says O'Brien, “But they're still good when woven into multifilament yarns.”

Kenn H. Gardner, a biophysicist at DuPont, points out that spider silk, both the natural and new synthetic versions, is essentially a form of nylon. “That's our business,” he says.

“What's particularly interesting to us is the way these organisms make silk nylons in environmentally benign ways,” O'Brien says. “They process proteins from water-based solutions, without using petroleum products or organic solvents. From a manufacturing point of view, this is very attractive.”

Given the “consumer love affair with natural fibres,” he adds, “we want to offer substitutes for natural fibres that are free of associated problems, such as poor wash-wear performance, stretching, wrinkling, and shrinkage.”

“Ideally, we're aiming for a better-than-natural alternative fibre.” -”

Obviously, with Termonia's predictive models, the spinneret (bio and mechanically illustrated on figure 12) advanced core technology of the company employing him, and thanks to the O'Brien's multidisciplinary team, the science and technology enterprise was in good hands. Bio-inspired materials were paving new frontiers for the fibre technology and business therewith.

This brings us to goats. Silk-producing goats were firstly bio-engineered and held by a Canadian company. A lot of hopeful press coverage in the mid-2000s for the BioSteel®, a spider silk-based material. By 2009, though, the goats had all but vanished from headlines news.

There is likely a lot to learn about open innovation and disruptive innovation with this case. Shall the bio-inspiration be limited to curiosity provocation and confidence gaining, at first; therefore yielding creative multiple concepts? Or shall one let engineering take over “immediately” based on core technology comforting knowledge therewith avoiding lateral thinking exposing uncertainty?

Up to date, inspiration of silk may have contributed to producing of synthetic fibres branded as Kevlar® (developed by DuPont in 1965; [92]⁹) and later on as Twaron® (developed by ENKA in 1972; [93]¹⁰). Currently, the USPTO registers 13,452 patents that contain the word “Kevlar” (Feb, 2014) that points out to its spectacular success and wide range of applications. It is used in protection clothing for military or personal use (helmets, vests, masks, and gloves), sport (tennis racquet, sport shoes) or music equipment (loudspeaker cones), can be used to make ropes or as a protective outer sheath for optical fibre cable, and many more [92]¹¹. Rebouillat et al., published abundantly in the field [94]–[100] (S. Rebouillat, Donnet, & Wang, 1997; S. Rebouillat, Liksonov, & Courgey, 2012; S. Rebouillat, Steffenino, & Miret-Casas, 2010; S. et al. Rebouillat, 1998; S. Rebouillat & Liksonov, 2010; S. Rebouillat, 1998, 2001).

⁹ www.dupont.com/products-and-services/fabrics-fibersnonwovens/fibers/brands/kevlar.html

¹⁰ www.tejjinaramid.com/aramids/twaron/

¹¹ www.dupont.com/products-and-services/fabrics-fibers-nonwovens/fibers/brands/kevlar.html

The next example of a natural polymer that we try to mimic is muscles. In essence, there are multiple chains of muscle fibrils (or myofibril), that in turn are long proteins strings (composed of actin, myosin, titin, and others) [87]¹². Artificial muscles are needed to develop prosthetic limbs, robots or actuators. Recently, inexpensive and high-strength polymers, specifically polyethylene (PE) and nylon fibers [101]¹³, were explored to be muscle precursors [102] (Haines et al., 2014). Due to their flexibility they can be reversibly contracted, twisted and therefore mimic the function of torsional muscles. Interestingly, it is possible to convert the twisted fibers to complete coil and this allows to exceed the maximum tensile contraction by 20% compared to human skeleton [102] (Haines et al., 2014). To create larger diameter coils, one can wrap twisted fibers around mandrel and stabilize the shape with heat. The resulted coils have reduced load capacity but can contract more, hence has larger stroke [102] (Haines et al., 2014). A coiled nylon muscle, powered by applying potential, successfully delivered 1.2 million cycles of rising and lowering 10 g weight without any significant creep. In addition, fast and high force actuation can be driven hydrothermally, authors driven coiled nylon muscle by switching between cold and hot water up to 1500 cycles under a 0.5 kg load. In a similar manner PE fiber muscle, with the addition of surfactant to enable wetting of the material, could lift 7.2 kg load generating mechanical work output 100 times more than the human biceps muscle. Series of experiments showed that a specific mechanical property of proposed artificial muscles depends on their structure and scale and suggested a variety of applications [102] (Haines et al., 2014).

The above section 7 related to natural polymers has been subject to semantic analysis performed by two different search engines then clustering. The study was performed on the first 1000 most relevant patent references for the sake of processing ease. Obviously the two searches distant themselves substantially as per comparison of the left and the right waterwheels clusters on figure 13.

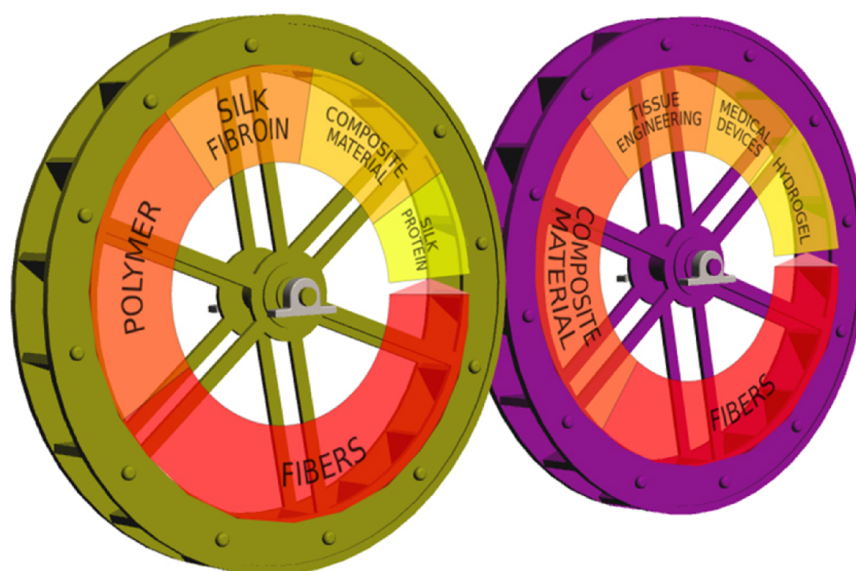


Figure 13. Semantic analysis and clustering of section 7 – “Natural Polymers”

8 FINAL REMARKS

Open disruptive innovation is probably an inevitable challenge to maintain the pace of changes occurring in some technology areas. Creative confidence is to be reinstated in the broader creativity scheme which embraces a much larger range of functions than the ones generally anticipated.

¹² muscle.ucsd.edu/musintro/jump.shtml

¹³ plastics.dupont.com/plastics/pdf/it/europe/zytel

Bio-inspired or bio-inspiration is a well of analogues that can translate into discovery beyond the logic of invention as traditionally conceptualised.

In everyday life “Semantic” has already evolved towards the integration of images and motion, as part of everyday communication and interpretation of events. Innovation is concomitant to that evolution. Patent search engines remain mostly centred within the logic of patent classification and search algorithms which may not be the most powerful stimulus for innovation, open innovation and disruptive innovation.

ATA©, adjacent technology analysis, tends to reduce this gap and is subject to other papers of the authors [1], [2] (S. Reboillat & Lapray, 2014; S. Reboillat, 2013).

Reboillat et Lapray (2014) [2], devoted a full review to patent search aspects. In the present study the use of semantic to collect patent literature from the same text excerpt reveals large to moderate variations in the resulting outputs in term of clusters. Black boxes around patent searches may have to be more explicitly unveiled to avoid user confidence depreciation.

There are endless list of examples of bio-inspired technologies in every area of modern technology [103]¹⁴. Only few of them have been noted in this review. We believe that there is many more to come. Why not to exploit the cryotolerance mechanism of the leech (turtle parasite) capable of surviving exposure to -90°C for up to 32 months [104] (Suzuki, Miyamoto, Kikawada, Watanabe, & Suzuki, 2014) or re-invent a way to fly by looking at the gliding technique of snakes favouring the “S” posture for that purpose [105] (Socha, 2002)? Reader can be further inspired by below reference list.

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¹⁴ www.asknature.org

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Sistema de recomendación por filtrado colaborativo para el sistema de publicación de contenido multimedia - VideoWeb 1.0

[Recommender system using collaborative filtering for the publication system of multimedia content - VideoWeb 1.0]

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ABSTRACT: Recommender systems are software solutions that provide a list of suggestions which contains elements that can be of preference for each user. The use of these systems in multimedia content publish platforms facilitates the search of audiovisual content. The objective of this research is to analyze the techniques of collaborative filtering recommendation based on using the benefits of a large user community. In this research is carried out the description of the process flow for generating recommendations. Collaborative filtering algorithms based on users and items were analyzed and the evaluated algorithms with best results in the data set of the platform were selected. The main problems of the selected collaborative filtering technique, such as the problem of the new items, were also analyzed and solutions were proposed. The developed system was encapsulated in a module for VideoWeb 1.0 platform that uses the Drupal CMS in version 6. The results were evaluated using the mean absolute error method and presented using a range of 50 to 200 neighbors. The integration of the recommendations module to the platform provides an increase in the personalization of the multimedia content posted in order to satisfy each user preferences. This module offers an increase in the reliability of the users and minimizes the research time of the multimedia content.

KEYWORDS: drupal, personalization, neighborhood, preferences, recommender system, VideoWeb.

1 INTRODUCCIÓN

Estudios realizados en el año 2012 por la Internet Word Stats (Estadísticas mundiales de internet) arrojaron porcentajes altos del uso de la red global en las diferentes regiones del mundo [1], donde se evidenció que aproximadamente la mitad de la población conectada a la red la utiliza con fines de entretenimiento y un apreciable porcentaje para consumo de información audiovisual [2].

Diariamente surgen variedades de empresas virtuales cuyo objetivo es satisfacer las demandas de los usuarios en cuanto al comercio electrónico y el ocio, además de sacar ganancias de las mismas, entre las que se encuentran los sitios de distribución de contenido multimedia [3]. Esta tendencia permite disponer de portales web en internet con alta variedad de materiales multimedia de distintas clasificaciones, lo que provoca que la red se convierta en una nueva ventana de consumo audiovisual, en la que cada usuario elige entre las extensas ofertas de contenidos disponibles en múltiples formatos [4].

En este ámbito, los individuos se enfrentan a escenarios caracterizados por la existencia de una voluminosa cantidad de contenidos, por lo que se auxilian de las recomendaciones de personas con mayor experiencia para tratar de solucionar los

problemas derivados de su limitado conocimiento, respecto a categorías o alternativas en el consumo de materiales [5]. Como forma de automatizar este proceso, mejorar el tratamiento de los clientes a partir de propuestas personalizadas de los contenidos ofertados y satisfacer sus necesidades, surgen los sistemas de recomendación. A lo largo de los años la definición de estos sistemas ha ido evolucionando, estando estrechamente asociada a los avances de las nuevas técnicas o ideas que van surgiendo en su estudio. Algunas de sus definiciones más completas fueron formuladas en el 2005, según los autores Sung-Hwan Min, Ingo Han se conceptualiza como: *“el filtrado de información que aplica técnicas de análisis de datos para el problema de ayudar a los clientes a encontrar los productos que les gustaría adquirir, realizando una predicción de calificaciones semejantes o un listado de productos a recomendar para un determinado cliente.”* [6]

Una de las soluciones del proyecto de Catalogación y Publicación de Medias es la plataforma VideoWeb, la cual se encuentra en despliegue en su versión 1.0. Esta plataforma tiene como principal objetivo la distribución de contenido multimedia a la comunidad de usuarios de la Universidad de la Ciencias Informáticas, mediante su publicación en un portal web. La publicación de materiales responde a distintas áreas de la universidad, por ende atiende a varios intereses: educación de pregrado, educación de postgrado, auto-preparación, conocimiento general integral, entretenimiento, educación política, actualización socio-económica, información, entre otros. El sitio mantiene una distribución de los contenidos por área temática, pero aun así la cantidad de información colapsa a los usuarios en los procesos de búsquedas de un audiovisual de su interés.

El buscador de la plataforma está regido por la documentación que se tenga de cada material y los intereses de los usuarios no están enmarcados en una única área temática, sino que pueden existir audiovisuales que cumplan con sus preferencias en varios ámbitos. La escasa personalización de la información propicia un aumento del tiempo empleado en las búsquedas de un material, así como una considerable disminución de la fidelidad hacia la plataforma.

Para conformar una solución ajustada a las necesidades de la comunidad universitaria que hace uso de la plataforma y brindar una oferta personalizada para cada usuario, la presente investigación se centra en el análisis de los sistemas de recomendación. Se presenta una descripción de estos sistemas y sus clasificaciones, manteniendo como objetivo principal el análisis de técnicas que utilicen las ventajas de una cuantiosa comunidad de usuarios, específicamente la técnica de filtrado colaborativo.

El presente artículo estará organizado según la siguiente distribución: Sección II análisis y clasificación de los sistemas de recomendación, sección III presentación de trabajos relacionados, sección IV técnica de filtrado colaborativo, tendencias y problemas que presenta, sección V presentación de la metodología seguida por la investigación, sección VI Conclusiones y trabajos futuros.

2 SISTEMAS DE RECOMENDACIÓN

Los sistemas de recomendación son, a consideración de la autora, herramientas de software encargadas de tres procesos fundamentales: filtrado de información relevante, obtención de los elementos que serán recomendados y presentación de las sugerencias.

Filtrado de información relevante: se extrae información referente al usuario a partir de algunas de sus acciones sobre los contenidos o utilizando métodos directos de recopilación de preferencias (cuestionarios de preguntas, formularios). La información extraída es filtrada para eliminar los datos que no tienen suficiente peso para ser considerados una preferencia válida. De este proceso se obtiene un listado de preferencias que caracterizan los gustos del usuario.

Obtención de los elementos que serán recomendados: estos elementos se obtienen a partir de una intercepción de las características de todos los elementos existentes con las preferencias extraídas del primer proceso, para aumentar la fiabilidad se hacen uso de métodos probabilísticos que permitan cuantificar la medida en la que cada contenido multimedia cumple con el listado de preferencias, obteniendo una probabilidad de satisfacción de cada contenido para el usuario.

Presentación de las sugerencias: la presentación de las sugerencias depende de las características de cada plataforma que hace uso del sistema de recomendación. En muchos casos el sistema de recomendación se encarga de brindar un listado de sugerencias de elementos y la plataforma que hace uso del sistema se encarga de presentarlos, sin embargo en otros, un usuario administrador puede establecer una configuración para mostrar los resultados de acuerdo a sus necesidades.

La metodología a seguir para la ejecución de cada proceso varía según la técnica de recomendación utilizada y está estrechamente relacionada al tipo de elemento que se recomienda. La presente investigación se enfoca en recomendaciones

de contenidos multimedia, estos elementos presentan varias características que los diferencian de otros elementos, como la cantidad de descriptores que pueden ser insertados para su caracterización.

Existen varias técnicas utilizadas en los sistemas de recomendación, entre las más abordadas por la comunidad científica se encuentran:

- **Sistemas de recomendación basados en contenido:** recomienda materiales audiovisuales similares a aquellos que les han gustado al usuario, en función de características de los mismos [7].
- **Sistema de recomendación por filtrado colaborativo:** recomienda contenidos multimedia que hayan tenido votaciones o valoraciones satisfactorias y que no hayan sido vistos por el usuario, pero sí por usuarios que comparten preferencias similares a este [8].
- **Sistemas de recomendación basados en conocimiento:** realiza sugerencias de audiovisuales fundamentadas en inferencias sobre las necesidades de los usuarios y sus preferencias [9]. Estos sistemas están regidos por conocimientos del entorno en el que se generan las recomendaciones y es provisto por especialistas en la materia.
- **Sistemas de recomendación basados en la utilidad:** utiliza una fórmula de utilidad que interviene directamente en el proceso de la recomendación y que contempla variables como disponibilidad, calidad de los contenidos y formatos.
- **Sistemas de recomendación demográficos:** realiza las recomendaciones a partir de información geográfica, lo que permite crear grupos geo-localizados de usuarios a partir de su consumo audiovisual.

Cada una de las técnicas anteriores tiene sus propias fortalezas, pero presentan problemas como la alta dependencia de conocimiento del entorno o el requerimiento de gran cantidad de datos que caractericen a los materiales que recomiendan, por citar algunos; para minimizar estos problemas y aumentar la fiabilidad de las recomendaciones surgen los sistemas híbridos. Estos sistemas son formados por dos o más técnicas de recomendación a partir de varios criterios de hibridación. Los sistemas híbridos tienen altos indicadores de precisión en las recomendaciones pero son complejos en su desarrollo.

3 TRABAJOS RELACIONADOS

A partir del auge de los sitios de distribución de contenido multimedia un considerable número de sistemas de recomendación han sido introducidos para mejorar el tratamiento de los usuarios. Entre ellos se encuentra el sistema de recomendación de FilmAffinity [10] que recomienda contenidos multimedia asociados al área del cine. Este sistema cuenta con una base de datos con fichas técnicas detalladas de cuantiosa cantidad de películas, documentales, cortometrajes y series de televisión. Su funcionamiento se basa en el cálculo de la media de puntuaciones realizadas por los usuarios tanto a cada contenido como a sus críticas.

El sistema de recomendación películas de Movielens [11] está basado en técnicas de filtrado colaborativo, este sistema ha sido desarrollado por el GroupLens Research de la Universidad de Minnesota. Cada usuario del sistema tiene asociado una vecindad de usuarios afines calculada a partir de las opiniones emitidas sobre las películas. La calificación de estos vecinos se utiliza para generar las recomendaciones.

Last.fm [12] es un sistema de recomendación de música. Obtiene las preferencias de los usuarios con gráficos generados a partir de las canciones más reproducidas por cada usuario y los autores asociados a estas. A partir de estos gráficos se calculan las recomendaciones finales haciendo uso de técnicas de filtrado colaborativo, esto permite a los usuarios explorar listas de reproducción de usuarios con preferencias similares.

Cada uno de los sistemas analizados presenta características específicas según los datos que utilizan para la generación de las recomendaciones, así como las acciones que deben realizar los usuarios sobre los contenidos multimedia para obtener sus preferencias. Analizándolos por separado se concluyó que ninguno cumple con las necesidades de la plataforma VideoWeb 1.0, debido a la gestión de tipologías que realiza la plataforma para cada contenido.

4 TÉCNICA DE FILTRADO COLABORATIVO

El filtrado colaborativo es una de las técnicas más utilizadas en los sistemas de recomendación. Está enfocado en la predicción y recomendación de elementos a partir de la recolección de preferencias de muchos usuarios. Se basa en la premisa de que si dos o más usuarios tienen similares características (comportamiento en cuanto a sus votaciones) deben

tener similares preferencias. Esta medida de similitud es cuantificada para asociar a cada usuario un grupo de colaboradores¹.

Existen dos tendencias para los algoritmos de filtrado colaborativo: los basados en memoria y los basados en modelos. Los **basados en memoria** realizan las predicciones a partir de una base de datos en la que se almacenan los usuarios, los contenidos multimedia y las votaciones con sus respectivas relaciones. Con estos datos se obtiene el historial de valoraciones de los colaboradores del usuario actual y se infiere una lista de audiovisuales para ser recomendados. Los **basados en modelos** crean un modelo de los usuarios y sus valoraciones, a partir de este se calcula el valor esperado para cada multimedia en función de las valoraciones realizadas por los colaboradores. Se basa en algoritmos de aprendizaje [13].

Los algoritmos de recomendación colaborativa basados en memoria establecen las relaciones de similitud entre usuarios o entre elementos. Estos algoritmos se basan en fórmulas matemáticas para cuantificar la semejanza entre dos de estas categorías. La técnica de filtrado colaborativo presentan varios problemas, entre estos se encuentra la escasez de datos debido a la necesidad de una cuantiosa cantidad de usuarios realizando valoraciones de contenidos similares, estos datos deben proveer una matriz de puntuaciones que permita realizar los cálculos de vecindad, predicciones y recomendaciones con un alto valor de fiabilidad. Otro problema es la escalabilidad del sistema: dada porque el costo computacional de los algoritmos utilizados para calcular los vecinos más cercanos crece a medida que aumenta el corpus de datos.

Basado en el funcionamiento de esta técnica un contenido multimedia es recomendado al usuario activo si alguno de sus colaboradores ha realizado valoraciones satisfactorias sobre este, cuando se publica un nuevo contenido en la plataforma este no es recomendado hasta que no haya recibido alguna valoración, presentando así el problema del nuevo elemento. Al registrarse un nuevo usuario en la plataforma no se tiene información suficiente sobre sus preferencias, debido a que no ha realizado valoraciones de los contenidos publicados, como consecuencia no puede ser asociado a ningún grupo y no recibe recomendaciones [14].

5 PROPUESTA DE SOLUCIÓN

Para la selección de la tendencia colaborativa, utilizada en la solución propuesta, se analizaron las características de la plataforma VideoWeb 1.0 que podrían interactuar directamente con cada uno de estos métodos. Los algoritmos de filtrado colaborativo basados en modelos tienen buenos resultados de precisión en entornos que manejan gran cantidad de datos [15], teniendo en cuenta que la cantidad de usuarios registrados en la plataforma y la cantidad de contenidos multimedia que se gestionan en la misma es muy variable, la generación de un modelo puede ser poco propicia en varios casos presentando el problema de la escasez de datos. En correspondencia a las características de los algoritmos basados en memoria es sustancial la utilización de la base de datos con que cuenta la plataforma. Para calcular la similitud se le presenta mayor interés a los basados en elementos, aunque se desarrollan ambos algoritmos para comparar los resultados obtenidos por estos en las pruebas realizadas con el corpus de datos que utiliza la plataforma.

5.1 METODOLOGÍA SEGUIDA POR LA INVESTIGACIÓN

La metodología utilizada para el desarrollo de la investigación cuenta con cuatro fases fundamentales, de las que se derivan varios procesos asociados al funcionamiento del módulo desarrollado. En la primera fase se establecen los procesos referentes a la detección de los datos necesarios para la generación de recomendaciones. En la segunda fase se especifica el funcionamiento del algoritmo para el cálculo de vecindad y la medida de similitud utilizada. En la tercera fase se presenta el flujo de las recomendaciones en la plataforma, se establecen soluciones para los problemas persistentes en el algoritmo de filtrado colaborativo desarrollado y se especifican características de la construcción de la solución. La última fase se encarga de la presentación y evaluación de los resultados obtenidos.

¹ Colaboradores: es la denominación que se les da a los usuarios en el filtrado colaborativo refiriéndose a los que comparten preferencias similares al usuario analizado, matemáticamente son los que su grado de similitud están más próximos al 0 en un rango de (0,1].

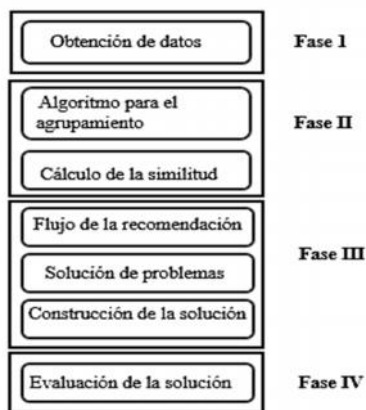


Fig. 1. Metodología utilizada en la investigación.

5.2.1. OBTENCIÓN DE DATOS

Las acciones realizadas por los usuarios sobre los contenidos multimedia publicados en la plataforma son almacenadas en base de datos por los módulos que la componen. Para la generación de las recomendaciones se realiza una extracción de las tablas y los datos necesarios para la ejecución de los procesos. Estos datos fueron el identificador, nombre, título, categoría y descriptores de las publicaciones de archivos multimedia, los usuarios registrados en la plataforma con los datos asociados a estos presentes en la tabla usuario y las votaciones almacenadas por el módulo *voting_api*, de estas votaciones se obtuvo el valor del voto, el usuario que la realizó, y el audiovisual al que está asociada.

5.2.2. ALGORITMO PARA EL CÁLCULO DE VECINDAD

Los datos recolectados en el proceso anterior son analizados para su agrupación por similitud, en la investigación se desarrollaron el cálculo de la similitud basados en usuarios y basados en contenidos multimedia. La explicación de los procesos se presenta a partir del cálculo de la similitud basados en contenidos multimedia debido a que ambos flujos de eventos son muy similares. El cálculo de vecinos más cercanos se realiza a partir del siguiente flujo:

- I. Se eligen aleatoriamente K contenidos multimedia que formarán los centroides² de los K grupos iniciales: la cantidad de grupos (K) será un dato especificado por el administrador en la configuración del módulo, debido a que esta cantidad debe variar en correspondencia con la cantidad de usuarios registrados y audiovisuales publicados.
- II. Los audiovisuales asignados como centroides son eliminados del conjunto total.
- III. Se calcula la similitud entre cada contenido multimedia y los centroides seleccionados para cada grupo, cada contenido será asignado al grupo del centroide con el que comparte menor similitud.
- IV. Cuando todos los audiovisuales han sido asignados a un grupo se vuelven a calcular los centroides por cada grupo, este paso se realiza a partir del cálculo de la similitud de cada contenido multimedia con los restantes del grupo, tomando como nuevo centroide al de menores similitudes totales.
- V. Cuando se han seleccionado los nuevos centroides se vuelven a ejecutar los pasos del II al IV, estos pasos se ejecutan hasta que los centroides anteriores son iguales a los obtenidos después del paso IV.
- VI. Se almacenan los grupos en la base de datos y los contenidos multimedia asociados a cada uno.

² Centroides: se refiere a los elementos de mayor generalización del grupo, inicialmente se toman de forma aleatoria, pero luego de varias iteraciones del algoritmo son actualizados por los más relevantes de cada grupo.

5.2.3. CÁLCULO DE LA SIMILITUD

En los pasos III y IV del algoritmo anterior se ejecuta el cálculo de la similitud entre contenidos multimedia a partir de la distancia euclidiana. Esta métrica de similitud se puede expresar como la distancia entre dos contenidos multimedia, partiendo de los usuarios como las dimensiones entre estos y sus valoraciones, los pesos a lo largo de esas dimensiones. El cálculo se realiza con los usuarios (dimensiones) que han realizado votaciones por ambos contenidos. En un lenguaje matemático se puede expresar como la raíz cuadrada de la sumatoria (suma por cada dimensión) del cuadrado de la diferencia de votaciones para cada par de contenidos.

$$\sqrt{\sum_{n=0}^n (N_i - M_j)^2}$$

Ecuación 1: Distancia euclidiana entre dos contenidos multimedia.

Donde:

m: cada uno de los usuarios (dimensión).

n: cantidad de usuarios que han votado por ambos contenidos multimedia.

i, j: contenidos multimedia para comparar su similitud.

M_i: votaciones realizadas por el usuario m al contenido multimedia i. (Matriz de valoraciones)

M_j: votaciones realizadas por el usuario m al contenido multimedia j. (Matriz de valoraciones)

5.2.4. FLUJO DE LA RECOMENDACIÓN

Para generar una recomendación en la plataforma se parte de la autenticación del usuario, seguidamente se busca el grupo al que se asocian los contenidos multimedia vistos por el este. Seleccionado el grupo se calcula la valoración de los contenidos multimedia pertenecientes al grupo pero que no han recibido valoraciones por el usuario. Se recomiendan los diez audiovisuales de mejor valoración. El flujo de eventos completos se ejecuta según el diagrama mostrado en la Fig. 2.

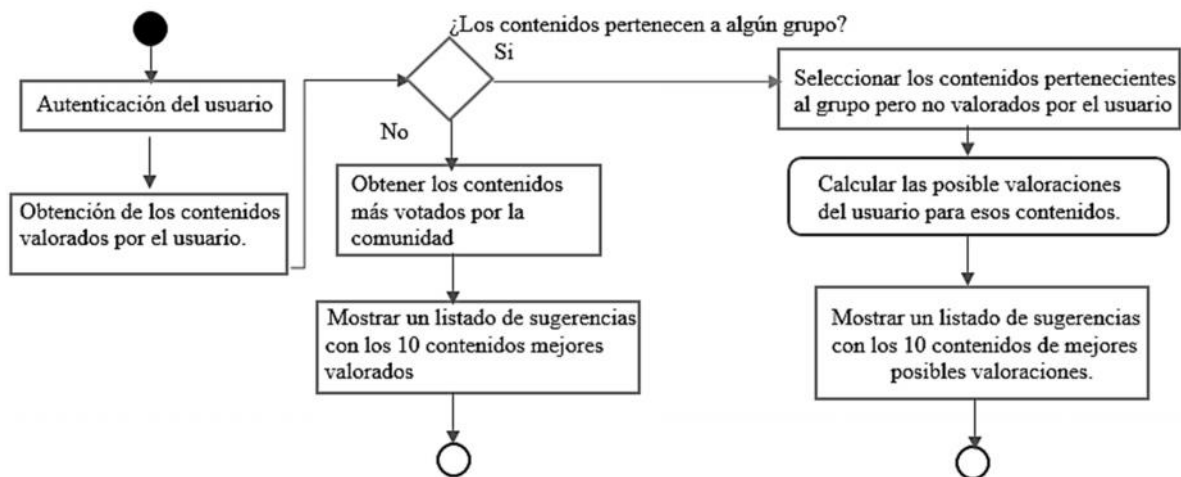


Fig. 2. Flujo de eventos para generar recomendaciones.

5.2.5. SOLUCIÓN DE PROBLEMAS DE LA TÉCNICA IMPLEMENTADA

Según las características del entorno en el que se utiliza la plataforma VideoWeb 1.0 el sistema de recomendación desarrollado no presenta el problema de la escasez de datos, debido a la cuantiosa comunidad de usuarios y contenidos multimedia publicados. El problema de la escalabilidad fue minimizado a partir de la utilización de un algoritmo basado en memoria que calcula la similitud a partir de los contenidos multimedia publicados, debido a que su cantidad es en gran medida menor que la cantidad de usuarios registrados.

Para minimizar el problema del contenido multimedia nuevo la plataforma muestra una recomendación con las últimas publicaciones de contenidos multimedia, aumentando las posibilidades de que se realicen votaciones a una nueva publicación de audiovisual. Como estrategia para la generación de recomendaciones a usuarios nuevos, teniendo en cuenta que no se tiene información de sus preferencias, se toman como colaboradores todos los usuarios registrados y se presentan como sugerencias los contenidos más votados por la comunidad.

5.2.6. CONSTRUCCIÓN DE LA SOLUCIÓN

El sistema de recomendación desarrollado está encapsulado en un módulo para la versión 6 del sistema de gestión de contenidos Drupal, debido a que en este CMS se desarrolló la plataforma VideoWeb 1.0. Se utilizan algunas de las funcionalidades del núcleo del CMS definidas en el componente .module. La solución cuenta con una interfaz administrativa en la que un usuario, con permisos de administración, puede definir la cantidad de grupos necesarios para el cálculo de vecindad, una vez que se ha instalado el módulo en la plataforma. Los componentes y sus relaciones están regidas por la familia de estilos arquitectónicos de llamada y retorno, haciendo uso del patrón arquitectónico Modelo-Vista-Controlador.

La integración con la plataforma se realiza a partir del módulo bloques, que es el encargado de mostrar a los usuarios los bloques de contenido en las distintas interfaces, esto se realiza a partir de los selectores de datos que implementa. Para esta integración se desarrolló un selector de recomendaciones que obtiene un listado de 10 sugerencias de contenido multimedia, este selector se comunica con el módulo de filtrado colaborativo desarrollado haciendo uso de una de la funcionalidad del núcleo de Drupal definida para ello (module_invoke).

5.2.7. EVALUACIÓN DE LOS RESULTADOS

Para definir la fiabilidad de las recomendaciones fue necesaria la utilización de métricas de evaluación, que permitiesen medir la calidad de los resultados obtenidos. Encontrar un estándar para la evaluación de sistemas de recomendación es un problema aún sin resolver en la comunidad científica, por ello los métodos de evaluación desarrollados varían para cada técnica de recomendación. La métrica utilizada para evaluar los resultados de la presente investigación fue el Error absoluto Medio (MAE), esta métrica tiene buen impacto en la evaluación de métodos estadísticos.

El principal objetivo de las pruebas fue la comparación de las potencialidades del cálculo de la similitud entre usuarios y entre contenidos multimedia en base a las variables que intervienen en el proceso. Para la evaluación de los resultados se instaló el módulo en una distribución local de la plataforma VideoWeb 1.0 y se probó el algoritmo desarrollado para el conjunto de datos obtenidos del despliegue de la plataforma en la Universidad de las Ciencias Informáticas en período de prueba. El conjunto de datos tomados para las pruebas fueron 950 votaciones realizadas por 600 usuarios a 162 contenidos multimedia, estos fueron separados en un 70% de entrenamiento del sistema de recomendación y un 30% de pruebas. Los valores de vecinos seleccionados para las pruebas fueron entre 50 y 200 vecinos en un rango de 50, estos valores fueron tomados a partir de los datos del conjunto de prueba.

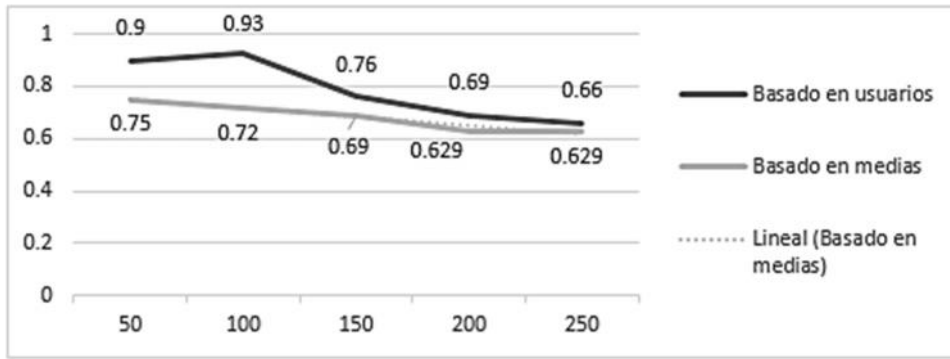


Fig. 3. Gráfica que muestra los resultados de MAE de ambos algoritmos a partir de los números de vecinos seleccionados.

En la Fig. 3 se representa el valor del MAE en el eje vertical y en el eje horizontal la cantidad de vecinos seleccionados para cada prueba, estos valores son representados para el algoritmo de filtrado colaborativo basado en usuarios y para el algoritmo de filtrado colaborativo basado en contenidos multimedia. Como se muestra en el gráfico los valores de MAE oscilan entre 0,69 y 0,93 con un número de vecinos de 50 a 150, esto indica que las recomendaciones no son muy buenas debido a que se debe aumentar el número de vecinos para agrupar los usuarios con características similares. A partir de 150 a 200 vecinos se muestra una tendencia de decrecimiento del MEA al aumentar el valor de la vecindad. Las pruebas realizadas para más de 200 vecinos se mantuvieron con una tendencia muy aproximada a los valores de MEA para 200 vecinos.

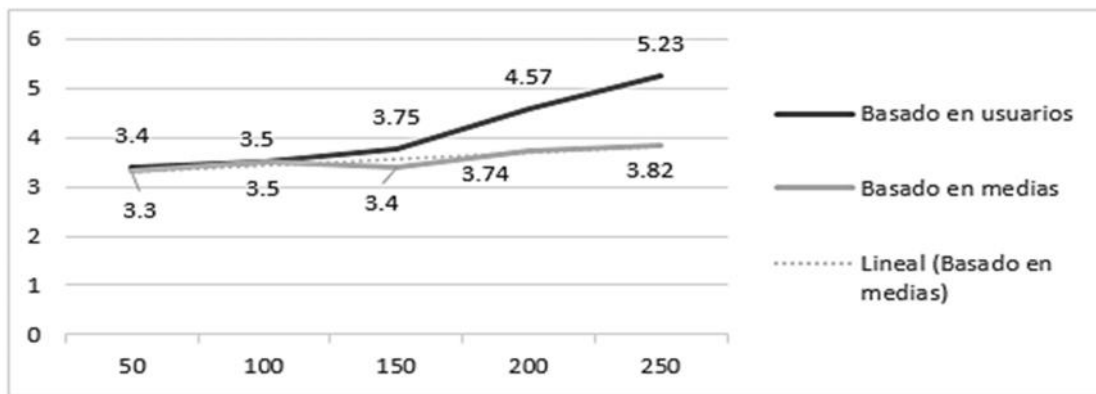


Fig. 4. Gráfica que muestra los resultados del tiempo de ejecución de ambos algoritmos a partir de los números de vecinos seleccionados.

En la Fig. 4 se presenta, en el eje vertical, el tiempo de ejecución de cada algoritmo para las diferentes vecindades representadas en el eje horizontal. Como se muestra en el gráfico el tiempo de ejecución de ambos algoritmos crece a medida que se aumenta la cantidad de vecinos, teniendo tiempos similares para una vecindad entre 50 y 150 usuarios. Se puede apreciar que a partir de 150 a 250 vecinos los tiempos de ejecución del algoritmo basado en usuarios tienen variaciones de mayor magnitud en comparación con los del algoritmo basado en contenidos multimedia.

Las pruebas realizadas indicaron un mejor comportamiento de los algoritmos desarrollados para una vecindad de 200 usuarios, teniendo en cuenta la métrica del valor absoluto medio. Los valores de MEA para el algoritmo basado en medias arrojaron mejores resultados que el algoritmo basado en usuarios. Analizando los tiempos de ejecución para la vecindad seleccionada de ambos algoritmos se evidencian mejores indicadores en el algoritmo basado en medias.

6 CONCLUSIONES Y TRABAJOS FUTUROS

La personalización de la información es una tendencia altamente utilizada por las empresas emergentes en los mercados en línea, enfocado a los sitios de distribución de contenido multimedia se ha convertido en una forma para promover el consumo audiovisual. En este sentido, la integración del módulo de recomendación a la plataforma VideoWeb 1.0 permite

presentar los contenidos publicados de acuerdo a las preferencias particulares de cada usuario, lo que le propicia un valor agregado a la misma viabilizando el proceso de búsqueda de un material y brindando un servicio ajustado a las necesidades de cada consumidor. Los resultados alcanzados por las pruebas posibilitaron la selección del cálculo de la similitud basado en elementos por presentar mejores indicadores en cuanto al MAE y el tiempo de ejecución en el entorno en el que se desarrolla la plataforma, esta selección estuvo guiada además por las tendencias del crecimiento del corpus de datos manipulado en el negocio de VideoWeb 1.0.

La técnica de filtrado colaborativo presenta buenos resultados, pero sus indicadores pueden ser mejorados a partir de su hibridación con otras técnicas. Se propone como trabajos futuros el análisis de otras técnicas de recomendación ajustadas al negocio de la plataforma VideoWeb 1.0. Además, se propone investigar sobre las técnicas de hibridación que arrojen mejores resultados frente a las pruebas realizadas al módulo desarrollado. La hibridación del filtrado colaborativo con otra técnica de recomendación es una tendencia muy utilizada en el mundo, esta estrategia se enfoca en el fortalecimiento de estos algoritmos con otros que minimicen las deficiencias que presentan las técnicas colaborativas. Para minimizar la escasez de los datos presentes en la matriz de votaciones se propone el análisis del historial de navegación del usuario teniendo en cuenta acciones sobre los contenidos multimedia como descarga o reproducción de un material, así como los comentarios realizados a una publicación; estos elementos pueden ser normalizados e incluidos en la matriz de valoraciones.

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Consumer buying decisions models: A descriptive study

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ABSTRACT: Most of the theories of consumer buying decision-making assume that the consumer's purchase decision process consists of several steps. However, it may vary from product to services but all the customers pass through similar process. This study will help the marketers to understand various steps in the whole process of consumer decision making for final purchase of the products of their choices. The marketers may improve their marketing strategies by understanding issues which are most common in the different consumer decision model developed by earlier researchers and scholars of marketing management. In the present study we have tried to identify the major cues for purchase decision making and we have also explained various buying decision model which are most valuable in marketing literature like consumer psychology (how consumers think, feel, reason, and select between different alternatives), the psychology of how the consumer is influenced by his or her environment, behavior while at shopping, consumer knowledge or information processing abilities etc. and we have focused as how marketer can improve methods to convince the customers effectively.

KEYWORDS: Consumer buying decision making, Decision Making model, Consumer psychology.

1 INTRODUCTION

Marketers need to understand the dynamics of the consumer decision making process. While the process and the internal and external factors affecting decision making would vary from person to person and within the same person from situation to situation, the study of consumer behavior attempts to draw certain generalizations. The major decisions taken by a consumer relates to what he buys (products and services), how much he buys (quantity), where he buys (place), when he buys (time) and how he buys (payment terms). A decision is defined as choosing an option out of the few/many available. Decision making is the process of choosing between two or more alternatives, it is the selection of an alternative out of the few/many choices that are available.

The present study of consumer behavior focuses on how individuals make decisions to spend their available resources (time, money, effort) on consumption-related items (Schiffman and Kanuk, 1997). Consumer behavior is a study of the processes involved when individuals or groups select, purchase, use, or dispose of products, services, ideas, or experiences to satisfy needs and desires (Solomon 1996).

A consumer purchase is actually a response to a problem. Consumer Decision Making pertains to making decisions regarding product and service offerings. It may be defined as a process of gathering and processing information, evaluating it and selecting the best possible option so as to solve a problem or make a buying choice. While decision making is defined as the selection of an alternative to solve a problem, the time and effort required to complete the process varies across buying situations.

The consumer buying decision models refer to varying orientations and perspectives with which consumers approach the marketplace and how/why they behave as they do. They refer to how the varying orientations impact the buying decision process and overall buyer behavior. Various models have been proposed by numbers of researchers with their most adequate model of consumer buying decision for all kinds of products/ services. In these models the researchers have tried to draw the ultimate direction of buying decisions whether programmed or non-programmed and its relevance. In the

present paper we would be discussing almost all recognized model of consumer buying decision model with comments as well as explanations.

Belch (1998) defines 'the process and activities people engage in when searching for, selecting, purchasing, using, evaluating, and disposing of products and services so as to satisfy their needs and desires'. Behavior occurs either for the individual, or in the context of a group, or an organization. Consumer behavior involves the use and disposal of products as well as the study of how they are purchased. Product use is often of great interest to the marketer, because this may influence how a product is best positioned or how marketer can encourage increased consumption to the masses. We are now presenting most of all important and relevant models developed by marketing scholars and research in the context of purchase decisions of products and services.

2 ANDREASON MODEL

Andreason (1965) proposed one of the earliest models of consumer behavior which is shown in Figure 2.1. The model recognizes the importance of information in the consumer decision-making process and emphasizes the importance of consumer attitudes although it fails to consider attitudes in relation to repeat purchase behavior. All the sources of information collection are filtered and matched with other behavioral aspects like belief, norms, values etc; along with the search for alternate, substitute and other probable suitable products. Finally it goes through the budget, priority and fit for needs which some time work as constraint against the initial needs and wants.

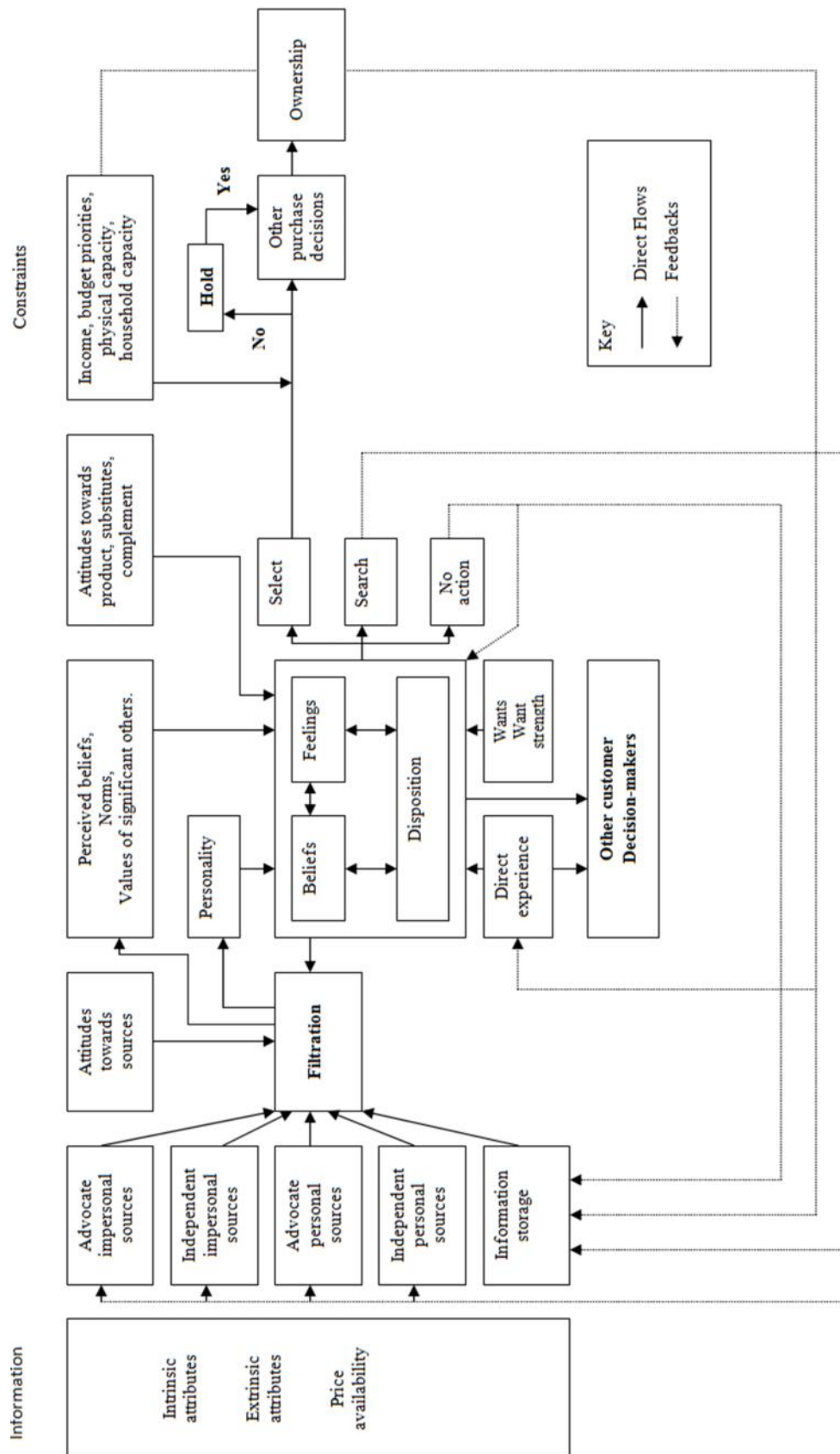


Figure 2.1 Anderson, A.R (1965) Attitudes and Consumer Behavior: A Decision Model in New Research in Marketing (ed. I. Preston). Institute of Business and Economic Research, University of California, Berkeley, pp.1-6

3 NICOSIA MODEL

Nicosia model concentrates on the buying decision for a new product, was proposed by Francesco Nicosia (1976) shown Figure 3.1. The model concentrates on the firm's attempts to communicate with the consumer, and the consumers' predisposition to act in a certain way. These two features are referred to as Field One. The second stage involves the consumer in a search evaluation process, which is influenced by attitudes. This stage is referred to as Field Two. The actual purchase process is referred to as Field Three, and the post-purchase feedback process is referred to as Field Four. This model was criticized by commentators because it was not empirically tested (Zaltman, Pinson and Angelman, 1973), and because of the fact that many of the variables were not defined (Lunn, 1974).

This model focuses on the relationship between the firm and its potential consumers. The firm communicates with consumers through its marketing messages (advertising), and the consumers react to these messages by purchasing response. Looking to the model we will find that the firms and the consumers are connected with each other, the firm tries to influence the consumer and the consumer is influencing the firm by his decision.

The Nicosia model is divided into four major fields:

Field 1: The consumer attitude based on the firms' messages

The first field is divided into two subfields. The first subfield deal with the firm's marketing environment and communication efforts that affect consumer attitudes, the competitive environment and characteristics of target market. Subfield two specifies the consumer characteristics e.g., experience, personality, and how he perceives the promotional idea toward the product in this stage the consumer forms his attitude toward the firm's product based on his interpretation of the message.

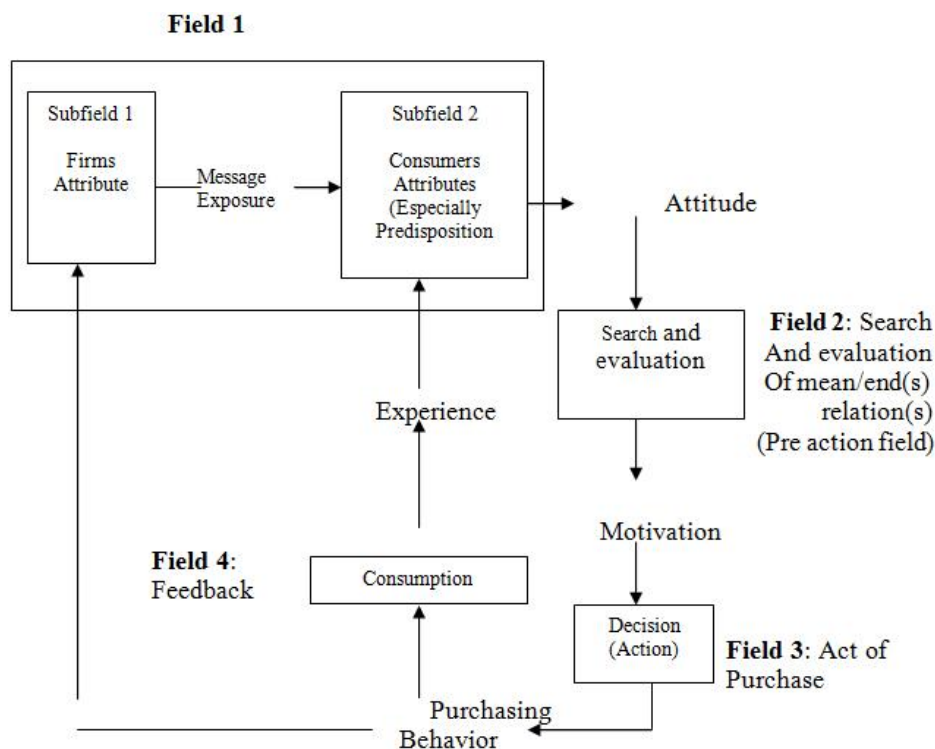


Figure: 3.1. Nicosia Model of Consumer Decision Process Source: Nicosia, (1976).

Field 2: search and evaluation

The consumer will start to search for other firm's brand and evaluate the firm's brand in comparison with alternate brands. In this case the firm motivates the consumer to purchase its brands.

Field 3: The act of the purchase

The result of motivation will arise by convincing the consumer to purchase the firm products from a specific retailer.

Field 4: Feed back

This model analyses the feedback of both the firm and the consumer after purchasing the product. The firm will benefit from its sales data as a feedback, and the consumer will use his experience with the product affects the individuals' attitude and predisposition's concerning future messages from the firm.

The Nicosia model offers no detail explanation of the internal factors, which may affect the personality of the consumer, and how the consumer develops his attitude toward the product. For example, the consumer may find the firm's message very interesting, but virtually he cannot buy the firm's brand because it contains something prohibited according to his beliefs. Apparently it is very essential to include such factors in the model, which give more interpretation about the attributes affecting the decision process.

The model proposed by Francesco Nicosia in the 1970s, was one of the first models of consumer behavior to explain the complex decision process that consumers engage in during purchase of new products. Instead of following a traditional approach where the focus lay on the act of purchase, Nicosia tried to explain the dynamics involved in decision making. Presenting his model as a flow-chart, he illustrated the decision making steps that the consumers adopt before buying goods or services, decision aiming was presented as a series of decisions, which follow one another. The various components of the model are seen as interacting with each other, with none being essentially dependent or independent, they are all connected through direct loops as well as feedback loops. Thus, the model describes a flow of influences where each component acts as an input to the next. The consumer decision process focuses on the relationship between the marketing organization and its consumers, the marketing organization through its marketing program affects its customers, the customers through their response to the marketer's actions affect the subsequent decisions of the marketer and thus the cycle continues.

4 HOWARD-SHETH MODEL

The most frequently quoted of all consumer behavior models is the Howard-Sheth model of buyer behavior, which was developed in 1969 shown in Figure 4.1. The model is important because it highlights the importance of inputs to the consumer buying process and suggests ways in which the consumer orders these inputs before making a final decision. The Howard-Sheth model is not perfect as it does not explain all buyer behavior; it is however, a comprehensive theory of buyer behavior that has been developed as a result of empirical research (Horton, 1984).

This model suggests three levels of decision making:

1. The first level describes the extensive problem solving. At this level the consumer does not have any basic information or knowledge about the brand and he does not have any preferences for any product. In this situation, the consumer will seek information about all the different brands in the market before purchasing.
2. The second level is limited problem solving. This situation exists for consumers who have little knowledge about the market, or partial knowledge about what they want to purchase. In order to arrive at a brand preference some comparative brand information is sought.
3. The third level is a habitual response behavior. In this level the consumer knows very well about the different brands and he can differentiate between the different characteristics of each product, and he already decides to purchase a particular product. According to the Howard-Sheth model there are four major sets of variables; namely:

a) Inputs

These input variables consist of three distinct types of stimuli (information sources) in the consumer's environment. The marketer in the form of product or brand information furnishes physical brand characteristics (significant stimuli) and verbal or visual product characteristics (symbolic stimuli). The third type is provided by the consumer's social environment (family, reference group, and social class). All three types of stimuli provide inputs concerning the product class or specific brands to the specific consumer.

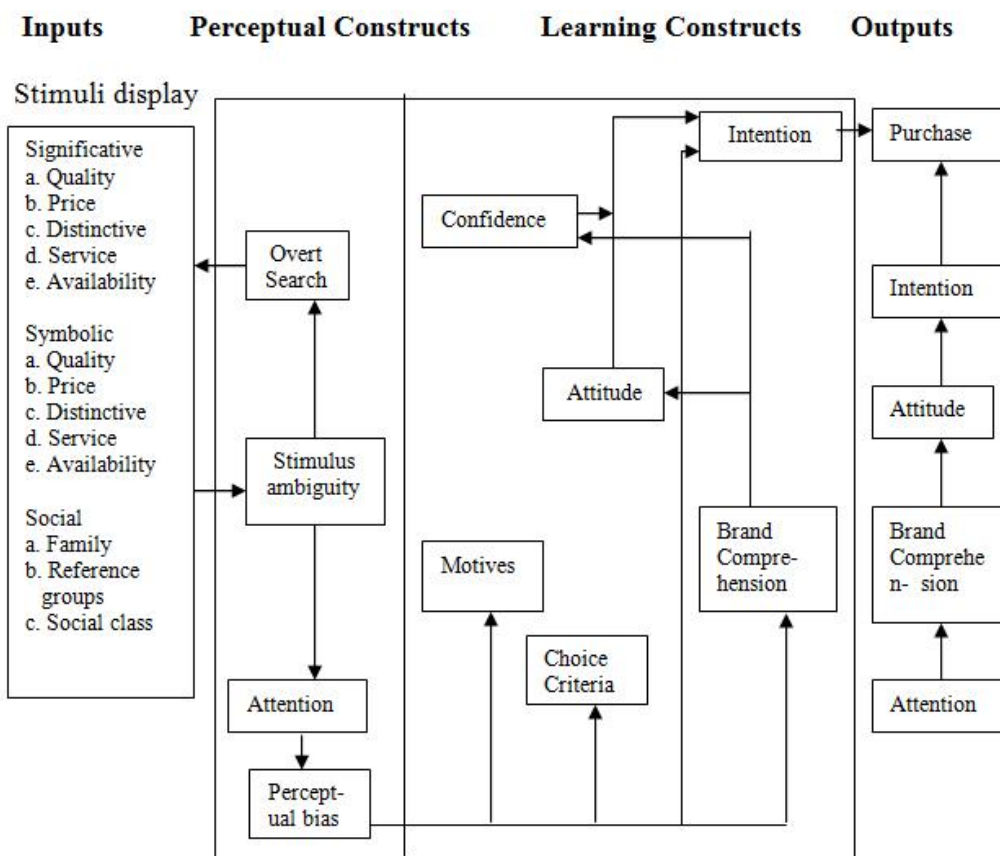


Figure 4.1 a Simplified Description of the Theory of Buyer Behavior

Source: Howard, and Sheth, pp. 32 (1969)

b) Perceptual and Learning Constructs

The central part of the model deals with the psychological variables involved when the consumer is contemplating a decision. Some of the variables are perceptual in nature, and are concerned with how the consumer receives and understands the information from the input stimuli and other parts of the model. For example, stimulus ambiguity happened when the consumer does not understand the message from the environment. Perceptual bias occurs if the consumer distorts the information received so that it fits his or her established needs or experience. Learning constructs category, consumers' goals, information about brands, criteria for evaluation alternatives, preferences and buying intentions are all included. The proposed interaction in between the different variables in the perceptual and learning constructs and other sets give the model its distinctive advantage.

c) Outputs

The outputs are the results of the perceptual and learning variables and how the consumers will response to these variables (attention, brand comprehension, attitudes, and intention).

d) Exogenous (External) variables

Exogenous variables are not directly part of the decision-making process. However, some relevant exogenous variables include the importance of the purchase, consumer personality traits, religion, and time pressure.

The decision-making process, which Howard-Sheth model tries to explain, takes place at three Inputs stages: Significance, Symbolic and Social stimuli. In both significant and symbolic stimuli, the model emphasizes on material aspects such as price and quality. These stimuli are not applicable in every society. While in social stimuli the model does not mention the

basis of decision-making in this stimulus, such as what influence the family decision? This may differ from one society to another.

Finally, no direct relation was drawn on the role of religion in influencing the consumer's decision-making processes. Religion was considered as external factor with no real influence on consumer, which gives the model obvious weakness in anticipation the consumer decision.

The model is an integrative model that incorporates many of the aspects of consumer behavior; it links together the various constructs/variables which may influence the decision making process and explains their relationship that leads to a purchase decision. It highlights the importance of inputs to the consumer buying process. It was one of the first models to divulge as to what constitutes loyalty towards a specific product. It helped gain insights in to the processes as to how consumer process information. The model is user friendly and is one of the few models which has been used most commonly and tested in depth. However, the limitation lies in the fact that the various constructs cannot be realistically tested; some of the constructs are inadequately defined, and thus do not lend to reliable measurements.

5 ENGEL-KOLLAT-BLACKWELL MODEL

This model was created to describe the increasing, fast-growing body of knowledge concerning consumer behavior. Engel et.al. model, like in other models, has gone through many revisions to improve its descriptive ability of the basic relationships between components and sub-components; which consists of four stages.

First stage: Decision-process stages

The central focus of the model is on five basic decision-process stages: Problem recognition, search for alternatives, alternate evaluation (during which beliefs may lead to the formation of attitudes, which in turn may result in a purchase intention) purchase, and outcomes. But it is not necessary for every consumer to go through all these stages; it depends on whether it is an extended or a routine problem-solving behavior.

Second stage: Information input

At this stage the consumer gets information from marketing and non-marketing sources, which also influence the problem recognition stage of the decision-making process. If the consumer still does not arrive to a specific decision, the search for external information will be activated in order to arrive to a choice or in some cases if the consumer experience dissonance because the selected alternative is less satisfactory than expected.

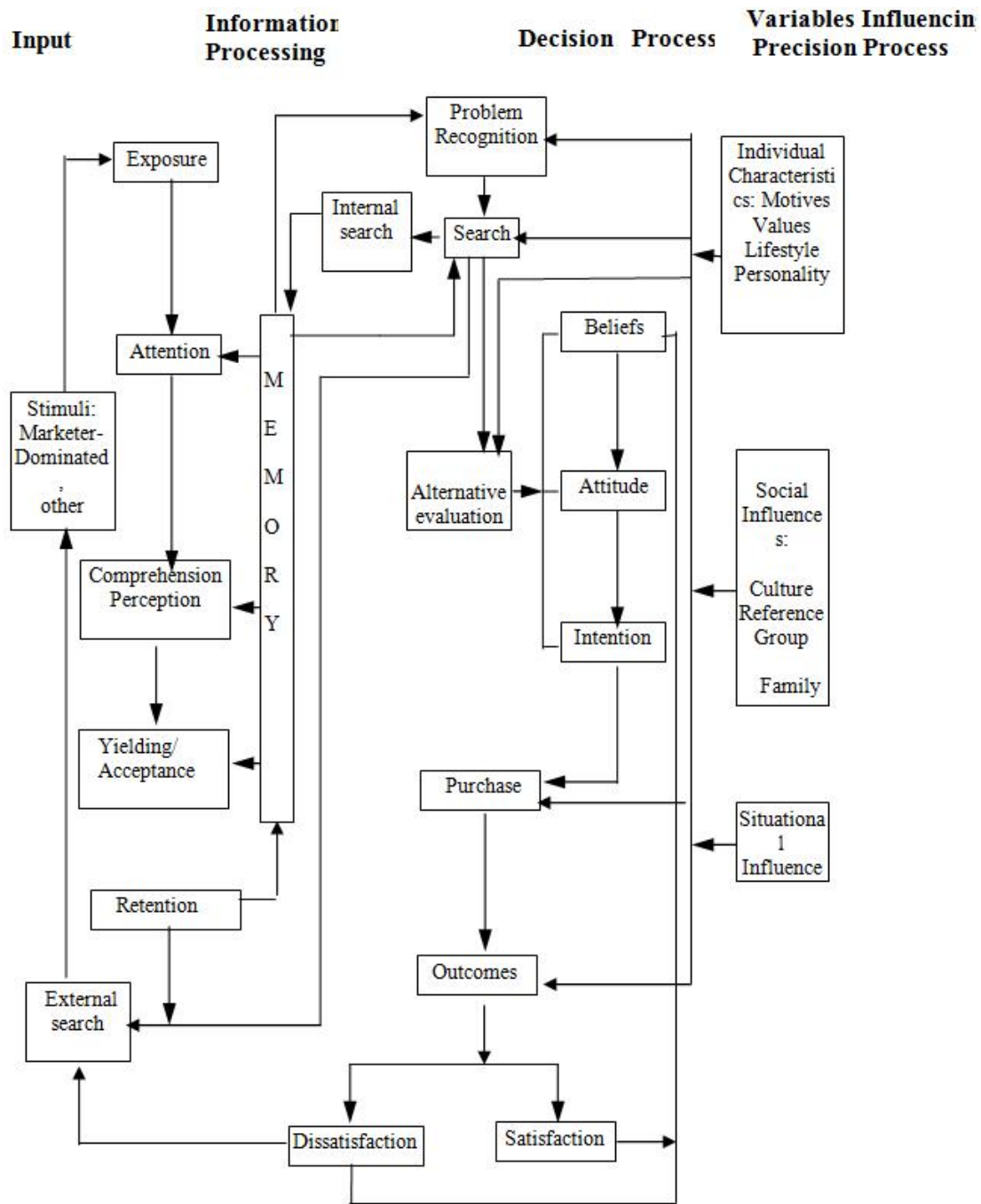


Figure 5.1 The Engel-Kollat-Blackwell Model of Consumer Behavior.

Source: Engel, Blackwell, and Miniard, (1995) page No 95

Third stage: Information processing

This stage consists of the consumer’s exposure, attention, perception, acceptance, and retention of incoming information. The consumer must first be exposed to the message, allocate space for this information, interpret the stimuli, and retain the message by transferring the input to long-term memory.

Fourth stage: Variables influencing the decision process

This stage consists of individual and environmental influences that affect all five stages of the decision process. Individual characteristics include motives, values, lifestyle, and personality; the social influences are culture, reference groups, and family. Situational influences, such as a consumer's financial condition, also influence the decision process.

This model incorporates many items, which influence consumer decision-making such as values, lifestyle, personality and culture. The model did not show what factors shape these items, and why different types of personality can produce different decision-making? How will we apply these values to cope with different personalities? Religion can explain some behavioral characteristics of the consumer, and this will lead to better understanding of the model and will give more comprehensive view on decision-making.

6 BETTMAN'S INFORMATION PROCESSING MODEL

Bettman (1979) in his model of Information processing and consumers' choice, describes the consumer as possessing a limited capacity for processing information. He implicate that the consumers rarely analyze the complex alternatives in decision making and apply very simple strategy. In his model there are seven major stages.

Stage 1: Processing capacity

In this step he assumes that the consumer has limited capacity for processing information, consumers are not interested in complex computations and extensive information processing. To deal with this problem, consumers are likely to select choice strategies that make product selection an easy process.

Stage 2: Motivation

Motivation is located in the center of Bettman model, which influence both the direction and the intensity of consumer choice for more information in deciding between the alternatives. Motivation is provided with hierarchy of goals' mechanism that provides a series of different sub-goals to simplify the choice selection. This mechanism suggests that the consumers own experience in a specific area of market and he doesn't need to go through the same hierarchy every time to arrive at a decision, which make this mechanism serves as an organizer for consumer efforts in making a choice. No concern was given on religious motives, and how religion may motivate the consumer in his decision. Most of the general theories of motivation such as Maslow's hierarchy of needs (1970) emphasize self-achievement, the need for power, and the need for affiliation.

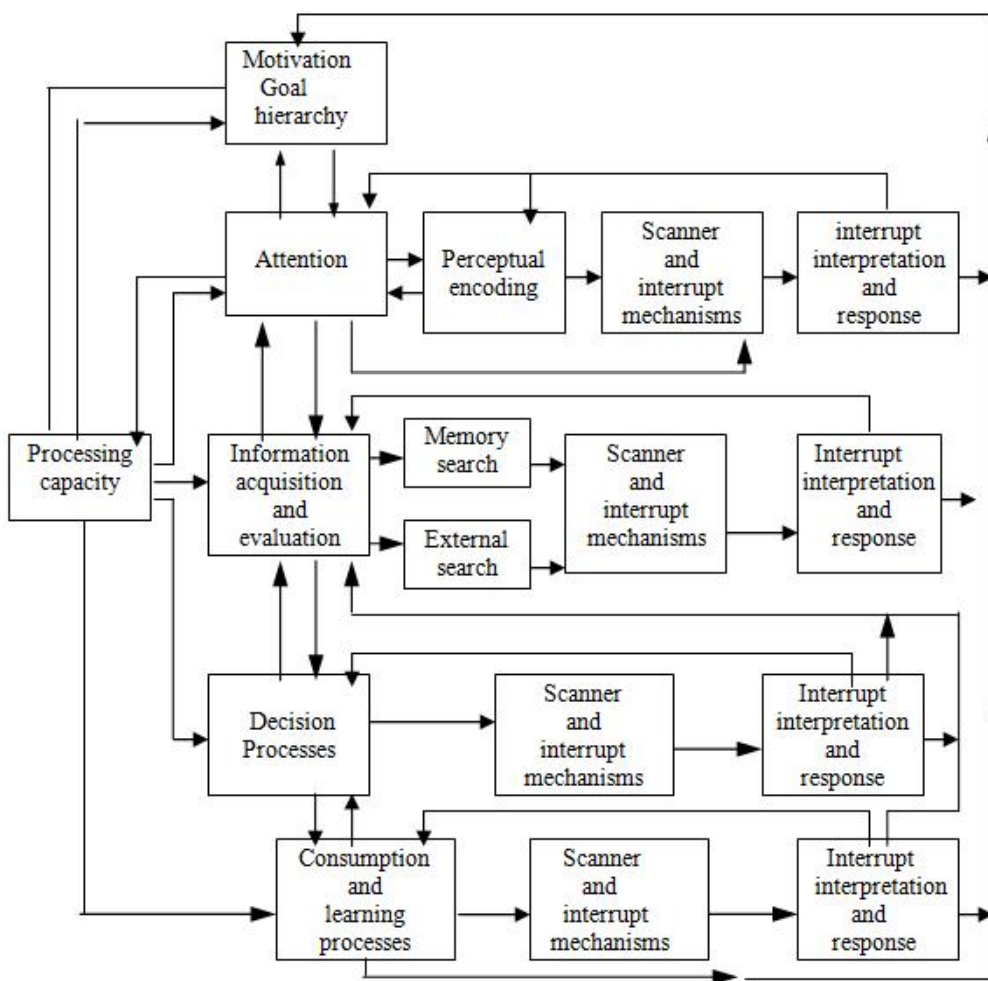


Figure 6.1 the Bettman Information-Processing Model of Consumer Choice

Source: Bettman. (1979). Pp 402

Stage 3: Attention and perceptual encoding

The component of this step is quite related to the consumer's goal hierarchy. There are two types of attention; the first type is voluntary attention, which is a conscious allocation of processing capacity to current goals. The second is involuntary attention, which is automatic response to disruptive events (e.g., newly acquired complex information). Both different types of attention influence how individuals proceed in reaching goals and making choices. The perceptual encoding accounts for the different steps that the consumer needs to perceive the stimuli and whether he needs more information.

Stage 4: Information acquisition and evaluation

If the consumer feels that the present information is inadequate, he will start to look for more information from external sources. Newly acquired information is evaluated and its suitability or usefulness is assessed. The consumer continues to acquire additional information until all relevant information has been secured, or until he finds that acquiring additional information is more costly in terms of time and money.

Stage 5: Memory

In this component the consumer keeps all the information he collects, and it will be the first place to search when he need to make a choice. If this information is not sufficient, no doubt he will start looking again for external sources.

Stage 6: Decision Process

This step in Bettman’s model indicates that different types of choices are normally made associated with other factors, which may occur during the decision process. Specifically, this component deals with the application of heuristics or rules of thumb, which are applied in the selection and evaluation of specific brand. These specific heuristics a consumer uses are influenced by both individual factors (e.g., personality differences) and situational factors (e.g., urgency of the decision); thus it is unlikely that the same decision by the same consumer will apply in different situation or other consumer in the same situation.

Stage 7: Consumption and Learning Process

In this stage, the model discusses the future results after the purchase is done. The consumer in this step will gain experience after evaluating the alternative. This experience provides the consumer with information to be applied to future choice situation. Bettman in his model emphasize on the information processing and the capacity of the consumer to analyze this information for decision making, but no explanation was given about the criteria by which the consumer accepts or refuses to process some specific information.

7 SHETH-NEWMAN GROSS MODEL OF CONSUMPTION VALUES

According to this model, there are five consumption values influencing consumer choice behavior. These are functional, social, conditional, emotional, and epistemic values. Any or all of the five consumption values may influence the decision. Various disciplines (including economics, sociology, and several branches of psychology, marketing and consumer behavior) have contributed theories and research findings relevant to these values, (Sheth *et al.* 1991). Each consumption value in the theory is consistent with various components of models advanced by Maslow (1970), Katona (1971), Katz (1960), and Hanna (1980). Five consumption values form the core of the model:

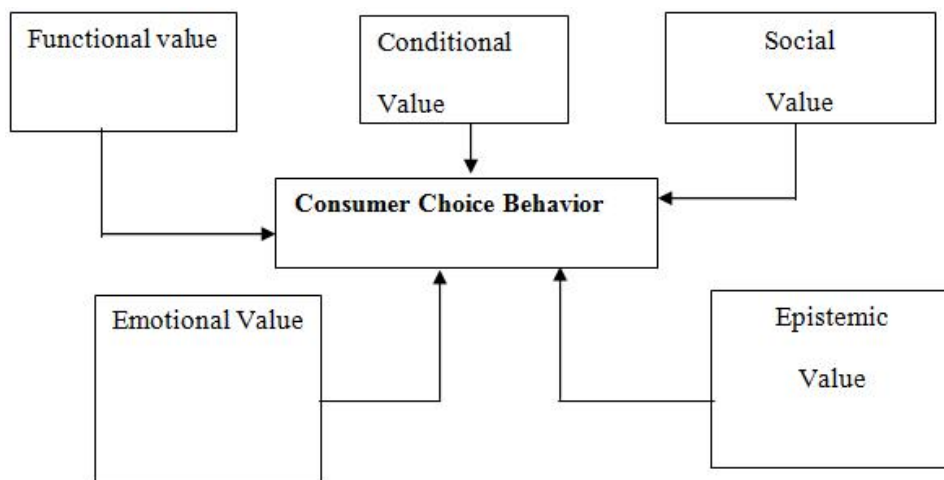


Figure 7.1: The five values influencing Consumer Choice Behavior

Source: Sheth, Newman, and Gross (1991) pp. 159-170

The first value: Functional value

To Sheth *et al.* (1991) the functional value of an alternative is defined as: "The perceived utility acquired from an alternative for functional, utilitarian, or physical performance. An alternative acquires functional value through the possession of salient functional, utilitarian, or physical attributes. Functional value is measured on a profile of choice attributes."

Traditionally, functional value is presumed to be the primary driver of consumer choice. This assumption underlies economic utility theory advanced by Marshall (1890) and Stigler (1950) and popularly expressed in terms of "rational economic man." An alternative's functional value may be derived from its characteristics or attributes, (Ferber, 1973) such as reliability, durability, and price. For example, the decision to purchase a particular automobile may be based on fuel economy and maintenance record.

By identifying the dominant function of a product (i.e., what benefits it provides), marketers can emphasize these benefits in their communication and packaging. Advertisements relevant to the function prompt more favorable thoughts about what is being marketed and can result in a heightened preference for both the ads and the product, (Solomon 1996).

The second value: Social value

Sheth *et al.* (1991) defined social value of an alternative as: "The perceived utility acquired from an alternative association with one or more specific social groups. An alternative acquires social value through association with positively or negatively stereotyped demographic, socioeconomic, and cultural-ethnic groups. Social value is measured on a profile choice imagery."

Social imagery refers to all relevant primary and secondary reference groups likely to be supportive of the product consumption. Consumers acquire positive or negative stereotypes based on their association with varied demographic (age, sex, religion), socioeconomic (income, occupation), cultural/ethnic (race, lifestyle), or political, ideological segments of society.

Choices involving highly visible products (e.g., clothing, jewelry) and good service to be shared with others (e.g., gifts, products used in entertaining) are often driven by social values. For example, a particular make of automobile is being chosen more for the social image evoked than for its functional performance. Even products generally thought to be functional or utilitarian, are frequently selected based on their social values.

The third value: Emotional value

Sheth *et al.* (1991) defined emotional value of an alternative as: "The perceived utility acquired from an alternative's capacity to arouse feelings or affective states. An alternative acquires emotional value when associated with specific feelings or when precipitating those feelings. Emotional values are measured on a profile of feelings associated with the alternative."

Consumption emotion refers to the set of emotional responses elicited specifically during product usage or consumption experience, as described either by the distinctive categories of emotional experience and expression (e.g., joy, anger, and fear) or by the structural dimensions underlying emotional categories such as pleasantness/ unpleasantness, relaxation/action, or calmness/excitement. Goods and services are frequently associated with emotional responses (e.g. the fear aroused while viewing horror movie). Emotional value is often associated with aesthetic alternatives (e.g. religion causes). However, more tangible and seemingly utilitarian products also have emotional values.

The fourth value: Epistemic value

Sheth *et al.* (1991) defined epistemic value as: "The perceived utility acquired from an alternatives capacity to arouse curiosity, provide novelty, and/or satisfy a desire for knowledge. An alternative acquires epistemic value by items referring to curiosity, novelty, and knowledge."

Epistemic issues refer to reasons that would justify the perceived satisfaction of curiosity, knowledge, and exploratory needs offered by the product as a change of pace (something new, different). Entirely new experience certainly provides epistemic value. However, an alternative that provides a simple change of pace can also be imbued with epistemic value. The alternative may be chosen because the consumer is bored or satiated with his or her current brand (as in trying a new type of food), is curious (as in visiting a new shopping complex), or has a desire to learn (as in experiencing another culture).

The Fifth value: Conditional value

Sheth *et al.* (1991) defined the conditional value as: "The perceived utility acquired by an alternative is the result of the specific situation or set of circumstances facing the choice maker. An alternative acquires conditional value in the presence of antecedent physical or social contingencies that enhance its functional or social value. Conditional value is measured on a profile of choice contingencies."

An alternative's utility will often depend on the situation. For example, some products only have seasonal value (e.g., greeting cards), some are associated with once in a life events (e.g., wedding dress), and some are used only in emergencies (e.g., hospital services). Several areas of inquiry have also influenced conditional value. Based on the concept of stimulus dynamism advanced by Hall (1963), Howard (1969) recognized the importance of learning that takes place as a result of experience with a given situation. Howard and Sheth (1969) then extended Howard's earlier work by defining the construct inhibitors as non-internalized forces that impede buyers' preferences. The concept of inhibitors was more formally developed by Sheth (1974) in his model of attitude-behavior relationship as anticipated situations and unexpected events. Recognizing that behavior cannot be accurately predicted based on attitude or intention alone, a number of researchers during the 1970s investigated the predictive ability of situational factors (e.g., Sheth 1974).

The five consumption values identified by the theory make differential contributions in specific choice contexts. For example, a consumer may decide to purchase coins as an inflation hedge (functional value), and also realize a sense of security (emotional value) from the investment. Social, epistemic, and conditional values have little influence. Of course, a choice may be influenced positively by all five consumption values for example, to a first-time home buyer, the purchase of a home might provide functional value (the home contains more space than the present apartment), social values (friends are also buying homes), emotional values (the consumer feels secure in owning a home), epistemic value (the novelty of purchasing a home is enjoyable), and conditional value (starting a family).

8 SOLOMON MODEL OF COMPARISON PROCESS

Schiffman and Kanuk (1997) mentioned that many early theories concerning consumer behavior were based on economic theory, on the notion that individuals act rationally to maximize their benefits (satisfactions) in the purchase of goods and services. A consumer is generally thought of as a person who identifies a need or desire, makes a purchase, and then disposes of the product during the three stages in the consumption process in Figure 8.1 (Solomon, 1996)

The model explains some of the issues that are addressed during each stage of the consumption process. The 'exchange' in which two or more organizations or people give and receive something of value, is an integral part of marketing. He also suggested that consumer behavior involves many different actors. The purchaser and user of a product might not be the same person. People may also act as influences on the buying processes.

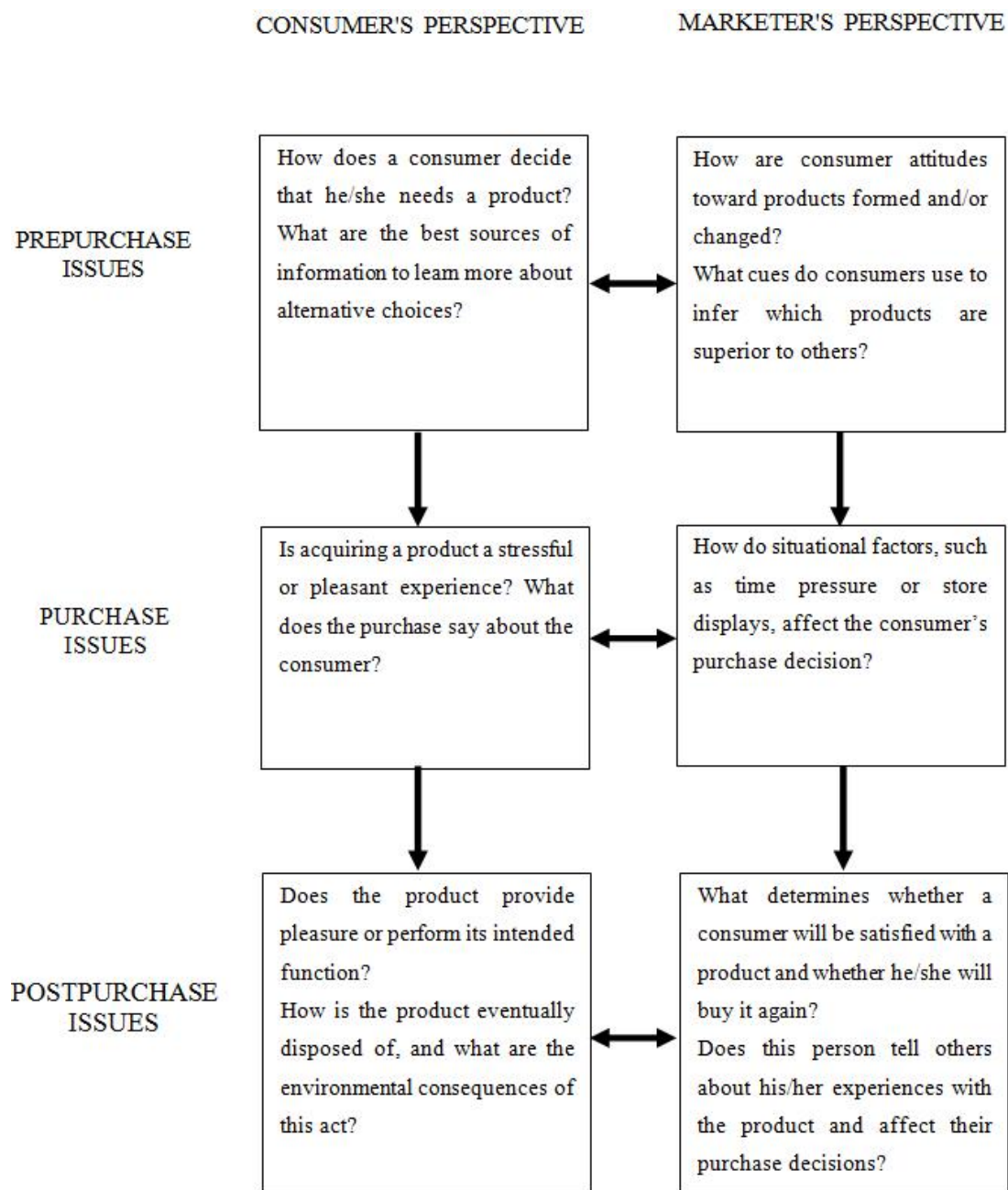


Figure 8.1 Model of comparison process

Source: Solomon (1996) pp. 33

Organizations can also be involved in the buying process for individuals. Much of marketing activity, they suggest, concentrates on adapting product offerings to particular circumstances of target segment needs and wants. It is also common to stimulate an already existing want through advertising and sales promotion, rather than creating wants. The definitions and models, which have been presented so far, have been from general marketing theory.

9 STIMULUS-RESPONSE MODEL OF BUYER BEHAVIOR

Middleton (1994) presented an adapted model of consumer behavior decision making, which was termed the stimulus-response model of buyer behavior. The model is shown in Figure 9.1. This model is based on the four interactive components with the central component identified as 'buyer characteristics and decision process'.

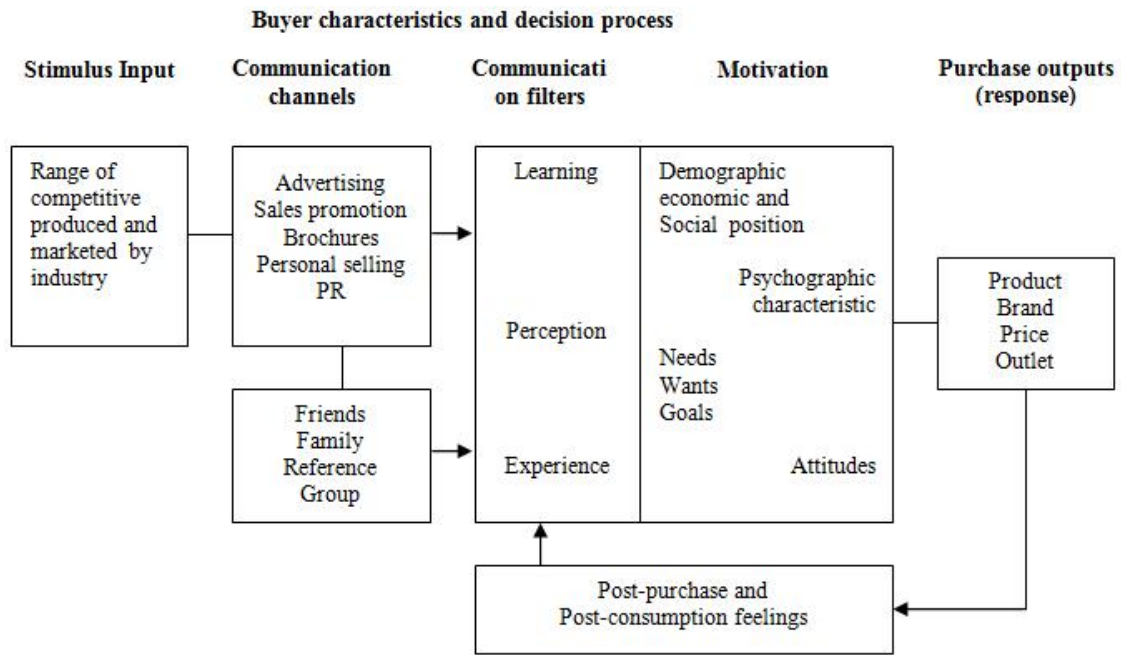


Figure 9.1 Stimulus-Response Model of Buyer Behavior

Source: Middleton (1994) pp. 104-112

The model separates out motivators and determinants in consumer buying behavior and also emphasizes the important effects that an organization can have on the consumer buying process by the use of communication channels.

10 MODEL OF CONSUMER DECISION-MAKING FRAMEWORK

Gilbert (1991) suggested a model for consumer decision-making in which is shown in Figure 10.1. This model suggests that there are two levels of factors that have an effect on the consumer. The first level of influences is close to the person and includes psychological influence such as perception and learning. The second level of influences includes those, which have been developed during the socialization process and include reference groups and family influences.

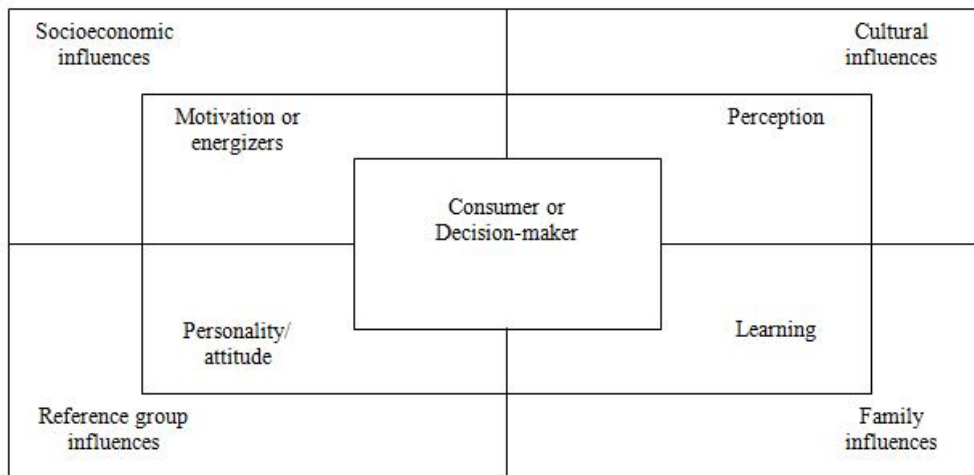


Figure 10.1 Consumer Decision-Making Framework

Source: Gilbert, (1991) In Cooper (Ed.). pp. 78-105

11 INDUSTRIAL BUYER DECISION MODEL

Jagdish N. Sheth (1973) developed a model of Industrial buyer behavior model focusing on the decision making of industrial buyer for industrial products. The model describes so far presumes that the choice of a supplier or brand is the outcome of a systematic decision making process in the organizational setting. However, there is ample of empirical evidence in the literature to suggest that at least some of the industrial buying decisions are determined by ad-hoc situational factors and not by any systematic decision making process. In other words, similar to consumer behavior, the industrial buyers often decide on factors other than rational or realistic criteria.

Figure 11.1 describe that it is important to realize that not all industrial decisions are the outcomes of a systematic decision making process. There are some industrial buying decisions which are based strictly on a set of situational factors for which theorizing or model building will not be relevant or useful.

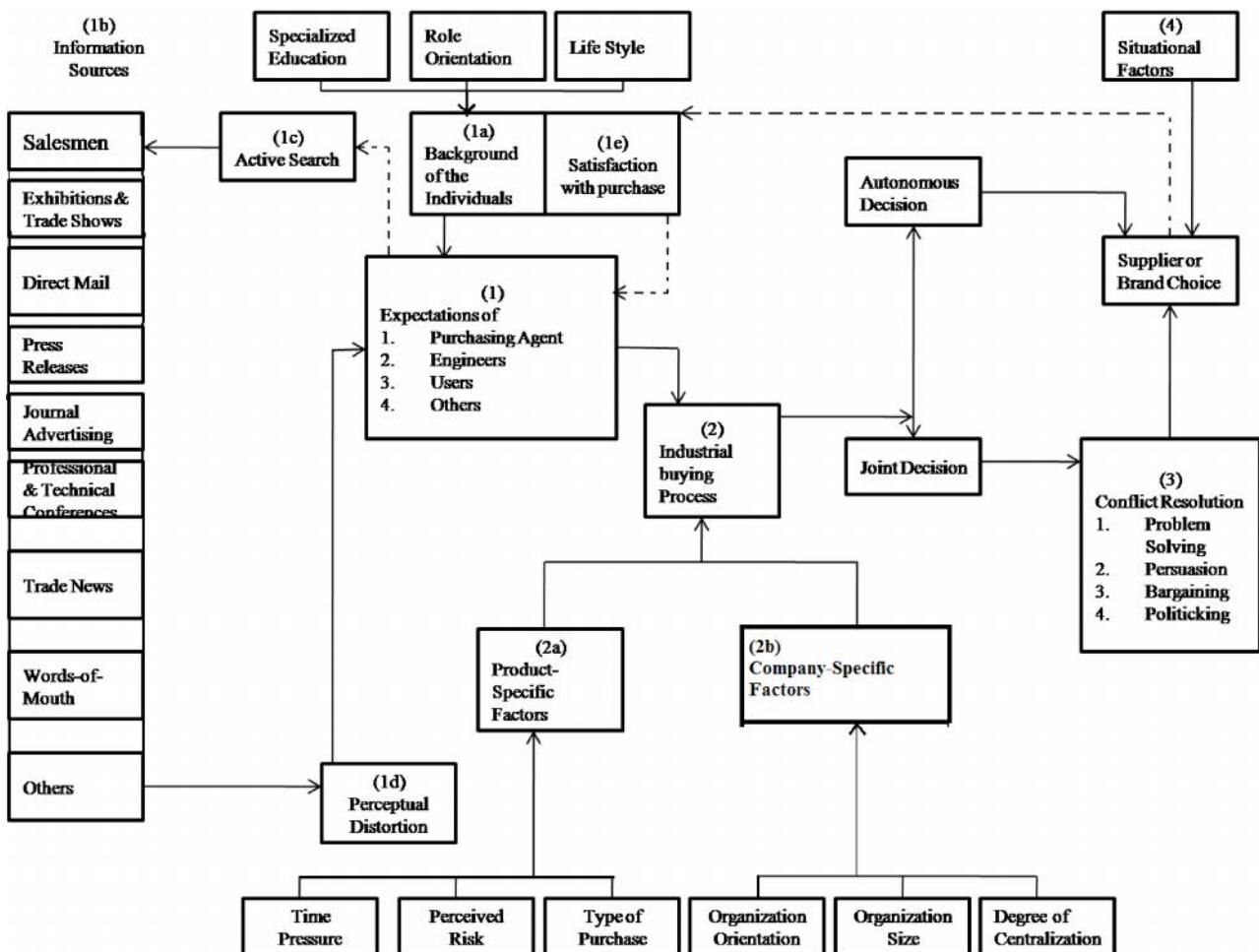


Figure 11.1 An integrative model of industrial buyer behavior

Source: Jagdish N. Sheth (1973), pp. 50-56

It is difficult to prepare a list of ad hoc conditions which determine industrial buyer behavior without decision making. However, a number of situational factors which often intervene between the actual choice and any prior decision making process can be isolated. These include temporary economic conditions such as price controls, recession, or foreign trade, internal strikes, walkouts, machine breakdowns, and other production-related events, organizational changes such as merger or acquisition and ad hoc changes in the market place such as promotional efforts, new product introduction, price changes, and so on, in the supplier industries.

12 CONCLUSION

The buyer behavior models discussed above postulate that if the actual outcome of a product is judged to be better than or equal to the expected, the buyer will feel satisfied, can plan for repeat purchase or become brand loyal. If, on the other hand, actual outcome is judged not to be better than expected, the buyer will be dissatisfied and will give negative word of mouth. The theories/ models of consumers buyers behavior are similar in its outcome, varies on the basis of consumers priorities and the intensity of need and wants of a particular product. Moreover products have their own relevance in consumer buying decision making process depending its utilities and urgencies to consumers apart from various consideration of price, quality etc and attitude, perception, self-concept etc; which have a value association, which determines the degree of demand. Correspondingly, the product image has also a value component reflective of the affective intensity associated with attribute that directs the intension to purchase and consume.

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Classroom Interaction: Investigating the Forms and Functions of Teacher Questions in Moroccan Primary School

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ABSTRACT: This study investigates to what extent Moroccan primary school teachers utilize questions as a powerful pedagogical implement to stimulate thinking and construct knowledge. The intent is to highlight the forms and functions of questions posed and how effective they are in consolidating understanding and scaffolding thinking. The theoretical framework underpinning this study is embedded within the sociocultural perspective that conceptualizes the classroom as a cultural location of meaning in which relationships, functions, regulations, values, and norms are socially constructed. The study draws on observation data in large-class settings. Twenty teachers from five different schools took part in the study. Fifty lessons covering a range of subjects and topics were observed. Some of the lessons were audiotaped following teachers' consent. Verbal manuscripts of classroom questions were analyzed qualitatively and quantitatively. The focus was on questioning exchanges and how they aided or obstructed knowledge construction and cognitive engagement of learners. The findings of this study illustrate how whole-class questioning is dominated by factual questions requiring prescribed responses. Few questions were of speculative nature, which invites opinions, hypotheses and imaginings. Teachers employ questioning to retain control and to support their teaching, rather than pupil learning. . From the results it can then be recommended that in-service workshops should be supplied for teachers, and courses on how to use effective classroom questions to advance attainment/ learning outcomes of students. The concern for good use of teachers' classroom questions for effectual learning outcomes should also be integrated in the training programs at different teacher training centers in Morocco.

KEYWORDS: Teacher Questioning, Classroom Observation, Higher Order Thinking, Transmission Teaching, Cognitive Engagement.

1 INTRODUCTION

Questioning is one of the most familiar forms of teacher talk in classrooms. It is acknowledged as a fundamental part of the staple diet of classroom interaction through which a variety of pedagogical and social actions are carried out. In fact, it is difficult to visualize teachers teaching without posing questions [1]. How teachers bring into play questions during whole-class instruction has spawned multitudinous discussions on the nature and role of this basic discursive implement for engaging learners in instructional interactions, checking comprehension, and building understandings of complex concepts ([2], [3], [4], [5]. Preceding classroom-based studies have identified a range of question types, for example, closed and open-ended questions [6] display and referential questions ([7], forced-choice questions [8], assisting and assessing questions [4], and clarification requests [9], [10], [11]. If, as Postman (1979) stated, "all our knowledge results from questions, . . . [and] question-asking is our most important intellectual tool" [12], then sustained research into this tool can potentially advance instruction.

Croom and Stair (2005) state that classroom questions are best used "as diagnostic tools to help indicate students' academic progress or to assess students' critical thinking" [13]. This view was upheld by Vogler (2005): "questions can monitor comprehension, help make connections to prior learning and stimulate cognitive growth" [14]. Unskilled classroom questions from teachers are characterized as low-level that mainly check whether knowledge has been transmitted. These

types of questions termed “recitation questions” rather than “in-depth questions” [15]. The act of posing questions has the potential to enormously facilitate or influence learning process; however, it may also have the capacity to hinder pupil’s learning if not conducted properly. As Chin (2006) indicates, flexibility in questioning is needed, the teacher adjusts questioning to accommodate students’ contributions and respond to students’ thinking in a neutral rather than evaluative manner [16]. By the same token, Hunkins (1995) observes that there is a shift from conceptualizing questions as devices by which students are evaluated about the specifics of learning to viewing question as instrument for active processing, thinking about, and using information productively [17]. Questions have been employed as key vehicles that “elicit awareness of the diversity, complexity, and richness of knowledge” [17].

Classroom teachers are expected to foster thought and inspire inquiry in pupils, and one effective instrument at teachers’ disposal for fulfilling that is proper questioning. When teachers’ questions are utilized appropriately [18], they can improve learning by enhancing critical thinking skills, reinforce pupil understanding, correct their misunderstanding, provide feedback for students and stimulate classroom discussion. Danielson (1996) confirms that “good and skilled questions, when they are carefully crafted and framed engage students in a true exploration of the content and allow the students to exhibit their understanding of the concept” [15].

Teacher questioning serves a number of functions in the classroom [19], [20], [21]:

- asking questions fosters students’ interest and maintain their active involvement;
- questions help students voice out their minds;
- questions are tools to follow-up and elaborate on students’ contributions;
- asking questions enables teachers to control disciplinary and behavioral issues;
- questions are an indispensable evaluative tool; to diagnose specific difficulties inhibiting pupil learning;
- to provide opportunity for students to assimilate and reflect upon information;
- to develop an active approach to learning .

2 THEORETICAL BACKGROUND

The theoretical framework underpinning this study is embedded within the sociocultural perspective that conceptualizes the classroom as a cultural site of meaning in which relationships, roles, rules , values and norms are socially constructed [22], [23] into being the local interactions of the community. Researchers within this tradition treat education and cognitive development as cultural processes whereby knowledge is not possessed individually but also shared amongst members of communities; and understandings are jointly constructed through their involvement in events which are shaped by cultural and historical factors. Education is viewed as occurring through dialogue whereby “the interactions between students and teachers” echo “the historical development, cultural values and social practices of the societies and communities in which educational institutions exist” [24]. The socially established cultural practices of the classroom become evident and repeatedly reconstructed in the pedagogical and social life of the classroom, mirrored in the customary ways of participation and communication [25], [26]. The interaction patterns in the classroom community can be seen as both fostering and also impeding opportunities for learning to classroom members [27], [23]. Sociocultural views of learning hinge on theories that underscore the social nature of development. Human activities in the sociocultural tradition are socially mediated and thus learning is seen as a matter of participation in a social process of knowledge construction rather than an individual endeavor [28]. Knowledge emerges through the network of interaction and is distributed among interactants. Learning is a process that, as stated by [29], takes place in a participation framework, not in an individual mind.

McCormick and Donato (2000), working within a sociocultural theoretical standpoint, suggest that teacher questions should not take on the position of an elicitation tool where teachers elicit pupils’ knowledge about the content of the discussion. Rather, they put forward that teacher questions need to be conceptualized as dynamic discursive tools that are meant to establish collaboration and scaffold understanding [30]. Operating within the same theoretical paradigm, Hall and Verplaetse (2000) propose that teachers’ questions need to be implanted within a context that permits students to engage in oral interactions that facilitates language production that will eventually aid learning [31]. According to Vygotsky (1978), questions are one case in point of symbolic linguistic tools that semiotically mediate, assist, and scaffold mental activity during both formal and informal instructional activity [28].

In this study, we believe that a framework to study classroom questions must reflect their mediational quality; that is, their ability to assist learning [32]. To attain this, we investigate the forms and functions of teacher questions and their link to knowledge construction and cognitive engagement of pupils. Three concepts of sociocultural theory specifically shored up this investigation of teacher questions. At the outset, learning transpires in well contextualized activities that often occur during collaboration [33]. Subsequently, collaboration with a more knowledgeable individual during problem solving often

gives rise to cognitive development in the learner [34], [35], [36]. As a final point, speaking is the principal semiotic tool used to lead learners to carry out what they cannot act upon unassisted [28], [37].

3 METHODOLOGY

Although questioning is a fundamental facet of any classroom interaction, it is still an under-researched area in the Moroccan classroom context. There is a scarcity of data into how teachers actually teach in Moroccan primary classrooms. There is a need for field data on which to base decisions and formulate policies so as to bridge the gap between the rhetoric and reality of educational development. The design of this research was observational. Service teachers were observed in classes and recordings were made following specified aspects of classroom interaction. Applying “focused whole-class observation” [38] enabled the researcher to be ‘covert’: not to reveal exactly what he was looking for in the observation to reduce ‘participants bias’ when they try to accommodate to what they assume the researcher was looking for. Additionally, having a checklist of entire criteria to observe helped the researcher to stay focused on aspects he wanted to investigate in the study.

Data were collected in four primary schools in Marrakech, including rural, urban, and suburban sites. All of them were public schools. They were selected to be as representative as possible –geographically, economically, and culturally. The schools operate from grade 1 to 6. The language of instruction is Standard Arabic and French. In practice the language of instruction turned out to be a blending of Standard Arabic and Moroccan Arabic. Even the teaching of French is heavily punctuated by the use of Moroccan Arabic. The numbers of pupils in classrooms ranged from 30 to 45. The main teaching aids in most classrooms were the chalkboard and textbooks.

Data collection took five weeks. Methods included eight to ten hours per week of classroom observation and around three to four hours of audio-taping. The focus was on the forms and functions of questions, and how effective they are in scaffolding thinking and consolidating understanding in the narrow context of classrooms. During classroom observation, I participated most through listening to what was going on in the classroom. In order to identify forms and functions of questions in classroom talk, based on Myhill’s classification [39], the researcher tracked the questions posed, the answers that they generated and how the teacher followed up on these answers. In deciding which utterances were to be considered as questions, I settled on that any question or statement that provoked a response would be characterized as a question. This would capture all those authentic endeavors on the part of the teacher to engage pupils in the talk. The unit of analysis was ‘IRF’ structure: Initiation–Response–Feedback [40]. Teachers’ initiating questions and the corresponding students’ answers that they elicited were analyzed, with a particular attention to the kind of questions asked, how they were posed, and the relationships between the cognitive level of questions and students’ responses, and the types of follow-up given in response to answers. I specifically focused on the effect of preceding utterances on subsequent ones, and to what extent teachers’ questions influenced what pupils contributed and whether they triggered further thinking.

To accomplish the purpose of this study, the subsequent questions were raised:

1. What is the frequency of the occurrence of different types of questions in the discourse of Moroccan primary school talk?
2. What functions do the questions fulfill?
3. How effective are these questions in engaging pupils cognitively?

4 FRAMEWORK FOR ANALYSIS OF TEACHER QUESTIONS

4.1 CLASSIFICATION OF QUESTIONS BY FORM

The researcher analyzed the observations and tape recordings and sought to categorize the questions used by the teachers. The outcome of data analysis was a classification of the questions used by the teachers both in terms of forms and functions in the context of Teaching. The classification of teacher questions was conducted through adopting Myhill’s taxonomy [39]. She suggested four types of questions namely; factual, speculative, process and procedural. The description of question types is described in Table 1.

Table 1.

Form	Definition	Example
Factual Questions	inviting a predetermined answer	What was in her pocket? Why did he wake up early?
Speculative Questions	Questions inviting a response with no predetermined answer, often opinions, hypotheses, imaginings, ideas	What do you think his next move might be? How would you behave in a similar situation?
Process	Questions inviting children to articulate their understanding of learning processes/explain their thinking	How did you come to that conclusion? Can you account for that choice?
Procedural	Questions relating to the organization and management of the lesson	Is that clear enough for everyone to see? Can you start with the one on your left?

4.2 CLASSIFICATION OF QUESTIONS BY FUNCTIONS

In terms of functions, the outcome of data analysis was a classification of the questions used by the teachers in the context of observed classrooms. The classification of teachers' questions by functions was conducted by adopting Myhill's taxonomy [39]. She suggested eleven functions of questions, namely; class management, practicing skills, checking prior knowledge, cued elicitation, developing vocabulary, recapping, checking understanding, building on content, building on thinking, and developing reflection. The description of question functions is described in Table 2.

Table 2.

Functions of question	Definition
Factual elicitation	meant to recall information/fact
Class management	linked to management of tasks/behavior
Practicing skills	pupils are expected to rehearse, repeat or practice a strategy or understand something
Checking prior knowledge	related to checking knowledge and experience relevant to lesson
Cued elicitation	cueing answers
Developing vocabulary	questions posed to assess or clarify understanding of vocabulary
Recapping	recalling prior lessons and work done in this lesson
Checking understanding	checking grasp of ideas and concepts already covered
Building on content	putting together information about the topic
Building on thinking	moving forward with pupils' ideas and concepts
Developing reflection	querying how pupils are learning and the strategies they are using.

5 RESULTS AND DISCUSSION

5.1 CLASSIFICATION OF THE FREQUENCY OF THE OCCURRENCE OF DIFFERENT TYPES OF QUESTIONS IN TERMS OF FORM

The researcher counted the questions in each type and calculated their relative frequency. Figure 1 shows the comparative distribution of the questions by type.

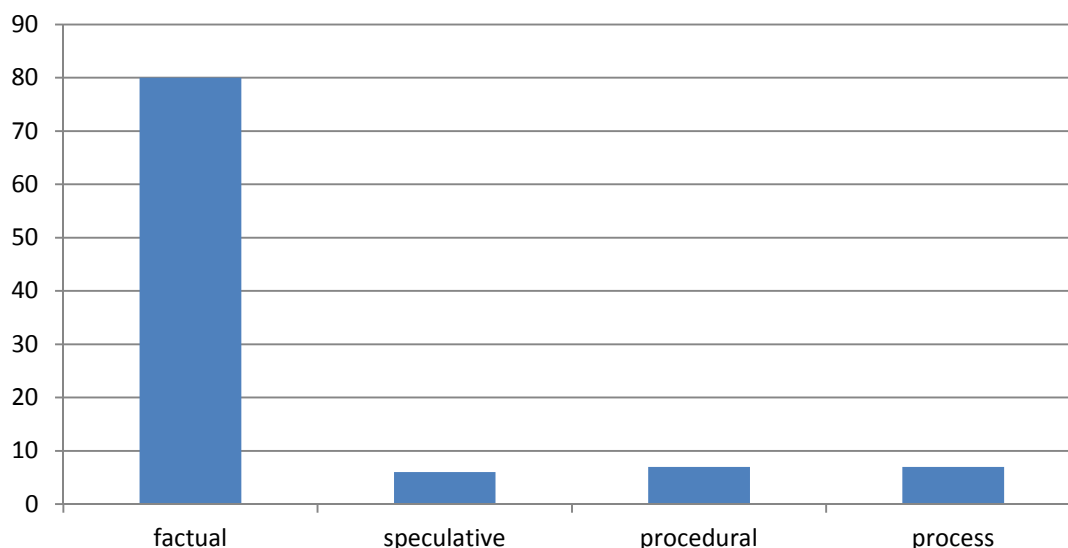


Fig. 1.

The analysis shows that a significant percentage of questions was factual. Over 80 % of questions posed were factual; that is, those that require a predetermined response. The analysis clearly indicates the relatively low percentage of questions aiming at triggering high order thinking. Speculative questions, which target opinion forming, hypothesis making and articulation of understanding, take a minority position in classroom talk patterns. Speculative questions constituted no more than 6 %. Pupils seemed hesitant to raise hands when speculative questions were posed. Many students often respond at a lower cognitive level than the questions demand. The fact that pupils hesitate or mutter to higher order questions might suggest that they are more used to, and therefore more at ease with, low level questioning requiring short and predetermined answers. Moreover, teachers seem to allot the same amount of time to both factual and speculative questions which puts students under pressure and therefore impacts on the length and quality of their responses. The interactive pace is sometimes fast. There are few pauses, answers come hard on the heels of questions, and transmission time is minimal [41].

Teachers paraphrase questions and strongly cue them to get the answer they have in mind. They just gloss over or ignore answers not leading to prescribed directions. The process of questioning serves to side pupils' thinking with the teacher: it is less a process of educational inquiry more of a process of "following the teacher's script" [42]. Teachers manipulate classroom interaction so that it revolves around their "frame of reference" [43]. Teachers use questions in a manner that narrows and limits thinking to factual recall, rather than use questions to develop learning and understanding. The dependence upon factual or closed questions emerges as a prevalent feature of teachers' talk repertoire in the observed classrooms. Alexander (2001) argues that open questions coupled with heavy prompts, clues and cues that close the door to cognitive engagement seriously impede students' cognitive engagement [41]. The paucity of speculative and process questions and dominance of factual questions might indicate that the teachers are not aware enough of the value of higher order questions to foster thinking, reasoning and problem solving skills. The teachers have always complained about the teaching load and felt under pressure to cover the curriculum which may have created the tendency towards factual questioning. This may be ascribed to the prioritizing of teaching (delivery and content) over learning (understanding). Black and William consider this pattern of questioning as wholly counter-productive to the enterprise of learning:

"So the teacher, by lowering the level of questions and by accepting answers from a few, can keep the lesson going but is actually out of touch with the understanding of most of the class – the question-answer dialogue becomes a ritual, one in which all connive and thoughtful involvement suffers" [44] .

This suggests a pattern of teaching which is transmissive, with the teachers imparting factual information, and asking factual questions. The pupils appear to be the depositories and the teacher is the depositor. This is "the 'banking' concept of education, in which the scope of action allowed to the students extends only as far as receiving, filing, and storing the deposits" [45]. Triggering and extending pupils thinking entails sensitive shaping of classroom talk and listening attentively to pupils' contributions. There is an urgent need to develop pedagogic confidence in framing classroom talk which permits children to be 'active in creating their own understandings' [46].

5.2 CLASSIFICATION OF THE FREQUENCY OF THE OCCURRENCE OF DIFFERENT TYPES OF QUESTIONS IN TERMS OF FUNCTIONS

The researcher counted the questions in each category and calculated the relative frequency of each function. Figure 2 shows the comparative distribution of the questions by functions.

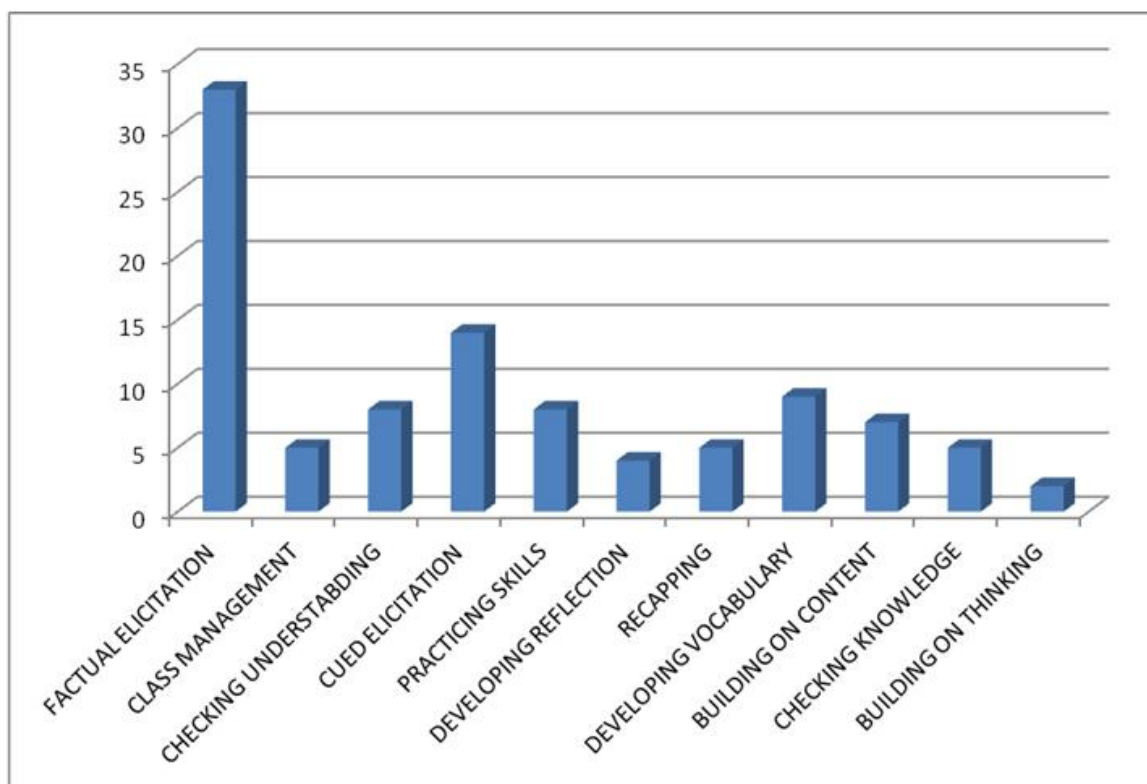


Fig. 2.

The analysis of questions according to their functions, once again, reveals that factual elicitation is by large the prevalent occurrence (33%). Cued elicitation takes second position (14%). Other remaining functions are tempted intermittently. For instance, questions developing reflection and building on thinking assumed a minority position; (4%) and (2%) respectively. This suggests a pattern of teaching which is transmissive, with teachers imparting factual information, and asking closed questions. The overuse of test questions is contrasted with 'authentic' questions that urge students to think for themselves. Most questions posed by the teacher use recurrently closed questions meant to accumulate knowledge and 'understanding' through testing or stimulating recall of what was previously taught, or to strongly cue pupils to figure out answers from clues embedded in questions. Teachers often map their questions in terms of the lesson's content, they seem to put less weight on considering questions in terms of the cognitive and linguistic demands made on their pupils. The results disclose that most favored type of questions are factual and short answer-retrieval style questions both of which situate pupils into an inactive, information seeker-receiver situation in the class.

The types of questions posed are typical of teacher-fronted lessons in which transmission of knowledge from teacher to student is the expected form of interaction. Learning involves listening to the teacher, reading, and studying in order to recollect information on demand. Teachers employ classroom questions principally to assess students' aptitude to retain information. Posed questions were almost entirely confined to low cognitive levels. This portrayed superficial teaching and superficial learning which placed a ceiling on the learners' linguistic and conceptual development.

The whole pattern of classroom questions in the observed classrooms has a tendency towards coverage of curriculum and elicitation of facts rather than the formation of thinking strategies, articulation of learning and construction of interconnected learning. Teacher questioning lacks flexibility as the teacher rarely regulates questioning based on pupil answers to engage students in higher-order thinking. Students are not encouraged to self-evaluate their answers and justify their claims. By missing the opportunity of readdressing the evaluative function back to the pupils, the teacher falls short of fostering a climate that values reasoning, speculation, and the co-construction of knowledge.

Alexander (2008) characterizes the type of classroom interaction observed in Moroccan primary classrooms as monologic because there is no true exchange of meaning and the teacher largely dominates and controls interaction content and direction, thus squelching autonomous thinking on which the fostering of talk for learning and understanding hinges [47]. When teachers' questions and comments are probing and open-ended, and students are offered the chance to pose questions and expand on the talk along with responding to the teacher; participation in classroom is expected to be conducive to 'genuine' learning. As noted By Nystrand "what ultimately counts is the extent to which instruction requires students to think, not just to report someone else's thinking" [48]. Classrooms need to be a platform where the importance of teaching as discussion and dialogue is emphasized and where there is an exchange with a view to sharing information and solving problems as well as achieving common understanding through structured and cumulative questioning, guided discussion and understanding [49]. Students can learn higher mental processes if the processes hold a central position in the teaching-learning practice.

Quality talk in classrooms is contingent upon the types of questions posed. Pedagogical interaction can have greater power to provoke cognitive engagement and understanding if teachers ask challenging and high order questions that equip pupils with skill and habits of mind that permit pupils to participate effectively in the wider communicative practices to which they have increasing access. Although questioning forms only one part of good teaching, it is also the most used instructional strategy in the classroom. Therefore, for students to reap the maximum benefit from their teachers' questioning, teachers are required to develop awareness of ways of enhancing their current techniques of posing questions to meet the needs of their students and the curriculum. Teaching should rely, to a certain extent, on questions that are "fundamentally open or divergent...in terms of allowing a broader degree of uncertainty in what would constitute an adequate answer" [50]. Speculative questions are not meant to test learners nor lead them to a narrow range of answers considered acceptable by the teacher. Rather, these questions target new understandings through meaningful inquiry. Accordingly, teachers are expected to work strategically with learner answer, prompting for justification, challenging assumptions and broadening pupil horizon. Teachers should realize that a good lesson should have a balance incorporation of both low and high level questions and select questions that emphasize major points and stimulate cognitive engagement. Chin (2006) depicts the concept of a "cognitive ladder" to scaffold student understanding by making progress from lower order to higher-order questioning and "enabling students to gradually ascend to higher levels of knowledge and understanding" [51]. As students start to engage with new content, teachers may utilize lower-level questioning focused on recall and application. As students are set to progress through the inquiry process, teachers can then employ higher-order questioning focused on reasoning, clarification, and generalizing to alternate contexts. This scaffolding helps to sustain students learning and narrow the gap between student knowledge and conceptual understanding of concepts [51].

Knowledge reproduction seems to be the most preponderant form of interaction in Moroccan primary classroom. Analysis gives evidence of the ways in which learners' habituated patterns of practice generally replicate traditional school learning in which value is positioned on individual 'products' and 'achievement'. Classroom pedagogic practice needs to be geared towards effective interaction that situates learners in a favorable position to question, to argue, to reason, to listen to others, and to contribute to problem solving. These practices are likely to equip Moroccan young learners with the prerequisite tools conducive to transformative thinking and learning in the information society.

6 IMPLICATIONS

This study was a limited-scale inquiry and therefore it needs to be expanded and generalized to a superior number of teacher observation and classroom investigation so as to reach more primary school classes and disclose more findings to weigh against the ones exposed in this study.

The conclusions derived from this study have potential in translating research insights into practical guidance for teachers on the subject of strategic moves in classroom discourse. The analysis of classroom discourse data can inform instructional practice, raise awareness of the array of discursive strategies on hand, and function as constructive pointers for teachers during pre-service training and in-service professional development. The capability to handle and coordinate classroom discourse to sustain student learning is a significant feature of pedagogical content knowledge [52].

Pupils should be offered manifold and diverse opportunities to engage in meaningful interactions in class. One of primary school teachers' responsibilities, then, is to heedfully arrange the interactional environment in their classrooms to make such opportunities readily accessible. Teachers are called upon to balance 'authoritative' talk which governs classroom talk with 'dialogue' which does not normally occur often [53], [54].

Research findings specify that introduction to diverse learning tools will improve learning environment and stimulate students in engagement process. As an implement, a good questioning strategy can assist teachers to craft a learning context

paving the ground for genuine communication and negotiation of meaning in the class and provide a dialogic process, allowing pupils to gain understanding of real-life situations.

Teachers need to comprehend the inextricable linkage between classroom practice and pupil progress and, more specifically, the vital function they fulfill in generating conditions that define both the substance and direction of pupil intellectual growth. There should be a shift from regarding questions as devices by which one assesses the essentials of learning to conceptualizing questions as an instrument of actively processing, thinking about, and using information productively [55]. Teachers should decisively plan and pose questions that entail engagement in higher-level thinking. Pupils need to be familiarized with the diverse levels of thinking and helped to be conscious of the kind of thinking required by the question. In accentuating the interactive form of teaching, it is palpable enough that questioning is a central part in the process. That would prepare student teachers to progressively absorb questioning culture such that after graduation, the culture may possibly remain.

Teaching practice supervisors are encouraged to lay emphasis on questioning to student teachers for the duration of teaching practicum, more than ever before. Supervisors from the ministries are correspondingly encouraged to foster this culture among service teachers in the course of timely visits. Above and beyond, workshops, seminars and conferences may be held for them for this rationale.

7 CONCLUSION

The purpose of this article was to verify the extent to which class teachers inter-act with their pupils in the course of questioning. In order to investigate forms and functions of questions in classroom talk, the researcher tracked the types and functions of questions posed, the answers they generated and how the teacher followed up on these answers. Analysis of obtained data demonstrated that the teachers passed on mostly factual questions but performed inadequately on other types of questions. The questions that teachers asked hinged on facts and recall rather than on questions which required options (opinions, hypotheses, imaginings, and ideas). The teachers performed inadequately in questions meant to hone critical skills. Teachers prioritized teaching (delivery and content) over learning (understanding). Ultimately, the article exposed how the analysis of classroom discourse data can inform instructional practice, raise awareness of the range of discursive strategies on hand, and function as constructive pointers for teachers during pre-service training and in-service professional development.

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Assessing the Challenges of Learning and Teaching of Mathematics in Second Cycle Institutions in Ghana

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ABSTRACT: The importance to incorporate mathematics in education has gain worldwide recognition, as it has a great potential of improving the level and quality of education completely. Mathematics is the bases of creation and is also the bases of learning and any student who is excellent in mathematics has a greater probability in excelling in other subjects as well. Today's era of technology cannot be discussed without making reference to the mathematics. Technology relates it building blocks to mathematics and any nation that wants to develop technologically must pay special attention to the study of mathematics. However, the teaching and learning of mathematics in our education is faced by a lot of hindrances. This study examines the challenges of the teaching and learning of mathematics in second cycle institutions in Ghana at Kumasi Metropolis. The researcher administered 400 total questionnaires, interviews and focus groups discussions, and a sample of three hundred and sixty (360) respondents made up of one hundred (100) teachers and two hundred and sixty (260) students respondent to them. Stratified sampling method was used to group the school population into two (2) main categories: teaching staff, and student. Random sampling was then used to select 360 respondents for data collection. After the study, it came out that, some of the problems are; lack of teaching and learning materials representing 22.22% according to the data gathered from the respondents ,from the respondents another problem was inconsistent syllabus by Ghana Education Service with a percentage of 16.67%, poor attitude towards the study of mathematics by students also had a percentage of 19.44%.

KEYWORDS: Assessing, Second Cycle, Institutions, Challenges, Teaching, Learning, Mathematics.

1 INTRODUCTION

The word mathematics comes from the Greek μάθημα (máthēma), which, in the ancient Greek language, means "what one learns", "what one gets to know", hence it is said Mathematics means "knowledge, study, learning". It is said that Mathematics is the gate and key of the Science (<http://uncyclopedia.wikia.com>).

According to the famous Philosopher Kant, "A Science is exact only in so far as it employs Mathematics". So, all scientific education which does not commence with Mathematics is said to be defective at its foundation. Neglect of mathematics works injury to all knowledge (www.preservearticles.com).

One who is uninformed of mathematics cannot know other stuffs of the World. Again, what is worse, who are thus unfamiliar are unable to perceive their own ignorance and do not seek any remedy. So Kant says, "A natural Science is a Science in so far as it is mathematical". The Mathematics as an academic discipline has played a very significant role in building up modern Civilization by perfecting all Science (www.preservearticles.com).

In this present era of Information Technology, emphasis is given on Science subjects such as Physics, Chemistry, Biology, Medicine and Engineering. Mathematics, which is a Science by any standard, also is an efficient and necessary tool being employed by all these Sciences. As a matter of fact, all these Sciences advance only with the aid of Mathematics. So it is pertinently remarked, "Mathematics is a Science of all Sciences and art of all arts" (<http://en.wikipedia.org>).

In the first instance, are there quality teachers to handle the subject mathematics? What comes into students mind when they hear the subject mathematics? Are these teachers employing the best teaching methods? Is the Government of Ghana committed to the teaching and learning of mathematics? And are there learning materials such as graph board, construction instruments to support the learning of mathematics? What learning style do learners used in studying mathematics?

According to the West African Examination Council, Ghana, 2013 the performance of students in Mathematics in West African Senior Secondary Schools Certificate Examination (WASSSCE) has decline .In 2013, there was a sharp decline in student's performance.47% excelled in Elective Mathematics as against 75.1% in 2012 while 36.8% excelled in core mathematics as against 49.9% in 2012

According to Prakash (2011), in the pedagogical study of mathematics we mainly concern ourselves with two things; the manner in which the subject matter is arranged or the method the way in which it is presented to the pupils or the mode of presentation. Mathematics is intimately connected with everyday life and necessary to successful conduct of affairs. It is an instrument of education found to be in conformity with the needs of human mind.

He also stated that," Teaching of mathematics has its aims and objectives to be incorporated in the school curricula".

If and when Mathematics is removed, the back-bone of our material civilization would collapse. So is the importance of Mathematics and its pedagogic. The Mathematician and the plain man each need one another (icenglish.co.in).

The democratization of Mathematics is a decisive step in the advance of a civil society (Hogben,1937).

According to Munna1 (2012) Mathematics is a fundamental part of human thought and logic, and integral to attempts at understanding the world and ourselves. Mathematics provides an effective way of building mental discipline and encourages logical reasoning and mental rigor. In addition, mathematical knowledge plays a crucial role in understanding the contents of other school subjects such as science, social studies, and even music and art.

1.1 COMPARISON BETWEEN 2012 AND 2013 CORE MATHEMATICS PERFORMANCE

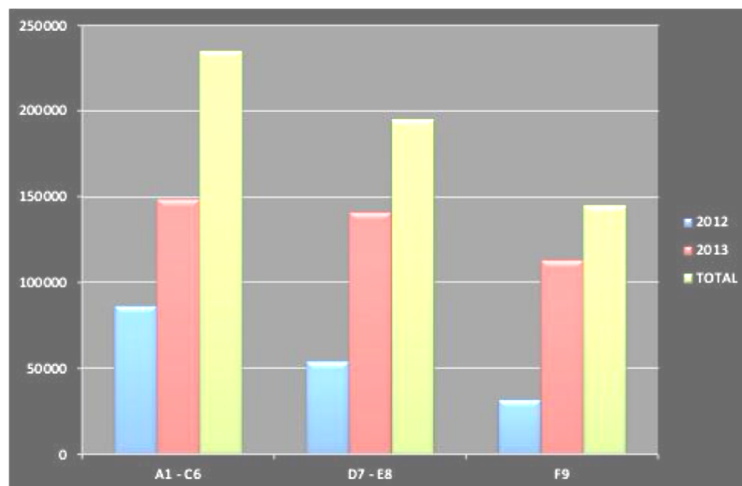


Figure. 1 Comparison between 2012 and 2013 Core Mathematics Performance Source (West Africa Examination Council, Ghana)

The performance of students in the 2012 WASSSCE core Mathematics examination was poor since the total number of students who passed was fewer than those who failed. 2013 May/June WASSSCE Core Mathematics examination also witnessed an abysmal performance similar to that of the 2012 examination. Performance of female students was very poor as compared to that of their male counterparts. The turnout for the 2013 (402,794) was more than double that of 2012 (173,499).

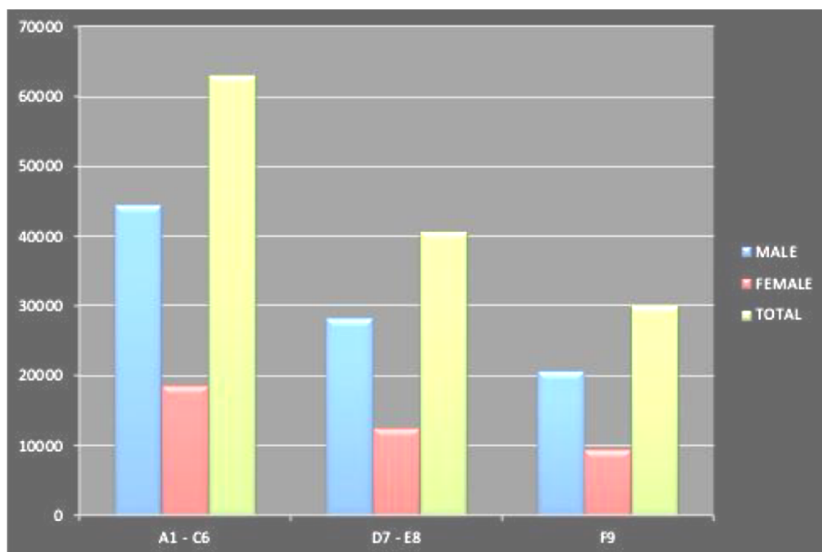


Figure. 2 Comparisons between 2012 and 2013 Elective Mathematics Performance Source (West Africa Examination Council, Ghana)

1.2 COMPARISON BETWEEN 2012 AND 2013 ELECTIVE MATHEMATICS PERFORMANCE

Results from the 2012 WASSSCE was fairly good with majority of the students passing examination with just a few failing. Many students sat for the 2013 Elective Mathematics examination, none the less, the performance was poor as compared to the 2012 results. Students who failed in the 2013 elective mathematics were greater than those who passed.

1.3 PROBLEMS AFFECTING THE LEARNING AND TEACHING OF MATHEMATICS

Studies has shown that even teachers who have an in depth knowledge in mathematics cannot integrate them in their teaching. They have attributed this to a high number of teachers who teach mathematics is not professional teachers and

lack basic skills in teaching. Some students also do not have mathematics anxiety and all that they say is “I fear mathematics”.

Not only have higher education systems expanded worldwide, the nature of the institution within these systems has also been shifting, through a process of differentiation (World Bank, 2000 as cited by Ololube, Ubogu & Ossai, 2007).

Mathematics, particularly in application, is of economic origin. But, they admit that an aware of Mathematics, is essential for civilized living (Bell, 1940).

According to Kolawole and Usman (2007), the challenges of Mathematics education in the 21st century were highlighted to include: incorporating new developments in Science and Technology into Mathematics, Acceleration of programs for the continued professional development of teachers; and Need for Mathematics educators to find new assessment instruments that reflect the new expectation of mathematics education.

They also stated that, to learn the essential mathematics needed for the 21st century, students need a non-threatening environment in which they are encouraged to ask questions and take risks. The learning climate should incorporate high expectations for all students, regardless of sex, race, handicapping condition, or socioeconomic status. Students need to explore mathematics using manipulative, measuring devices, models calculators and computers. They need to have opportunities to talk to each other about Mathematics. Students need modes of instruction that are suitable for the increased emphasis on problem solving, applications and higher order thinking skills. For example, cooperative learning allows students to work together in problem-solving situations to pose questions, analyze situations, try alternative strategies and check for reasonableness of results.

This paper measures the various challenges that confront the learning and teaching of mathematics in educational development in Second cycle institutions in Ghana. The paper measures the challenges by administration of questionnaires and interviews as well as focus groups discussions on a randomly sampled population made up of students and teachers relating to the various obstacles encountered by teachers and students.

2 METHODOLOGY

If the population size is around 1,500 samples size should be 20%, and if it is above a certain population size (approx $N > 5000$) a sample size of about 400 is adequate, Leedy and Ormond (2005).

The population is 1800 which is less than 5000 and thus 20% of the 1800 which is 400 of the population were considered as the suitable samples size and were used for the study. The researchers administered 400 total questionnaires, interviews and focus groups discussions, of which (360) respondents made up of one hundred (100) teachers and two hundred and sixty (260) students respondent to them giving a response rate of 90%. Stratified sampling method was used to group the school population into two (2) main categories: teaching staff, and student. Random sampling was then used to select 360 respondents for data collection. Stratified sampling technique was adopted as it embraced the distinct categories and organized them into separate strata. This technique was more efficient because it improves accuracy of estimates.

Purposive sampling was also used as a technique in data gathering. A study started with a survey, and then finally, purposive sampling was done based on the survey of the population of students and teachers.

The data (primary/secondary sources) collections were done with data collection instruments such as questionnaire, interview and focus group discussions, and the collected data was analyzed using Statistical software called general statistical package (GENSTAT), and the results interpreted and discussed.

3 RESULTS

The analyses of the data collected from survey in order to find out from teacher respondents what problem(s) they faced with in the teaching of mathematics in schools are shown below in Table 1.

Table 1 Challenges in teaching and learning of mathematics

PROBLEMS IN TEACHING AND LEARNING OF MATHEMATICS	FREQUENCY	PERCENTAGE
LACK OF TEACHING /LEARNING MATERIALS	80	22.22
INCONSISTENT SYLLABUS BY GHANA EDUCATION SERVICE (GES)	60	16.67
UNSERIOUSNESS ON THE PART OF STUDENTS	50	13.89
POOR ATTITUDE TOWARDS MATHEMATICS BY STUDENTS	70	19.44
POOR SUPERVISION	40	11.11
POOR TEACHING ENVIRONMENT	60	16.67
TOTAL	360	100

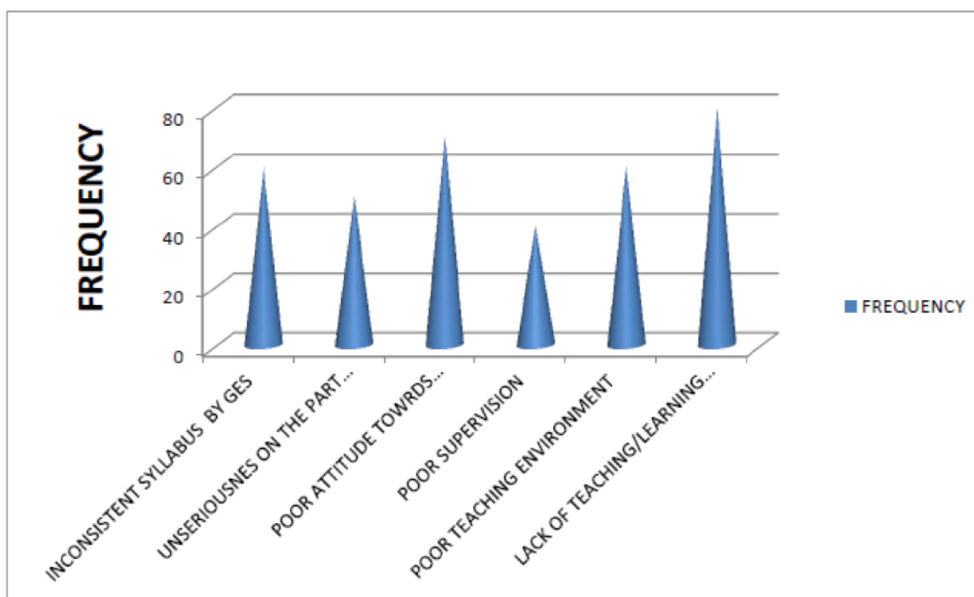


Figure 3 Problems with the teaching and learning of mathematics

From Table 1, it is clear that all 360 respondents showed that they face problems with the teaching and learning of Mathematics in their various schools. Some of the respondents showed that 80(22.22%) of schools lack of teaching /learning materials, 60(16.67%) of the respondents indicated that because of inconsistent syllabus by Ghana education service (GES).when it was 4 years the syllabus was different and when it came back to 3 years too ,the syllabus was also different. 50(13.89%) of them indicated that most students are not serious about the subject in their various schools, whiles poor supervision, poor attitude towards mathematics by students, and poor teaching environment provided by their various school all sum up to a percentage of 47.22 .

Table 2 challenges in teaching and learning of mathematics

CHALLENGES IN TEACHING AND LEARNING OF MATHEMATICS	FREQUENCY	PERCENTAGE
LACK OF GOOD LEARNING MATERIALS	40	11.11
USE OF ABSTRACT CONCEPTS IN TEACHING	45	12.50
FEAR FOR THE SUBJECT	60	16.67
POOR ATTITUDE TOWARDS TEACHING BY TEACHERS	20	5.56
INCOMPETENT TEACHERS	25	6.94
THREATING ENVIRONMENT	40	11.11
LIMITED MATHEMATICS PERIODS	45	12.50
LAZINESS ON THE PART OF TEACHERS	30	8.33
BAD TEACHING METHODS	55	15.28
TOTAL	360	100

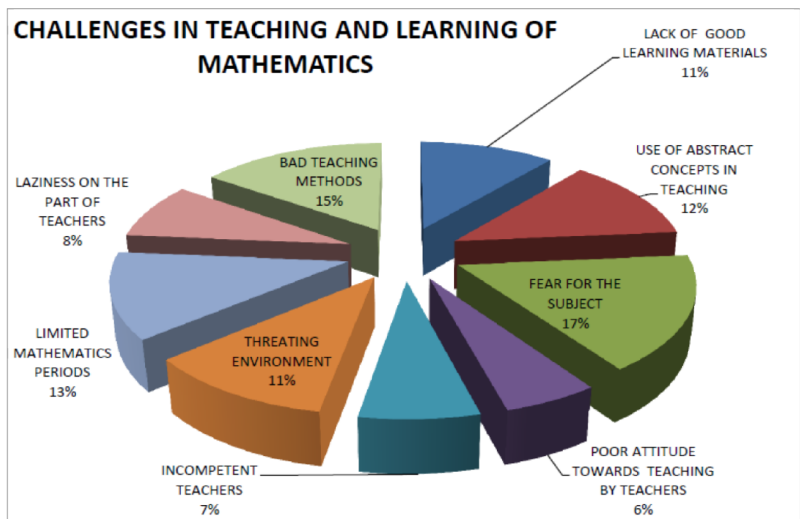


Figure 4 Challenges with the teaching and learning of mathematics

The analysis of the factors reveals some of the challenges that respondents are faced with, teaching and learning of mathematics in educational development in schools. This result is shown in Table 2 and Figure 4.

The Majority of the respondents 60 (16.67%) said that most students have fear for the subject mathematics. Others also had other challenges which have been captured in table 2 and figure 4

4 DISCUSSION

The research seeks to find out the problems with the teaching and learning of mathematics in various second cycle institutions in the Kumasi Metropolis. After the research, it came out that , some of the problems are; lack of teaching and learning materials representing 22.22% according to the data gathered from the respondents ,from the respondents another problem was inconsistent syllabus by Ghana Education Service with a percentage of 16.67%, poor attitude towards the study of mathematics by students also had a percentage of 19.44% ,lack of competent Teachers in the Metropolis was also a major problem with percentage of 6.94 , another problem meet by the study is the limited mathematics periods during schools hours in the Metropolis, the data gathered shows that majority of students has fear for the subject as it has a whopping percentage of 16.67% and one of the other challenges confronting the teaching and learning of mathematics in the Metropolis was bad teaching methods used by teachers. Per the analysis of the data gathered from the respondents, it shows that at least there is a problem or challenge hindering the teaching and learning of mathematics in almost all the second cycle institutions used for the study.

5 CONCLUSIONS

In conclusion, the problems and challenges confronting the teaching and learning of mathematics by various second cycle institutions in the Metropolis drawn from the analysis are that most institutions lack competent teachers, some also lack good teaching and learning materials and on the part of the students most of them has poor attitude towards the study of mathematics and they also have fear for the subject as they say mathematics is too abstract. Also poor supervision by Educational heads and bad teaching methods used by teachers in the Metropolis are some of the few challenges confronting the Metropolis.

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CONTRIBUTION TO THE MODELING OF A 2DEG CURRENT A HIGH ELECTRON MOBILITY TRANSISTOR BASED ON GAN/ALGAN HETEROSTRUCTURES

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ABSTRACT: The development of systems using microwaves for military telecommunications and consumer, requires discrete components and power that can operate at high frequencies. It is efficient components for operating systems such as high electron mobility transistor (HEMT).

The potential of transistors HEMTs based heterostructure AlGaN / GaN high interest to the international scientific community and are certainly the most currently studied worldwide. They have emerged as attractive candidates for applications in high voltage, high frequency to microwave power. By the spontaneous and piezoelectric polarization, they have the facility to produce a two-dimensional electron gas (2DEG) at the interface with a high concentration without doping intentional. The market for power components based on this material is booming for many applications.

In this article we studied some properties of nitride materials existing in the structure for a better functioning of the component, it is necessary to have a physical simulation model for describing the heterojunction AlGaN / GaN, and the fundamental principles of electrical operation a HEMT transistor. In this model, this electron mobility 2DEG depending on the gate voltage in the transistor channel and the Al concentration.

KEYWORDS: SEMICONDUCTOR, ALGAN, GAN, HETEROJUNCTION, HEMT, 2DEG.

1 INTRODUCTION

Since its resurgence in the early 1990s, gallium nitride (GaN) has been considered as a very interesting and very promising semiconductor material for its potential applications in optoelectronics for the emission and absorption in the ultraviolet and power electronics. In this area, the physical properties of III nitrides element such as wide band gap energy, a reasonable electron mobility, a high breakdown field and high chemical stability have allowed this material system to be a good candidate for high power microwave applications, and high temperature. Demonstrated the first high electron mobility transistor (HEMT) based on a heterostructure AlGaN / GaN has confirmed the great potential for this sector approached [1]. Today, these components have almost the best compromise between power and frequency in a wide range of applications. Spread applications of power electronics through communications without son to the radar stations and bases and soon they will cover the area of millimeter waves.

Transistors high electron mobility GaN / AlGaN (HEMT) have recently received considerable attention because of their potential use for high voltage operation and high power at microwave frequencies [2,3]. The performance of heterostructure AlGaN / GaN is assigned to a high density two-dimensional electron gas (2DEG) at the heterointerface limited. Due to the effects of the spontaneous and piezoelectric polarization in heterostructures AlGaN / GaN, the density of 2DEG interface obtained in AlGaN / GaN is as high as 10^{13} cm^{-2} [4]. In the HEMT, a high current capacity results from the combination of high carrier density and good transmission characteristic. It is therefore essential to further improve the mobility and density of 2DEG in the channel, the conduction band offset between AlGaN and GaN and the large piezoelectric effect (fig 1). In AlGaN / GaN HEMT, the charge bias, the conduction band discontinuity and the molar fraction are important parameters which affect the carrier density (2DEG) at the interface. The existence of spontaneous polarization fields and piezoelectric change the

2DEG density. An increase in the aluminum composition (mole fraction) increases the density of two-dimensional electron gas and the electrons are closer to the interface.

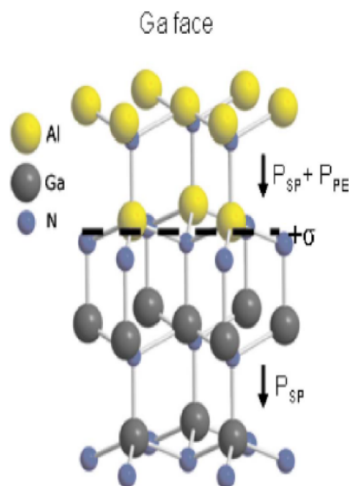


Fig. 1. Schema structure of AlGaN / GaN indicating the presence of the polarized piezoelectric load interface between the two materials [5].

In this work, we highlight the structure of the AlGaN alloy, the variation of the lattice parameter of this structure depends on the concentration of aluminum (Al%) which affects the energy band which also varies depending on the temperature. A model was constructed showing the variation of the current density functions of the concentration of the aluminum (Al%) and the gate voltage (V_g).

2 STRUCTURE OF DEVICE

The HEMT structure as shown in Figure 2 was used to verify the analytical model. It generally consists of 3 μm thick GaN buffer layer undoped, 30 \AA thick $\text{Al}_{0.3}\text{Ga}_{0.7}\text{N}$ spacer layer, and a thickness of 220 \AA of $\text{Al}_{0.3}\text{Ga}_{0.7}\text{N}$ doped Si active layer. The doped epitaxial layers are grown undoped and by phase organometallic chemical vapor deposition on the thin buffer layer GaN and the sapphire substrate. Mesa isolation is realized with inductively coupled plasma. The ohmic contacts are made of Ti / Al / Pt / Au, deposited by electron beam [6].

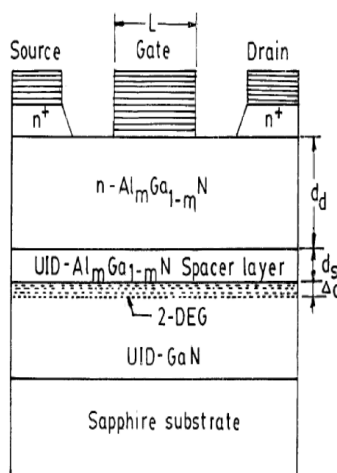


Fig. 2. Cross section HEMT AlGaN / GaN [7].

3 MODEL FORMULATION

The basic structure of HEMT AlGa_xN / GaN considered in this analysis is illustrated in Figure 2. To determine the carrier concentration of the 2DEG channel from the charge density induced by the polarization from equation 1, we use the following approximations [8].

$$n_s = \frac{\varepsilon(x)}{qd} (V_g - V_{th}(x) - E_F)$$

V_g: voltage the gate

E_F: Fermi energy level

ε (x): The dielectric permittivity as a function of the aluminum mole fraction (x) can be written as [9]:

$$\varepsilon(x) = 9.5 - 0.5x$$

The threshold voltage V_{th} is given by the following expression which depends on the temperature T and the molar fraction x [10]:

$$V_{th}(T, x) = \phi(x) - \Delta E_c(T, x) - \frac{qN_D d_d^2}{2\varepsilon(x)} - \frac{\sigma(x)}{\varepsilon(x)} (d_d + d_s)$$

With:

σ (x): The charge density at the interface of a heterostructure Al_xGa_{1-x}N/GaN Face Ga and given by the following function [9]:

$$\sigma(x) = [P_{spontaneous}(Al_xGa_{1-x}N) - P_{spontaneous}(GaN) + P_{piezoelectric}(Al_xGa_{1-x}N)]$$

With

$$P_{piezoelectric}(Al_xGa_{1-x}N) = 2 \left(\frac{a(0) - a(x)}{a(x)} \right) * \left(e_{31}(x) - \frac{e_{33}(x)c_{13}(x)}{c_{33}(x)} \right) \text{ C/m}^2$$

$$P_{spontaneous}(Al_xGa_{1-x}N) = -0,52x - 0,029 \text{ C/m}^2$$

$$P_{spontaneous}(GaN) = -0,029 \text{ C/m}^2$$

Where a (x) is constant lattice Al_xGa_{1-x}N, e₃₁ (x) and e₃₃ (x) are piezoelectric constants, c₁₃ (x) and c₃₃ (x) are elastic constants, and a (0) is the value of lattice GaN = 3.189 Å.

d = (d_d + d_s) is the separation between the gate and the channel (2DEG) or d_d is the thickness of the doped AlGa_xN layer and d_s is the thickness of the undoped layer (spacer).

φ (x): The height of the Schottky barrier metal / AlGa_xN based on the mole fraction of aluminum (Al), given by [9]:

$$\phi(x) = 0.84 + 1.3x$$

The discontinuity of the conduction band ΔE_c(T, x) at the interface Al_xGa_{1-x}N/GaN is written [10]:

$$\Delta E_c(T, x) = 0.70 [E_g^{AlGaN}(T, x) - E_g^{GaN}(T)]$$

The width of the gap of the ternary Al_xGa_{1-x}N can be written as:

$$E_g^{AlGaN}(T, x) = xE_g^{AlN}(T) + (1 - x)E_g^{GaN}(T) - 0.6x(1 - x)$$

The width of the band gap of GaN following the empirical law of Varshni and writes [11]:

$$E_g(T) = E_g(0) - \alpha \frac{T^2}{T + \beta}$$

E_g (0) is the bandgap temperature (T₀=0K), E_g(0) = 3.39 eV for GaN. The adaptation of the parameters Varshni equation for bandwidth variation with temperature are α (meV / K) and β = -1.08 (K) = 745

4 RESULTS AND DISCUSSION

Figure 3 shows the variation of the lattice constant (a) of the $\text{Al}_x\text{Ga}_{1-x}\text{N}$ layer depending on the concentration of aluminum (x). By increasing the rate of (Al), a perturbation in the lattice occurs because the location of the Al atom in the GaN material thereby inducing a decrease of the lattice constant a .

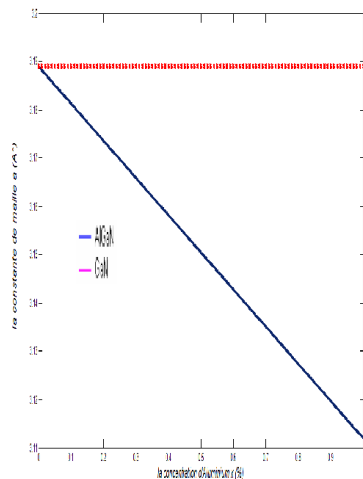


Figure 3. The variation of the lattice constant a (x) as a function of the concentration of aluminum.

Figure 4 shows the effect of temperature on the energy gap of GaN and AlGa_{0.3}N for the $x = 0.3$ as an example, which shows a decrease in the energy (GaN, AlGa_{0.3}N) by increasing the temperature and this effect is due to the thermal expansion which modifies the interatomic distances in the crystal lattice, which causes a change of the positions of the valence band and the conduction band as well the electron-phonon interactions that change the width of the forbidden band

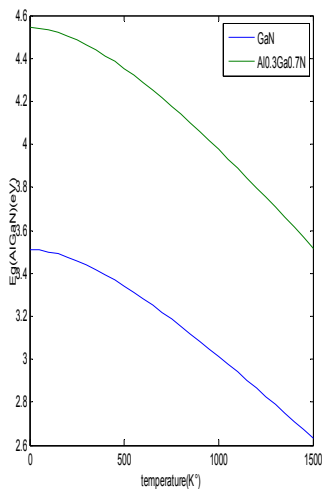


Fig. 4. Bandgap of $\text{Al}_x\text{Ga}_{1-x}\text{N}$ versus temperature

Figure (5) represents the variation of the energy gap as a function of increasing temperature and the aluminium concentration x (of 0% to 1%), a disturbance in the forbidden energy which involves a decrease in forbidden depending on two parameters band is shown.

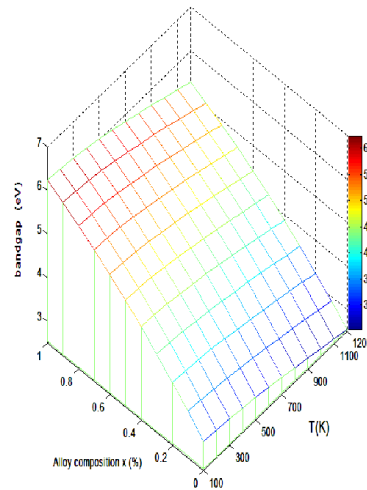


Fig. 5. Bandgap of $Al_xGa_{1-x}N$ versus Al content x and temperature

Figure 6 shows the variation of the density of the 2DEG in the quantum well as a function of the mole fraction of aluminum (%) in the layer of $Al_xGa_{1-x}N$, and the 2DEG is important value, in the range of Al variation of 0 to 1%, the 2DEG concentration increases. And this increase proportional to the aluminum content due to the spontaneous and piezoelectric polarization in the interface of the heterostructure of $AlGaN / GaN$ to Ga face is favorable for a HEMT operation.

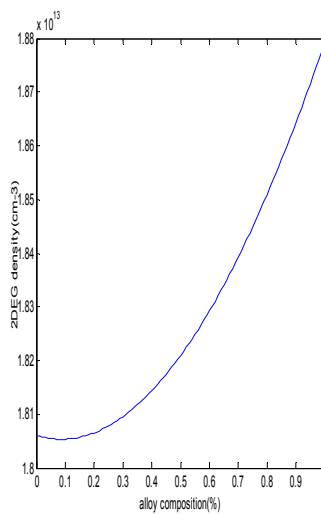


Figure 6. Variation of density of 2DEG with mole fraction for $AlGaN$

We note in Figure 7, the increase of the 2DEG density (N_s) according to the gate bias (V_g). The major values (n_s) are attributed to the presence of polarization charges in the HEMT. The slope of this curve corresponds to the capacity of the structure, which is directly related to the separation between the gate and the (2-DEG), more precisely to the donor layer of $AlGaN$, the density increases further more capacity and performance increase, and to have a high density (2-DEG), and the lower ability of gate, avoid the disappearance of channel HEMT.

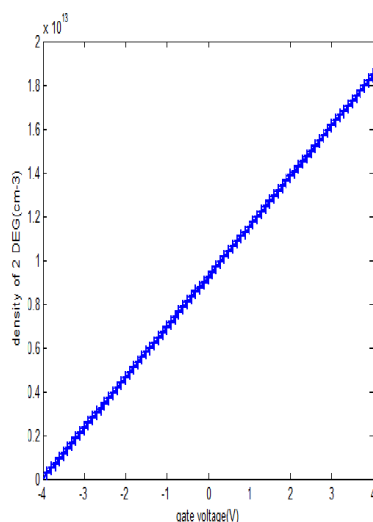


Fig. 7. The 2DEG density verse V_g for AlGaIn/GaN heterostructure

5 CONCLUSION

The basic principle of a high electron mobility transistor (HEMT) is to take advantage of the properties of high mobility two-dimensional electron gas a 2DEG from the physical separation of free electrons ionized donors which they come . The HEMTs are electronic devices operating at high frequencies with very high speeds through the appropriate base material. The HEMTs are electronic devices operating at high frequencies with very high speeds through the appropriate base material. The GaN hexagonal structure is a promising candidate for these transistors thanks to its physical properties

In this model, we studied the effect of the Al mole fraction and the gate voltage for the 2DEG density using the variation of the band gap with temperature and the mole fraction of (Al), which also indicate the dependency spontaneous and piezoelectric polarization on the Al composition is extremely useful for determining the performance of the device for high performance applications.

The results of this analysis show clearly that the increase of the gate voltage leads to an increase of the 2DEG density. These behaviours depend upon the thickness of the 2DEG channel and the Al molar fraction

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Influence of variations in thickness of buccal cortical bone on stress distribution around immediately loaded mandibular implants: A non-linear finite element study

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ABSTRACT: Objective: To investigate the influence of immediate loading on the stress distribution around dental implants with reductions in buccal cortical bone thickness.

Materials and Methods: Three bone level dental implants (3.8mm, 4.5mm and 5.0mm diameters and a standard length of 10mm) were modeled and each placed in three mandibular bone segments having variations in buccal cortical bone thickness (2.0mm, 1.5mm and 1.0mm). A total of 9 such models were created and discretized with tetrahedral elements of parabolic displacement function. Implant-bone interface was simulated with non-linear contacts zone with friction. Implants were assumed to be placed at an insertion torque of 40Ncm and the fixation force was mathematically calculated for each of the three implants. A uniformly distributed vertical static load of a 150N was applied to the horizontal surfaces of the abutments. The overall stress distribution of von Mises criteria and micro-strain were recorded along the contact areas of implant and surrounding bone and statistically analyzed.

Results: At an insertion torque of 40Ncm the pre-load calculations indicate a reduction in the compressive stresses as the diameters of the implants increase with fixation forces of 93.14N, 83.49N and 75.49N for the 3.8mm, 4.5mm and 5.0mm diameter implants. The maximum stresses were seen in the upper one third of the buccal cortical bony plates which tends to reduce as the diameter of the implant increases. The peak von Mises stresses were 173MPa, 126MPa and 98MPa for the 3.8mm, 4.5mm and 5.0mm implants. The total maximum mesh displacement seen for the 3.8mm, 4.5mm and 5.0mm models was 55µm, 32µm and 12µm respectively.

Conclusions: Implants placed at the same level of insertion torque seem to be at different levels of stability as a consequence of implant thread variations. Stresses reduce with an increase in diameter of the implants. With reductions in thickness of the buccal bone there is an increase in stress transmission and micro-movements. The magnitude of stress transmission however does not vary significantly with reductions in thickness of the buccal bone for the larger diameter implants.

KEYWORDS: Immediate loading, buccal bone thickness, Maximum stress and micro-strain.

INTRODUCTION

Successful implant treatment requires the formation of a predictable bond between the implant and the surrounding bone. The original Brånemark protocol required the implant to be submerged beneath or at the level of the alveolar crest, with soft tissue well approximated, in an un-loaded capacity for 3-6 months. The countersinking of the implant with the pretext of preventing bacterial infection, apical proliferation of the oral epithelium and load induced disruption on the bone healing led to predictable results (1).

Immediate loading not only has the advantages of the one stage protocol which includes avoiding a second stage surgery and the maturation of soft tissue prior to the fabrication of the prosthesis but also involves non-functional loading of the implant with a provisional restoration placed at the time of implant insertion or within 2 weeks of placement (3). These implants have yielded a variety of clinical results, with some studies revealing more crestal bone loss and higher failure rates as compared to the delayed loading protocol, while other researchers indicating no differences in the success rates of the two modalities (2-5).

Upon placement of a dental implant, the threads of the fixture bite into mature lamellar bone and although the cellular connection is yet to form, the implant is considered more stable at the time of insertion than after 3 months(6). The surgical trauma triggers a cellular response leading to woven bone appositional growth which starts as early as 2 weeks after placement. The implant is considered most susceptible to over load failure between 3-5 weeks of placement since the interface comprises of weak, unorganized bone(7). The biomechanical environment from the time of immediate loading and during healing till a healthy osseointegration is established needs to be carefully maintained such that micro-motions of the implant, bone deflections or fracture of bone due to over loading is circumvented to avoid failure (8).

The anatomy of the implant site presents with variations that influence treatment planning. Following extraction of a tooth, bone undergoes resorption with the magnitude of this change been described along with soft tissue volume changes following the extraction of single premolars and molars(9, 10). It is observed that the buccal-lingual/palatal dimension during the first 3 months is reduced by about 30% and after 12 months the edentulous site can lose up to 50% of its original width with maximum reductions from the buccal cortical side(11). When encountering thin buccal cortical bony plates, clinicians hence have to carefully choose the correct implant diameter and design. Bone augmentation procedures are widely advocated to increase the width of the ridge however this translates into a larger cost of the overall treatment and a possible extension of the surgical intervention(12, 13).

Finite element analysis has long served as a method to study the biomechanical behavior of dental implants and the associated stress distribution in the peri-implant environment(14, 15). As occlusal forces can lead to damaging micro-motions of fixtures, the magnitude of loading on a freshly placed dental implant is of paramount importance to the success of such a treatment modality. Literature reveals biomechanical factors such as length, diameter, surface topography, load magnitude along with patient physiological factors such as density of bone, absence of infection, medical conditions etc influencing success of immediate loaded dental implants(16). Additionally, a number of clinical studies have shown a strong correlation between thickness of the cortical bone and the primary stability achieved prior to immediate loading(17). Okumura et al showed a strong influence of maxillary cortical bone thickness on stress distribution around implants loaded in the posterior maxilla. A recent FEM study by Chou et al examined the effect of implant neck design on stress transmission with variations in maxillary bone thicknesses and showed an increase in stress with reductions in bone thickness (18).

There however, remains a paucity of evidence that identifies an acceptable, sub-critical force that can be subjected onto immediately loaded implants placed in mandibular bony ridges with reduced buccal cortical plate thicknesses. The purpose of this FEA study is therefore to investigate the effect of vertically applied static load on the stress and strain distributions on freshly placed dental implants with variations in the thickness of the buccal cortical bone.

MATERIALS AND METHODS:

FE Modeling

A 3D finite element model of a bone block representing the second pre-molar region of a sectioned mandible was created in SolidWorks Premium 2012 software (Dassault Systèmes SolidWorks Corporation, Concord, MA, USA). The bone block consisted of two bodies modeled separately having an inner trabecular structure surrounded with cortical bone with variations only in the thickness of the buccal cortical layer (2.0mm, 1.5mm and 1.0mm).

The bone level implants along with the prescribed solid abutments selected in this study were designed and modeled in Solidworks Premium 2012 with dimensions acquired from the manufacture (SM internal, DIO Corp, 1464 Woolong,

Haeul'Idae-iw, Pusan City, Korea). The fixture diameters were 3.8mm, 4.5mm and 5.0mm with a standard length of 10mm. The diameter of the abutment for the 3.8mm implant is 3.9mm while those for the 4.5mm and 5.0mm implants is 4.8mm as mentioned in the product catalog. All abutments were 4mm in height. The dimensions of the simulated bony segment included a height of 16mms with a 6mm distance from the apex of all implants to the base of the models. The maximum bucco-lingual dimension of the 3.8mm, 4.5mm and 5.0mm implant models were 9.11mms, 9.73 and 9.89mms respectively. The positioning of the dental implant assemblies within each bone block model was kept such that an equal area of buccal bone made identical contacts with the threads of the three implants. A total of 9 models were created.

The geometries were imported into ANSYS Mesh separately to create meshes for the four solid bodies and assembled as high quality tetrahedral models (Figure 1a-1e). To capture fine geometrical features such as curves of threads or curvatures advanced size function was used to reduce element sizes to 0.05mm (Figure 2). Similarly, it was expected that mesh cells would cluster in regions of high gradients of stress and strains and hence contact sizing was used at interfaces where the pre-selected element size ranged from 0.03 to 0.09mm consequently resulting in finer mesh density. The maximum size of the parabolic tetrahedral elements was 0.5mm kept at regions of the models where stress transfer was not expected such as the base of the models and hence where a finer meshing was not needed (Figure 3).

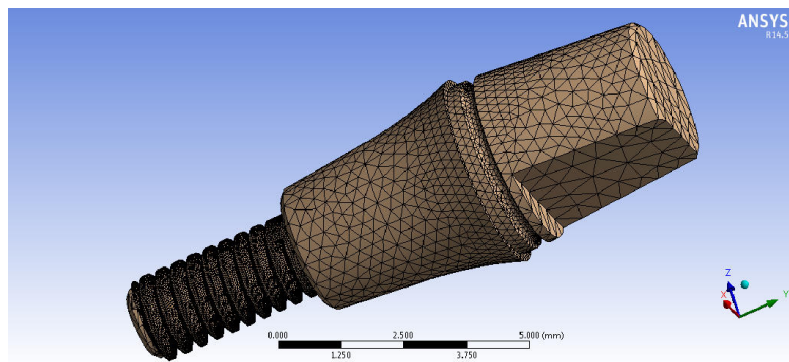


Figure 1a: Abutment.

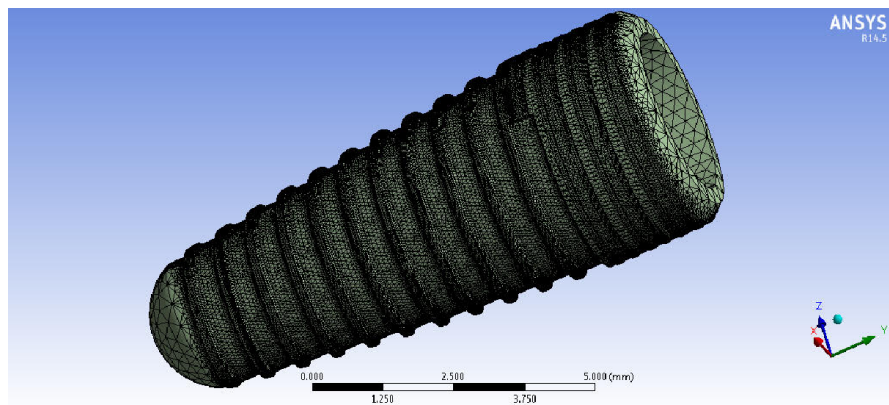


Figure 1b: Implant/Fixture.

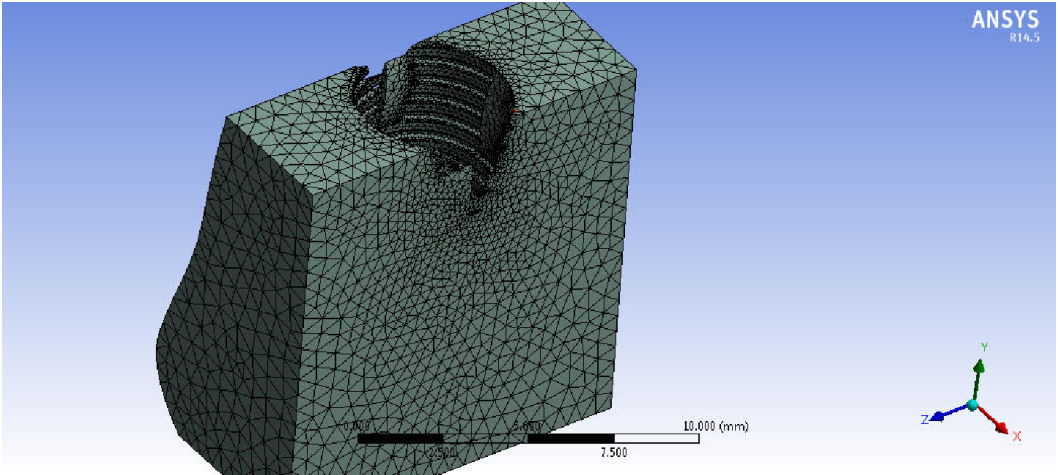


Figure 1c: Inner trabecular bone.

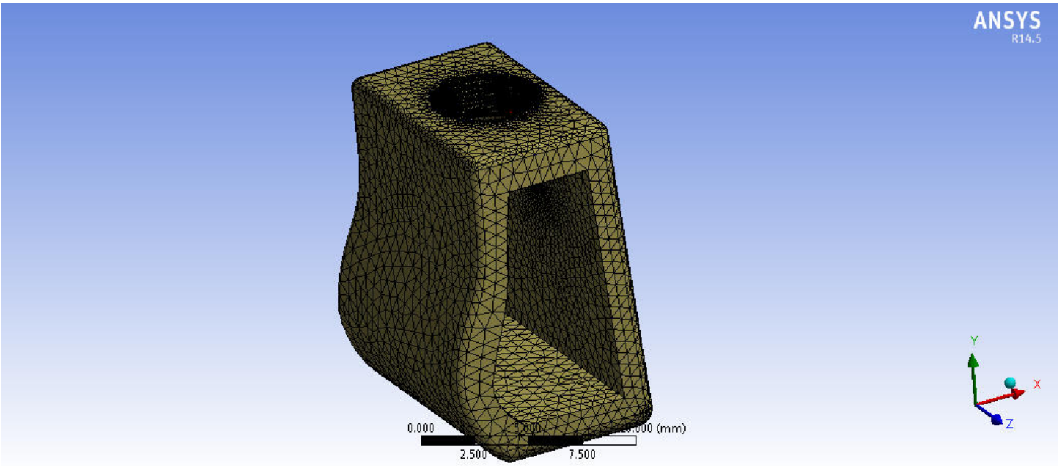


Figure 1d: Cortical shell.

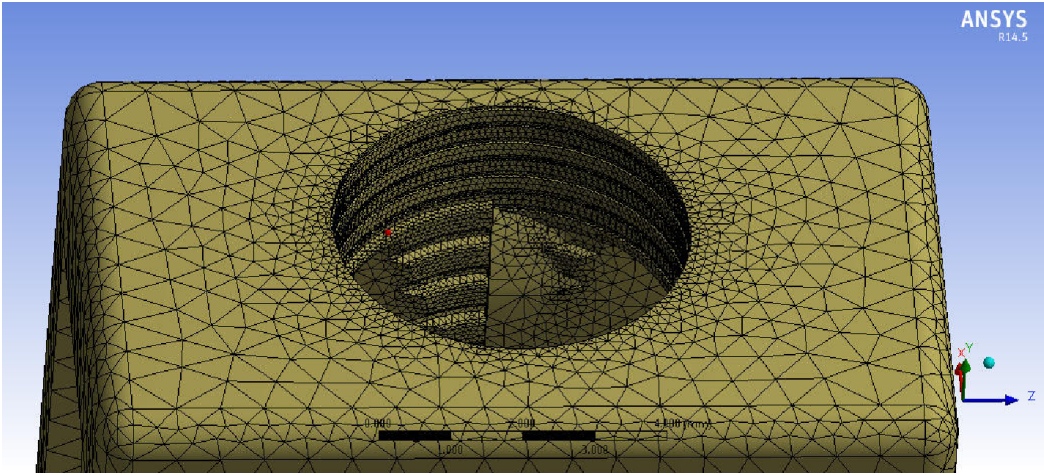
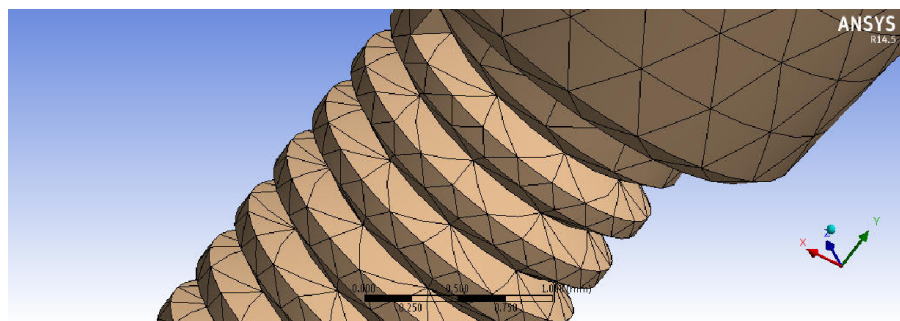
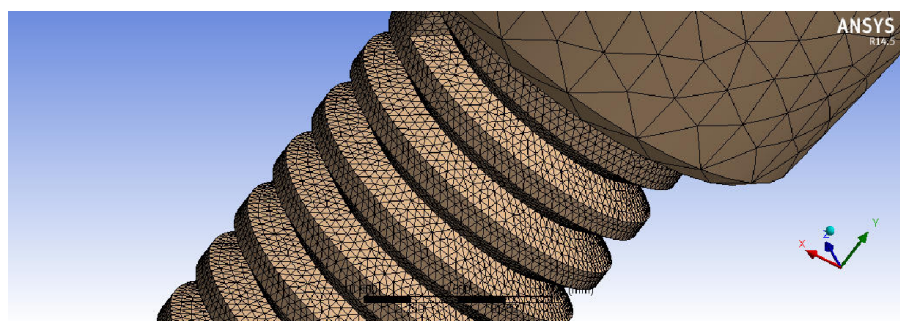


Figure 1e: Inner view of buccal cortical bone.

Each model presented with a total of 15, 73,748 nodes and 10, 78,904 elements. The implant presented 96, 8868 nodes and 14, 11,373 elements. The cancellous and cortical bones presented 10, 9917 and 52,458 nodes and 75,999 and 34,037 elements, respectively.



(a)



(b)

Figure 2: Mesh of threads without (a) and with (b) size function.

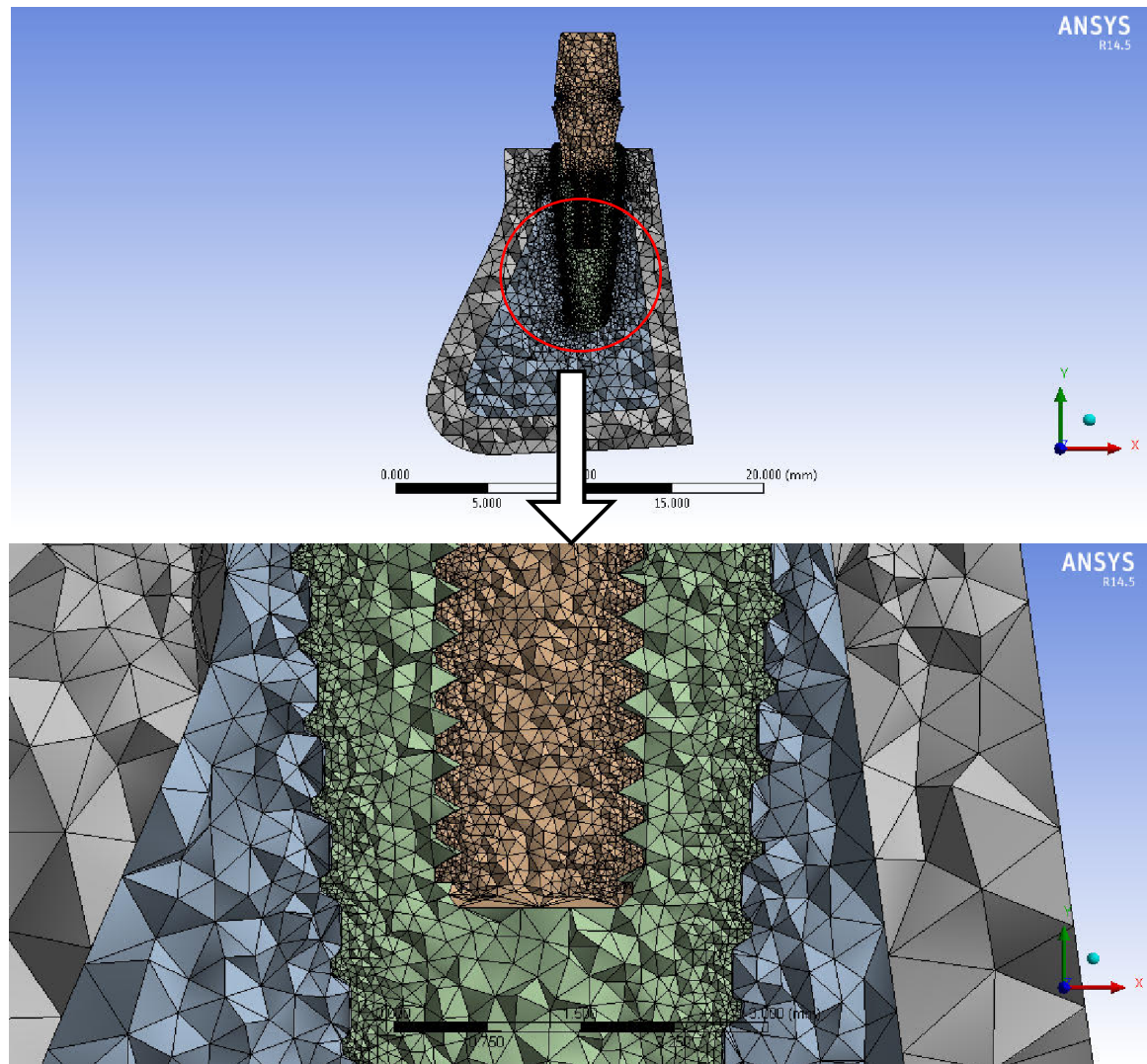


Figure 1:-Mesh on central plane of (Full and enlarged view).

Material Properties

The mechanical properties of all the materials were assumed to be homogenous, isotropic and linearly elastic. The values of Young's elastic modulus (E) and Poisson's ratio (ν) were $E = 13.7$ GPa and $\nu = 0.3$ for the cortical bone, and $E = 1.37$ GPa and $\nu = 0.3$ for the cancellous bone. The elastic properties of the titanium implant were $E = 103.4$ GPa and $\nu = 0.35$ (15).

Implant–Bone Interface Design

To investigate stress distribution immediately after implantation, the implant–bone interface was assumed as before the occurrence of osseointegration and simulated by non-linear contact zones with friction. The coefficient of friction was set to 0.3(19). This means that the contact zones transfer only pressure and tangential frictional forces, whereas tension is not transferred. The interface between cortical and cancellous bones and the threads of the abutments with those present inside the implants were assumed to be bonded (Figure 4).

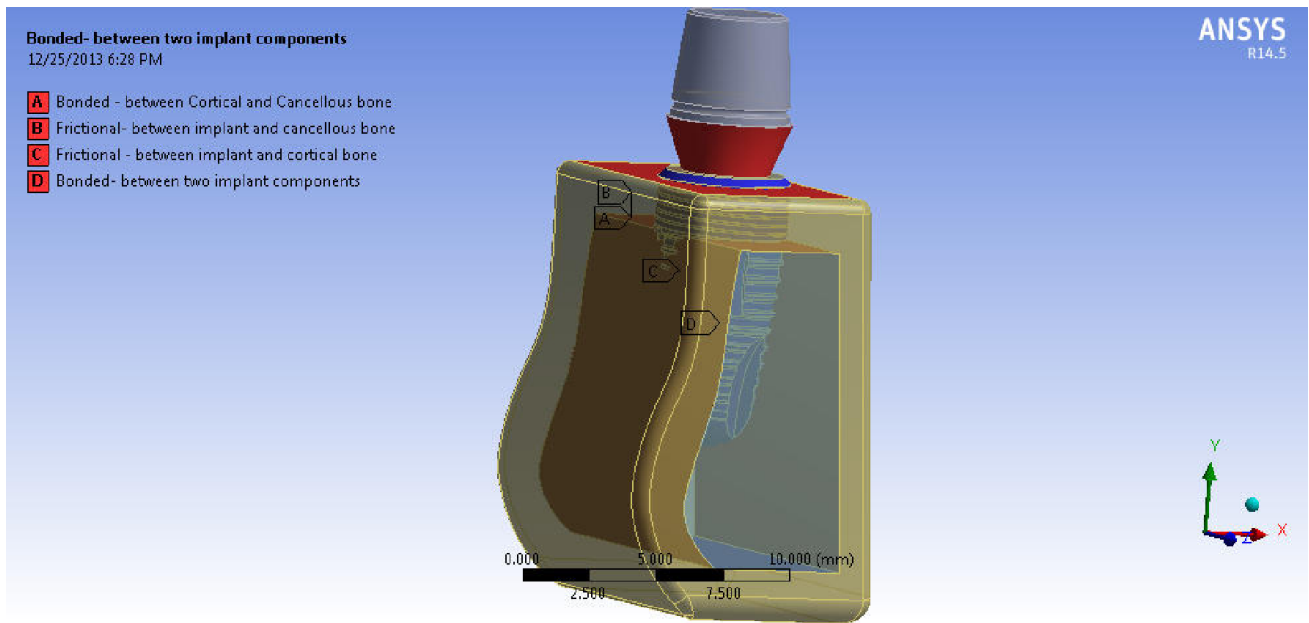


Figure 4:- Contacts between different components.

Boundary conditions and loading

Boundary conditions were set by constraining the mesial and distal surfaces of the bone block along with the base of the model with zero degrees of freedom(20). A uniformly distributed vertical load of a 150N was applied to the horizontal surfaces of the abutments. Softwares from the ANSYS package were used and integrated through ANSYS 14.5 workbench (Swanson Analysis Inc., Huston, PA, USA).

Pre-load of the dental implants:

The pre-load of a dental implant is a consequence of the level of insertion torque at which the implant is finally placed into the bony compartment. Insertion torque is a measure of the resistance upon rotation as the dental implant advances apically, imparting compressive stresses onto the walls of the adjacent body. The inclined plane of the implant thread helix converts torque into a force transmitted as compressive stress. The implants in this study were assumed to be placed into the bony segment at an insertion torque of 40Ncm and hence the compressive stresses created due to a tightened implant or bolt would need to be computed using the following equation (21):

$$P_i = \frac{T}{K D}$$

Where,

P_i = bolt preload (called F_i in Shigley)

T = bolt installation torque (40Ncm)

K = torque coefficient

D = bolt nominal shank diameter (i.e. 3.8mm, 4.5mm and 5.0mm)

Torque coefficient K is a function of thread geometry, thread coefficient of friction μ_t , and collar coefficient of friction μ_c . K can be calculated using relation

$$K = \left\{ \left[\frac{(0.5 d_p)(\tan \lambda + \mu_t \sec \beta)}{1 - \mu_t \tan \lambda \sec \beta} \right] + [0.625 \mu_c D] \right\} / D$$

Where

- D = bolt nominal shank diameter (3.8mm, 4.5mm and 5.0mm)
- p = thread pitch (0.65mm)
- α = thread profile angle (60°)
- β = thread profile half angle = $60^\circ/2 = 30^\circ$.
- $\tan \lambda$ = thread helix angle = $\tan p/(p d_p)$.
- d_p = bolt pitch diameter (3.56mm, 4.26mm and 4.76mm)
- μ_t = thread coefficient of friction (0.3)
- μ_c = collar coefficient of friction (0.3)

The torque coefficient K for the 3.8mm, 4.5mm and 5.0mm implant diameters was 0.381, 0.377 and 0.376 respectively according to the above equation.

STATISTICAL ANALYSIS

Pearson’s correlation was employed for evaluating the association between bone thickness, implant diameter and maximum stress and micro-strain. Since there were two outcome variables being measured, two separate linear regression models were generated using SPSS version 17.0.

RESULTS

At an insertion torque of 40Ncm the pre-load calculations indicate a reduction in the compressive stresses as the diameters of the implants increase. Forces of 93.14N, 83.49N and 75.49N for the 3.8mm, 4.5mm and 5.0mm diameter implants suggest that as the diameter of the implant increases the compressive force with which the tapered solid body is held within the bony segment reduces at the same level of insertion torque.

At a static load of a 150N applied along the long axis of the abutment-implant assemblies, the maximum stresses were seen in the upper one third of the buccal cortical bony plates (Figure 6) which tends to reduce as the diameter of the implant increases (Figures 7a-7c). The stresses in the buccal cortical plates however diminish further apically as indicated by a plane cut along the y co-ordinate with measurements taken at 9 equal intervals between the coronal and apical extent of the buccal plates for all 9 models (Figure 8).

Table 1

Implant diameter	3.8mm			4.5mm			5mm		
Buccal bone thickness	Max stress [Mpa]	Min Stress [Mpa]	Micro Strain [micro meter]	Max stress [Mpa]	Min Stress [Mpa]	Micro Strain [micro meter]	Max stress [Mpa]	Min Stress [Mpa]	Micro Strain [micro meter]
2mm	155	6.2	41	119	6	20	93	5.9	6
1.5mm	165	6.2	49	123	6	27	96	5.9	8
1mm	173	6.2	55	126	6	32	98	5.9	12

The simulation results show that the occlusal forces are primarily distributed in the crestal bone surrounding the neck of the implant and hence the coronal one-third of the implants transfer the maximum stresses to the adjacent bone in particular the buccal bone. The peak von Mises stresses were 173MPa, 126MPa and 98MPa for the 3.8mm, 4.5mm and 5.0mm implants indicating a reduction in stress with an increase in implant diameter (Table 1).

Considering that micro-movements in excess of 150 μ m at the implant-bone interface can jeopardize healing and can result in fibrous encapsulation, the total maximum mesh displacement seen for the 3.8mm, 4.5mm and 5.0mm models was

55µm, 32µm and 12µm respectively. The micro-movements increase with a reduction in either the implant diameters or the thickness of the buccal cortical bone (Table 1).

With a reduction in the thickness of the buccal cortical bone the peak von-Mises stresses tend to increase, with the maximum stresses seen in the 1mm thick cortical bone adjacent to the 3.8mm immediately loaded implant (Figure 9).

A very strong negative correlation was calculated for the association between implant diameter and micro-strain ($r = -0.96$, $p < 0.05$). The correlation between the bone thickness and micro-strain association was comparatively weak ($r = -0.26$, $p > 0.05$). Results also showed that with a unit decrease in implant diameter at the same bone thickness, the stress levels showed an increase of 32.95 MPa.

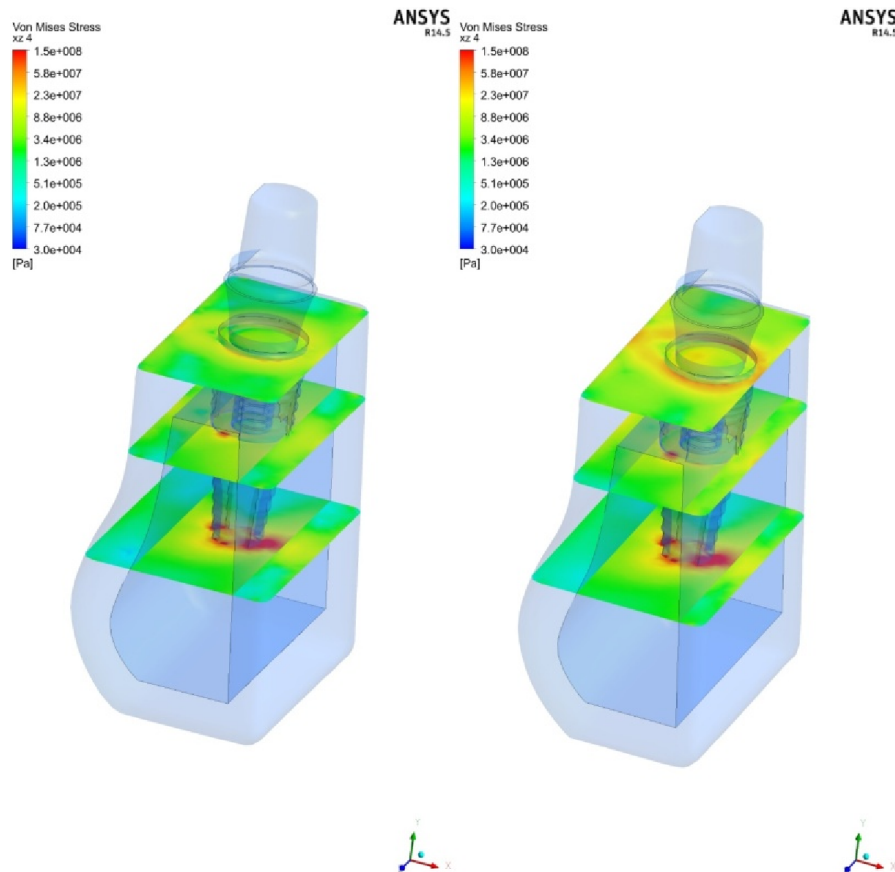
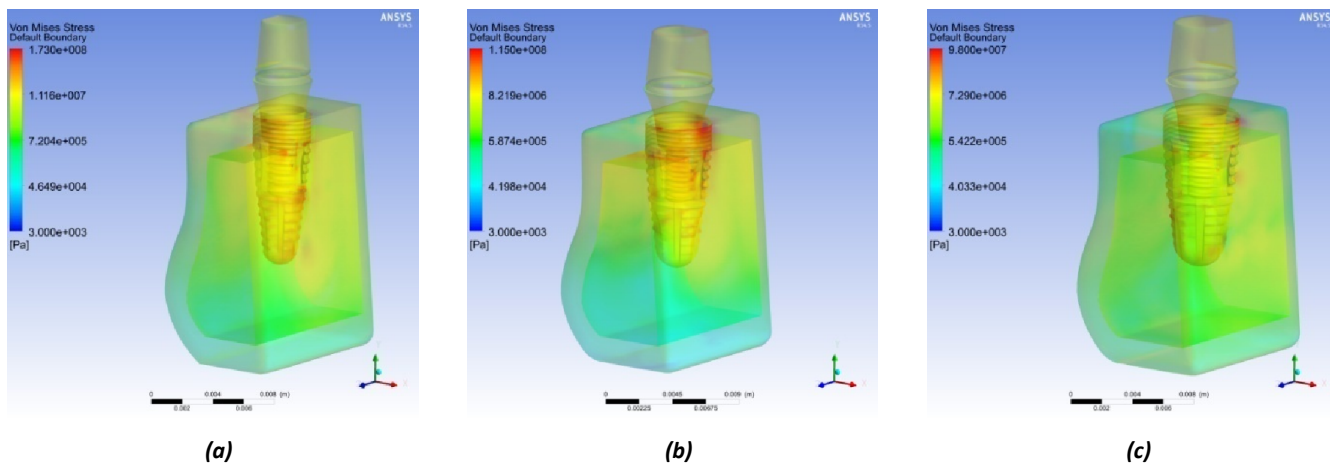


Figure 6: Comparison of stresses at different plains for the 5.0mm diameter implant with buccal wall thickness of 2mm and 1mm showing stress concentration primarily around the neck of the implant and beneath the apex.



Figures 7a-7c: Reduction in stresses with an increase in diameter from 3.8mm (a), 4.5mm (b) and 5.0mm (c) diameters with the buccal bone having a thickness of 1mm.

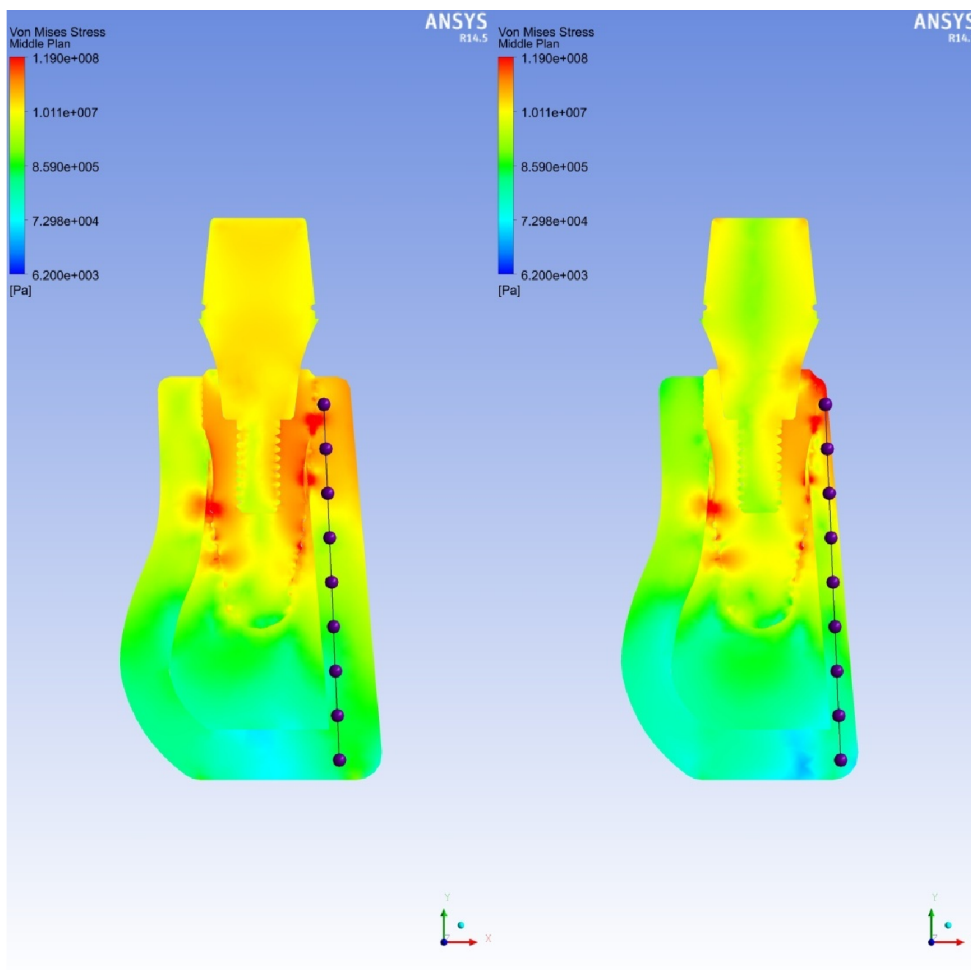


Figure 8: Plane cut along the Y-axis at a similar thickness in the 2mm and 1mm bone showing a reduction in stress from the buccal crest to the base of the model apical to the implant.

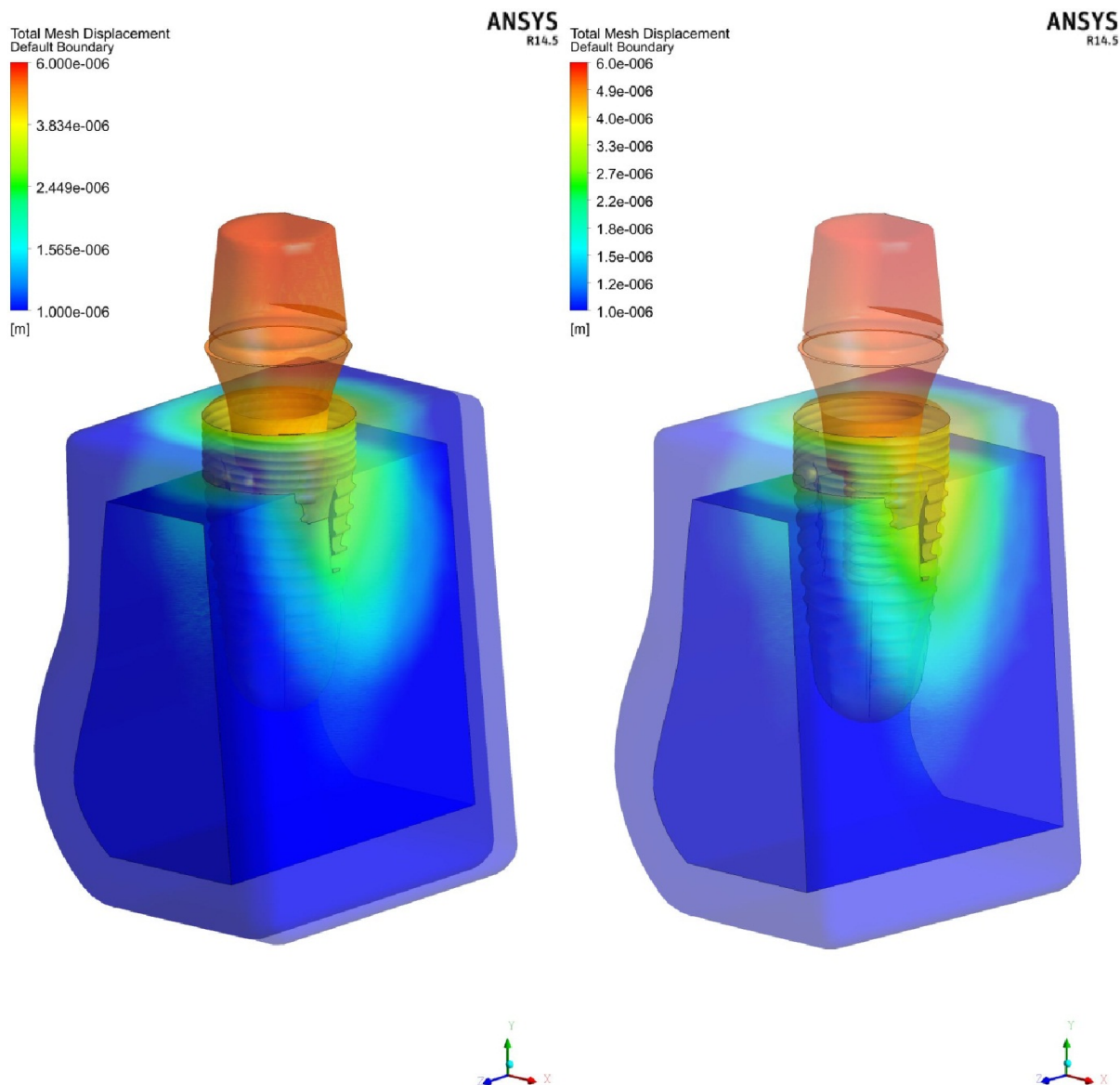


Figure 9:- Comparison of total displacement (implant diameter 5mm) with buccal wall thicknesses of 2mm and 1mm.

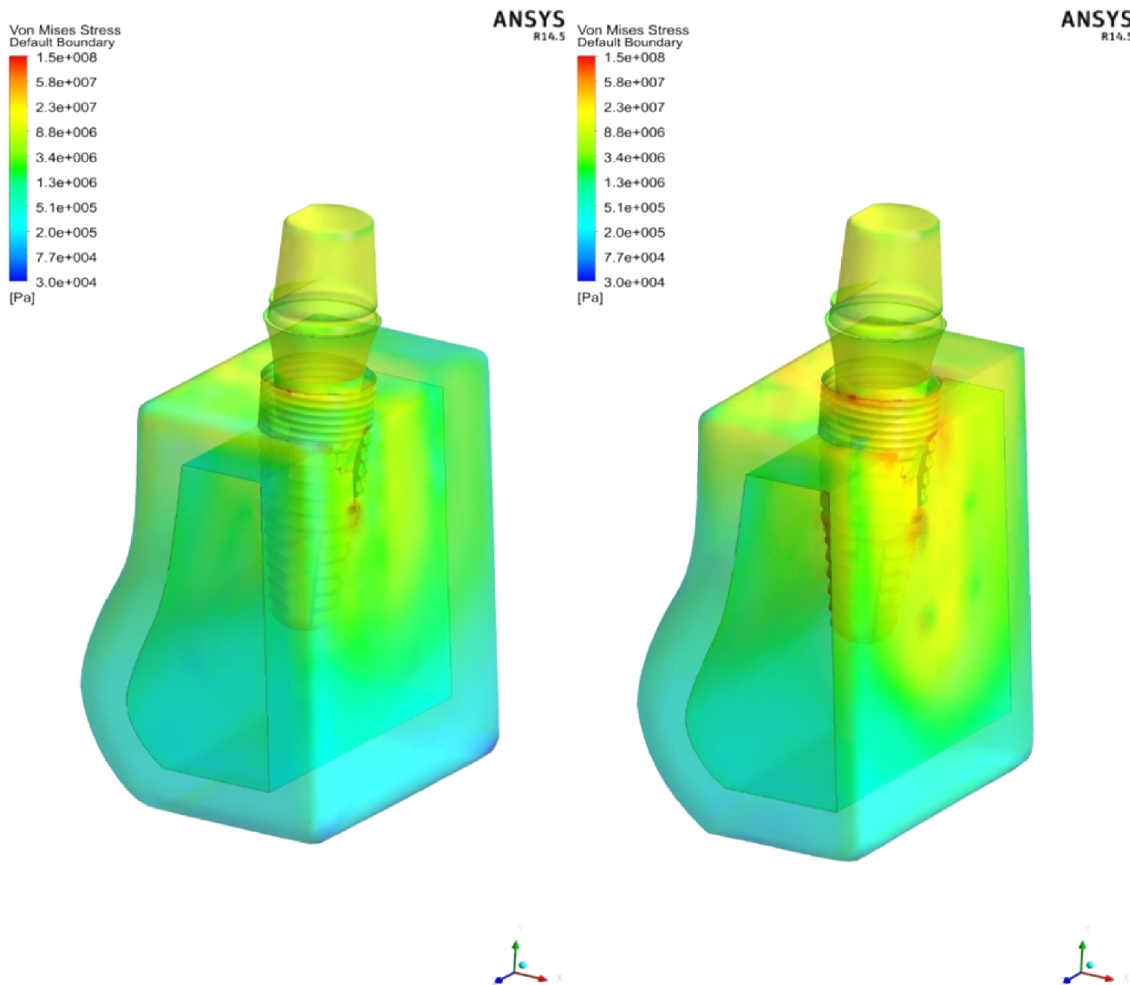


Figure 10:- Comparison of stresses between 3.8mm diameter implants with buccal wall thickness 2mm and 1mm.

DISCUSSION

With a rise in the number of implant placements each year worldwide, along with an increase in general dentists engaged in implant treatments, there exists a need to establish additional biomechanical guidelines when encountering compromised bony ridges(22). Bone loss as a consequence of infection, occlusal trauma, periodontal disease and finally resorption following extraction can lead to a compromised implant bed, with the buccal cortical bone thickness as less as 1mm as mentioned in clinical studies(23). The implant surgeon has to decide from a biomechanical view point whether a bone augmentation procedure is essential in situations when a dental implant has otherwise been satisfactorily placed without any fenestrations adjacent to a thin buccal cortical plate.

Since our study involved an assessment of the variations in thickness of the buccal cortical bone, conversion of the medical images into a patient specific 3D model would not have allowed us to create bone thicknesses of 2.0mm, 1.5mm and 1.0mm without alterations.

Of all the surgery-related factors involved, primary stability seems to be the most important determining factor on immediate implant loading(16). Functional loading on an implant rigidly placed at an adequate installation torque is an essential ingredient in avoiding fibrous encapsulation and achieving osseointegration. Dental implants would behave as bolts which are fastened into the receiving channels created in bone for each of these metal bodies. As the implant is being advanced into such a space, an increase in resistance to tightening should ideally be experienced which is a measure of the magnitude of fixation achieved or primary stability. The dental implant in such a state imparts forces on the walls of the bony surfaces. A quantification of the compressive force with which our implants were assumed to be fixated into the bony segments at the same level of insertion torque was therefore necessary. Our calculations indicate that as the diameter of the

implant increases the pre-load decreases. Although, primary stability of an implant is clinically measured by the achieved insertion torque, variables such as diameter, thread type, thread pitch, thread profile angle, depth etc seem to effect the magnitude of implant fixation and therefore different implants can be in different states of true primary stability even at the same insertion torque.

In order to restrict the computational solving time, this parametric study employed 9 models with a static load applied along the long axis of the implants. However, since actual function involves dynamic loading under oblique forces as well, we cannot suggest the clinical feasibility of immediate loading of bone level implants adjacent to buccal bone as thin as 1mm. Having said this, the results of this study indicate that static loads of 150N seem to be well tolerated from the bone-deflection view point for all 9 models. Furthermore, the forces applied on the teeth vary with the type of food being chewed. The force applied to a single tooth is also different to that of total force between all the contacting teeth during chewing. On foods such as biscuits, carrots and cooked meat forces range between 70 and 150 N on a single tooth(24). Also, a static 150N as a loading condition has previously been used in immediate loading FEA studies(14, 25).

The maximum stresses were seen concentrated in the buccal cortical bones and around the neck of the implants which is in agreement with other studies and hence validate our findings. Also, according to the findings of Siegele and Soltesz(26) and Patra and colleagues(27), stresses are also concentrated near the apices of immediate loaded implants. We also found stresses focused around the threads of implants as shown in a study by Chun and colleagues (25, 28). The structures in our models were assumed to be homogeneous, isotropic and to possess linear elasticity. The properties of the living tissues, are however different. For instance, it is well described that the actual cortical bone of the mandible is transversely isotropic and inhomogeneous(29). Therefore, the absolute stress and strain values cannot be related to results computed under different conditions. The stress of 5.0mm diameter implants was significantly lower ($p < 0.05$) than those of 3.8 mm diameter but not statistically different from that of the 4.5 mm diameter.

The reduction in stress values in the buccal cortical bones with a progression from the crest towards the apex of an implants, as seen along the points on the Y co-ordinate (Figure 8) seem to validate the stress absorbing properties of cancellous bone, however such a inference can be more accurately observed when bone is modeled as an anisotropic structure with all anatomic variations of trabecular bone realistically simulated (30). The un-supported cortical plates on either side of the implants are subjected to the maximum stresses with stress increasing with reduction in thickness of the buccal bone(31). Larger diameter implants not only transfer lesser stresses to the adjacent bone, but the reduction in thickness of the buccal bone does not significantly vary stresses as compared to the smaller diameter implants (Figures 11-12).

The ultimate yield strength of cortical and cancellous bone has been mentioned as 190MPa and 40MPa respectively(32). At a static load of 150N there were no indications of fracture in any of the 9 models. Compared to a bonded interface as seen in an osseointegrated simulation, setting a frictional co-efficient between the fixture and bone does yield higher stresses in the cortical bone. A bonded interface transmits forces in both the compressive and tension sites and hence stress transmission is more homogenous and quantitatively less as compared to an immediate loaded implant. Although, in our study the micro-motion has been less than 150 μ m for all 9 implant models which favors immediate loading, the effect of oblique loading affecting osseointegration and the possibility of long term bone loss especially in thinner buccal cortical bones due to inappropriate loading is also worthy to be investigated.

The change in peri-implant stress around the 5.0mm diameter implant with reductions in buccal bone thicknesses were statistically insignificant as compared to stress values associated with the 3.8mm implant. It would appear that larger diameter implants although require larger osteotomies to be surgically prepared, are more favorable in terms of stress distribution when immediately loaded even when placed adjacent to residual buccal bone as thin as 1mm(33).

CONCLUSIONS

Within the limitations of this study, the following conclusions for an immediately loaded mandibular implant are suggested:

1. The stresses transmitted within the peri-implant bony environment upon immediate vertical loading are concentrated in the mesial and distal crestal region and beneath the apex of the implants.
2. With reductions in the thickness of the buccal cortical plate the magnitude of stress increases. The general trend is an increase in the micro-motions at the implant-bone interface with reductions in the thickness of the buccal bone, however at a vertically applied static load of 150N the micro-motions are less than the critical value of 150 μ m.

3. Stresses reduce with an increase in diameter of the implants.
4. The magnitude of stress transmission does not vary significantly with reductions in thickness of the buccal bone for the larger diameter implants.
5. Primary stability can vary as a consequence of variations in the properties of threads. At the same level of insertion torque the larger diameter implants according to mathematical calculations are less rigidly fixated in bone.

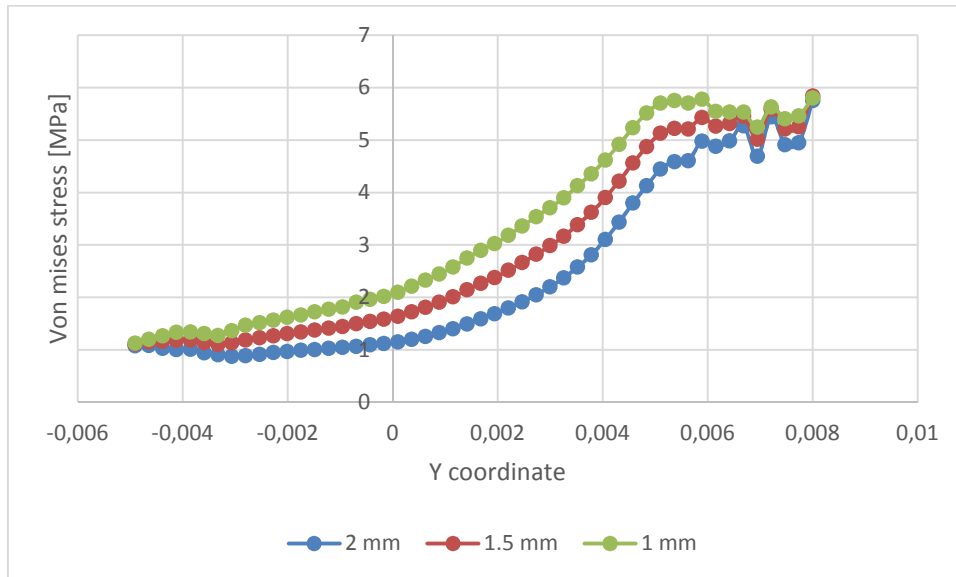


Figure 11:- Comparison of stresses on the Y-axis (implant diameter 5.0mm).

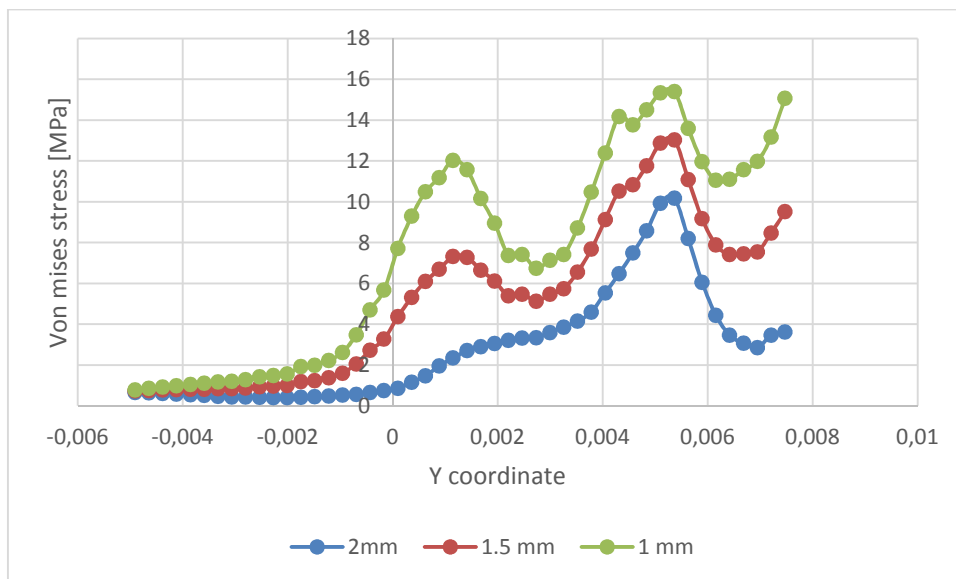


Figure 12:- Comparison of stresses on the Y-axis (implant diameter 4.5mm).

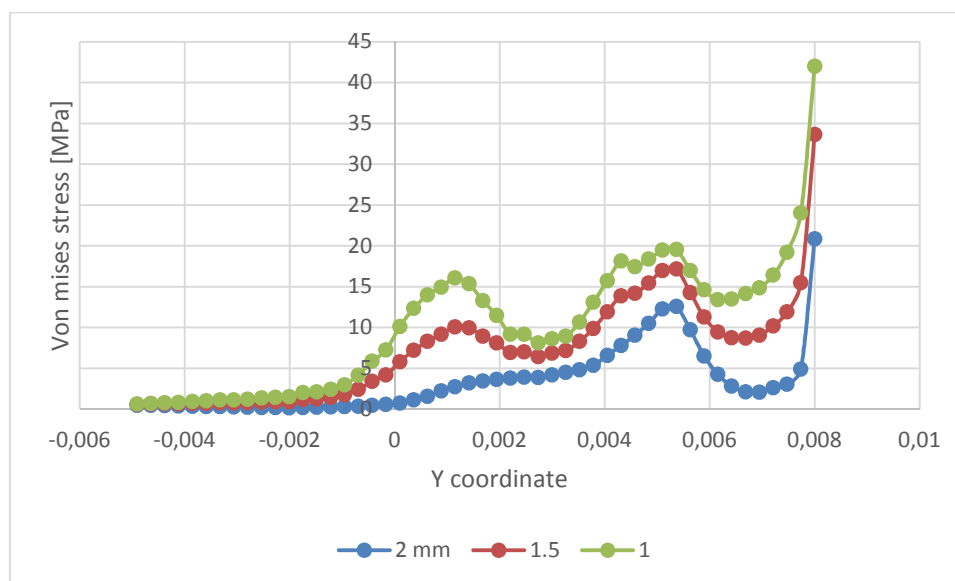


Figure 13:- Comparison of stresses on the Y-axis (implant diameter 3.8 mm).

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Design and development of slot-0 controller for EM-diagnostics

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ABSTRACT: A new design of Microcontroller-TMS320F28335 based control card is being design and developed. This card is used to control and monitor the parameters of the analog signal conditioning cards which are used to measure the different plasma characteristic of the upcoming globally challenging and competitive Tokamak, SST-1 in the Institute for Plasma Research.

The characteristics of the long time plasma may change in a large dynamic range and the number of diagnostic channels are in more than two hundreds, so the remote controlling of some parameters of the signal conditioning electronics such as amplifier gain, automatic testing is very essential. The existing card, which is based on 8 bit architecture with very limited features. This necessitates the need of new design with more advanced features to accommodate all required features. The details of this new design will be described in this paper.

KEYWORDS: TMS320F28335 (Digital signal controller), CAN(Controller area network) protocol, LabVIEW, PWM.

1 INTRODUCTION

INSTITUTE FOR PLASMA RESEARCH is a pioneer and globally reputed organization in the field of plasma and fusion research. The sun and the universe consists of plasma, the fourth state of matter. To create, confine and to control the plasma in a laboratory is extremely challenging. Such a machine is called tokamak. SST-1 (SUPER CONDUCTING STEADY STATE TOKAMAK) is being indigenously built and in the stage of completion in IPR. In this machine plasma will be created for long time about 1000 seconds. To study the characteristics of plasma, different diagnostic tools are used. ELECTRO MAGNETIC DIAGNOSTICS (EM) is one of the important tool to study about plasma. The signal conditioning instrumentation for these diagnostics are fully indigenously designed and developed in the electronics section of the institute. The characteristics of the long time plasma may change in a large dynamic range and the number of diagnostic channels are more so the remote controlling of some parameters of the signal conditioning electronics such as amplifier gain, or automatic testing is very essential.

The existing slot-0 controller card (Based on P80C592) has many limitations like; there is no provision for offset calibration, attenuation, time stamping, storing of default settings, etc. These limitations, inspired for the development of new control card. Texas Instruments make TMS320F28335 based new Control card which is under development, has many advanced features. This facilitates to design a new compact card which meets all the required specifications. The key features of the newly selected controller are, 32-bit architecture, In-built flash memory (256KB), Integrated peripherals- SPI, CAN, I2C, UART etc, In-built 64KB RAM, In-built DSP for signal processing, Integrated 12-bit ADC, Fast interrupt response manager, 12-bit ADC module for implementing extra on-board features like temp sensing etc, Up to 88 shared GPIO pins for full remote

control parameter implementation,3-timers with 32-bit each for implementing timing applications like time-stamping application for event management.

2 DEVELOPMENT OF SLOT-0 CONTROLLER CARD



Fig. 1. Instrumentation chassis diagram

In EM-diagnostics, there are 12 chassis arranged in 19 inch racks. In every chassis there are 8+1 modules, which are also known as slots. The 1st module is known as slot-0 which is the controller-card and other 8 slots contain analog module. Slot-0, the micro controller card can control and monitor all the parameters of the analog modules. Each chassis consists of one Slot-0 micro controller card, and up to eight SCS analog modules. Each analog module consists of two channels so one chassis can accommodate maximum 16 channels. All slot-0 cards of different chassis are connected in single CAN network and connected to a remote PC host PC also. USB-to CAN convertor is used in the pc end. LabVIEW based GUI is developed and available in the host PC. The diagnostics user can access this interface to set any parameter of the analog module.

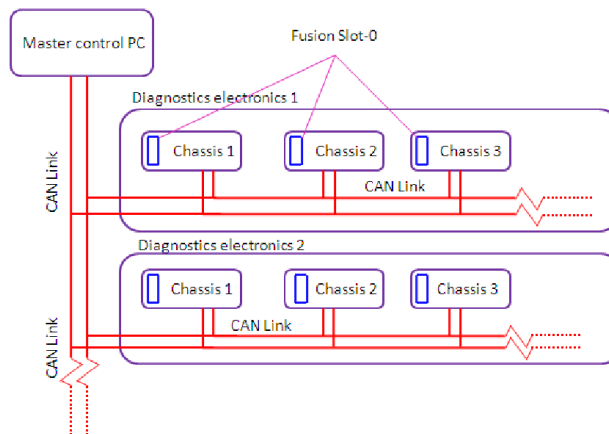


Fig. 2. Signal conditioning block diagram

The design of new slot-0 controller card will be 3U size instead of 6U. It will increase the number of available chassis in a rack. These slot-0 will contain TMS320F28335 (digital signal controller), FPGA, level translator, etc. Slot-0 controller card can control these analog modules like Gain/Attenuation, Saturation detection, Offset calibration, Test-mode. The paper describes about controlling of gain analog module and offset calibration for remote operation.

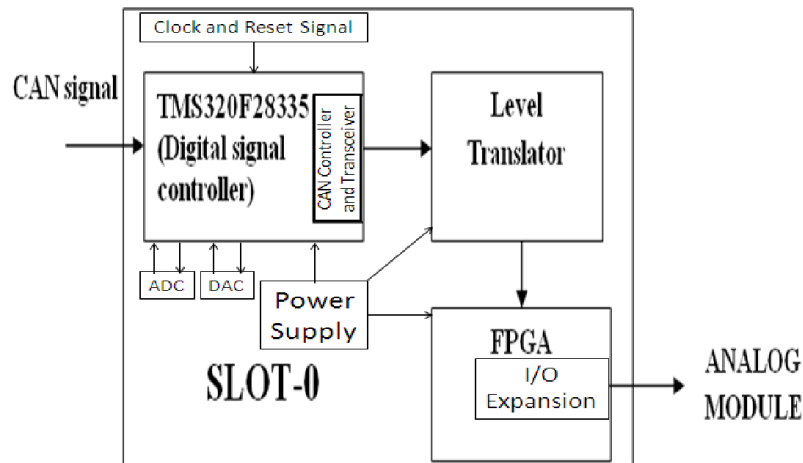


Fig. 3. New slot-0 block diagram

2.1 STANDARDIZED CODE

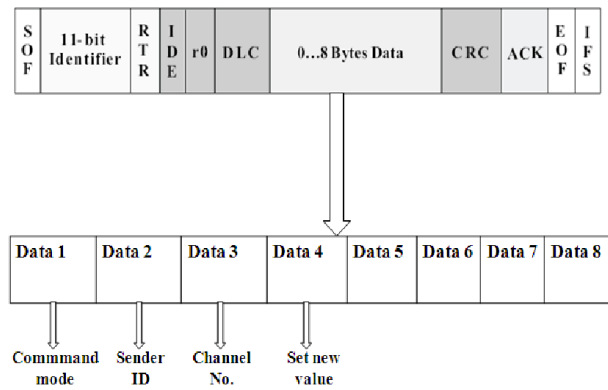


Fig. 4. Standardized data packet

Data 1 is Command Code. This data defines the different command to be executed; a maximum of 256 different commands can be coded throughout the network. The different commands presently implemented are:

- 00 = gain/attenuation
- 01 = offset calibration
- 02 = test mode on/off etc.

Data 2 contains sender ID, data 3 will contain channel no. of analog module, data 4 will contain the new value of analog parameter, which has to be changed and others are undefined.

2.2 LABVIEW CAN PROGRAM FLOW

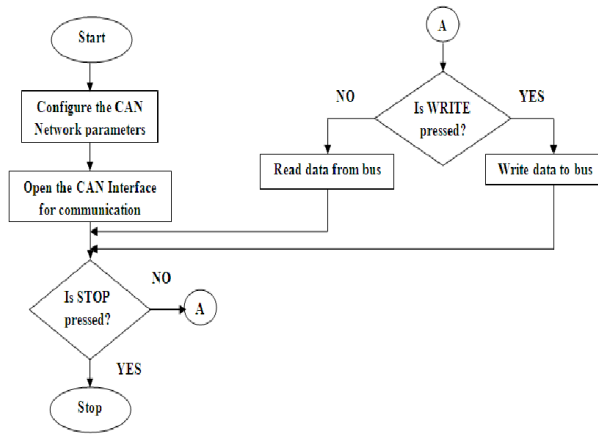


Fig. 5. LabVIEW CAN program flow

2.3 GAIN CONTROL MODULE

Gain control module used consists of the PGA203 and PGA202 IC. Each IC requires two bits as inputs, which by the standard followed at IPR is in the 4th byte of CAN data. PGA203 takes two bits as inputs and provides gain steps of 1, 2, 4 and 8 and PGA202 takes two bits as inputs and provides gain steps of 1, 10, 100 and 1000.

EX: - for the input of 400mvpp , the output will be:

Table 1. Gain table

Control bits		output
A1	A0	
0	0	400 mvpp
0	1	800 mvpp
1	0	1.6 vpp
1	1	3.2 VPP

2.4 OFFSET CALIBRATION

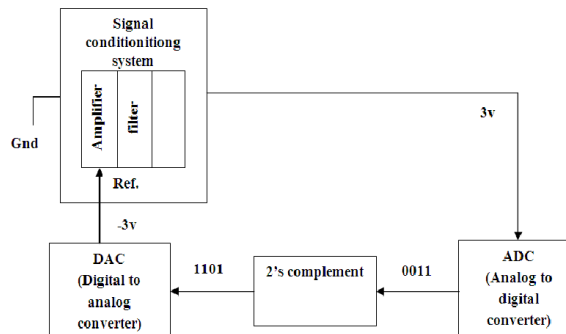


Fig. 6. offset calibration block diagram

As in above figure, to eliminate the offset error the output of signal conditioning system is converted to digital value using ADC. This digital value is complemented and converted to analog through DAC and then given as input reference to amplifier of signal conditioning system. This EVM module has unipolar ADC, so we get only positive voltages. This limitation will be reduced in SLOT-0. In TMS320F28335, ADC has 16 inputs with 12-bit digital output. PWM is digital output signal with binary amplitude, 0 or 1 as in analog 0V or 3V. By changing set-point we can change duty cycle of PWM so we get according final analog output is obtained from PWM via internally connected LPF.

3 SIMULATION RESULTS

3.1 CAN FRONT PANEL

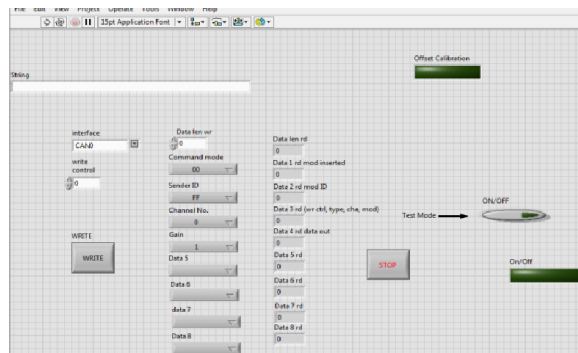


Fig. 7. CAN front panel

3.2 GAIN PARAMETER RESULTS

3.2.1 CAN FRONT PANEL FOR GAIN

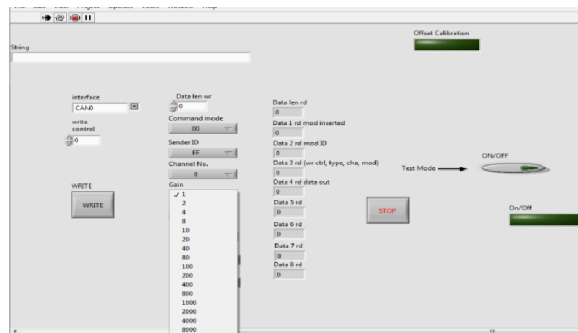


Fig. 8. CAN front panel for GAIN

3.2.2 SETUP FOR GAIN CONTROL

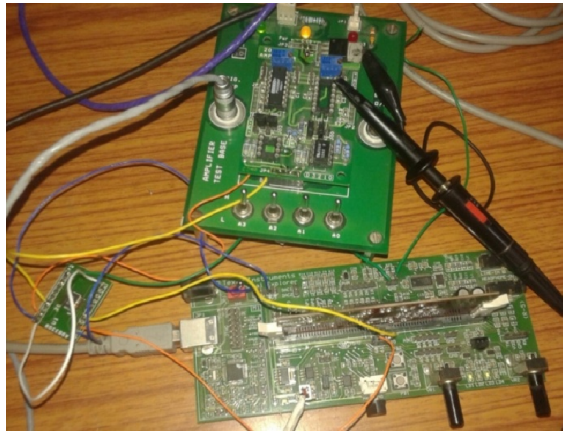


Fig. 9. Setup for Gain control

3.2.3 GAIN CONTROL RESULTS



Fig. 10. Gain control results

3.3 OFFSET CALIBRATION RESULTS

3.3.1 CAN FRONT PANEL FOR OFFSET CALIBRATION

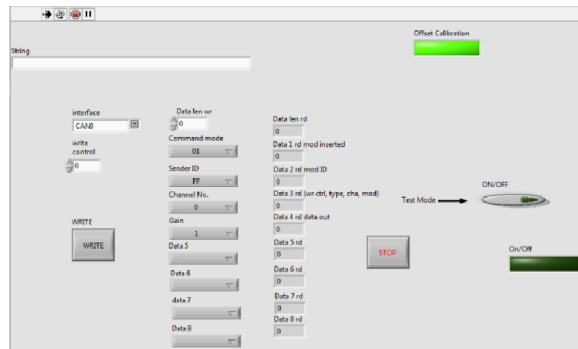


Fig. 11. CAN front panel for offset calibration

3.3.2 2'S COMPLEMENT RESULT

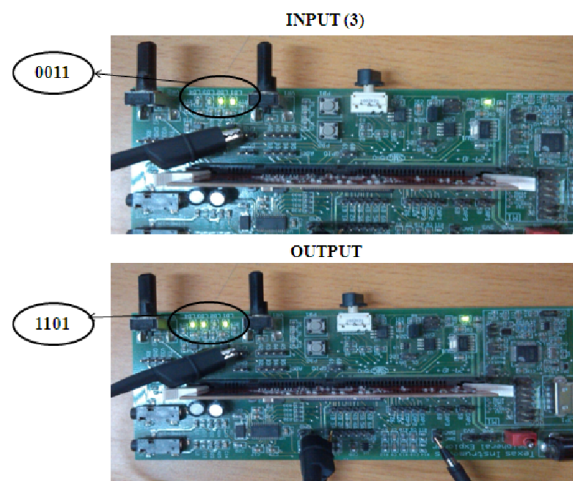


Fig. 12. 2's complement Result

3.3.3 DAC AND PWM RESULTS

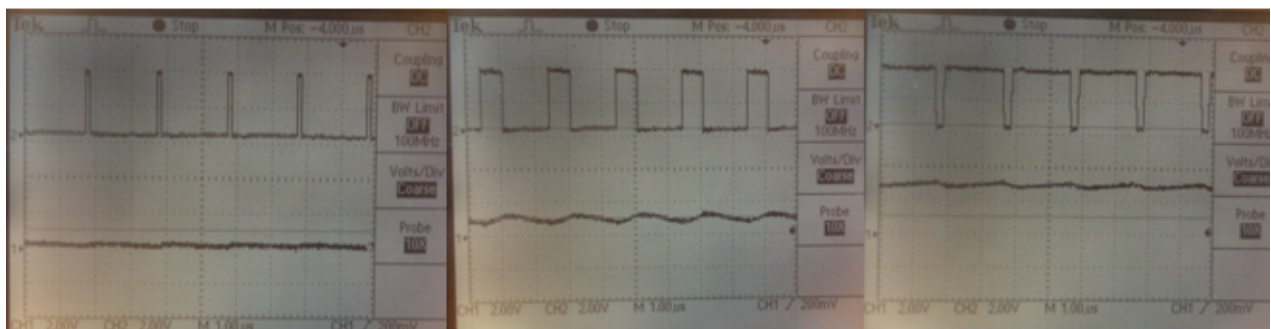


Fig. 13. DAC and PWM results

4 CONCLUSION

This paper presents the development of a new design of Slot-0 microcontroller card based on TMS320F28335 for controlling the parameters and monitoring the status of analog signal conditioning cards which are used as plasma diagnostics measurement instruments in the institute. This paper also describes the use of CAN (Controller Area Network) protocol in scientific application for remote controlling of instruments. The basic features of the new slot-0 card are tested with available board from Texas Instruments. Embedded coding is also successfully done in Code Composer Studio. CAN protocol networking is established. All the required framework has been successfully established.

ACKNOWLEDGMENT

For making all resources available throughout the development of the project and for their guidance, we would like to thank Ms. Pramila Gautam and all the team members of the Electronics & Instrumentation Section. Also we would like to thank the friends who have helped during the period of development of this project.

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Contrôle d'un réacteur industriel multi-étagé à lits fixes catalytiques

[Control of an industrial multi-staged catalyst fixed bed reactor]

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ABSTRACT: In this paper, we study the control of a fixed catalyst multi-staged reactor. This reactor is an industrial one, used for sulphur dioxide oxidation. The aim of this work is to determine the best control strategy between one whom consist to control the production capacity of the reactor and another, more usual, whom consist to control the maximal catalyst temperature in order to avoid the occurrence of hot spot inside the catalyst. Command algorithm used is the generalised predictive control (GPC) with on line process identification. The results obtained by numerical simulation show that the control of the production capacity is possible and also preferable, since the reactor is strongly influenced by inlet reagent concentrations and, on the other hand, it presents a notable thermal stability conferred by the thermal inertia due to the important catalyst mass.

KEYWORDS: Sulfur dioxide, reactor, catalyst, fixed bed, control, GPC algorithm.

RESUME: Dans cet article, on étudie le contrôle d'un réacteur multi-étagé à lits fixes catalytiques. Le réacteur étudié est de type industriel et constitue le siège de la réaction d'oxydation du dioxyde de soufre. Le but de ce travail est de déterminer la meilleure stratégie de contrôle entre celle qui consiste à contrôler la capacité de production du réacteur et celle, plus habituelle, qui consiste à contrôler la température maximale du catalyseur en vue d'éviter la formation de points chauds dans la masse catalytique. L'algorithme de contrôle utilisé est celui à commande prédictive généralisée (GPC) avec identification en ligne du procédé. Les résultats obtenus par simulation numérique montrent que le contrôle de la capacité de production est non seulement possible, mais aussi préférable, compte tenu du fait que le réacteur est fortement influencé par les perturbations des teneurs en réactifs et que, d'autre part, il présente une grande stabilité thermique conférée par l'inertie thermique de l'importante masse catalytique.

MOTS-CLEFS: Dioxyde de soufre, réacteur, catalyseur, lit fixe, contrôle, algorithme GPC.

1 INTRODUCTION

Les réacteurs à lit fixes catalytiques sont très utilisés dans l'industrie chimique pour la fabrication de produits chimiques très utiles et très variés [1-2]. Dans cette étude, on s'intéresse à un type de réacteur très utilisé dans l'industrie chimique, à savoir : le réacteur catalytique à lit fixe adiabatique. Le réacteur étudié est le siège d'une réaction chimique fortement exothermique. Cette réaction consiste en l'oxydation de l'anhydride sulfureux (SO₂) en anhydride sulfurique (SO₃). L'anhydride sulfurique ainsi produit va servir de matière première pour la fabrication de l'acide sulfurique.

Afin d'atteindre des taux de conversion élevé, l'utilisation d'une cascade de lit catalytique s'impose. En conséquence, le réacteur industriel sera constitué, en général, de trois à quatre lits catalytiques fixes disposés en série [3]. Habituellement le contrôle d'un tel réacteur a pour but surtout d'éviter l'apparition d'un point chaud dans la masse de catalyseur constitutive du lit catalytique et cela par l'utilisation d'une boucle de contrôle, spécifique à ce dernier, qui aura pour but de stabiliser la température maximale catalytique à une valeur préalablement connue et fixée [4].

Dans cette étude, on va exploiter une nouvelle approche, consistant non pas à contrôler la température maximale catalytique, mais à contrôler la capacité de production de chaque étage. Cette dernière approche serait acceptable si on parvient à démontrer que le lit catalytique est thermiquement très stable par rapport aux perturbations possibles. Dans ce

but, on va d'abord intégrer le modèle dynamique du réacteur, et cela en tenant compte de son point de fonctionnement nominal [3]. Par la suite, on appliquera l'algorithme GPC au modèle dynamique du procédé.

2 REACTEUR CATALYTIQUE MULTI-ÉTAGE

Globalement, le réacteur industriel est constitué de quatre étages catalytiques disposés en série. Ces quatre étages catalytiques sont contenus dans une enceinte cylindrique de 8,6 mètres de diamètre. Chaque étage catalytique est formé d'un empilement compact et immobile de grains catalytiques. Les quatre étages catalytiques sont agencés d'une façon verticale donnant ainsi au réacteur une allure d'une grande colonne cylindrique. Le mélange réactionnel gazeux traverse les quatre étages catalytiques du haut vers le bas tel que l'illustre la figure 1 [3]. Chaque étage catalytique possède son propre point de fonctionnement nominal, spécifié par des paramètres physiques relatifs au mélange réactionnel (température du gaz à l'entrée de chaque étage qui doit être bien déterminée) et au lit catalytique (granulométrie et la masse du catalyseur doivent être rigoureusement prédéfinies et calculées). Afin de suivre l'adiabatique de conversion et donc d'atteindre le taux de conversion escompté à la sortie du réacteur, il est indispensable de refroidir le mélange réactionnel à la sortie de chaque étage catalytique. Un tel refroidissement est assuré, tel que le montre la figure 1, par des échangeurs de chaleur disposés après chaque lit. L'adiabaticité de chaque étage est réalisée en recouvrant sa paroi externe par une couche d'un isolant thermique. La paroi interne étant, alors isolée par une couche de briques réfractaires [4].

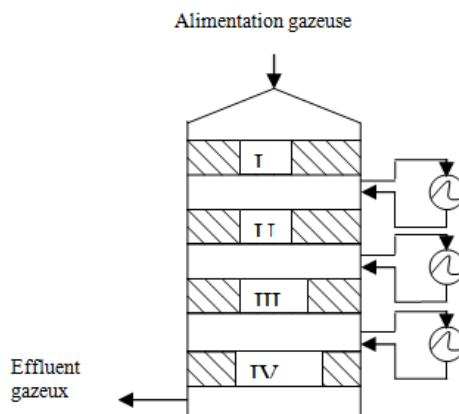


Fig. 1. réacteur catalytique étagé d'oxydation du SO₂ avec refroidissements intermédiaires [3].

2.1 CARACTERISTIQUES DU CATALYSEUR

Pour réaliser l'oxydation de l'anhydride sulfureux (SO₂), on utilise des catalyseurs à base de pentoxyde de vanadium (V₂O₅). Le catalyseur se présente sous forme de granulés dont la teneur en pentoxyde de vanadium varie entre 6 et 8 % en moyenne [5]. Le catalyseur n'est actif que dans une certaine fourchette de température; celle-ci va de 400 à 650 °C [5]. A partir de 650 °C, le catalyseur employé commencera par perdre ses qualités catalytiques avant de se dégrader d'une façon irréversible [6].

2.2 EXPRESSION DE LA CINÉTIQUE REACTIONNELLE

La réaction d'oxydation de l'anhydride sulfureux est fortement exothermique. La variation d'enthalpie associée à cette réaction avoisine 8.8910⁴ J/mole [3] ; elle varie très peu dans l'intervalle de température allant de 400 à 600 °C. La cinétique de l'oxydation du dioxyde de soufre a été largement étudiée [6]. Plusieurs expressions semi-empiriques de la vitesse de la réaction ont été établies. Pour notre étude on a utilisé l'expression de Calderbank basée sur le concept de Langmuir-Hinshelwood et sur l'observation que la réaction entre le SO₂ adsorbé et l'oxygène constitue l'étape limitante [7] :

$$r = \frac{K_1 \cdot P_1 \cdot P_2 \cdot [1 - P_3 / (P_1 \cdot P_2^{1/2} \cdot K_p)]}{22.414 [1 + K_2 \cdot P_1 + K_3 \cdot P_3]^2}$$

avec

$$K_1 = e^{[12.16 - (5473/T)]}; K_2 = e^{[-9.953 + (8619/T)]}$$

$$K_3 = e^{[-71.745 + (525265/T)]};$$

$$K_p = e^{[(11300/T) - 10.68]}$$

Dans l'expression de la cinétique, T représente la température de la phase solide catalytique et r est exprimée en kmole de SO₂/(kg de catalyseur.heure).

2.3 POINT DE FONCTIONNEMENT NOMINAL DU REACTEUR

La composition molaire moyenne du mélange réactionnel qu'on a considéré dans notre étude est comme suit [5] :

N_2 : 79 % , O_2 : 11 % , SO_2 : 10 % . La température d'alimentation du premier étage catalytique doit être impérativement supérieure à 430 °C. Les valeurs nominales des paramètres de fonctionnement du réacteur sont tels que [3] :

$$L = 0,48 \text{ m} ; D = 8,6 \text{ m} ; S = 568 \text{ m}^{-1} , \epsilon_c = 0,5 ; \rho_u = 620 \text{ kg/m}^3$$

$$n_g = 47.65 \text{ Kmole m}^{-2} \cdot \text{h}^{-1}$$

$$\lambda_e = 0,465 \text{ W.m}^{-2} \text{ K}^{-1}; \alpha = 151 \text{ W.m}^{-1}\text{K}^{-1}$$

$$\Delta H = 8.89 \cdot 10^4 \text{ KJ/ Kmole}$$

$$C_{p\text{seff}} = 2.1 \text{ kJ. Kg}^{-1} \cdot \text{K}^{-1}; d_p = 1.8 \text{ mm}$$

$$P_T = 1, 2 \text{ atm}$$

2.4 MODELE DYNAMIQUE DU REACTEUR

Un modèle uni-dimensionnel a été employé pour simuler le comportement dynamique du réacteur. Dans ce modèle dynamique, seul les gradients axiaux des grandeurs physiques (température et concentration) ont été pris en considération ; les gradients radiaux ont été négligés [3]. En outre, à l'échelle du grain catalytique, il a été supposé une température et une concentration uniforme. En tenant compte de toutes ces hypothèses, le modèle dynamique est comme suit [3] :

$$n_g \cdot C_{pg} \cdot \frac{\partial T_g}{\partial x} + \alpha \cdot S \cdot (T_g - T_k) = 0 \quad (1)$$

$$\lambda_e \cdot \frac{\partial^2 T_k}{\partial x^2} - \rho_u \cdot C_{ps} \cdot \frac{\partial T_k}{\partial t} + \alpha \cdot S \cdot (T_g - T_k) + \Delta H \cdot r \cdot \rho_u = 0 \quad (2)$$

$$n_g \frac{\partial C_i}{\partial x} + r_i \cdot \rho_u = 0 \quad (i = 1, 2, 3) \quad (3)$$

2.4.1 CONDITIONS AUX LIMITES ET CONDITIONS INITIALES

- *Conditions initiales*

On a considéré dans notre étude que

$$T_k(x, t) = T_g(x, t) = T(x) \quad (0 \leq x \leq L).$$

$T(x)$ est une distribution initiale de la température à travers le lit catalytique. On a supposé que le réacteur démarrerait à partir d'un état froid (démarrage à froid), car dans la pratique, un tel démarrage est très utilisé. Dans le démarrage à froid, la masse catalytique est à la température du milieu ambiant. Pour que le catalyseur devienne actif, il est impératif de préchauffer celui-ci, avec de l'air chaud, jusqu'à une température supérieure à 400 °C. La fonction $T(x)$ s'identifiera alors à une fonction constante, et ceci à travers tout le lit catalytique. Dans cette présente étude on a posé que

$$T(x) = 460 \text{ °C} \quad (0 \leq x \leq L).$$

- *Conditions aux limites*

Les conditions aux limites concernent les deux extrémités du lit catalytique, spécifiés par leurs abscisses $x = 0$ et $x = L$.

i) Pour $x = 0$ on a

$$C_1(0, t) = C_{1in}(t) ; C_2(0, t) = C_{2in}(t)$$

$$C_3(0, t) = 0$$

$$\lambda_e \frac{\partial T_k}{\partial x} = (1 - \epsilon_c) \cdot \alpha \cdot [T_k(0, t) - T_{gin}(t)]$$

$$T_g(0, t) = T_{gin}(t)$$

ii) Pour $x = L$ on a

$$n_g \cdot C_{pg} \cdot [T_g(L, t) - T_{gout}(t)] = (1 - \epsilon_c) \cdot \alpha \cdot [T_{gout} - T_k(L, t)]$$

$$\frac{\partial T_k}{\partial x} = 0$$

$$T_g(L, t) = T_{gout}(t)$$

2.5 RESOLUTION DU MODELE DYNAMIQUE

Les équations (1) et (3) sont des problèmes différentiels du type de CAUCHY, donc facilement intégrables par la méthode de RUNGE-KUTTA du quatrième ordre [8]. L'équation (2) étant un problème différentiel du type aux limites, en conséquence, cette équation a été résolue par la méthode implicite de CRANK- NICOLSON [9] avec un facteur d'implicité ('implicitness factor') égal à 1/2.

3 ALGORITHME DE CONTROLE GPC

L'objectif de la loi de commande GPC ('Generalised Predictive Control') est de calculer à chaque instant d'échantillonnage (t), une grandeur de commande $u(t)$ dont le but sera celui de rapprocher les signaux de sorties futures $y(t+j)$ ($j=1, N_2$) autant que possible des signaux de consigne $w(t+j)$ ($j=1, N_2$) [8]. La grandeur de commande est calculée de façon à minimiser le critère quadratique suivant [8] :

$$j=N_2, j=N_2$$

$$J = \sum_{j=N_2} [y(t+j)-w(t+j)]^2 + \sum \lambda(j) \cdot [\Delta u(t+j-1)]^2$$

$$j=N_1, j=N_1$$

$$\text{avec : } \Delta u(t) = u(t) - u(t-1)$$

A partir de l'expression du critère J , il apparaît clairement que l'objectif de la loi de commande GPC est double. D'une part, la loi de commande minimise, au sens des moindres carrés, la somme étendue à tout l'horizon de prédiction ($j=1, N_2$) des erreurs futures ; et d'autre part, cet objectif sera réalisé de façon à minimiser la consommation d'énergie. Le vecteur de pondération $\lambda(j)$ a pour but, justement, de pondérer tout excès d'activité du signal de commande, et ceci par un choix à priori et judicieux des valeurs de ces composantes. En général, pour simplifier, on pose que $\lambda(j) = \lambda$ et λ sera appelé, en l'occurrence, coefficient de pondération de la commande [10]. Le coefficient λ constitue, en plus des paramètres N_1 et N_2 , un important paramètre de conception de la loi algorithmique de contrôle GPC.

4 RESULTATS ET DISCUSSION

Dans cette présente étude, on s'est intéressé seulement au premier étage catalytique du réacteur. Mais, il est évident que les résultats trouvés sont transposables à tous les autres lits catalytiques. Le réacteur est soumis à des perturbations de natures diverses, se matérialisant par des fluctuations aléatoires des paramètres opératoires tels que les fractions molaires des réactifs. Le contrôle de l'étage catalytique aura pour but de prévenir tout emballement ou extinction de la réaction chimique et donc d'éviter l'apparition de zones chaudes catalytiques susceptibles de causer une baisse notable de l'activité catalytique ou de provoquer la détérioration du catalyseur. Une stratégie de contrôle très utilisée consiste à réguler la température maximale catalytique. Dans cette étude, on appliquera cette stratégie en utilisant comme grandeur de commande le débit volumique traversant le lit catalytique. De plus, nous étudierons une autre stratégie qui consiste à contrôler directement la capacité de production du réacteur, en utilisant, également, le débit volumique comme grandeur de commande. Les perturbations considérées dans cette étude sont principalement dues aux variations des concentrations (fractions molaires) des réactifs dans l'alimentation du réacteur.

4.1 LIT CATALYTIQUE EN BOUCLE OUVERTE

La figure 2 illustre le fait que malgré l'occurrence d'une intense perturbation relative à la teneur en dioxyde de soufre (C_{1in}), la température maximale catalytique ne dépasse pas 650 °C. On constate, surtout que le lit catalytique ne présente aucun emballement dangereux de la température.

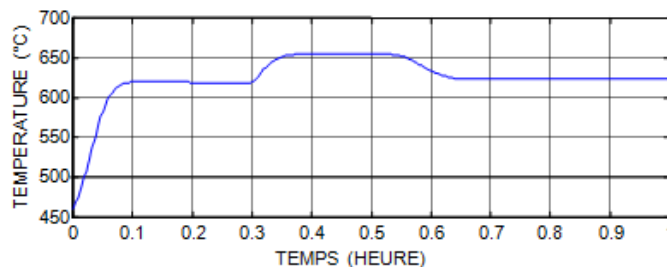


Fig. 2. Injection d'une perturbation impulsion sur C_{1in} ($C_{1in} = 0.1$), A 0.3 heure, durant: 10 minutes valant +20 %

La figure 3 montre que malgré l'occurrence d'une perturbation d'une intensité importante relative à la teneur en dioxyde de soufre ; la température maximale catalytique subit une faible diminution. Par contre cette perturbation provoque une

importante diminution de la capacité de production. Celle-ci passe, alors, de 15 à 12,3 tonnes de SO₃ par heure. Cette baisse très importante du rendement du lit catalytique dure à peu près autant que dure la perturbation.

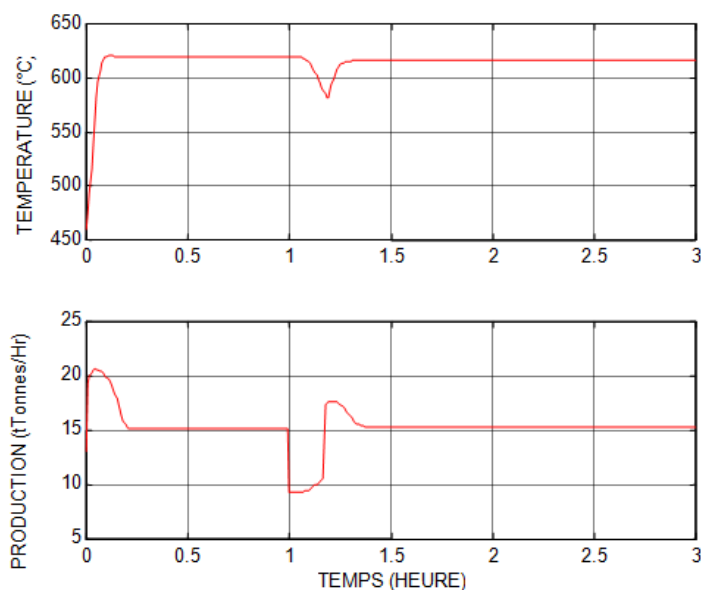


Fig. 3. Injection d'une perturbation impulsion sur C1in (C1in =0.1), à 1 heure, valant -20%, durant : 10 minutes

4.2 LIT CATALYTIQUE EN BOUCLE FERMEE

Pour le contrôle de la température maximale de la phase solide on utilise des thermocouples, insérés dans le lit catalytique, le long du sens d'écoulement du mélange réactionnel. Dans le cas où on désire contrôler la capacité de production du lit catalytique, on utilisera un analyseur de la teneur d'oxygène (analyseur de composition) comme capteur, car la teneur ou taux de conversion en oxygène est liée directement à la capacité de production en SO₃.

Le contrôle de l'étage catalytique a été effectué en utilisant l'algorithme de la commande prédictive généralisée (GPC) [10] et avec une période d'échantillonnage égale à vingt secondes. L'identification en ligne du procédé a été effectuée en utilisant l'algorithme des moindres carrés récursifs.

La figure 4 illustre le cas où le contrôle de la température est appliqué (pour une consigne valant 610 °C) avec occurrence d'une forte perturbation (-20 %) relative à la teneur en dioxyde de soufre. On constate alors, que l'algorithme GPC arrive à stabiliser la température à sa valeur de consigne. Malheureusement, comme le montre la figure 5, parallèlement à la régulation de la température, la capacité de production de l'étage catalytique diminue fortement, et ceci en conséquence de l'action du contrôle.

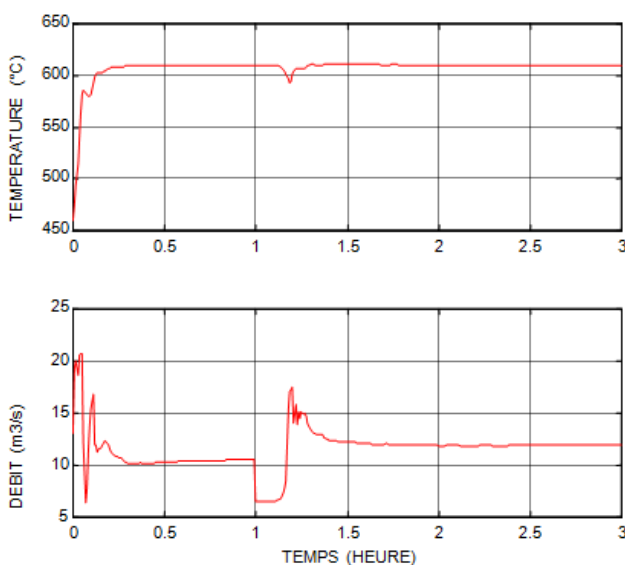


Fig. 4. Régulation de la température à 610 °C Injection d'une perturbation impulsion sur C1in (C1in =0.1) à 1 heure, valant -20 %, durant 10 minutes

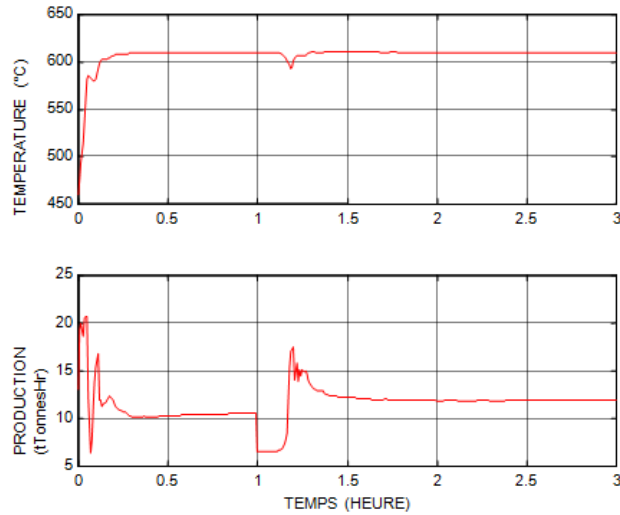


Fig. 5. Régulation de la température à 610 °C
Injection d'une perturbation impulsion sur C_{1in} ($C_{1in}=0.1$) à 1 heure, valant -20 %, durant 10 minutes

La figure 6 montre que malgré l'occurrence d'une très forte perturbation (-20 % sur C_{1in}), l'algorithme GPC réussit à contrer cette perturbation en faisant en sorte à ramener rapidement la production d'une valeur proche de 5 tonnes de SO_3 /heure à presque 10 tonnes/heure, et ceci pendant toute la durée d'application de la perturbation. Donc l'action de contrôle GPC arrive à minimiser la perte de production.

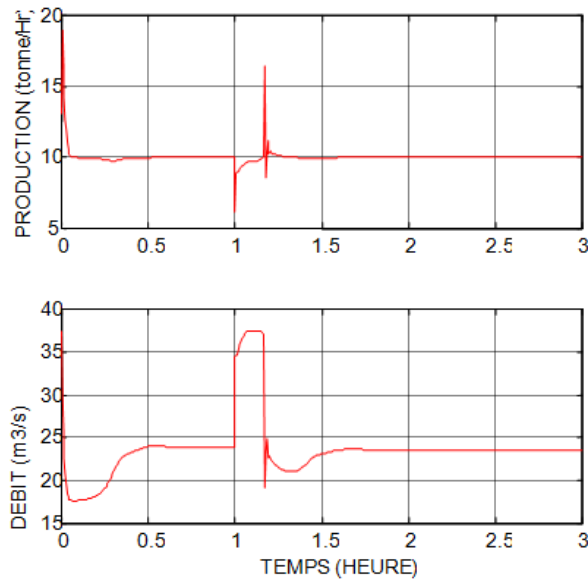


Fig. 6. Régulation de la température à 610 °C *Injection d'une perturbation impulsion sur C_{1in} ($C_{1in}=0.1$) à 1 heure, valant -20 %, durant 10 minutes*

5 CONCLUSION

Sous réserve que la température du mélange réactionnel entrant dans le premier lit catalytique soit très bien contrôlée et donc stabilisée (ce qui est généralement le cas dans la pratique industrielle) ; chaque étage catalytique, constitutif du réacteur, présente une stabilité thermique notable. Cette stabilité se traduit essentiellement par l'absence de tout emballement ou extinction de la réaction chimique sous l'effet des perturbations. Les deux stratégies de contrôle qu'on a analysées, en l'occurrence : contrôle de la température maximale catalytique et contrôle de la capacité de production, ont donné des résultats très acceptables. Etant donné que la capacité de production de l'étage fluctue considérablement sous l'effet des perturbations ; cette étude préconise fortement le recours au contrôle de la capacité de production de l'étage catalytique. En effet, cette stratégie de contrôle permet de stabiliser la production de chaque étage, et donc de l'ensemble du réacteur, en s'opposant efficacement aux perturbations.

6 NOMENCLATURE

- C_i : fraction molaire d'un constituant i
 C_{pg} : chaleur spécifique molaire du gaz ($J/mole.K^{-1}$)
 C_{ps} : chaleur spécifique massique du solide catalytique ($(J/mole.K^{-1})$)
 D : diamètre du lit catalytique.
 n_g : débit molaire superficiel total d'alimentation ($mole/m^2.s^{-1}$).
 α : coefficient de transfert thermique, par convection, entre le gaz et le solide catalytique ($W/m^2.K$).
 K_1, K_2, K_3 : constantes de vitesse de la réaction.
 K_p : constante d'équilibre chimique.
 L : épaisseur ou profondeur du lit catalytique (m).
 P_i : pression partielle d'un constituant i (atm).
 P_T : pression totale opératoire (atm).
 r : vitesse de la réaction chimique ($mole/kg.s^{-1}$).
 S : surface spécifique du catalyseur (m^2/m^3).
 T_g : température de la phase gazeuse (K).
 T_k : température de la phase solide catalytique (K).
 λ_e : conductivité thermique effective du solide catalytique ($Watt.m^{-1}.K^{-1}$).
 ρ_u : masse volumique du lit catalytique (Kg/m^3).
 ΔH : variation d'enthalpie accompagnant la réaction chimique ($J/mole$).
 ϵ_c : porosité du lit catalytique (%).
 t : variable de temps (s).
 x : variable d'espace comptée à partir de l'entrée du lit catalytique (m).
 N_1 : valeur minimale de l'intervalle de prédiction du signal de sortie.
 N_2 : valeur maximale de l'intervalle de prédiction du signal de sortie.
 j : indice de prédiction.
 $\Delta u(t)$: incrément du signal de commande à l'instant courant t .

7 INDICES

- 1 : dioxyde de soufre (SO_2).
2 : oxygène moléculaire (O_2).
3 : trioxyde de soufre (SO_3).
4 : azote moléculaire (N_2).
in : entrée du lit catalytique.
out : sortie du lit catalytique.

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Evaluation de l'activité anti-oxydante des extraits aqueux, méthanolique et éthanolique de l'espèce saharo-endémique *Myrtus nivellei* Batt et Trab. (Myrtaceae)

[Evaluation of the antioxidant activity of aqueous, methanolic and ethanolic extracts of the Sahara-endemic species *Myrtus nivellei* Batt and Trab. (Myrtaceae)]

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ABSTRACT: *Myrtus nivellei* Batt and Trab. is a Sahara-endemic plant belonging to the Myrtaceae family, this plant is very famous in southern Algeria for its therapeutic properties in folk medicine. However, its uses are limited exclusively to the ancestral know-how. In the present work, three extracts were prepared from the leaves of this plant: an ethanolic extract, a methanolic extract and an aqueous extract. The yields of dry crude extracts are respectively 11.12%, 12.45% and 16.5%. The quantitative estimation of flavonoids, flavonols and total phenols by the spectrophotometric method showed that the three extracts contain these compounds. The evaluation of antioxidant capacity by the method of free radical scavenging test showed that all of the extracts have a very good reductive activity, especially for ethanolic extract which presented a percentage of inhibition equal to 78.81% with an EC50 estimated to 0.59 mg/ml. On the other hand, the FRAP test revealed that the methanolic extract has the best reducing power (66.71%) than those of the other extracts, but it remains relatively low compared to the ascorbic acid used as positive control.

KEYWORDS: *Myrtus nivellei* Batt and Trab, flavonoids, flavonols, total phenols, antioxidant activity.

RESUME: *Myrtus nivellei* Batt et Trab. est une plante saharo-endémique, appartenant à la famille des Myrtaceae, Cette plante est très réputée au sud algérien pour ses vertus thérapeutiques en médecine populaire. Cependant, ses usages restent toutefois, exclusivement limités au savoir-faire ancestral. Dans le présent travail trois extraits ont été préparés, à partir des feuilles de cette plante: un extrait éthanolique, un extrait méthanolique et un extrait aqueux. Les rendements en extraits brutes secs sont de l'ordre de 11,12%, 12,45% et 16,5% respectivement. L'estimation quantitative des flavonoïdes, des flavonols et des phénols totaux par la méthode spectrophotométrique a montré que ces trois extraits contiennent ces composés. L'évaluation du pouvoir anti-oxydant par la méthode du piégeage des radicaux libres a montré que les extraits étudiés ont tous une très bonne activité réductrice, surtout pour l'extrait éthanolique ayant présenté un pourcentage d'inhibition égale à 78,81% avec une EC50 égale à 0,59 mg/ml. D'autre part, le test de FRAP a révélé que l'extrait méthanolique a le meilleur pouvoir réducteur (66,71%) par rapport ceux des autres extraits, mais qui reste, toutefois, relativement faible par rapport à celui de l'acide ascorbique utilisé comme contrôle positif.

MOTS-CLEFS: *Myrtus nivellei* Batt et Trab., flavonoïdes, flavonols, phénols totaux, activité anti-oxydante.

1 INTRODUCTION

L'utilisation des anti-oxydants de synthèse est actuellement remise en cause en raison des risques toxicologiques potentiels. Désormais, de nouvelles sources végétales d'anti-oxydants naturels sont recherchées [1]. En effet, les composés phénoliques sont des molécules naturelles très répandus dans le règne végétal. Ces derniers regagnent une importance croissante grâce à leurs effets bénéfiques sur la santé [2]. Leur rôle d'anti-oxydants naturels suscite un très grand intérêt, notamment pour la prévention et le traitement du cancer, des maladies inflammatoires et cardiovasculaires [3]; ils sont également utilisés en tant qu'additifs en industrie agro-alimentaire, en pharmacie et en cosmétologie.

Myrtus nivellei Batt et Trab. est un arbuste de 0,5 à 2 mètres de hauteur, il s'adapte très bien à la sécheresse. Cette plante est une espèce saharo-endémique, restreinte aux montagnes du Tassili n'Ajjer, Tassili n'Immidir, Tefedest et des massifs de l'Ahaggar algérien ainsi que les montagnes du Tibesti tchadien, où elle couvre des zones très réduites [4]. Elle apparait au delà de 1400 à 2000 mètres d'altitude [5]. Elle jouit notamment d'une grande faveur populaire au sud de l'Algérie comme remède contre les infections respiratoires, les troubles gastro-intestinaux et les mycoses [6]-[4].

Dans cet article, nous ferons le point sur la composition en polyphénols des extraits de l'espèce *Myrtus nivellei* Batt et Trab., ainsi que leurs éventuels effets anti-oxydants. Des travaux antérieurs sur l'analyse de l'huile essentielle de cette plante ont montré qu'elle possède un excellent pouvoir antimicrobien [7].

Il nous paraissait alors intéressant d'investiguer, pour la première fois, le pouvoir anti-oxydant des extraits alcooliques et aqueux, préparés à partir de cette plante, dans la perspective d'obtenir de nouvelles sources potentielles de nouvelles biomolécules ayant des effets anti-oxydants.

2 MATERIEL ET METHODES

2.1 MATÉRIEL VÉGÉTAL

Les feuilles de la plante ont été récoltées sur des pieds adultes, à 146 km du chef lieu de la wilaya de Djanet, cette station est située à 94,8 km au sud de la ville d'Ihrir, faisant partie du parc national du Tassili (tableau1). Le matériel végétal récolté a été séché à température ambiante pendant 2 semaines, à l'abri du soleil, puis réduit en poudre fine qui est soigneusement conservée dans un bocal en verre jusqu'à son utilisation.

Table 1. Coordonnées géographiques du site de récolte.

Région	Altitude	Latitude	Longitude	Période de récolte	Etage bioclimatique
Tassili n'Ajjer	2018 m	24°59' Nord	8°07' Ouest	05/2012	Aride à hiver frais (Sahara central)

2.2 PRÉPARATION DES EXTRAITS ALCOOLIQUES

La préparation des extraits alcooliques est réalisée par épaulements de la poudre végétale à l'aide d'un solvant, à froid par macération dans l'éthanol [8] et à chaud par Soxhlet avec du méthanol [9]. L'extrait est ensuite stocké à 4°C durant 24h. Après filtration, le solvant est évaporé à sec sous pression réduite à 50°C à l'aide d'un évaporateur rotatif.

2.3 PRÉPARATION DE L'EXTRAIT AQUEUX

Elle est basée sur la préparation d'une décoction, en introduisant 10g de la poudre végétale dans 150ml d'eau distillée, le tout est chauffé à reflux pendant 2h. Après refroidissement et filtration, le filtrat récupéré est évaporé à sec sous pression réduite à 65°C à l'aide d'un évaporateur rotatif [10].

2.4 DOSAGE DES PHÉNOLS TOTAUX

La teneur en phénols totaux des extraits a été déterminée par la méthode de Folin-Ciocalteu [11]. Une quantité de 200ml de chaque extrait (1mg/ml) est mélangée avec 1ml du réactif de Folin-Ciocalteu et 0,8ml de carbonate de sodium à 7,5%.

L'ensemble est incubé à température ambiante pendant 30 minutes et la lecture est effectuée contre un blanc à l'aide d'un spectrophotomètre à 765nm. Les résultats sont exprimés en microgrammes équivalent par mg d'extrait sec.

2.5 DOSAGE DES FLAVONOÏDES

La teneur en flavonoïdes des extraits est déterminée en utilisant la méthode colorimétrique décrite par Kim et al [12]. Une quantité de 100ml de chaque extrait (1mg/ml) est mélangée avec 0,4ml d'eau distillée et puis avec 0,03ml d'une solution de nitrite de sodium NaNO_2 à 5%. Après 5min, 0,02ml d'une solution d' AlCl_3 à 10% est ajouté. On additionne à ce mélange 0,2ml de solution de Na_2CO_3 1M et 0,25ml d'eau distillée après 5 min de repos. L'ensemble est agité à l'aide d'un vortex et l'absorbance est mesurée à 510 nm. Les résultats sont exprimés en microgrammes équivalent par mg d'extrait sec.

2.6 DOSAGE DES FLAVONOLS

La teneur en flavonols est déterminée par la méthode de Yermakov et al [13]. On mélange 2 ml de chaque extrait (1mg/ml) avec 2 ml d'une solution d' AlCl_3 (20 g/l) et 6 ml d'une solution d'acétate de sodium (50 g/l). Après 2 heures et demi d'incubation à 20°C, la lecture de l'absorbance est réalisée à 440 nm. Le taux des flavonols est déterminé en microgramme équivalent par milligramme d'extrait sec.

2.7 EVALUATION DE L'ACTIVITÉ ANTI-OXYDANTE PAR LE TEST DPPH

Le test anti-oxydant est réalisé avec la méthode au DPPH [14]. 50 μ l de chaque extrait à différentes concentrations (de 0,25 à 1mg/ml) sont ajoutés à 1,95 ml de la solution méthanolique du DPPH (0,025g/l). Parallèlement, un contrôle négatif est préparé en mélangeant 50 μ l de méthanol avec 1,95 ml de la solution méthanolique de DPPH. Après 30 min d'incubation à l'obscurité et à température ambiante, la lecture de l'absorbance est faite à 515nm contre un blanc. Le contrôle positif est représenté par une solution d'un anti-oxydant de référence: l'acide ascorbique dont l'absorbance a été mesuré dans les mêmes conditions. Pour chaque concentration, le test est répété 3 fois. Les résultats ont été exprimés en pourcentage d'inhibition (%) et les valeurs de l'EC50 sont déterminées graphiquement par régression linéaire.

2.8 EVALUATION DU POUVOIR CHELATEUR DU FER FRAP

Le pouvoir réducteur du fer dans les extraits est déterminé selon la méthode décrite par Oyaizu [15]. Un millilitre de chaque extrait (1mg/ml) est mélangé avec 2,5ml d'une solution tampon phosphate 0,2 M (pH 6,6) et 2,5ml d'une solution de ferricyanure de potassium $\text{K}_3\text{Fe}(\text{CN})_6$ à 1%. L'ensemble est incubé au bain-marie à 50°C pendant 20 min, ensuite 2.5ml d'acide trichloroacétique à 10% sont ajoutés pour stopper la réaction. Les tubes sont ensuite centrifugés à 3000 rpm pendant 10min. Un aliquote (2,5ml) de surnageant est combinée avec 2,5ml d'eau distillée et 0,5ml d'une solution aqueuse de FeCl_3 à 0,1%. La lecture de l'absorbance est réalisée à 700nm contre un blanc préparé dans les mêmes conditions, mais en remplaçant l'extrait par de l'eau distillée, afin de calibrer le spectrophotomètre (SHIMADZU UV-1601). L'acide ascorbique et la quercétine sont utilisés comme contrôles positifs, dont l'absorbance est mesurée dans les mêmes conditions opératoires.

3 RESULTATS ET DISCUSSION

3.1 TENEURS EN PHÉNOLS TOTAUX ET EN FLAVONOÏDES

La détermination des teneurs en phénols totaux et en flavonoïdes dans les extraits: méthanolique (MeOH), éthanolique (EtOH) et aqueux de *Myrtus nivellei* a été faite par des dosages spectrophotométriques.

La teneur en phénols totaux pour chaque extrait a été rapportée en μg équivalent/mg d'extrait sec. Les résultats montrent que l'extrait éthanolique a une forte teneur en phénols totaux (734,3 \pm 0,145 μg eq/mg) par rapport à l'extrait aqueux (466,5 \pm 0,569 μg eq/mg) et à l'extrait méthanolique (348,1 \pm 0,809 μg eq/mg).

Les résultats du dosage des flavonoïdes révèlent que ces extraits présentent des teneurs modérées. En se basant sur ces données, on peut déduire que ces derniers représentent 43,74% des phénols totaux de l'extrait méthanolique, et environs 29,05% des phénols totaux de l'extrait aqueux. Ce taux ne dépasse pas 24,66% des phénols totaux de l'extrait éthanolique.

Pour ce qui est des flavonols, l'extrait éthanolique a présenté la plus forte teneur (71,75 \pm 0,456) part rapport aux autres extraits, en représentant 9,77% des phénols totaux de l'extrait éthanolique (Tableau 2).

Table 2. Résultats du rendement et des dosages réalisés sur les extraits de *M nivellei* Batt et Trab.

Paramètre	Etalon sélectionné	Longueur d'onde (nm)	Taux (µg eq/mg)*		
			Extrait aqueux	Extrait MeOH	Extrait EtOH
Phenols totaux	Acide gallique	765	466,5±0,569	348,1±0,809	734,3±0,145
Flavonoïdes	Quercetine	510	135,5±0,256	152,25±0,485	181,1±0,073
Flavonols	Rutine	440	40,485±0,654	38,5±0,457	71,75±0,456
Rendement des extraits			16,5%	12,45%	11,12%

*Les valeurs sont la moyenne de trois répétitions ± écart type

3.2 RÉSULTATS DU TEST DPPH

L'activité anti-oxydante des extraits étudiés et de l'acide ascorbique (contrôle positif) vis-à-vis du radical DPPH, à été évaluée en suivant la réduction de ce radical qui s'accompagne par son passage de la couleur violette (DPPH[•]) à la couleur jaune (DPPH-H), mesurable au spectrophotomètre à 515nm. Cette capacité de réduction est déterminée par une diminution de l'absorbance induite par des substances anti-radicalaires [10]. Les valeurs EC50 déterminées en mg/ml expriment la concentration efficace de l'extrait anti-oxydant nécessaire pour le piégeage et la réduction de 50% de molécules de DPPH en dissolution dans du méthanol. Un autre paramètre exprimant la puissance anti-radicalaire à été calculé nommé "ARP" qui est égale à 1/EC50 (Tableau 3).

Table 3. Effet anti-oxydant des trois extraits de *M nivellei* Batt et Trab.

Extraits étudiés	% d'inhibition	EC ₅₀ (mg/ml)	PAR
Extrait aqueux	74,08	0,71±0,115	1.41
Extrait MeOH	52,00	0,98±0,256	1,02
Extrait EtOH	78,81	0,59±0,052	1,69
Acide ascorbique (Cp)	86.62	0.39±0,754	2.56

Selon les résultats enregistrés, l'extrait éthanolique est doté d'un bon pouvoir anti-oxydant (EC50=0,59mg/ml), meilleur que celui exprimé par l'extrait aqueux et l'extrait méthanolique, mais reste d'une efficacité moindre par rapport à celle exprimée par l'acide ascorbique utilisé comme contrôle positif (fig 1, fig 2, fig 3 et fig 4).

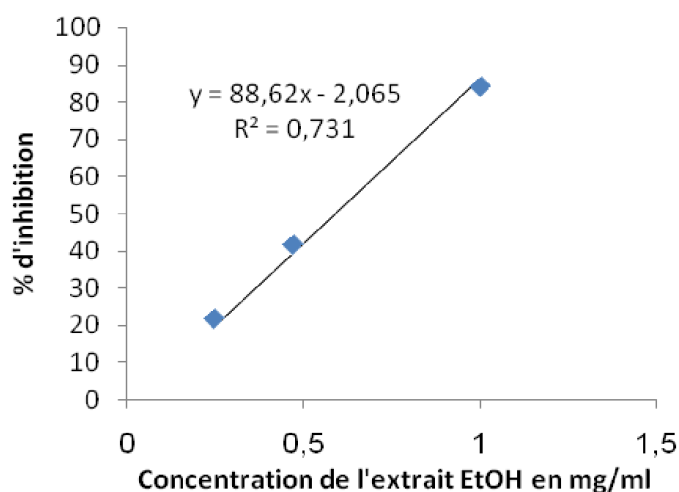


Fig. 1. Pourcentage d'inhibition du DPPH en fonction des concentrations de l'extrait éthanolique

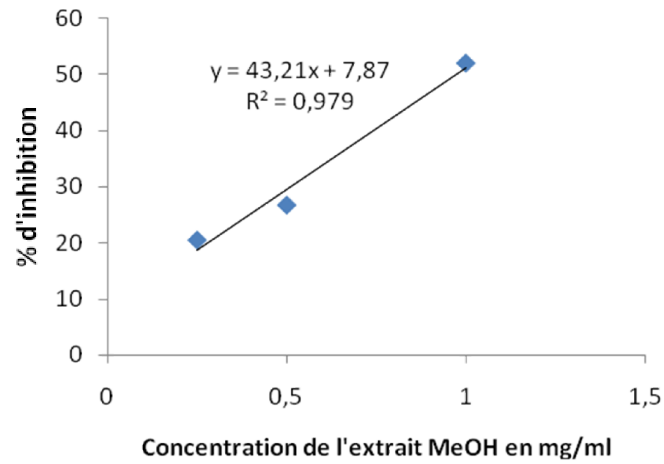


Fig. 2. Pourcentage d'inhibition du DPPH en fonction des concentrations de l'extrait méthanolique

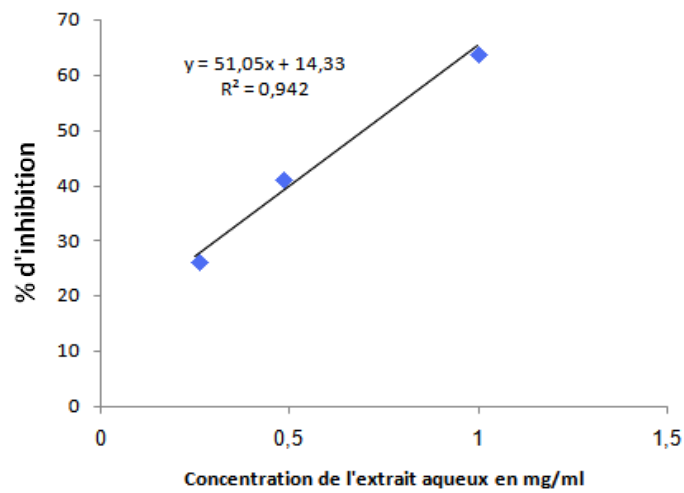


Fig. 3. Pourcentage d'inhibition du DPPH en fonction des concentrations de l'extrait aqueux

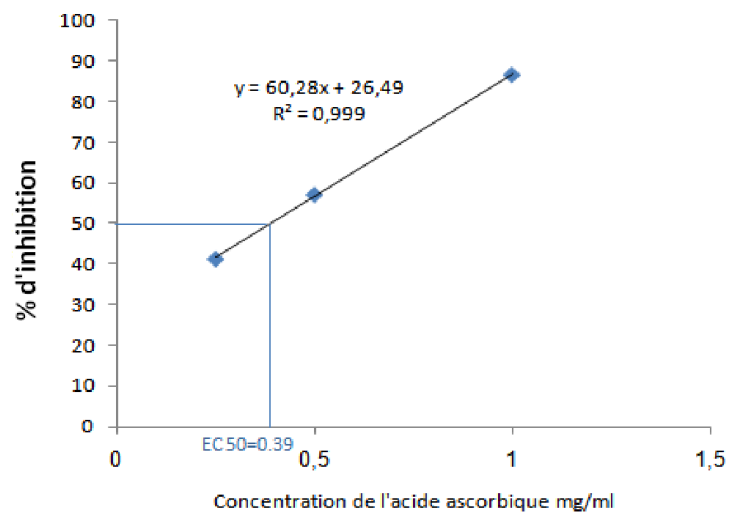


Fig. 4. Pourcentage d'inhibition du DPPH en fonction des concentrations de l'acide ascorbique

Il a été démontré que les molécules anti-oxydantes telles que l'acide ascorbique, l' α -tocophérol, les flavonoïdes et les tanins réduisent et décolorent le radical DPPH à cause de leur capacité à céder l'hydrogène [16]. La richesse de l'extrait éthanolique en composés phénoliques témoigne de son remarquable effet anti-oxydant enregistré.

L'activité anti-oxydante des extraits dépend essentiellement du taux des polyphénols accumulés durant le cycle végétatif de la plante [17]. L'EC50 de l'espèce *Myrtus communis* L., rapportée par les travaux de Gardeli et al. [18], est comprise entre 0,0095 et 0,017mg/ml, ces mêmes auteurs ont également démontré que les extraits de *M communis* L. récoltés en période estivale sont les plus anti-oxydants.

3.3 RÉSULTATS DU TEST FRAP

L'étude du pouvoir réducteur des ions Fe^{3+} est évalué par le test FRAP, qui est largement applicable aussi bien sur les plantes que les plasmas et dans les extraits organiques et aqueux [19].

Le pourcentage de chélation des ions Fe^{2+} exercé par l'acide ascorbique est égal à 43,22%. Ce dernier est dix fois plus important, que celui de la quercétine n'ayant exprimé que 4,98% (tableau 4).

Les résultats obtenus montrent que l'extrait éthanolique de *M nivellei* présente le meilleur pouvoir chélateur estimé à 64,8577%, largement supérieur à celui exprimé par l'extrait aqueux et l'extrait méthanolique ainsi qu'à celui des contrôles positifs (Cp).

D'après les travaux de Gardeli et al. [18], l'extrait méthanolique de *M communis* L. exerce un important effet chélateur en pourcentage de réduction des ions Fe^{2+} estimé entre 63,4 \pm 0,4 et 70,2 \pm 2,3 mmol Fe^{2+} /l, il a aussi confirmé qu'il varie significativement selon les saisons.

Les variations de l'activité réductrice des radicaux libres, sont, en général, directement liées aux taux des composés phénoliques présents dans la plante récoltée [20].

Table 4. Effet réducteur des extraits de *M nivellei* Batt et Trab.

	Contrôles positifs (Cp)		Extrait EtOH	Extrait MeOH	Extrait aqueux
	Acide ascorbique	Quercétine			
% FRAP	43,22	4,98	64,8577	3.309	35.1422

La présence des réducteurs dans les extraits des plantes provoque la réduction de Fe^{3+} /complexe ferricyanide à la forme ferreux. Par conséquent, le Fe^{2+} peut être évalué en mesurant et en surveillant l'augmentation de la densité de la couleur bleu dans le milieu réactionnel à 700nm [21].

En d'autre terme, le complexe réactionnel $FeCl_3/K_3Fe(CN)_6$ facilite la détermination "semi-quantitative" de la concentration des composés phénoliques qui participent à la réaction rédox [22]

On suggère que Le pouvoir réducteur des extraits de l'espèce *Myrtus nivellei* Batt et Trab. est probablement dû à la présence de groupements hydroxyles dans les composés phénoliques qui jouent le rôle de donneurs d'électrons. Par conséquent, on peut les qualifier comme des réducteurs et inactivateurs des radicaux libres. Plusieurs travaux ont également montré que le pouvoir réducteur d'un composé peut être considéré comme un indicateur de son potentiel effet anti-oxydant [23, 24]

4 CONCLUSION

L'étude de l'activité anti-oxydante des extraits issus de l'espèce *Myrtus nivellei* Batt et Trab. selon la méthode de la réduction du fer et celle du piégeage du radical libre DPPH a montré que les extraits éthanolique, méthanolique et aqueux possèdent une activité anti-oxydante intéressante. Ces extraits pourraient ainsi constituer une alternative à certains additifs de synthèse, bien que cette activité reste, néanmoins, nettement inférieure à celle exprimée par l'acide ascorbique.

Cependant, ces extraits sont constitués d'un mélange de plusieurs composés de nature chimique différente. Il est ainsi très probable qu'ils contiennent des molécules susceptibles d'avoir des propriétés anti-oxydantes similaires à celle de la l'acide ascorbique, ce qui ouvre de larges perspectives pour établir des études plus approfondies afin de les isoler et les identifier.

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Design and Development Efficient Pressure Generating System at Expiratory End in a Bubble CPAP System

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ABSTRACT: Application of Continuous Positive Airway Pressure (CPAP) in neonate with respiratory distress is associated with reduction of respiratory failure, reduced complications and mortality. Devices used to generate CPAP include conventional ventilators, the “bubble bottle” system and the infant flow driver. CPAP supports the breathing of preterm infants in a number of ways. It splints the upper airway and reduces obstruction and apnea, assists expansion of the lungs, and prevents alveolar collapse. But when we consider using Bubble CPAP system in Emergency Medical Services like Air Ambulance, it is extremely difficult to maintain constant back pressure created by bubbles in water bottle to the expiratory end of nasal prongs of an infant. So in order to provide constant back pressure, there is a need to replace water bottle which produce back pressure by bubble at expiratory end with a Electro-Mechanical constant pressure generating system. A Proportional solenoid valve based Electro-Magnetic Pressure Generator device is proposed, which produce constant back pressure of 5-10cmH₂O Pressure and Pressure versus Voltage relationship is studied which shows pressure generated is proportional to input Voltage.

KEYWORDS: bubble CPAP, Low Pressure Generation, Electro-mechanical device, Expiratory End.

1 INTRODUCTION

Acute respiratory infections are the leading cause of global child mortality. In the developing world, nasal oxygen therapy is often the only treatment option for babies who are suffering from respiratory distress. Without the added pressure of bubble Continuous Positive Airway Pressure (bCPAP) which helps maintain alveoli open, babies struggle to breathe and can suffer serious complications, and frequently death.

Continuous positive airway pressure (CPAP) is a non-invasive and spontaneous breathing form of positive ventilation. Bubble CPAP (continuous positive airway pressure) supports spontaneous breathing by delivering a continuous, pressurized

gas flow to an infant’s airway. The gas is usually humidified air, enriched with oxygen, and is delivered to the infant’s nose through a breathing circuit and nasal prongs. The pressure of the delivered gas is controlled by simply adjusting the depth of a partially submerged tube attached to the end of the infant’s breathing circuit. B-CPAP may provide additional benefits over conventional nasal CPAP systems because as gas exits the submerged tube it forms bubbles that create small airway pressure oscillations. These oscillations are transmitted to the patient’s lungs and are thought to improve gas exchange, enhance lung recruitment and reduce the work of breathing.

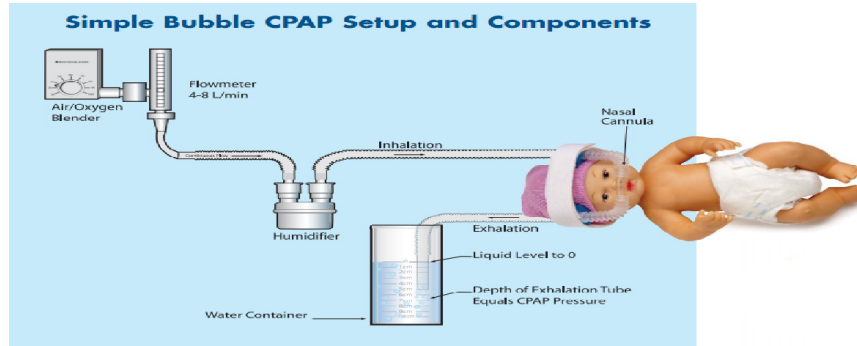


Fig.1: Infant under Bubble CPAP System

The vibration and pressure created by the combination of the humidified air and water column is why doctors like the CPAP system. A new born's lungs are sensitive organs and can be easily damaged by a mechanical ventilator. The CPAP opens the lungs without the use of the pressure created by the mechanical ventilator. The CPAP creates only the pressure needed to open the baby's lungs for proper air flow and, unlike a mechanical ventilator, it doesn't force a new born to breathe.

2 METHODOLOGY

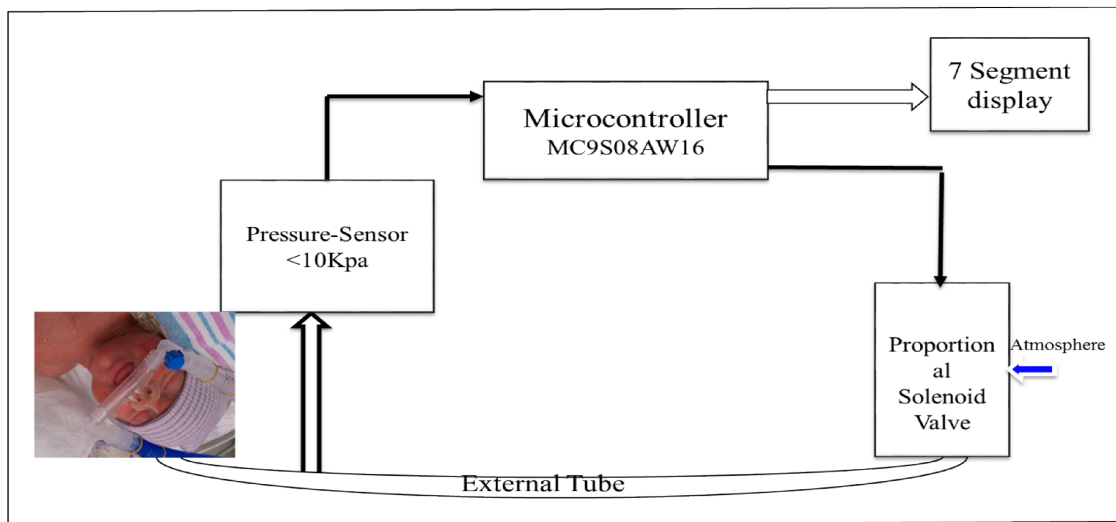


Fig.2: System Block Diagram

The block diagram below depicts the steps involved in the implementation of the project. Microcontroller digital ON or OFF output drive the Miniature Solenoid Valve and able to produce desired Pressure,

The Pressure Generated by normally opened Miniature solenoid Valve is validated by using differential Pressure Sensor. The output analog voltage from Pressure Sensor is converted into digital value using inbuilt 10 Bit-ADC. The ADC result is converted into appropriate standard Pressure Value and displayed in seven segment display.

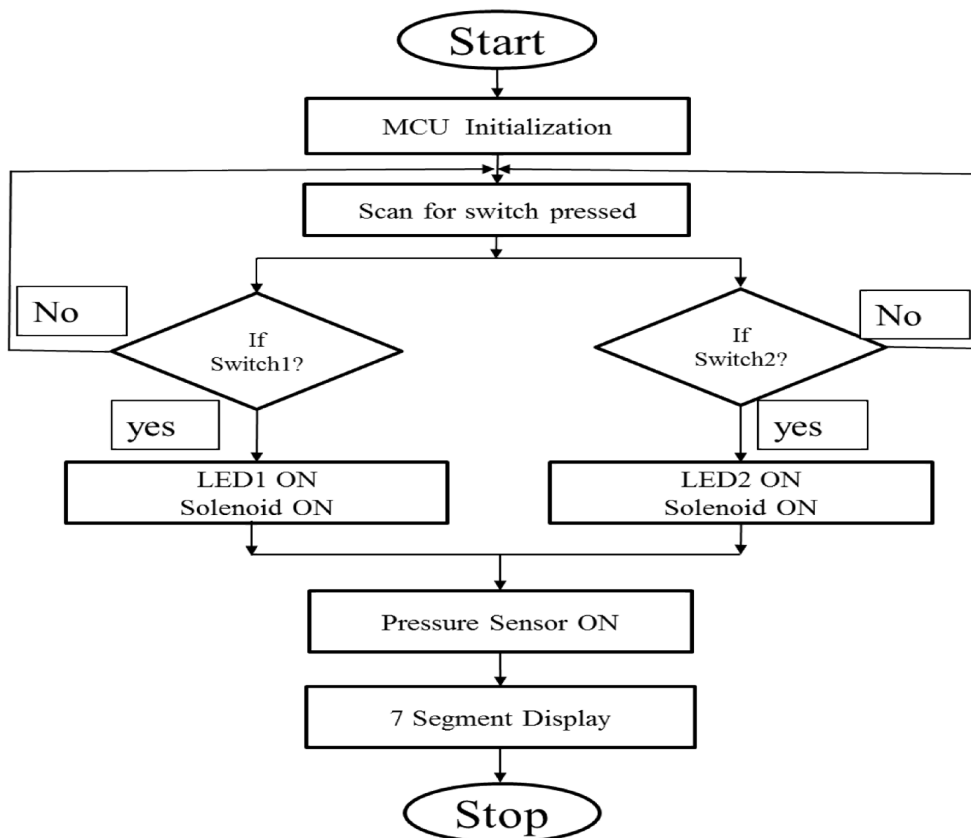


Fig.3.Flowchart

3 RESULTS

Stage-1

Initially, the pressure created by bubble in water bottle is measured by pressure sensor, the pressure sensor converts pressure into analog voltage. This voltage is given to ADC Pin of free-scale microcontroller and displayed in seven segment display.

The relation between Pressure and Voltage is studied and tabulated below

$$V_{out} = (5 \pm 1.275) (0.009 \times P) \dots\dots\dots (6.1)$$

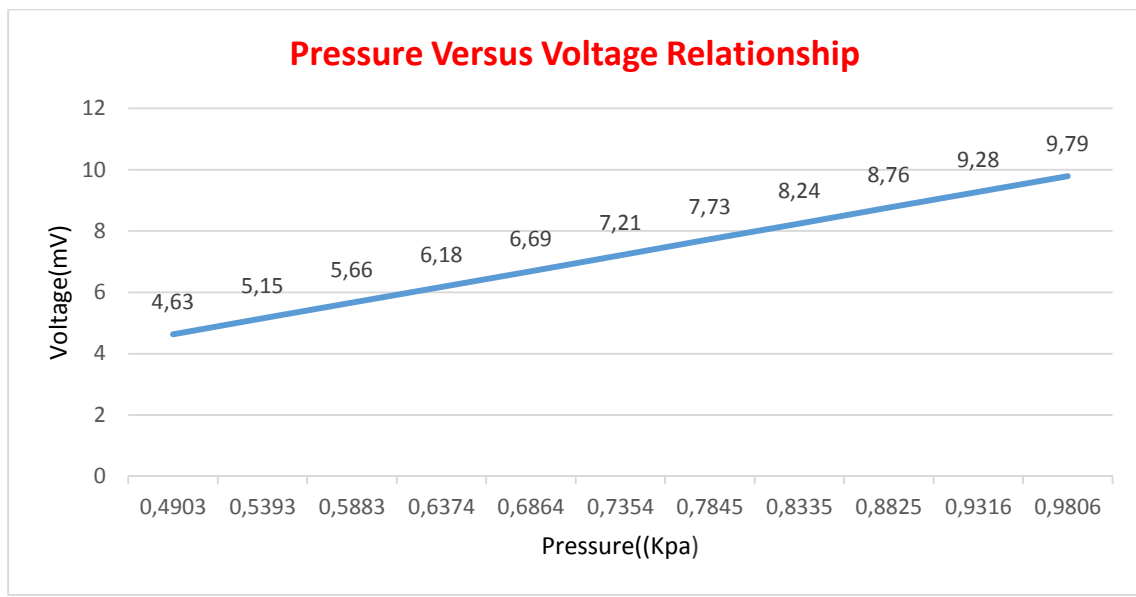
$$P_{in\ KPA} = V_{out} + (.5) \times 0.095 \dots\dots\dots (6.2)$$

V_{out} = Output Voltage

$P_{in\ Kpa}$ = Pressure in unit Kilo-Pascal

Tabular Column of pressure and voltage reading

Pressure value in cm of water(cm H ₂ O) unit	Pressure value in Kilo-Pascal(Kpa) unit	Analog Voltage(mV)
5	0.4903	4.63
5.5	0.5393	5.15
6	0.5883	5.66
6.5	0.6374	6.18
7	0.6864	6.69
7.5	0.7354	7.21
8	0.7845	7.73
8.5	0.8335	8.24
9	0.8825	8.76
9.5	0.9316	9.28
10	0.9806	9.79



According to above graph, it can be shown that pressure and voltage are directly proportionally. So display of voltage value in seven segment display is directly proportional to pressure produce by 'bubble' in water bottle system.

Stage-2

Proportional solenoid valve is connected to pressure sensor and make it ON and OFF.

With altering delay in time (ms), we can able to achieve desired pressure which is equal to pressure produced by 'bubble' in water bottle.

Tabular Column of delay, pressure and voltage reading

Solenoid with different delay(ms)	Pressure value in Kilo-Pascal(Kpa) unit	Analog Voltage(mV)
15000	0.4903	4.63
14150	0.5393	5.15
13300	0.5883	5.66
12450	0.6374	6.18
11600	0.6864	6.69
10750	0.7354	7.21
9900	0.7845	7.73
9050	0.8335	8.24
8200	0.8825	8.76
7350	0.9316	9.28
6500	0.9806	9.79

4 CONCLUSION

In the Proposed model, efficient portable electro-mechanical pressure generating system for a bubble CPAP system is possible and constant pressure of about 5-10cm H₂O (0.490-0.980Kpa) produced and is equal to pressure produced by 'bubble' in water bottle which is attached to an expiratory end of nasal prong attached to infant nose Thus these proposed system can be used as portable system in emergency medical system like air ambulance and makes maintenance easy compare to present bubble CPAP system .

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Wear behaviour of sand cast eutectic Al-Si Alloy in hydraulic brake fluid

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ABSTRACT: The report of investigation of the wear behaviour of aluminium alloy samples used in the floating calliper of master cylinder clutch or brake is presented in this paper. As-received commercial aluminium alloy sample sourced from automobile hydraulic brake cylinder calliper was melted in electric furnace under a controlled atmosphere, and sand cast at pouring temperature range of 700-800 oC into rod of 300 mm long by 30 mm diameter. A wear jig was used to determine the wear resistance of the aluminium samples with and without the use of hydraulic fluid. The microstructures and surface of the as-received and cast specimen were examined under high resolution microscope to assess the effects of wear with and without hydraulic oil. It was observed that the aluminium sample wears faster in the absent of hydraulic fluid and was reduced to a bearable minimum when hydraulic fluid was applied. The results obtained are presented in figures showing the wear rates and weight loss of the aluminium samples with respect to the wear cycle, from which models equations are derived. The test results show that eutectic structured cast aluminium alloy behaves relatively better than the as-received aluminium alloy specimen in oil. It is significant that the oil functions as lubricant on the alloy under test, hence the common deteriorations experience from the cast alloy under service must have aggravated from the chemical adulterations in the oil wherewith a thin film of more wear and chemical resistance would bring effective and significant wear and corrosion protection or both to the surface.

KEYWORDS: Wear rate, cast aluminium, sand casting, eutectic Al-Si Alloy, hydraulic brake fluid.

1 INTRODUCTION

The use of aluminium alloys in machine building and automobile industries is very popular which is characterised by its high strength to weight ratio. Many engineering devices such as automotive engines, in cylinder blocks and crankcases, cylinder heads, master brake and clutch cylinder are produced from varieties of aluminium alloys [1]. This characteristic is no doubt has contributed to the combination of light weight–high strength characteristics of the component under application. Nevertheless cylinder components contribute to about 30% of total friction in an automotive engine [2] and this may include the hydraulic brake and clutch. Wear is a mechanical material deterioration process occurring on rubbing or impacting surfaces, while corrosion involves chemical or electrochemical reactions of the material. The former is commonly reduced by lubrication while the latter could be controlled by the composition of the fluid. [3]

Hydraulic fluid is used in hydraulic brake and clutch applications in automobiles. Most accepted brake fluids used today are glycol-ether based and are not expected to be corrosive. Untreated or poorly formulated lubricants (mineral-based oils and synthetic-based oils) do not possess the necessary properties to be effective in the demanding lubrication environments that exist today. To perform the above-mentioned functions properly, base fluids need the help of chemical additives as inhibitors [4]. Nigeria automobile markets are circulated with imported low quality or adulterated hydraulic brake oil and aluminium alloy products from the Asian world (specifically China, Taiwan and even Japan) which in many instances do not meet with the international standards specifications [5]. The fluids tend to condense and cause corrosion under service application. Since friction generates heat, there is tendency for temperature change and the occurrence of condensation.

To make things worse, many local foundry shops produce cast aluminium products of very poor surface finishing. The combination of friction and fluid has the potential to cause wear of the aluminium alloy component under application. The corrosive fluid accelerates wear and vice versa [6]. Hence there can be corrosion accelerated wear or wear accelerated corrosion and this is known as tribocorrosion. [7], [8]. Wear, fatigue failure, corrosion, and oxidation all begin at the surface and can rapidly lead to stress concentration, fracture, increased friction, and other problems [9], [10].

There are many reports on the mechanical, thermal, electrical and corrosion behaviours of various classes of aluminium and aluminium alloys in different media and environments such as acid, bases, salts, organic and in-organic fluids and agro-fluids [11], [12]. Tribological and corrosion experiment reports are the most popular and have been in literature. [13], [14], [15]. Wear is a mechanical material deterioration process occurring on rubbing or impacting surfaces, while corrosion involves chemical or electrochemical reactions of the material [16], [17], [18]. Hence, the need to assess the wear characteristics of the cast aluminium alloy in hydraulic fluid under application is investigated and reported in this paper.

2 MATERIALS AND METHOD

2.1 SOURCING AND THE CHARACTERISATION OF SAMPLE

The aluminium alloy sample was sourced from the floating calliper of the automobile master brake cylinders procured from automobile spare part shop at Ado Ekiti. The specimen was designated as Sample 1 (As received Al alloy). It was melted and sand cast to get a specimen designated as Sample 2 (cast aluminium). The hydraulic fluid sourced from Brake oil (DOT 3) was procured from automobile spare part shop. The equipments used for the experiment include: electronic digital weight meter (model DT-502A, 0.0001g), lathe machine, drilling machine, mitre saw and wear jig.

The chemical compositions of Aluminium alloy specimens were determined using Atomic Absorption Spectrometer (AAS) Thermo series 2000 Model. The results of chemical composition are presented in Table 1. The properties of hydraulic fluid (brake oil) as published by the manufacturer is given on Table 2 (Appendix). Micro-structures of as-received and cast aluminium alloy samples were studied under higher resolution metallurgical microscope with digital camera. The microstructures of the sections were examined under x200, x400, x800 magnifications and are presented in Plates 4.1 (a-c) and 4.2 (a-b). An average of four points of harness tests was carried out over an area of each of the specimen surface to determine the BHN following the standard procedure and specification tables attached to the machine. The BHN is determined using Equation 1 and the results of hardness tests are presented in Table 3.

$$\text{BHN} = \frac{F}{\frac{\pi}{2}D(D - \sqrt{D^2 - D_i^2})} \quad (1)$$

Where BHN = the Brinell hardness number, F = imposed load in kg, D = diameter of the spherical indenter in mm, Di = diameter of the resulting indenter impression in mm

2.2 PREPARATION OF TEST SAMPLES

The specimen for the wear test are prepared from 2000 g of as-received aluminium alloy sourced from automobile master brake calliper (piston) was melted at range of temperature of 750~800 °C in electric furnace under a controlled atmosphere. The alloy was sand cast into rod of 30 cm long by 3 cm diameter (Plate 1) from which the set of piston specimen were cut and machined out. The cast aluminium was turned on the lathe machine to obtain smoother surface of the sample. They were machined to obtain pistons of 10 cm long by 1.2 cm diameter suitable for wear resistance test (Plate 2). The surface of the aluminium alloy samples were grinded and polished with different types of polishing grit which include 50µm, 60µm, 100µm, 220µm, 320µm, 400µm, 600µm, 800µm, 1200µm and 2400µm on the grinding and polishing machines.



Plate 1: Turned cast aluminium alloy



Plate 2: Machined specimen for wear test

2.3 WEAR TEST OF ALUMINIUM ALLOY SAMPLES WITH AND WITHOUT HYDRAULIC FLUID

The as-received Aluminium alloy or cast machined sample (calliper or piston) specimen is material inserted inside master cylinder of the wear test jig machine after taking the initial weight of the specimen. The machine is powered on to jig the aluminium alloy piston thereby causing some wearing effect on it during the operation of the machine. The specimen was jig at different wear cycles or revolutions (1,225 to 269,500 wear cycles). The final weight of the specimen was determined using a very sensitive digital weight meter. The experiment was first performed without filling the oil cavity with brake oil and later performed with the use of hydraulic fluid for necessary comparison of the wear rate.

Determining the wear surface area A of aluminium alloy specimen

$$d = 15 \text{ mm}, l = 100 \text{ mm}$$

$$A = l \times \pi d / 2 = 23.565 \text{ cm}^2$$

Where d = diameter, l = length of the specimen and A = wear surface area

The volume loss (wear volume) of aluminium alloy sample during the experiment was determined using Equation 2,

$$\text{Density } \rho \text{ (in gcm}^{-3}\text{)} = \text{mass } M \text{ (g)} / \text{volume } V \text{ (cm}^3\text{)}. \tag{2}$$

where V = Wear volume loss $V_w = M/\rho$,

given that $\rho_{\text{aluminium}} = 2.7 \text{ g cm}^{-3}$

Whereas the wear rate was calculated in $\text{mg/cm}^2/\text{mins}$ using Equation 3

$$\text{Wear rate} = V_w / \rho A t \tag{3}$$

Where: V_w = Wear volume loss (cm^3), M = Weight loss or wear loss (mg), ρ = Density of the material (in gcm^{-3}) = 2.7 gcm^{-3} for aluminium alloy

A = Surface area of wear exposure (cm²), t = Wear time (in minutes)

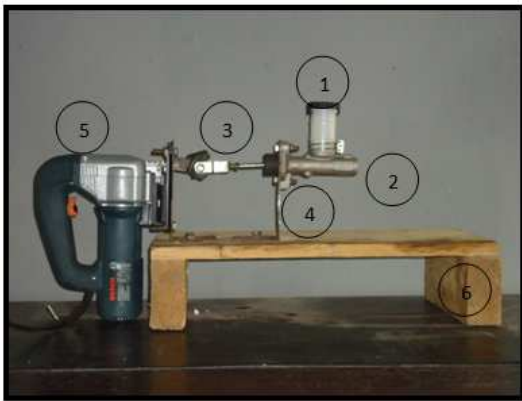
1 minute revolution of jiggling = 1225 wear cycles.

Wear resistance, R, which is simply defined as the reciprocal of wear volume w:

$$R = \frac{1}{W} \tag{5}$$

Where the wear volume is given as $W = k_3 \frac{Ld}{H}$ (6)

In Archard's equation which was derived for adhesive wear but also, has proven very useful in abrasive wear. The results and micrographs of surface wear of as-received and cast aluminium alloys with and without oil are presented in Figures 1-4 and Plates 6-8.



- 1-Hydraulic brake oil chamber
- 2-Cylinder containing the calliper
- 3-Coupling
- 4-L-support
- 5-Electric power jig
- 6-Wooden platform

Plate 3: Pictorial view of wear jig

3 RESULTS AND DISCUSSION

The results of chemical compositions of As-received Aluminium alloy and Cast aluminium alloy sample used in this experiment are presented in Table 1.

Table 1: Chemical composition of Aluminium alloy

Samples	Al	Si	Mg	Fe	Mn	Cu	Zn	Cr	Ti
As-received aluminium alloy	98.87	0.38	0.40	0.23	0.001	0.01	0.001	0.001	0.001
Cast aluminium alloy	98.44	0.32	0.29	0.16	0.001	0.01	0.001	0.001	0.001

The microstructure obtained from as-received and cast aluminium alloy samples studied under higher resolution metallurgical microscope with digital camera are shown in Plate 4(a-c) and Plate 5(a-c)



Plate 4: Micro-structure of As-received aluminium alloy sample

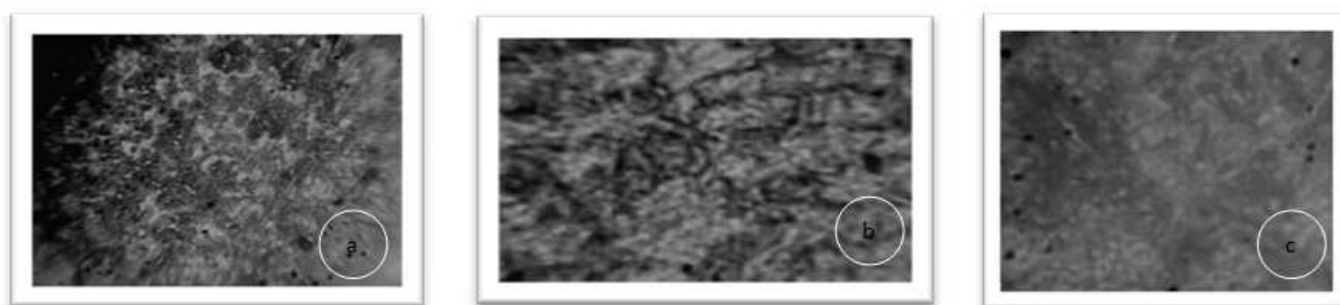


Plate 5: Microstructure of sand cast eutectic Al-Si Alloy.

The results of four point hardness tests of Sample 1 (As received alloy AR) and Sample 2 (Cast aluminium alloy AC) are presented in Table 3.

Table 3: Hardness tests of aluminium alloy samples

Samples	Point 1	Point 2	Point 3	Point 4	Average BHN
As-received A alloy (AR)	43.8	43.7	43.2	43.7	43.6
Cast Al alloy (AC)	63.4	64.4	64.1	63.3	63.8

3.1 CHARACTERISTICS OF THE ALUMINIUM SAMPLES

As-received and cast samples were characterised by carrying out the chemical analyses by AAS, and XRD for structural analyses. This is done to ascertain the chemical composition of the sample. The micro-structural examination is carried out to reveal the micro structure of the alloy and to compare the similarities and differences between the grain sizes, phases and structures of as-received and cast samples. The hardness tests of Aluminium alloy samples were determined using Brinell Hardness Testing Machine. The hardness values are compared as means of identifying their behaviour under friction with respect to their composition and micro-structure. With these, some reasons for their corrosion and wear behaviours could be understood.

The results of chemical compositions of as-received Aluminium alloy and Cast aluminium alloy sample used in this experiment are presented in Table 1. The analysis shows that 98.87 %Al, 0.38 %Si, 0.40 %Mg, and 0.23 %Fe were present in the as-received aluminium alloy; 98.44 %Al, 0.32 %Si, 0.29 %Mg, and 0.16 %Fe were present in the cast aluminium alloy while equal amount of 0.001 %Mn, 0.01 %Cu, 0.001 %Zn, 0.001 %Cr and 0.001 %Ti were obtained in both as-received and cast aluminium specimens.

The eutectic Al-Si microstructures obtained from the cast aluminium alloy samples studied using higher resolution metallurgical microscope with digital camera under x200, x400, x800 are shown in Plates 4(a-c) and 5(a-c). The microstructure of as-received aluminium alloy sample has more coarse grains than the cast aluminium alloy sample. This is reflected in the result of hardness tests obtained on the as-received aluminium alloy (control sample) and Cast aluminium alloy in Table 3. The average BHN obtained from the as-received aluminium alloy sample is lower as compared with the cast aluminium alloy examined under the same conditions. From these results, the wear behaviours could be understood since fine grained microstructure would produce produced hard material in the cast alloy.

3.2 WEAR TEST OF ALUMINIUM ALLOY SAMPLES WITH AND WITHOUT HYDRAULIC OIL.

Figures 1-4 illustrate the wear rate study of AR and AC aluminium alloy samples with and without hydraulic oil. The figures show the variation in the wear cycle and wear loss of as-received and cast aluminium alloy samples with and without hydraulic oil. Figure 1 shows obviously that both AR and AC aluminium alloy samples have higher wear loss without hydraulic oil than with hydraulic oil. It is shown in Figures 2 and 3 that AC has lower wear rates than AR the under wear tests, with and without hydraulic oil. The wear loss and wear rate of AR and AC increase steadily with the increase in the wear time from zero to 134750 wear cycle above which there is sudden sharp increase in the wear loss and wear rate of both samples under test. The resistance to wear of AR and AC under test with hydraulic oil is much higher that the counterpart AR and AC without hydraulic oil. Likewise, the resistance AC to wear under test with hydraulic oil is much higher that the counterpart AR with hydraulic oil.

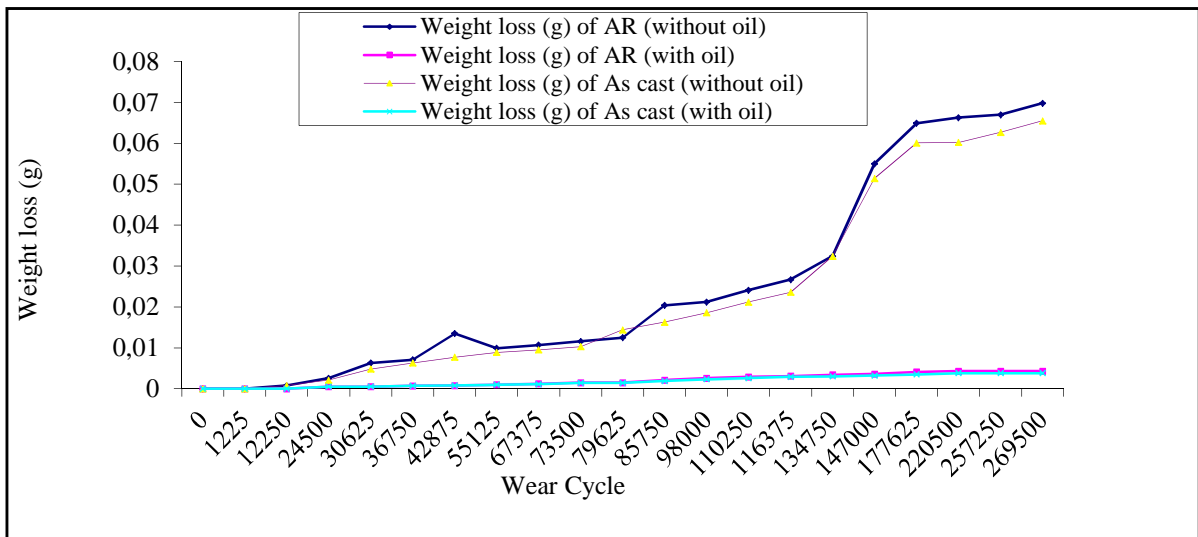


Figure 1: Wear loss of As-received and Cast aluminium alloys with and without oil

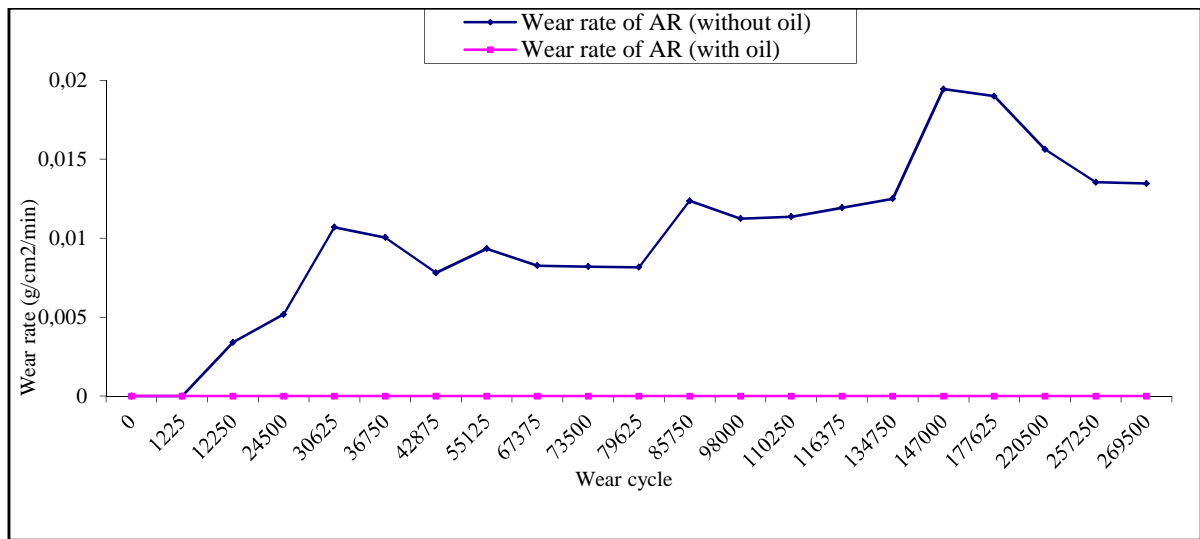


Figure 2: Wear rate of As-received aluminium alloy with and without oil

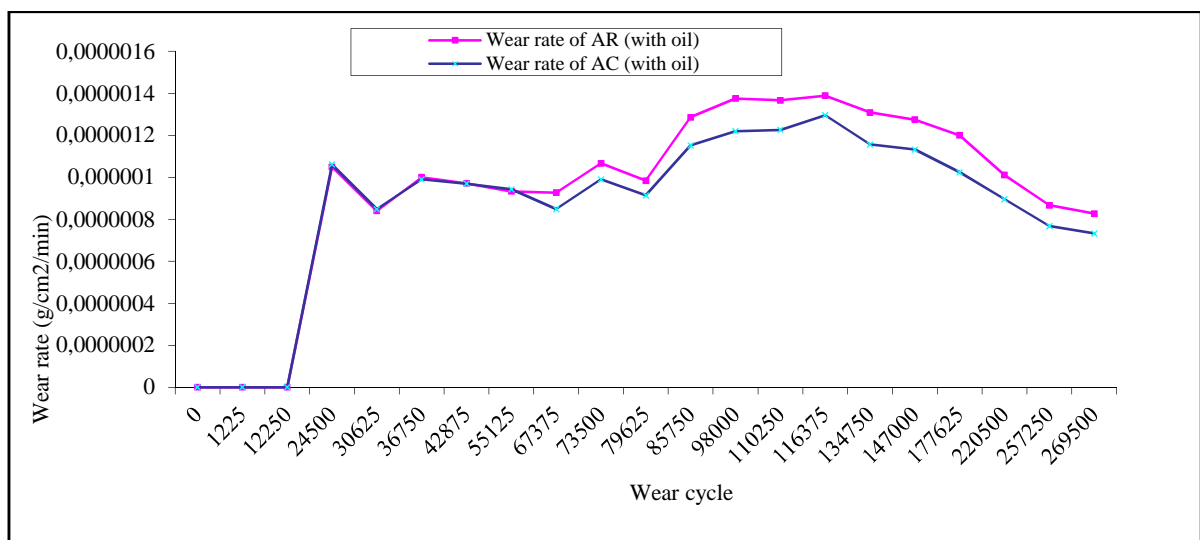


Figure 3: Wear rates of As-received and cast aluminium alloys with oil

The trend of the wear rate with respect to increasing wear cycle was studied using the experimental data generated from the experiment. The best fit models for the trend using MS excel application were of polynomial equations to power 2 relating the wear loss and wear rates of AR and AC to wear cycle tested with and without hydraulic oil respectively.

The models developed for the wear rate from the study are:

$$\text{AR wear rate with oil} \quad M_{n1} = -8E-09c^2 + 2E-07c - 3E-07 \quad (7)$$

$$\text{AC wear rate with oil} \quad M_{n2} = -8E-09c^2 + 2E-07c - 2E-07 \quad (8)$$

$$\text{AR wear rate without oil} \quad M_{n3} = -3E-05c^2 + 0.001c - 0.000 \quad (9)$$

$$\text{AC wear rate without oil} \quad M_{n4} = -3E-08c^2 + 1E-06c - 3E-07 \quad (10)$$

Where $0 \leq c \leq 269500$, c = wear cycle, M_{n1} , M_{n2} , M_{n3} and M_{n4} are the wear rates (in $g/cm^2/min$) of as-received AR and cast aluminium alloy AC with respect to wear cycle tested with and without hydraulic oil respectively. Similar trend of wear rate equations were defined by the two samples during the tests with and without hydraulic oil.

The model equation 7 for the wear of AR without oil is avoided while model equation 8 for the AR with oil is the traditional condition under which the hydraulic master brake operates.

Model equation 9 and model equation 10 are both applicable under the condition where there is need for the replacement of less wear resistant AR while model equation 10 could be applied to reduce fretting corrosion and tribocorrosion effects on the application of cast aluminium alloy in service.

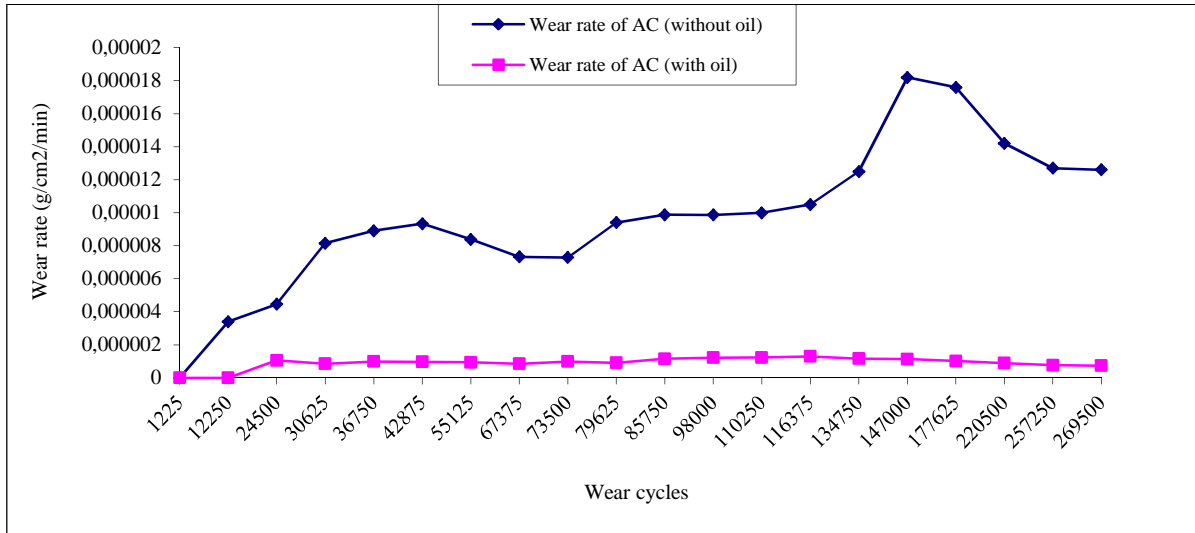


Figure 4: Wear rates of cast aluminium alloys with and without oil

Micrographs of as-received and cast aluminium alloy samples before and after wear tests are shown in plates 6-8 below.

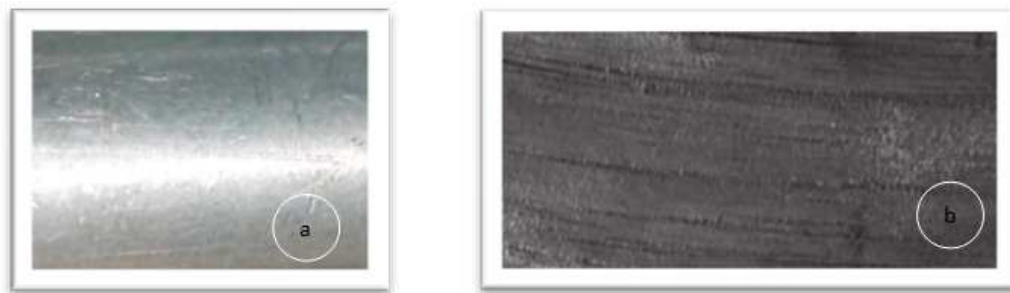


Plate 6: As-received surfaces (a) before and (b) after wear test in hydraulic oil

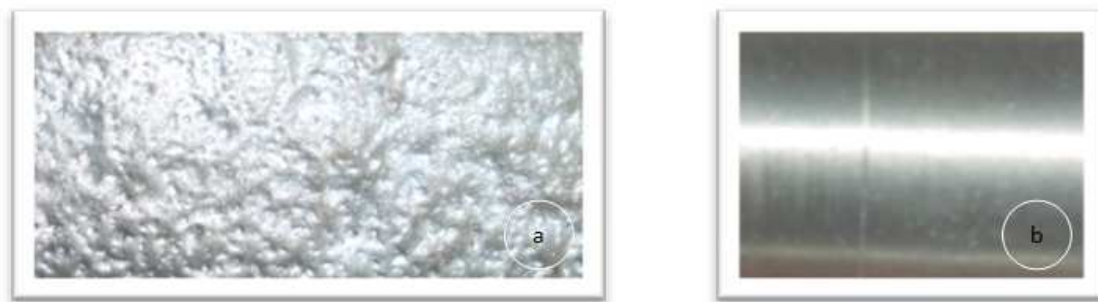


Plate 7: As cast surfaces (a) before and (b) after machining (turning) on lathe



Plate 8: Machined as-cast surface after wear tests (a) with oil and (b) without oil

4 CONCLUSION

The test results show cast aluminium alloy behaves relatively better than the as-received aluminium alloy specimen in oil. It is significant that the oil functions as lubricant on the alloy under test, hence the common deteriorations experience from the cast alloy under service must have aggravated from the chemical adulterations in the oil. A thin film of more wear and chemical resistance would bring effective and significant tribological and corrosion protection or even both to the surface.

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6 APPENDIX

Table 2: Properties of hydraulic fluid (brake oil)

Composition / Information on Ingredients	
Ingredient Name	% wt or % vol
Alkylene Glycols	5-20
Trade Secret Inhibitor Package	<3
Physical and Chemical Properties	
Physical State	Liquid
Appearance and Odour	Yellow to amber liquid with a mild odour.
Vapour Density (Air = 1):	>1
Density:	8.33 to 9.02 lb/gal
Specific Gravity (H ₂ O = 1, at 4 °C):	1.000 to 1.070
pH	10.0 – 11.5
Water Solubility:	Soluble
Boiling Point:	(248.9 °C)
Chemical name	DOT 3 brake fluid
Chemical Formula	Not applicable, this product is a mixture of glycols / glycol ethers

Source: Manufacturer-Dot Chemicals, Inc. Texas

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Assessment of genetic diversity through D² analysis in tomato (*Solanum lycopersicon .L*)

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ABSTRACT: The present experiment was conducted during spring-summer 2013 to study genetic variability, correlation, path coefficient analysis, and genetic diversity for quantitative and qualitative traits in tomato in vegetable research farm Hisar. Using Mahalanobis D² statistics method, the 27 genotypes were grouped into nine clusters, indicating the presence of diversity for different traits. The cluster I had the highest number containing 16 genotypes followed by cluster III and VII containing three and two genotypes respectively. However, the cluster II, IV, V, VI, VIII and IX were solitary. The maximum intra-cluster distance was recorded within cluster III (10.88) and the maximum inter-cluster distance between cluster VI and VII (20.80), indicating the existence of wide genetic variability. Based on mean performances, the cluster VIII with single genotype ranked first and appeared to contain the potential genotype. The cluster VIII and II registered high plant height. The genotypes included in clusters V and VIII took less number of days to 50% flowering (29.67). The cluster III registered high fruit yield per plant (1004.60), average fruit weight (38.07), and ascorbic acid (28.7) can be utilised in breeding programme for enhancing their respective characters. The cluster IX had high number of fruits per plant (40.53). Based on cluster mean analysis these genotypes can be used in crop improvement programme in tomato for above-mentioned characters.

KEYWORDS: Genetic diversity, Tomato, (*Solanum lycopersicon .L*).

1 INTRODUCTION

Tomato [*Solanum lycopersicon .L*], a member of Solanaceae family, is one of the most important vegetable crops grown widely all over the world. It is often called poor man's orange, because of its high nutritive value. The cultivated tomato originated in the Peru-Ecuador-Bolivia area of the South American (Vavilov, 1951). Its ripe fruits are consumed fresh as well as after cooking as a protective supplementary food and also utilized in the various value added durable products such as puree, paste, powder, ketchup, sauce and canned whole fruits, while the green unripe fruits are used for making pickles and chutney.

Tomato crop has wider adaptability, high yielding potential and multipurpose uses in fresh as well as processed food industries. It stands unique among vegetables because of its high nutritive values and innumerable uses (Vitamin A, C and Minerals). Its firmly ripened fruits are a source of lycopene (an antioxidant), ascorbic acid, and beta-carotene. Lycopene is treasured for its anticancer attribute It is reported to have properties as antiseptic and blood purifier. It acts as an antioxidant which is often colligated with carcinogenesis. Systematic study and evaluation of germplasm is of great importance for current and future agronomic and genetic improvement of the crop. Furthermore, if an improvement program is to be carried out, evaluation of germplasm is imperative, in order to understand the genetic background and breeding value of the

available germplasm (Singh *et al.*, 2002). Reshuffling the genes through recombination is the principal way of developing improved genotypes in breeding programs.

Evaluation of germplasm is of immense important in genetic improvement of the crop. Genetic diversity analysis assists in interpreting the genetic background and breeding value of the germplasm. It was also said that plant breeders use a much less diverse genetic pool than the overall available genetic diversity within the crop (Joshi *et al.*, 2012). Heterogeneous local population of the genus forms an important source of genetic variation (Zeven, 1998). For the selection of parents in hybridization, diversity among parents for the character of interest, estimation of genetic distance is most important as diverse plants are supposed to give high hybrid vigour (Harrington, 1940). Estimation of genetic divergence also allows breeders to eliminate some parents in downsizing the gene pool available and concentrate their efforts in a smaller number of hybrid combinations (Fuzzato *et al.*, 2002) Diversity relative to its use and production environments is high. However, the genetic base of cultivated tomato is narrow (Bai & Lindhout 2007). The multivariate analysis provides valuable information on the extent of variation present in the crop under improvement and usually helps a plant breeder in choosing desirable parents for breeding programme. Also inclusion of genetically diverse parents in any breeding programme is essential to generate new variability and desirable recombinants.

Among the various methods identified/developed to study the genetic divergence in the genotypes, the Mahalanobis D² (Mahalanobis, 1936) is reliable and most frequently used. D² analysis is a useful tool in quantifying the degree of divergence between biological population at genotypic level and to assess relative contribution of different components to the total divergence, both at the inter- and intra-cluster levels. Keeping these points in mind, the present study, the genetic divergence was estimated by using D² statistics suggested by Mahalanobis (1936), which is based on multivariate analysis of quantitative traits. It is one of the very potential tools for measuring genetic divergence within a set of population using the concept of statistical distance employing multivariate measurements. The grouping of genotypes into different clusters is done by following Tocher's method as described by Rao (1952). Improvement in self-pollinated crops like tomato is normally achieved by selecting the genotypes with desirable character combinations existing in nature or by hybridization (Meena *et al.*, 2013). Such studies are also useful in the selection of parents for hybridization to recover superior transgressive segregates. Considering the above facts, the research has been planned with the following objective to assess the extent of genetic diversity in the available germplasm based on fifteen traits comprising of qualitative and quantitative traits.

2 MATERIALS AND METHODS

The present investigation was carried out at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during spring-summer 2012-2013. The experimental materials comprised of twenty-seven genotypes (Table-1) of tomato collected from different sources. The experiment was laid out in a randomized block design with three replications accommodating 14 plants in each genotype. Seeds were transplanted at a spacing of 75x45 cm. The genotypes studied are Palam Pride, Palam, Pink, EC 620445, BBWR-11-1, BBWR-18-17, EC 620533, EC 620534, EC 620378, EC 620383, EC 620380, EC 620391, BBWR-10-3-17, BBWR-10-3-18, Punjab Varkha Bahar-2, Hisar Arun, Punjab Chhuhara, EC 620516, EC 620536, Arka Vikas, Saksham, Abhilash, Arka Meghali, US1196, US 3140, DVRT 2, S-12 and Hisar Lalit. All the recommended cultural practices were adopted for raising the crop successfully. The experimental details and observations to be recorded are as follows: The observation were recorded on five randomly selected plants per replication for each genotype on fifteen characters: i) plant height (cm), ii) days to 50% flowering, iii) average fruit weight (g), iv) number of branches per plant, v) polar diameter (cm), vi) equatorial diameter (cm), vii) number of locules per fruit, viii) number of flowers per cluster, ix) fruit yield per plant (g), x) number of clusters per plant, xi) number of fruits per plant, xii) number of fruit per truss, xiii) total soluble solids (%), xiv) acidity (%) and xv) ascorbic acid (mg/100 g). Mean across three replications were calculated for each traits and the analysis of variation was carried out. Multivariate analysis was done utilizing Mahalanobis D² statistic which are cited below (Mahalanobis, 1936) and genotypes were grouped into different clusters following Tocher's method. The inter and intra cluster distances were worked out as per method suggested by Murty and Arunachalam (1967) to find actual divergence within and between the clusters.

a) Mahalanobis D² analysis

Mahalanobis (1936) D² analysis was used for assessing the genetic divergence among the test entries involving quantitative characters. The generalized distance between any two populations is given by the formula.

$$D^2 = \sum \sum \lambda_{ij} \sigma_{ai} \sigma_{aj}$$

Where,

D^2 = Square of generalized distance

λ_{ij} = Reciprocal of the common dispersal matrix

$\sigma_{ai} = (\mu_{i1} - \mu_{i2})$

$\sigma_{aj} = (\mu_{j1} - \mu_{j2})$

μ = General mean

Since, the formula for computation requires inversion of higher order determinant, transformation of the original correlated un-standardized character mean (Xs) to standardized uncorrelated variable (Ys) was done to simplify the computational procedure. The D^2 values were obtained as the sum of squares of the differences between pairs of corresponding uncorrelated (s) values of any two uncorrelated genotypes (Rao, 1952).

b) Cluster of D^2 values

All n (n-1)/2 D^2 values were clustered using Tocher's method described by Rao (1952).

c) Intra cluster distance

$$\text{Square of the intra cluster distance} = \frac{\sum D^2 i}{n}$$

Where, $\sum D^2 i$ is the sum of distance between all possible combinations of the entries included in a cluster.

n = Number of all possible combinations

d) Inter cluster distance

$$\text{Square of the inter cluster distance} = \frac{\sum D^2 i}{n_i n_j}$$

Where,

$\sum D^2 i$ is the sum of distances between all possible combinations ($n_i n_j$) of the entries included in the clusters study.

n_i = Number of entries in cluster i

n_j = Number of entries in cluster j

3 RESULTS AND DISCUSSION

3.1 CLUSTERING

Clustering of genotypes under study is presented in Figure 1. Based on the D^2 values all the genotypes were grouped into nine clusters, signaling the presence of diversity for different traits. The cluster I had the highest number of genotypes (16) followed by cluster III (3) and cluster VII (2). The cluster II, IV, V, VI, VIII and IX were monogenotypic. The analysis of the Table 1 clearly indicated that clustering pattern there was no parallelism between geographical distribution of genotypes and genetic divergence. Therefore, geographical diversity could not be related to genetic diversity in the material investigated. This is an agreement with results of Singh et al. (2006), Reddy et al. (2013) and Basavaraj et al. (2010). So selection of genotypes for hybridization to generate diverse new gene combinations should be based on genetic diversity rather than geographic diversity (Pawar et al., 2013). It is very difficult to establish the actual location of origin of a genotype. The diverse use of genetic material among the crop improvement programmes in the country makes it unmanageable to conserve the real identity of the genotypes. Mostly, breeding progenies incorporate genes from motleyed sources, resulting in casting off the basic geographical identity of the genotype (Meena et al., 2013).

In perusal of the Table No.2 the intra-cluster distances indicates the divergence among the genotypes within the clusters and inter-cluster indicates diversity between clusters. The maximum intra-cluster distance was recorded within cluster III (10.88) followed by cluster I (9.94) and cluster VII (9.67). The maximum inter-cluster distance is observed between cluster VI & VII (20.80) followed by cluster III & VII (20.52), VII & VIII (19.98). These results suggest maximum divergence between genotypes of cluster VI with genotypes of cluster VIII, indicating the fact that the genotypes when used in hybridisation programme produce superior segregants. The information obtained from inter-cluster distances may be used to select genetically diverse and superior genotypes. The genotypes possessing maximum genetic divergence is expected that more heterotic F₁ and most promising segregant in segregating generations. Intercrossing of divergent groups would lead to greater opportunity for crossing over, which may release hidden variability (Kumar et al., 2010). The minimum inter-cluster distance was observed between cluster III and II (9.56) followed by cluster IV & VIII (11.34). In general, less intra-cluster distance than inter cluster distance suggested homogenous and heterogeneous nature of the genotypes within and between the clusters, respectively Pawar *et al.*, (2013). These results are conformity with the findings by Veershetty (2004), Mehta and Asati (2008) and Kumar *et al.* (2010).

3.2 CONTRIBUTION OF CHARACTERS TOWARDS DIVERGENCE

The diversity among 27 genotypes was measured by employing D² statistic. The contribution of each character towards total genetic diversity is presented in Table 3. The characters, fruit yield per plant (20.51), total soluble solids (17.38), and equatorial diameter (15.38) contributed high for divergence. Thus, these characters may be given high emphasis while selecting the lines for hybridization programme to generate large variability and will provide immense scope for the improvement of yield through selection. The same has been suggested by Kumar *et al.* (2010). Other characters like number of flower clusters per plant (0.57%) and days to 50% flowering (1.14%) contributed very little for divergence.

3.3 CLUSTER MEAN ANALYSIS

The Table No.4 demonstrates the mean values for fifteen characters in nine clusters, which vary in their value differently from each other. The plant height was high for cluster VIII (130.33 cm). The genotypes included in cluster V and VIII are recorded minimum days to 50% flowering (29.67). Numbers of branches per plant were highest for cluster IV (9.33). Choice of parents is the most important aspect of crop improvement programme and highly diversified parents were selected based on the yielding ability of the respective parents. The economically important character high fruit yield per plant was supreme for the cluster III (1004.60) which indicates that the genotypes included in these clusters could effectively be used for the crop improvement programme for increasing yield-contributing characteristics. The number of fruits per plants and average fruit weight, which directly correlates with yield per plant, was high for the cluster IX (40.53) and cluster II (28.80) respectively. In case of ascorbic acid content of fruit, the cluster II (28.85 mg/ 100g), for TSS °Brix the cluster VII (7.45 °Brix) and for acidity the cluster VII (0.75 %) possess the highest values. Equatorial and Polar diameter is high in cluster VII (5.01) and cluster VI (5.17) respectively. It is suggested that hybridization among the genotypes of above said clusters would produce segregants for more than one economic character. The potential lines are picked out from different clusters and used as parents in a hybridization programme. The choice should based on genetic distance and depending upon the objective of the breeding programme.

Many workers have observed that more diverse the parents within its overall limits of fitness, the greater are the chances of heterotic expression in F₁'s and a broad spectrum of variability in segregating generations (Arunachalam,1981). In choosing parents for hybridisation programme the clustering pattern could be employed that would likely to render the maximum possible variability for various economic characters (Hazra *et al.* (2010) and Kumar *et al.* (2010). Moreover, it will be effective to intercross genotypes belonging to more diverse clusters like cluster VI and VII, cluster III and VII and cluster VIII and VII to create wide spectrum of variability and to produce transgressive segregates for tomato.

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Table 1: List of germplasm lines and standard released varieties included in the study

Sr. No.	Genotype/Origins	Sr. No.	Genotype/Origins
1.	Palam Pride/Palampur	15.	Hisar Arun/Hisar
2.	Palam Pink/Palampur	16.	Punjab Chhuhara/Hisar
3.	EC 620445/NBPGR	17.	EC 620516/ NBPGR
4.	BBWR 11-1/Bangalore	18.	EC 620536/ NBPGR
5.	BBWR 18-17/Bangalore	19.	Arka Vikas/IIHR
6.	EC 620533/NBPGR	20.	Saksham/Monsanto
7.	EC 620534/NBPGR	21.	Abhilash/Monsanto
8.	EC 620378/NBPGR	22.	Arka Meghali/IIHR
9.	EC 620383/NBPGR	23.	US 1196/Dharwad
10.	EC 620380/NBPGR	24.	US 3140/Dharwad
11.	EC 620391/NBPGR	25.	DVRT 2/IIVR
12.	BBWR 10-3-17/Bangalore	26.	S 12/Panjab
13.	BBWR 10-3-18/Bangalore	27.	Hisar Lalit/Hisar
14.	Punjab Varsha Bahar 2/Punjab		

Note: -National Bureau of Plant Genetic Resources (NBPGR), Indian Institute of Vegetable Research (IIVR), Indian Institute of Horticultural Research (IIHR)

Table 2. Intra-cluster distance of different groups.

Groups	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9
Group 1	9.94	12.48	13.24	11.86	12.38	12.57	15.77	13.69	14.40
Group 2		0.00	9.56	16.46	16.24	16.05	19.02	14.85	14.79
Group 3			10.88	16.02	15.92	15.27	20.52	13.99	14.19
Group 4				0.00	15.10	15.39	15.01	11.34	16.59
Group 5					0.00	12.73	13.05	18.64	13.72
Group 6						0.00	20.80	19.43	17.04
Group 7							9.67	19.98	18.01
Group 8								0.00	17.92
Group 9									0.00

Table 3. Contribution of 15 characters towards total genetic diversity of *Solanum lycopersicon*(Mill.) Wettstd.

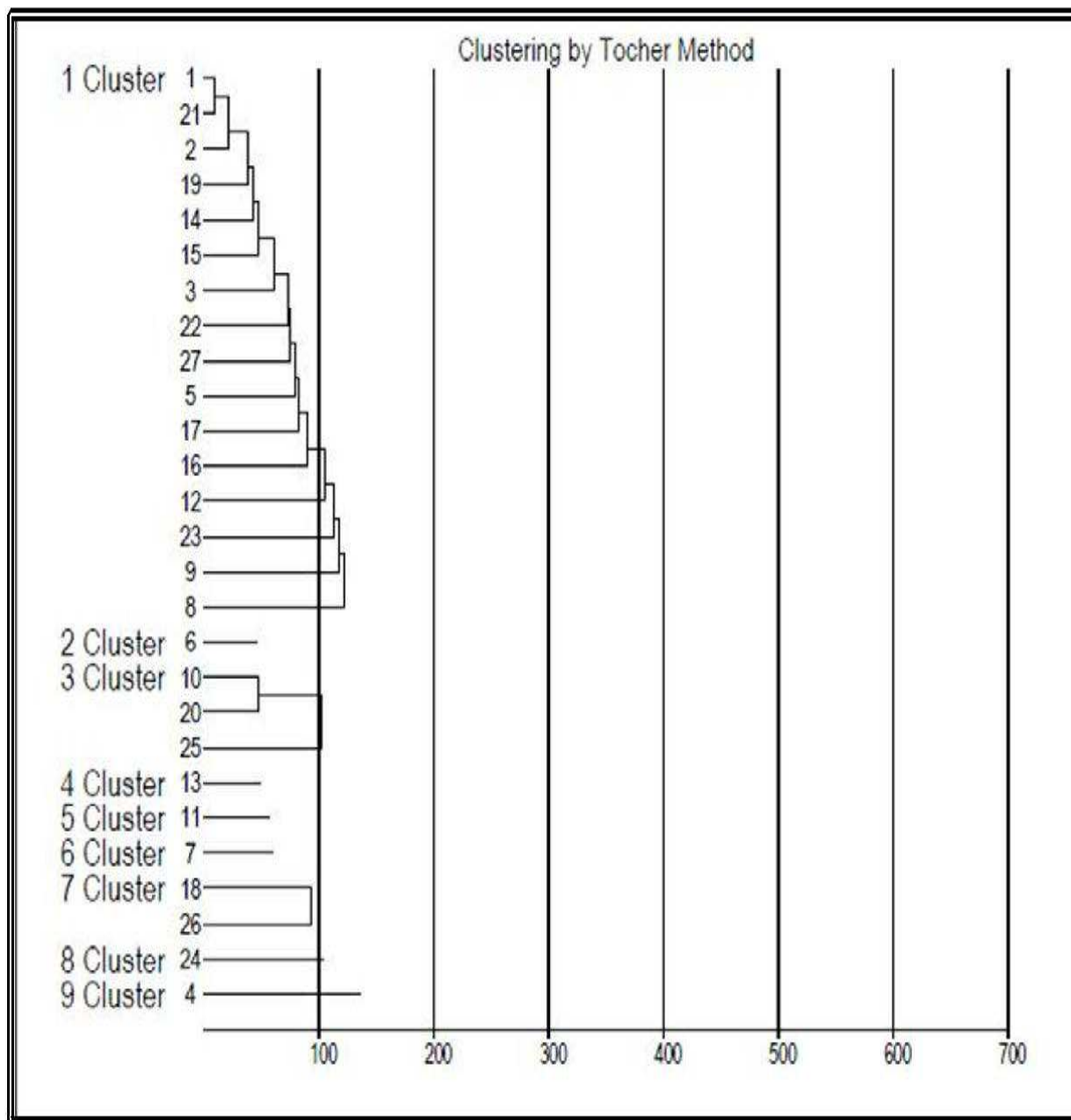
Sr.No.	Source	Contribution (%)
1.	Plant height (cm)	5.13
2.	Number of branches per plant	2.56
3.	Days to 50% flowering	1.14
4.	Number of flowers per cluster	4.27
5.	Number of fruits per plant	3.13
6.	Average fruit weight (g)	1.71
7.	Number of fruits per truss	2.28
8.	Number of flower clusters per plant	0.57
9.	Polar diameter of fruit	14.53
10.	Equatorial diameter of Fruit	15.38
11.	Number of locules per fruit	6.55
12.	Fruit yield per plant (g)	20.51
13.	Total soluble solids (TSS)	17.38
14.	Acidity (%)	0.00
15.	Ascorbic acid (mg)	6.55

Table: 4 Cluster means for different characters in different cluster group's

Characters	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9
Plant height (cm)	72.96	117.93	107.91	84.53	68.20	61.13L	61.50	130.33H	61.93
Number of branches per plant	6.10	6.87	7.40	9.33H	4.84L	6.40	5.70	5.73	9.07
Days to 50% flowering	31.15	32.00	33.00	31.67H	29.67L	33.33	31.00	29.67L	30.00
Number of flowers per cluster	7.56	8.20	9.49	9.13	9.00	6.73	7.90	10.07H	8.07L
Number of fruits per plant	25.10	28.80	27.40	23.87	26.03	19.53L	25.13	20.93	40.53H
Average fruit weight (g)	31.23	31.47	38.07	30.15	22.07L	32.21	24.66	46.27H	24.90
Number of fruits per truss	3.34	2.53L	2.95	3.56	4.43	2.62	4.86H	2.78	4.63
Number of trusses per plant	7.76	11.40H	9.76	6.67	5.87	7.47	5.33L	7.53	8.73
Polar Diameter of fruit	4.15	4.98	5.16	3.90	3.49	5.17H	2.42L	4.43	3.39
Equatorial diameter of fruit	4.12	4.21	4.14	4.74	2.94	4.13	2.93	5.01H	2.68L
Number of locules per fruit	4.43	3.33	5.07H	2.70L	4.20	2.95	3.20	4.99	4.60
Fruit yield per plant (g)	776.25	905.67	1004.60H	715.27	572.00	624.00	577.37	969.00	943.13
TSS	5.41	3.91	5.04	5.13	6.39H	7.45	3.14L	4.99	6.22
Acidity (%)	0.69	0.59L	0.68	0.78H	0.71	0.67	0.68	0.75	0.66
Ascorbic acid (mg)	23.02	28.85H	28.27	23.06	24.03	26.99	22.02	19.63	15.05L

Note: H-maximum cluster and L-lowest cluster means

Figure 1. Clustering of Different genotypes of *Solanum lycopersicon*(Mill.) Wettstd. based on D^2 values.



Pretreatment of Agro Residues for Bioethanol Production

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ABSTRACT: Crop residue left in the field after grain harvests have a large potential as a bioenergy feedstock. Crop residues of interest for bioenergy include; wheat straw, soybean straw, and rice straw, paddy straw etc. Paddy straw and wheat straw are potential substrate which can be exploited in industries in future for bioethanol (biofuel) production as they are cheap, abundant and high cellulose content. In this study rice (paddy) and wheat straw had been given both acid (1%-2.5%) and heat treatment (100°C for 1 hour) for better sugar extraction in media and different parameters were optimized for bioethanol production. Conc. of reducing sugar in the sample after heat treatment were 0.30µg/ml (wheat straw), 15µg/ml (paddy straw), 18µg/ml (mixed sample). After acid treatment total reducing sugar was 56µg/ml (wheat straw), 70 µg/ml (paddy straw), and 170µg/ml (mixed). The optimized parameters for bioethanol production were pH =5.5, Temp=37°C, conc. of (NH₄)₂SO₄ = 0.6mg/ml and yield of ethanol was 5.4%. The concentration of bioethanol for acid treatment of 1%, 2%, 2.5% were 1.3%, 3.4%,5.4%.

KEYWORDS: Paddy straw, Wheat straw, Optimization, Acid treatment, Heat treatment, Bioethanol.

1 INTRODUCTION

The world's present economy is highly dependent on various fossil energy sources such as oil, coal, natural gas, etc. These are being used for the production of fuel, electricity and other goods [1]. Excessive consumption of fossil fuels, particularly in large urban areas, has resulted in generation of high levels of pollution during the last few decades. The level of greenhouse gasses in the earth's atmosphere has drastically increased [2]. With the expansion of human population and increase of industrial prosperity, global energy consumption also has increased gradually. Import of transport fuel is affected by limited reserves of fossil fuel. Annual global oil production will begin to decline within the near future [3]. In this scenario, renewable sources might serve as an alternative. Wind, water, sun, biomass, geothermal heat can be the renewable sources for the energy industry whereas fuel production and the chemical industry may depend on biomass as an alternative source in the near future [4]. All petroleum-based fuels can be replaced by renewable biomass fuels such as bioethanol, bio-diesel, bio-hydrogen, etc., derived from sugarcane, corn, switchgrass, algae, etc. Requirements of electricity may be supplied by solar and wind-farms. The energy consumption rate includes each person's share of electricity and fuel used in making foods and goods and their transport. Biogas has also been identified as a possible motor fuel on organic farms in the short and medium terms. Biogas is produced by anaerobic digestion of organic material. When used as biofuel, CO₂ is removed from the gas to increase the energy content and the gaseous fuel can be stored at high pressure. Biogas can be substituted for natural gas or propane as fuel for boilers and for electricity generation in rural areas. Approximately 1281 megawatt biogas is potentially produced from agrowastes in India [5]. Annual methane production in Sweden from organic waste is about 38 PJ, catering to 11% of the domestic energy requirement for transportation in 2007 and projected to be sufficient for fulfilling the EU target for 2020 [6]. Countries across the globe have considered and directed state policies toward the increased and economic utilization of biomass for meeting their future energy demands in order to meet carbon dioxide reduction targets as specified in the Kyoto Protocol as well as to decrease reliance and dependence on the supply of fossil fuels. Although biomass can be a huge source of transport fuels such as bioethanol, biomass is commonly used to generate both power and heat, generally through combustion. Ethanol is at present the most widely used liquid biofuel for motor vehicles [7,8]. The importance of ethanol is increasing due to a number of reasons such as global warming and climate change. Bioethanol has been receiving

widespread interest at the international, national and regional levels. The global market for bioethanol has entered a phase of rapid, transitional growth. Many countries around the world are shifting their focus toward renewable sources for power production because of depleting crude oil reserves. The trend is extending to transport fuel as well. Ethanol has potential as a valuable replacement of gasoline in the transport fuel market. However, the cost of bioethanol production is more compared to fossil fuels. The world bioethanol production in 2001 was 31 billion liters [9]. It has grown to 39 billion liters in 2006 and is expected to reach 100 billion liters in 2015 [10]. Brazil and the USA are the two major ethanol producers accounting for 62% of the world production [11]. Large scale production of fuel ethanol is mainly based on sucrose from sugarcane in Brazil or starch, mainly from corn, in the USA. Current ethanol production based on corn, starch and sugar substances may not be desirable due to their food and feed value. Economy of the ethanol production process from grains is dependent on the market of its by-product i.e. distillers' dried grains with solubles (DDGS) as animal food. The market of DDGS may not expand like that of ethanol in the future [10]. Cost is an important factor for large scale expansion of bioethanol production. The green gold fuel from lignocellulosic wastes avoids the existing competition of food versus fuel caused by grain based bioethanol production [12]. It has been estimated that 442 billion liters of bioethanol can be produced from lignocellulosic biomass and that total crop residues and wasted crops can produce 491 billion liters of bioethanol per year, about 16 times higher than the actual world bioethanol production [11]. Lignocellulosic materials are renewable, low cost and are abundantly available. It includes crop residues, grasses, sawdust, wood chips, etc. Extensive research has been carried out on ethanol production from lignocellulosics in the past two decades [13-15]. Hence bioethanol production could be the route to the effective utilization of agricultural wastes. Rice straw, wheat straw, corn straw, and sugarcane bagasse are the major agricultural wastes in terms of quantity of biomass available [11].

2 MATERIAL AND METHODS

2.1 MATERIAL

Crop residues are the most promising non-conventional source for energy generation. Paddy and wheat are the widely cultivated crops in India. With the increase in production, the amount of crop-residues generated each year has also increased. These residues are generally burnt in the field as a means of disposal. But these organics are rich source of lignocelluloses. Generally they are used as animal feed. But they can also be used as alternate source for fuel generation. The substrate for paddy straw and wheat straw were pasiala, sahabad, sidora.

2.2 CULTURE USED

Yeast (*Saccharomyces cerevisiae*) was used. The yeast culture was maintained on yeast extract broth. The composition of yeast extract broth are KH_2PO_4 (0.2mg/100ml), $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ (0.05mg/100ml), Yeast extract (0.2mg/100ml), $(\text{NH}_4)_2\text{SO}_4$ (0.6mg/100ml).

2.3 PRETREATMENT

The most important processing challenge in the production of biofuel is pretreatment of the biomass. Lignocellulosic biomass is composed of three main constituents namely hemicellulose, lignin and cellulose. Pretreatment methods refer to the solubilization and separation of one or more of these components of biomass. It makes the remaining solid biomass more accessible to further chemical or biological treatment [7]. The lignocellulosic complex is made up of a matrix of cellulose and lignin bound by hemicelluloses chains. The pretreatment is done to break the matrix in order to reduce the degree of crystallinity of the cellulose and increase the fraction of amorphous cellulose, the most suitable form for enzymatic attack [16]. Pretreatment is undertaken to bring about a change in the macroscopic and microscopic size and structure of biomass as well as submicroscopic structure and chemical composition. It makes the lignocellulosic biomass susceptible to quick hydrolysis with increased yields of monomeric sugars [17]. Goals of an effective pretreatment process are (i) formation of sugars directly or subsequently by hydrolysis (ii) to avoid loss and/ or degradation of sugars formed (iii) to limit formation of inhibitory products (iv) to reduce energy demands and (v) to minimize costs.

2.3.1 PRETREATMENT OF SUBSTRATE BY HOT AIR OVEN TREATMENT

The substrates viz., paddy straw, wheat straw were dried at 45 °C in a hot air oven and powdered in a grinder (dry milling) and sieved to obtain particle sizes of 500 μ and 1cm in each substrate.

2.3.2 PRETREATMENT OF SUBSTRATE BY HEAT TREATMENT

The following substrate goes for heat treatment are Paddy straw (20g/100ml, 20g/150ml, 20g/200ml), Wheat straw (20g/100ml, 20g/150ml, 20g/200ml), Mixed, 20g/200ml. These substrates were autoclaved at 121°C, 15 lb pressure for 1 h. The heat treatment temperature was 121°C for 15 min which breakdown the cellulose lignin, hemicellulose present in the sample.

2.3.3 PRETREATMENT OF SUBSTRATE BY ACID TREATMENT

For the acid treatment of the substrates, used the sulphuric acid (H₂SO₄) at different concentration (1%-2.5%). After acid treatment sample (wheat straw) and mixed were placed at 60°C in water bath for 1h.

3 TREATMENT OF SUBSTRATES WITH COMMERCIAL CELLULASE ENZYME:

Five grams of the delignified samples (all two substrates of 500 μ size) were taken in flask of 250ml capacity separately. The cellulase were used to treat substrates at substrate to enzyme ratio 1:14 (5 g substrate : 70 ml enzyme). The flasks were incubated at 50°C in a water bath for 48h (11).

4 CHEMICAL ANALYSIS:

4.1 ESTIMATION THE CONCENTRATION OF REDUCING SUGAR BY DNSA METHOD (18)

The reducing sugar present reduce the nitro groups present in dinitro salicylic acid to amino groups and itself get oxidized to sugar acids. The orange colour solution formed shows absorption maximum at 540nm.

4.2 ESTIMATION THE CONCENTRATION OF CARBOHYDRATE BY ANTHRONE METHOD (19)

The anthrone reaction is a rapid and convenient method for determination of hexoses and aldopentose, hexuronic acid either free present in polysaccharide. The blue green solution formed shows absorption maxima at 620 nm. The reaction is not suitable when proteins containing a large amount of tryptophan are present.

5 FERMENTATION

Filter the sample (wheat straw & mixed) and take liquid parts. Add the media in proper way

6 ETHANOL ESTIMATION BY SPECTROPHOTOMETRIC METHOD (20)

The yeast (*Saccharomyces cerevisiae*) convert the fermentable sugar (glucose, fructose, & sucrose) into ethanol and CO₂. Molasses a byproduct in sugar industry contain 45-55% w/v fermentable by yeast through temp and alcohol and CO₂ are the end product of the fermentation.

7 PURIFICATION

The purification of the sample was done by distillation process.

8 RESULTS AND DISCUSSION

Concentration of reducing glucose content in the sample after heat treatment is shown in figure 1.

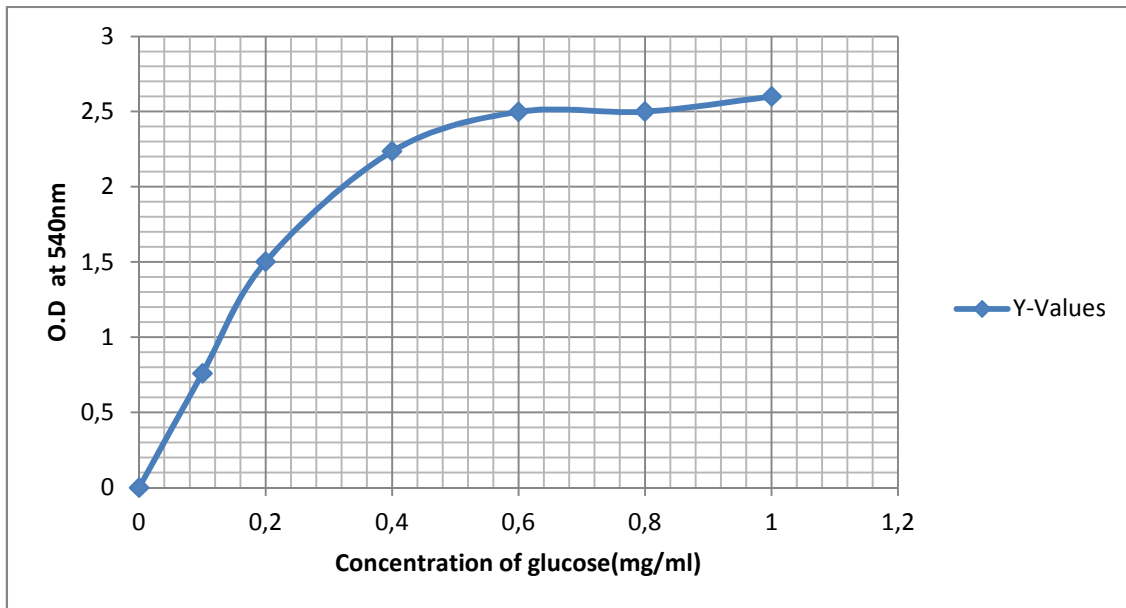


Fig. 1. The concentration of the reducing sugar in the sample after heat treatment were 30 μ g/ml(wheat straw),15 μ g/ml(paddy straw),18 μ g/ml(mixed).

Concentration of total sugar content in the sample after heat treatment is shown in figure 2.

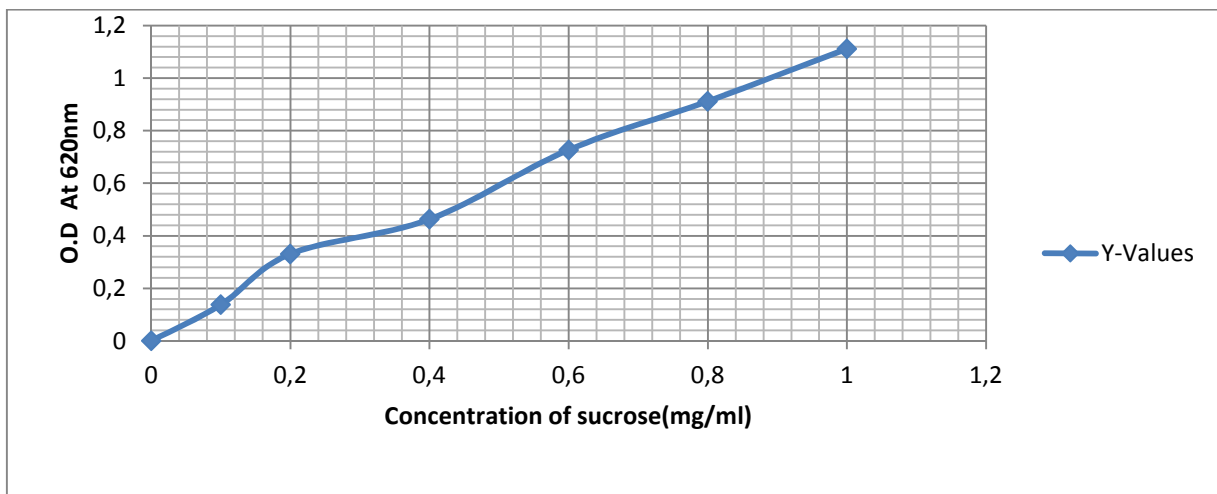


Fig. 2. The concentration of total sugar in sample after heat treatment were 50 μ g/ml(wheat straw),33 μ g/ml(paddy straw),45 μ g/ml(mixed).

Concentration of reducing sugar content in the sample after acid treatment is shown in figure 3.

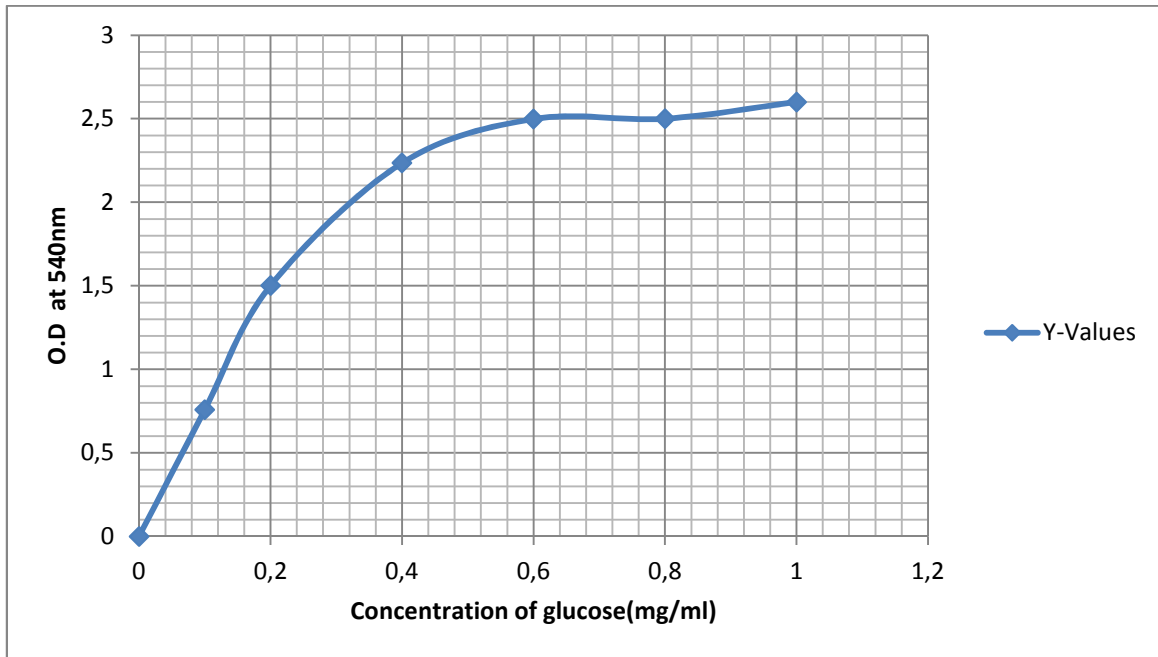


Fig. 3. The concentration of reducing sugar in sample after acid treatment was $56\mu\text{g/ml}$ (wheat straw) and $170\mu\text{g/ml}$ (for mixed sample).

Concentration of total sugar content in the sample after acid treatment is shown in figure 4.

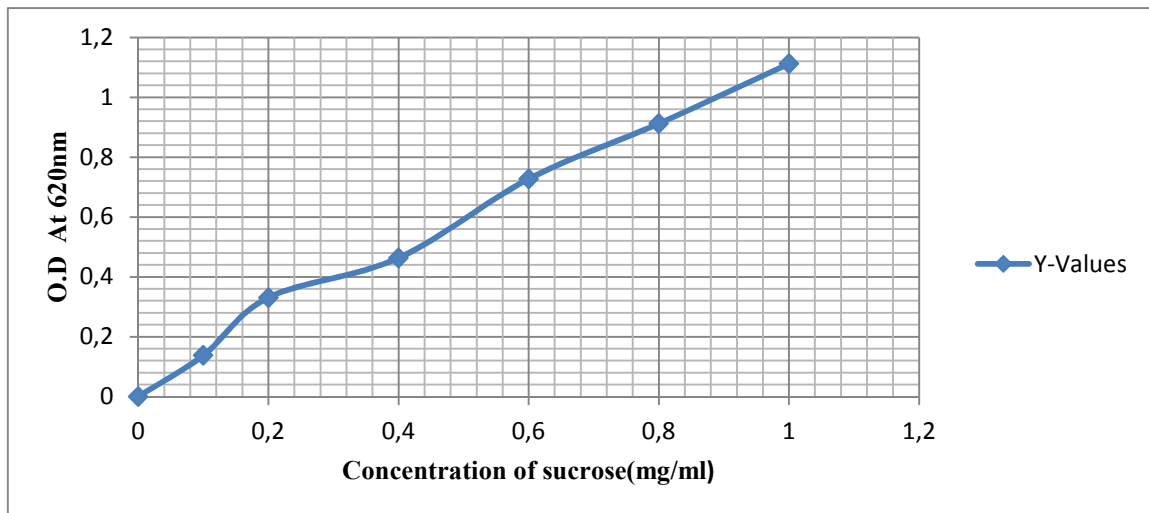


Fig. 4. The concentrations of total sugar in sample after acid treatment were $134\mu\text{g/ml}$ in wheat straw sample and $70\mu\text{g/ml}$ in paddy straw sample.

In acid pretreatment, dilute sulphuric acid is added to the feedstock to hydrolyze hemicellulose (1%-2.5%, temperature was 37°C). Sometimes, concentrated sulphuric acid is also utilized for feedstock pretreatment but care should be taken as

this might lead to the formation of fermentation inhibit phenolic compounds. Moreover, the acid must be removed or neutralized before fermentation. Dilute acid pretreatment is the most preferred method for feedstock pretreatment. Acid treatment gives more amount of reducing sugar and total sugar as compare to the heat treatment, so the author prefer the acid treatment for the bioethanol production.

After acid treatment of 1% the concentration of ethanol is shown in figure 5.

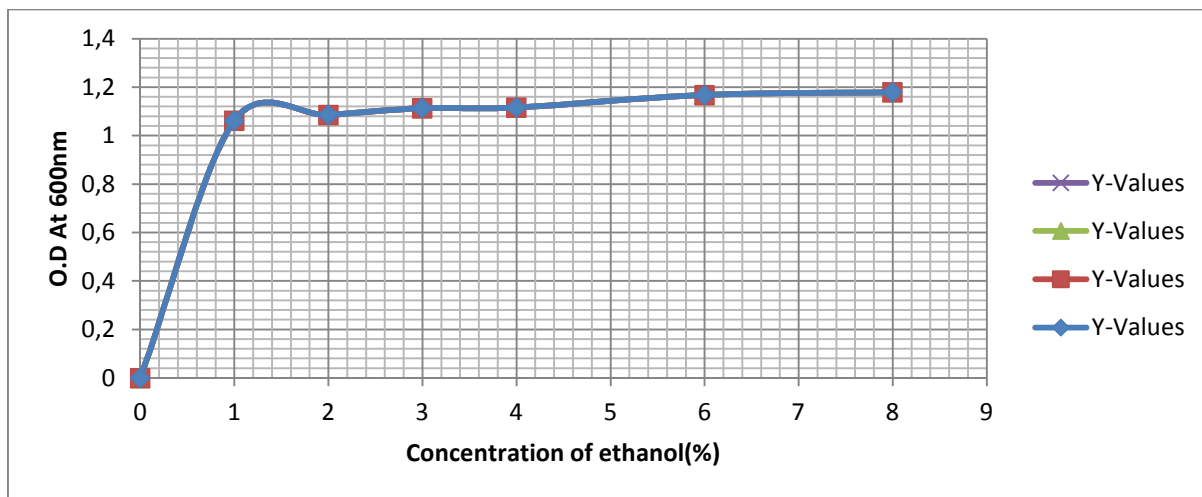


Fig. 5. The concentration of ethanol for acid treatment of 1% was 1.3%.

After acid treatment of 2% the concentration of ethanol is shown in figure 6.

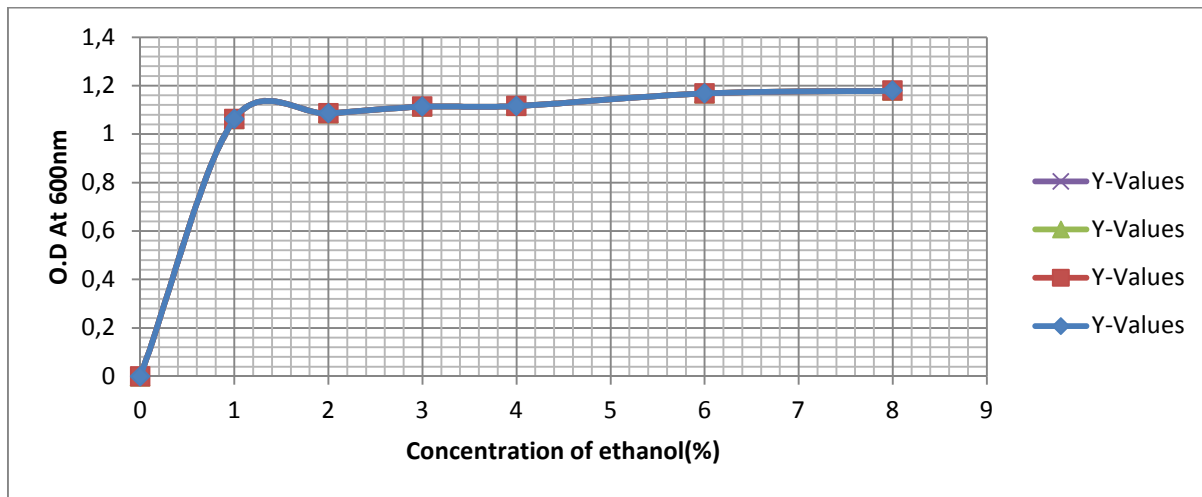


Figure6. The concentration of ethanol for acid treatment of 2% was 3.4%.

After acid treatment of 2.5% the concentration of ethanol is shown in figure 7.

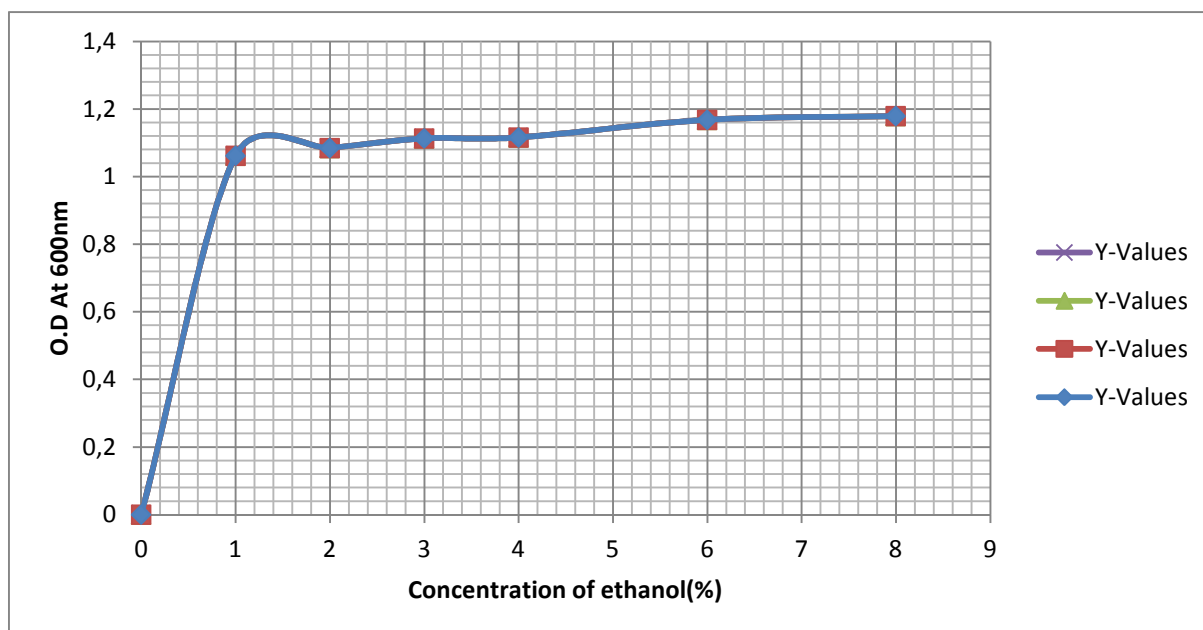


Fig. 7. The concentration of ethanol for acid treatment of 2.5% was 5.4%.

Henning Jørgensen reported that Wheat straw hydrolysate produced by enzymatic hydrolysis of hydrothermal pretreated wheat straw at a very high solids concentration of 30% dry matter (w/w) was used for testing the effect of nutrients on their ability to improve fermentation performance of *Saccharomyces cerevisiae*. The highest volumetric ethanol productivity was 1.16 g kg⁻¹ h⁻¹ and with an ethanol yield close to maximum theoretical. The use of urea or (NH₄)₂SO₄ separately, together or in combination with MgSO₄ or vitamins did not improve fermentation rate and resulted in increased glycerol formation compared to the use of yeast extract. Yeast extract was the single best component in improving fermentation performance and a concentration of 3.5 g kg⁻¹ resulted in high ethanol yield and a volumetric productivity of 0.6 g kg⁻¹ h⁻¹[21]. Héctor A. Ruiz et al. reported that hydrothermal pretreated wheat straw with high cellulose content (>60%) at 180°C for 30 min was used as substrate in simultaneous saccharification and fermentation (SSF) process for bioethanol production using a thermotolerant flocculating strain of *Saccharomyces cerevisiae* CA11. In order to evaluate the effects of temperature, substrate concentration (as effective cellulose) and enzyme loading on: (1) ethanol conversion yield, (2) ethanol concentration, and (3) CO₂ concentration a central composite design (CCD) was used. Results showed that the ethanol conversion yield was mainly affected by enzyme loading, whereas for ethanol and CO₂ concentration, enzyme loading and substrate concentration were found to be the most significant parameters. The highest ethanol conversion yield of 85.71% was obtained at 30 °C, 2% substrate and 30 FPU of enzyme loading, whereas the maximum ethanol and CO₂ concentrations (14.84 and 14.27 g/L, respectively) were obtained at 45 °C, 3% substrate and 30 FPU of enzyme loading, corresponding to an ethanol yield of 82.4%, demonstrating a low enzyme inhibition and a good yeast performance during SSF process. The high cellulose content obtained in hydrothermal pretreatment and the use of a thermotolerant flocculating strain of *S. cerevisiae* in SSF suggest as a very promising process for bioethanol production[22]. Wi et al. reported that the optimal doses of cellulase and xylanase enzymes were 23 FPU and 62 IU/g biomass, respectively. Using the optimized enzyme condition and popping pretreatment of rice straw (15% substrate loading, w/v), a sugar recovery of 0.567 g/g biomass (glucose; 0.394 g/g) was obtained in 48 h, which was significantly higher than that from untreated rice straw (total sugar recovery; 0.270 g/g biomass). Fermentation of the hydrolyzates by *Saccharomyces cerevisiae* resulted in 0.172 g ethanol/g biomass after 24 h, equivalent to 80.9% of the maximum theoretical yield (based on the amount of glucose in raw material) [23].

9 CONCLUSION

Finally the author conclude that acid treatment is better then heat treatment because after acid treatment he got more amount of reducing sugar, which is further used for bioethanol production. 2.5% sulphuric acid gives more amount of reducing sugar. The pH of media was 5.5 with 0.6mg/100ml (NH₄)₂SO₄ with 37°C temperature. The amount of ethanol

produced was 5.4 % (v/v). So the author can say that reducing sugar and carbohydrates of agro wastes, particularly paddy straw and wheat straw are potential substrates which can be exploited in industries for bioethanol (biofuel) production in future. These agro residues (wheat straw and paddy straw) are cheap, abundant and more importantly renewable source for bioethanol production. Based on the results obtained, it can be concluded that reducing sugar and carbohydrates of agro residues can be used as raw materials for bio-ethanol production. Acid treatment is more effective method for extraction of reducing sugar from these cellulosic agro residues.

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EVALUATION DE L'ETAT DE LA COLONISATION DE LA FLORE ADVENTICE DANS LE CHAMPS DE MAÏS (*Zea mays*) A LWIRO, SUD-KIVU, REPUBLIQUE DEMOCRATIQUE DU CONGO

[WEEDS SPECIES IN THE FIELDS OF MAYS (*Zea mays*) AND HIS COLONIZATION ASTIMATE IN LWIRO AREA, SUD-KIVU, REPUBLIQUE DEMOCRATIQUE DU CONGO]

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ABSTRACT: The malherbology is a science that studies the adventitious plants or weeds species. It also takes place in the mechanism of palynological studies especially in the understanding of the dissemination of pollen. The phytosociological method of data recording was been used in this study. Forty six (46) species from 15 families were recorderd. The biologic type was been established as Hémicryptophytes > Chaméphytes > Thérophytes > Géophytes > Nanophanérophytes. The statistical test indicates that there was no difference between the two sites of the study and between the individual fields and the quadra ($F=0,6473$; $df=14,73$; $p=0,5969$, $F=0,7545$; $df=5,252$; $P=0,423$).

KEYWORDS: Assement, invasion, adventitious flora, land, corn.

RESUME: La malherbologie est une science qui étudie les plantes adventices de cultures ou les mauvaises herbes, est aussi parmi celle qui prend place dans le mécanisme des études palynologique spécialement dans la compréhension de la dissémination de pollen. la méthode de relevé phytosociologique était réalisé dans cette étude. 46 espèces étaient inventoriées et réparties dans 15 familles. Le spectre biologique était de la forme Hémicryptophytes > Chaméphytes > Thérophytes > Géophytes > Nanophanérophytes. le test statistique a montré qu'il ya pas de différence entre le site et entre les champs et quadra ($F=0,6473$; $df=14,73$; $p=0,5969$, $F=0,7545$; $df=5,252$; $P=0,423$).

MOTS-CLEFS: mauvaises herbes, culture, invasion, répartition.

INTRODUCTION

Parmi les grands défis qui guettent aujourd'hui l'agriculture dans le monde, il ya la grande influence négative que présente la flore adventice. Depuis longtemps la flore adventice a existée mais une faible attention y était apportée, à part certaines tentatives (*Étude des groupements d'adventices dans le Maroc occidental, Sugar Beet Weeds in Tadla Region (Morocco): Species Encountered, Interference and Chemical Control ; note sur la présence d'une forme stérile d'Oxalis*

pescaprae L. au Maroc ; contribution a l'étude des communautés d'adventices des cultures du secteur phytogéographique oranais (nord-ouest algérien) : aspects botanique, agronomique et phyto-écologique ; Etude Phyto-Écologique des Adventices dans les Agro-Écosystèmes Élaeicoles de la Mé et de Dabou, Côte d'Ivoire). Ces diverses tentatives restent toujours de moindre importance car il n'y a que quelques sociétés étatiques ou non étatiques impliquées dans l'agriculture moderne qui essayent de s'y prendre mais avec beaucoup de controverse, et aussi dans le chef de la population paysanne c'est une histoire veine car il n'y a qu'une seule façon de faire, c'est le désherbage manuel à la houe.

Dans les pays développés, l'histoire est aussi hypothétique due au controverse multiple qui ne facilite pas la mise en place de méthode adéquate; mais les alternatives au "tout herbicide" existent, mais elles sont encore relativement peu utilisées car elles nécessitent une plus grande connaissance de la biologie et de l'écologie des mauvaises herbes au niveau spécifique, d'une part, et au niveau de la communauté, d'autre part ; Navas (1999), Dessaint et al. (2001).

Ceci serait peut être du à des méthodes culturales appliquées au champ.

L'agriculture biologique, la pollution de l'eau sont parmi les facteurs favorisant les phénomènes de résistance et de la prolifération des mauvaises herbes. De ce fait, il ya nécessité de connaître d'abord cette flore avant d'envisager quoi que ce soit ;Heap (1999),Dessaint et al. (2001).

Les études montrent que, l'effet de prendre en compte de manière plus importante la diversité et la structure de communauté des espèces végétales est déjà un atout (Dessaint et al. 2001).

Or, selon l'utilisation de toute communauté biologique dans les systèmes de conservation et/ou de surveillance des eaux ou autre chose nécessite la caractérisation de sa diversité et de sa structure (Mushayuma et al. 2012).

Dans cette partie de la sous région de l'Est de la RDC les études de ce genre sont rare pourtant point sensible face aux aléas pertinents défavorisant la production agricole. En Afrique, il n'y a que la partie nord et la petite partie occidentale qui a déjà un peu des travaux sur les mauvaises herbes (Maroc, Algérie, Burkina-Faso,...),Tani et al. 2010.

La présente étude vise à introduire une recherche sur la lutte contre les mauvaises herbes qui restent une inertie dans cette partie de la République Démocratique du Congo RDC .Elle va tenter d'élucider d'abord leur diversité mais aussi leur structure malherbologique sur le plan biologique, leur composition du point de vue spécifique dans les champs et sites ainsi que connaître la composition floristique de chacune d'elles en fin de les comparer et d'en dégager des différences s'il y en a ou s'il n'y en a pas. Ainsi, une question se pose s'il ya diversité, a-t-elle d'impact sur les cultures?

MATERIELS & METHODES

Milieu d'étude

Cette étude a été effectuée à Lwiro dans le groupement d'Irambi-Katana situé entre 28°48' longitude Est et 2°15' latitude sud Est sur le flanc du massif de Kahuzi-Biega compris entre 1470 m et 2200 m d'altitude et bénéficiant d'un climat tropical humide comprenant une longue saison de pluie de 9 mois (septembre à mai) et une courte saison sèche de 3 mois (de Juin à Aout).La température moyenne annuelle varie entre 18 et 20 °c et l'humidité de l'air entre 68 et 75 % (Station climatologie du CRSN-LWIRO). Cette région à sol volcanique est formée par l'alternance des collines et des larges vallées qui renferment des marais irrigués par des cours d'eau et affluents du lac-Kivu qui prennent sources dans le Parc National de Kahuzi-Biega (PNKB) et même dans les vallées, Tete et al.(2006), Mushayuma et al. (2012). La végétation est constituée d'une savane herbeuse de montagne dominée par les graminées fortement diversifiées et quelques arbustes. Cette végétation a remplacé une autre très primitive qui était constituée de forêt primaire à *Albizia grandibracteata* original (Bagalwa et Baluku, 1997).

Collecte et traitement des données

La réalisation de ce travail menée sur deux sites dans Lwiro consisté au prélèvement et dépouillement des échantillons, suivi du traitement des données.

La collecte des échantillons avait nécessité les matériels spéciaux pour le prélèvement mais aussi pour la caractérisation de chaque site selon les champs. La caractérisation des sites et des champs est présentée dans le tableau 1 ci-dessous.

Tableau 1 : Caractéristiques de site et des champs étudiés

Caractéristiques	SITE 1				SITE 2			
	1	2	3	4	5	6	7	8
Nature du champ	+++	0	+	0	++	0	++	+
Type de culture	Sm	Mc	sm	Mc	M	M	Mc	Mc
Etat de la colonisation	Ms	ms	Ss	Ms	ms	Ms	Ms	Ms
Stade de développement de culture	Fl	Pc	Fr	Pc	Fl	Aa	Fr	Ph
Nombre de sarclage	-	-	--	-	--	---	--	-

Légende : 1 : champs 1, 2 : champs 2, 3 : champs 3, 4 : champs 4, 5 : champs 5, 6 :champs 6, 7 :champs 7, 8 :champs 8, + : moins engorgé(l'eau n'est pas visible dans le champs), ++ : moyennement engorgé(l'eau est moyennement visible dans le champs), +++ : engorgé(l'eau est visible dans le champs), 0 : terre ferme, M : Mixte, Sm : Semi-mixte, Mc : Mono culture, Ms : moins saturé(le sol est visible ;les plantes laissent les espaces entre elles), ms : moyennement saturé(sol moyennement visible ;les plantes laissent moyennement des espaces entre elles), Ss : sursaturé(sol pas visible ; c.à.d. les plantes sont enfermées entre elles), Fr : fructification, Fl :floraison, Pc : Phase de croissance, Age adulte :Aa, - :une fois, -- : 2 fois, --- :3 fois.

Pour le prélèvement des échantillons, nous avons utilisé la méthode classique de relevé phytosociologique où on procède à la mise en place de 4 petits carrés de 1m² pris aléatoirement dans chaque champs mais souvent dans les coins des champs . Chaque carré est balayé systématiquement en dénombrant les nombres des pieds par espèces mais en identifiant ces espèces et enfin la description de leur type biologique de chaque espèce végétale rencontrée. Quelques échantillons étaient récoltés en cas de doute de son identité pour une identification appropriée à l'Herbarium de LWI soit en confrontant les échantillons avec ceux conservés ou en utilisant certains ouvrages [AGNEW et al. (1996), FISCHER (2008), TROUPIN (1985, 1988)]. , Un sac avait servi au transport des échantillons, un sécateur avait servi à la récolte, une presse en vu de les presser et sécher. Un GPS a aidé à prendre les coordonnées géographiques de chaque parcelle et un appareil photo numérique pour la prise des photos.

Les données étaient saisies en utilisant le logiciel EXEL pour les analyses avec PAST. L'identification de types biologiques était aussi nécessaire, pour ce faire, la classification de Raunkier (1934), adoptée aux régions tropicales par Lebrun (1966) et NYAKABWA (1982) a été utilisée. Ceci pour pouvoir évaluer le pouvoir de colonisation des espèces

Suivant cette classification, nous avons retenu les types biologiques suivants :

- les nanophanérophites (NPh) : plantes dont l'appareil caulinair porte à plus de 2-8m du sol les bourgeons ;
- les chaméphytes (Ch) : plantes ayant l'appareil végétatif d'une hauteur inférieure à 40 cm, avec les bourgeons protégés par le débris végétaux.
- les hémicryptophytes (H) : plantes dont les bourgeons persistant sont enfouis dans le sol.
- les thérophytes (T) : Plantes qui persistent sous formes de graines
- les géophytes : dont les bourgeons de génération sont enfuies dans le sol

RESULTATS

Aspect Floristique

Au total, 8 champs échantillonnés à Lwiro, dans lesquels 46 espèces des mauvaises herbes étaient répertoriées, réparties dans 32 carrés relevés sur l'ensemble de nos sites. Ces espèces sont regroupées dans 15 familles et 36 genres. Trois familles ont dominé nettement la flore adventice de Lwiro, à savoir :

- ✓ La famille des *Poaceae* avec 14 espèces soit 30,43 % de l'ensemble de la flore
- ✓ La famille des *Asteraceae* avec aussi 10 espèces (21,73%) et,
- ✓ La famille des *Amaranthaceae* avec 4(8,69%) espèces seulement.

Caractérisation biologique des espèces

Le spectre brut du recouvrement des parcelles de cultures de maïs inspectées dans la partie de Lwiro ont mis en évidence 5 types biologiques, Thérophytes, Chaméphytes, Hémicryptophytes, Géophytes, Nanophanérophytes qui dont voici leur représentation dans le tableau 2 ci-dessous

Tableau 2. : Spectre de présentation des types biologiques des espèces

Types biologiques	Nombre	Pourcentage
Thérophytes	9	19,56%
Chaméphytes	13	28,26%
Hémicryptophytes	16	34,78%
Géophytes	7	15,21%
Nanophanérophytes	1	2,7%

Le tableau ci-dessus montre une hétérogénéité spécifique du milieu sur son aspect biologique du faite des taux de représentation un peu serré. Une prédominance des Hémicryptophytes était observée (34,78%) sur l'ensemble des échantillons, suivis de Chaméphytes (28,26%), Thérophytes (19,56%), puis géophytes et enfin des Nanophanérophytes. Tenant compte de la capacité de nuisance selon les types rencontré, il faut dire que les hémicryptophytes forment un groupe qui est en transition entre Thérophytes et géophytes capable de mettre en danger les cultures de part leur taux de représentation du faite que les géophytes ont une capacité de résistance élevée suite à leur adaptation face au menace et les thérophytes dont leur capacité de multiplication est réputé de surélevée (www.Tela-botanica.org). Les hémicryptophytes et les géophytes sont des espèces résistant à l'aridité, donc leur présence est fatale aux cultures alors que les thérophytes sont bien adaptés à des répétitions culturales (www.Tela-botanica.org). Les géophytes étant un groupe aussi important qui s'adapte facilement aux perturbations culturales (www.Tela-botanica.org) n'étaient pas si important, mais un peu représentés.

Les phanérophytes (nanophanérophytes) étaient les moins représentés (2,7%). Cela pourra se justifier par la présence des cultures car leur présence caractérise le non culture. ; Ce groupe de mauvaises herbes ne présente aucun danger pour les cultures. Les chaméphytes (28,26%) étaient le deuxième groupe ayant eu beaucoup d'espèce, ceci signifie que leur menace aux cultures n'est pas à négliger sur le plan agronomique du fait qu'ils ont un grand pouvoir colonisateur et disséminateur dans le champ.

En fin, le spectre biologique pour les cultures de cette partie de Lwiro étudiée est de la forme : Hémicryptophytes > Chaméphytes > Thérophytes > Géophytes > Nanophanérophytes. A titre comparatif, les communautés d'adventices observées dans des jachères, green (prairies) ouest africain (Dahmani, 1984), on avait un schéma du genre thérophytes > hémicryptophytes > géophytes > chaméphytes > nanophanérophytes qui était un peu contraire au notre.

Spectre biologique tenant compte du biotope

La répartition des espèces selon leur biotope donne, 5 types biologiques pour les marais et 4 types pour les espèces de la terre ferme (Tableau 3).

Tableau 3. : Spectre biologique selon les biotopes

Biotope de cultures	Types biologiques (%)				
	Ch	G	H	T	Nph
Marais	31,42	14,28	28,57	22,85	2,85
Terre ferme	28,57	17,85	35,71	17,85	0,00

Légende : cfr. Matériels et méthodes

Le tableau indique que dans les marais ce sont les chaméphytes qui avaient pris le dessus sur les autres contrairement à ceux de la terre ferme où la répartition avait gardé la logique de l'ensemble de deux biotopes où les hémicryptophytes dominaient.

Variabilité dans les sites (individu et présence des espèces)

La variabilité des espèces selon les individus dans les sites est présentée dans tableau 4.

Le tableau 4. ci-dessous montre que l'espèce *Galinsoga ciliata* L. a la plus grande fréquence (11.90%) que les autres dont le nombre d'individu est de 173 suivie de *Bidens pilosa* L. (11.42%) avec le plus grand nombre d'individu (206 individus) puis *Commelina diffusa* BOURM (10.42%) avec 200 individus ensuite viennent les autres. Les espèces les moins fréquentes sont celles dont le nombre d'individu est 1 (0.476%).

Tableau 4. : Variabilité des espèces du point de vue de leur présence et quantité

Nom d'espèce	Nbre d'individu	Nbre de présence	Nom d'espèce	Nbre d'individu	Nbre de présence
<i>Ageratum conyzoides</i> L.	39	7	<i>Galinsoga ciliata</i>	173	25
<i>Achyranthes aspera</i> L.	18	4	<i>Ipomoea batata</i>	1	1
<i>Amaranthus hybridus</i>	11	4	<i>Justicia strica</i>	1	1
<i>Amaranthus viridus</i>	18	2	<i>Lactuca kenyaensis</i>	6	4
<i>Bidens pilosa</i> L.	206	24	<i>Manihot glaziovii</i>	1	1
<i>Biophytum sensilivum</i> L. DC.	1	1	<i>Melanthera scandens</i> (SCHUM. ET THONNE) Rorberty	2	1
<i>Celosia trigina</i>	4	2	<i>Mentha aquatica</i> L.	3	3
<i>Cloris gayana</i> KUNTH.	1	1	<i>Oxalis corymbosa</i> D.C	201	10
<i>Colocasia esculenta</i>	9	5	<i>Panicum brevifolium</i> L.	2	1
<i>Commelina bengelensis</i>	47	2	<i>Pennisetum purpureum</i>	1	1
<i>Commelina diffusa</i> BOURM.	200	22	<i>Panicum caugoense</i> Franch.	1	1
<i>Conyza sumentrensis</i>	1	1	<i>Penicum massaiense</i> MEZ.	1	1
<i>Crassocephalum bumbens</i> S.Moore	1	1	<i>Polygonum salicifolium</i> WILD.	10	5
<i>Crassocephalum mannii</i> (Hook) Milne redh.	10	4	<i>Rumex bequaertii</i>	1	1
<i>Cynodon dactylon</i>	7	3	<i>Sanicula elata</i> BUCHMAN ex DON	10	3
<i>Cyperus distans</i> L.	13	4	<i>Setaria homonyma</i> (Steud)Chiov.	5	1
<i>Cyperus latifolia</i> Poiret	82	11	<i>Setaria pallidifusca</i> STAFP.	12	3
<i>Digetaria vestida</i>	85	8	<i>Setaria qngustifolia</i> STAFP	12	3
<i>Digistaria velutina</i> (FORSK) BEAUV.	1	1	<i>Sida acuta</i>	1	1
<i>Digistaria scalarum</i> (SCHW.)Chiov.	32	6	<i>Spermacoce princae</i> (K.shun.) verb	1	1
<i>Digitaria yakoensis</i> VDR.	11	2	<i>Spilantes</i>	13	7
<i>Digitaria acuminata</i> SPAPF.	2	1	<i>Tagetes minita</i> L.	14	5
<i>Drynaria cordata</i>	136	13	<i>Hibiscus calyphyllus</i> CAV.	1	1
				1408	210

La capacité de nuisance des espèces est bien perceptible dans ce tableau. Il est à indiquer que la nuisance varie de façon qu'on retrouve des espèces densément représentées en rapport avec celles en faibles présence telle que *Commelina bengelensis*, *Digitaria vestida*, ... Ces espèces sont dangereuses car ayant une forte capacité colonisatrice. Il est donc clair qu'il faudrait bien surveiller ces genres d'espèces. Ce sont surtout les hémicryptophytes et les géophytes dont la prolifération est remarquable.

D'autres espèces qui sont densément visibles avec de forte présence sont *Galinsoga ciliata* L. (11.90%), *Commelina diffusa* (11.42%), *Bidens pilosa* L. (10.42 %) ont aussi une capacité de nuisance non négligeable. Ce groupe des plantes sont celles dont la résistance est adaptée aux perturbations culturales et d'autre dont la prolifération est considérable.

Répartition des individus dans les différents champs et selon le quadra

La répartition des individus dans les champs est présentée à la figure 1. Cette répartition semble être inadéquate par rapport au test statistique qui montre certaine différence indiquant une montée graduelle dans le champ 6 du site2, 1^{er} quadra où on a observé 90 individus (fig. 1). La figure montre qu'il y a une variation des individus dans différents champs et quadras mais au niveau de la composition il s'avère qu'au niveau structurelle cela soit différent, c'est ainsi que nous verrons que d'autre part statistiquement il n'y a pas de différence significative entre les champs mais aussi entre quadras (tableau 4.) du fait que p est supérieur à 0,05.

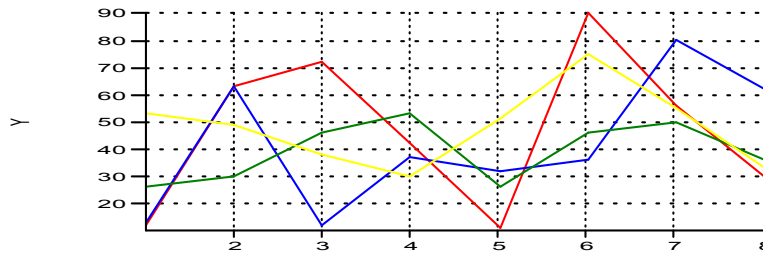


fig.1 : représentation graduelle de variation de nombre d'individus dans les champs et quadras

Légende : 1 : champ 1, 2 : champ 2, 3 : champ 3, 4 : champ 4, 5 : champ 5, 6 : champ 6, 7 : champ 7, 8 : champ 8, rouge : 1^{er} quadra, bleu : 2^{ème} quadra, verte : 3^{ème} quadra, jaune : 4^{ème} quadra, x : les champs, les proportions des individus dans les quadras

Tableau 4. : Résultats des tests des variabilités des individus entre les 2 sites et entre champs et les quadras.

Test de la variation des individus dans les champs et selon le quadra	Test de la variation des individus entre les deux sites
F=0,6473 ; df=14,73 ; p=0,5969	F=0,7545 ; df=5,252 ; p=0,423

Ceci montre en quelque sorte que sur le plan colonisation de champs dans les deux sites il y a pas des différences.

CONCLUSION ET DISCUSSION

Il vient d'être observé que la flore adventice des cultures dans la contrée dLwiro est importante vue le nombre d'espèces(46) inventoriées.

Les types biologiques dominants sont les hémicryptophytes qui sont très caractérisés par le camouflage étant en transition entre thérophytes et géophytes.

Dans son travail sur aspects floristiques de la flore des champs du domaine phytogéographique oranais (Nord-Ouest algérien) et persistance d'espèces rares et endémiques en Algérie, Tani et al. (2010) avait trouvé une prédominance des thérophytes et les hémicryptophytes qui dans notre étude occupaient respectivement la première et la troisième place. Ceci veut montrer un rapprochement du point de vue biologique des espèces entre les deux études.

Notre étude a laissé encore observé que La diversité des espèces était autant dans le marais que sur les terres fermes mais avait divergé au niveau des individus. Ceci montre que les deux biotopes divergent seulement écologiquement.

Galinsoga ciliata était l'espèce la plus fréquente avec 25 présences dans les quadras, soit 0,1190 et 136 individus. Il a été remarqué que l'espèce *Bidens pilosa* avait aussi 22 présences et un nombre élevé d'individus(206) dans tous les quadras et une fréquence de 0,1047. Les espèces comme *Commelina bengelensis* et *Digitaria vestida* (47individus, 2 présences soit 0,0095 ; 82 individus, 8 présences soit 0,0380 respectivement) étaient moins fréquentes mais densément représentées. Cette

situation présente un risque de nuisance sur les cultures. D'autres espèces avaient affiché une forte densité et une forte présence mais elles avaient semblé ne pas mettre en cause les cultures étant donné que leur taux de croissance (évolution en taille) est le même ou inférieur à celle de la culture appliquée. L'on a constaté que l'espèce *Oxalis corymbosa* une fois englouti dans les cultures ne serait qu'une accompagnatrice de culture dans les champs.

Les accidentelles qui ne sont que des espèces qui n'avaient qu'un individu mais aussi une présence amoindrie, étaient aussi enrôlées dans ce groupe. Les deux sites de notre étude n'ont pas montré une différence statistique sur le plan spécifique mais une différence au niveau du nombre d'individus dans les champs et dans les quadrats. Ceci dit qu'il y a pas de différence sur le plan structurel mais diffère au niveau de la composition. Vu cette situation, nous sommes arrivés à dire qu'il existe encore une flore adventice des cultures originales et qu'on a intérêt de concentrer notre attention sur cette matière. C.à.d. qu'un effort doit être fait avant qu'on arrive à leur extinction. L'abandon des pratiques agricoles traditionnelles (labours annuels superficiels, rotation diversifiant les cultures, peu d'intrants, semences non triées et récoltées dans l'exploitation, semis clair...) pour des modes de production plus intensive (labours profonds, mécanisation lourde, monoculture, intrants chimiques, semences triées et sélectionnées, semis denses ...) entraîne la régression de la diversité des adventices (Maillet et al.1997; Jauzein 2001) et dans ce contexte, il est très important de signaler que le déclin des adventices n'est pas restreint aux espèces endémiques ou rares mais affecte semblablement les espèces habituellement communes dans les champs (Fried et al. , 2009).

En fin, il a été très bien constaté par les prédécesseurs ailleurs que la flore adventice est un peu négligé au profit des inventaires forestiers et qu'il est grand temps d'arrêter la discrimination dans la science. Que les botanistes ne visent plus à travailler seulement sur les plantes sauvages mais avoir aussi un regard sur celles-là dites d'origine humaines. Ce travail ajoute donc un plus tant soit peu à la connaissance malherbologique du Congo où ces travaux sont encore rares.

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Morphogenèse hydrique et éolienne au sud du Hodna (Algérie)

[Fluvial and eolian morphogenesis in south Hodna (Algeria)]

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RESUME: La zone du Hodna, localisée en zone aride au centre de l'Algérie, est marquée par une érosion éolienne importante ; elle est aussi traversée par plusieurs petits cours d'eau dont les crues humidifient le sol et déposent les alluvions. Elles contribuent ainsi au lessivage des sels et à l'enrichissement du sol en éléments minéraux fins. Dans ce travail, il s'agit d'étudier l'origine des sédiments en utilisant la morphoscopie des sables, d'analyser leur granulométrie et leur variation verticale sur fosses pédologiques. Trois profils localisés dans des parcelles travaillées depuis plusieurs années et des témoins adjacents ont été utilisés. Au total 23 échantillons ont été prélevés. L'analyse statistique des horizons des profils montre que la fraction sableuse est importante et marque la composition granulométrique de ces sols. L'augmentation de la fraction fine (argile et limon fin) coïncide avec la diminution des pourcentages des sables totaux et vis versa et, le calcaire évolue proportionnellement avec la fraction fine, ce qui suggère sa localisation dans cette fraction. En profondeur, la diminution des sables correspond toujours à une augmentation de la fraction fine. Cet enrichissement semble être localisé dans les horizons médians où le profil textural marque une onde indiquant les valeurs les plus élevées. Dans les horizons de surface des parcelles cultivées, la teneur en éléments fins est toujours supérieure à celle du témoin. Ceci est en fait lié au travail du sol qui ramène ces éléments fins en surface. L'analyse morphoscopique des sables a révélé un apport mixte fluvatile et éolien. La comparaison des parcelles travaillées et des parcelles témoins indique un changement au niveau de l'horizon de surface suite au travail du sol. Cette étude révèle aussi des signes d'une action éolienne actuelle en surface.

MOTS-CLEFS: Sud Hodna, morphoscopie des sables, granulométrie, transport éolien, transport hydrique, agriculture.

ABSTRACT: Hodna is located in arid region in central Algeria. In this area, wind erosion is very important; it is also crossed by several small water courses. Periodic floods moisten the soil, bring alluvium and contribute to leaching salts. They also enrich the soil with minerals. The main objective of this work is to study the origin of the sediments using quartz grain morphoscopy, to analyse their particle size distribution and their vertical variation in soil profiles. Three profiles, located in agricultural parcels used for several years, were selected. Control samples were taken in adjacent parcels. 23 samples, corresponding to the soil horizons were collected in the field. Statistical analysis of soil samples shows that the sand fraction is important and dominates the particle size distribution of these soils. The increase of the fine fraction (fine silt and clay) coincides with the lower percentage of total sand and vice versa and, limestone changes proportionally with the fine fraction and suggesting its location in this fraction. At depth, the decrease of sands always corresponds to an increase of the fine fraction. This enrichment appears to be located in the median horizons where the textural profile marks a wave showing the highest values. In the surface horizons in agricultural parcels, the fine elements content are always greater than the controls. This is related to the tillage which comes back the fine elements in the surface. The morphoscopic analysis of sands revealed mixed deposits fluvial and wind. The comparison of agricultural parcels and controls indicates a change in the surface horizon due to tillage. This study shows also signs of significant current wind action in surface.

KEYWORDS: South Hodna, quartz grain morphoscopy, particle size distribution, water transport, wind transport, agriculture.

1 INTRODUCTION

Les écosystèmes steppiques en Algérie connaissent aujourd'hui une forte tendance à la dégradation qui se traduit par la réduction du potentiel biologique et la rupture des équilibres écologiques et socioéconomiques [1], [2]. Le sud du Hodna, région steppique du centre de L'Algérie, est une région soumise notamment à l'érosion éolienne. C'est une région venteuse où l'érosion éolienne pose de graves problèmes pour la mise en valeur et même les villages ne sont pas épargnés. Elle se traduit dans l'espace par des accumulations dunaires qui ont été remises en mouvement par les hommes, par leurs actions de destruction de la végétation naturelle [3]. Cette zone est marquée aussi par les crues de ses oueds comme les oueds Defla, Oultem, El Mehakoub, et Roumana. Ces crues influencent considérablement les caractéristiques du sol même pour les cours d'eau de moindre importance. L'occupation du sol montre bien ces larges cônes, ouverts dans le sens de la pente, et portant des cultures qui, sans irrigation, ne rapportent que dans le cas d'un épandage de crue. Ces crues en humidifiant le sol et déposant les alluvions, contribuent aussi au lessivage des sels et à l'enrichissement du sol en éléments minéraux fins. C'est ainsi qu'au sud du Hodna, l'évolution des sols est marquée par deux phénomènes : une morphogenèse hydrique et une morphogenèse éolienne [4].

L'objectif de ce travail est d'aborder l'origine des sédiments en utilisant la morphoscopie des sables, d'analyser la granulométrie des matériaux et de vérifier leur variation verticale sur fosses pédologiques. La comparaison des sites où l'action anthropique est très intense et des témoins permet aussi de prévoir le sens d'évolution des sols dans ce milieu suite à la mise en culture en irrigué.

2 PHYSIOGRAPHIE

Le Hodna, localisée en zone aride au centre de l'Algérie, est une cuvette de 8500 km², très déprimée et entourée de massifs montagneux. Elle présente en son centre le Chott El Hodna (lac Salé) de 1100 km² qui sert d'exutoire aux Oueds dont les plus importants viennent du Nord.

Les grands traits de la sédimentation détritique quaternaire et des modalités de formation du Quaternaire et de la cuvette du Hodna ont fait l'objet de travaux de nombreux spécialistes [5],[6]. La nature des dépôts quaternaires du Hodna et leur façonnement dépendent essentiellement des variations cycliques du climat : succession de périodes pluvieuses (pluviaux) et de périodes sèche (interpluviaux). La zone Sud du Hodna est constituée de dunes de sable, de dépôt alluviaux récents et de collines rocheuses isolées (cas de Djbel Meharga, 900 m). Cette zone est aussi sous l'influence d'une forte érosion éolienne. En effet, constituée de terrains légers sans tapis végétal consistant et constamment ameublés par les labours, le Sud du Hodna est le siège d'une érosion éolienne intense. En outre, il est drainé par de nombreux oueds. Les crues de ces derniers contribuent au lessivage des sels du sol en profondeur et à l'enrichissement du sol par les limons qu'elles transportent.

3 CLIMAT

Le climat du sud du Hodna est aride. La caractéristique essentielle du climat du Hodna est l'extrême variabilité des précipitations dans l'espace et dans le temps [3]. Selon les données de la station météorologique de Ain Diss (Sud du Hodna), la pluviométrie moyenne annuelle est de l'ordre de 172 mm répartie sur 57 jours pluvieux venant souvent sous forme d'averse, la température moyenne annuelle est de 19,4 °C et l'évapotranspiration potentielle d'environ 1422 mm/an. Les vents sont relativement fréquents dans cette région. On enregistre 59,7 jours de sirocco et 69,4 jours de vent de sable au cours de l'année. L'humidité relative moyenne est faible, elle est plus élevée en hiver qu'en été. Elle varie d'environ 27% en Juillet à 59% en Janvier. La moyenne annuelle est de l'ordre de 43 %. La radiation solaire est importante dans la région car l'atmosphère présente une grande clarté durant toute l'année. La durée d'insolation moyenne est de 8,2 heures par jour.

4 SOLS

Les sols, en majorité sableux, présentent des caractères salins, calcaires ou gypseux ou soumis à l'effet de la nappe phréatique ou à l'érosion éolienne. D'une manière générale, à cause de leur texture et leur faible teneur en matière organique, le niveau de fertilité est faible (faibles capacités d'échange ionique et de rétention en eau) ; le recours à la fertilisation et aux amendements organiques est indispensable pour assurer des rendements acceptables. Toutefois, la fertilisation est pratiquée d'une manière empirique.

En se référant à la carte pédologique du Hodna [7], La zone soumise à la mise en valeur agricole en irrigué présente les principaux types de sols suivants selon la CPCS 1967 [8] :

- sols minéraux bruts non climatiques d'apport alluvial et minéraux bruts xérique inorganisés d'apport.
- sols peu évolués non climatiques d'apport alluvial et éolien,
- sols hydromorphes minéraux ou peu humifères à redistribution de calcaire ou gypse à encroûtement gypseux.
- sols halomorphes à structure non dégradée et/ou dégradée, salins à alcalis.

5 MISE EN CULTURE EN IRRIGUE ET CHANGEMENT DE L'OCCUPATION DES SOLS

La mise en culture en irriguée a commencé en 1976 environ dans le cadre de la révolution agraire avec comme objectif d'irriguer 300 ha à partir de la nappe en charge sous jacente [3]. Après une trentaine d'années, on a constaté une progression des surfaces cultivées, une diminution des zones de parcours et une augmentation de l'ensablement [9]. La réduction des superficies de parcours et leur dégradation est due non seulement à des causes climatiques mais aussi et surtout au surpâturage et à l'extension des surfaces agricoles ayant comme résultat une érosion éolienne [10] avec formation de surfaces dunaires.

L'agriculture s'est développée là où les potentialités en eau ont été mises en évidence. C'est à dire dans la zone sableuse du sud du Chott. Selon les données de la direction des services agricoles (DSA), la superficie agricole utile (SAU) avoisine 42 000 ha. Les superficies irriguées ont enregistré une extension considérable depuis la mise en valeur en irrigué. Ainsi, les superficies irriguées avoisinent 21 000 ha ce qui représente approximativement 50% de la SAU.

6 MATERIEL ET METHODES

Suite aux différentes prospections pédologiques sur le terrain, trois sites ont été retenus pour l'implantation de profils pédologiques. Les profils se présentent sur une séquence d'environ 7 km allant du chott vers le sud de la zone. Ils se localisent dans des parcelles ayant été cultivées et irriguées depuis plus de 15 ans. Des profils adjacents à ces parcelles n'ayant jamais été ni irrigués ni cultivés ont été considérés comme témoins (figure 1). Des prélèvements de sol ont été effectués sur 06 profils, soit 23 échantillons au total. Les échantillons de sols ont été séchés à l'air libre, broyés puis tamisés à 2 mm.

6.1 ANALYSE DES SOLS ET TRAITEMENT DES ECHANTILLONS

La morphoscopie des sables : elle peut être définie comme la détermination statistique des différents types de grains de quartz dans les dépôts sableux. Elle permet la recherche de la nature de l'agent de transport donc d'usure. La morphoscopie des sables est une méthode très pratiquée dans les études de sédimentologie [11],[12], [13], [14], [15], [16], [17]. C'est une méthode pouvant aider, quand un doute subsiste, à identifier certains dépôts.

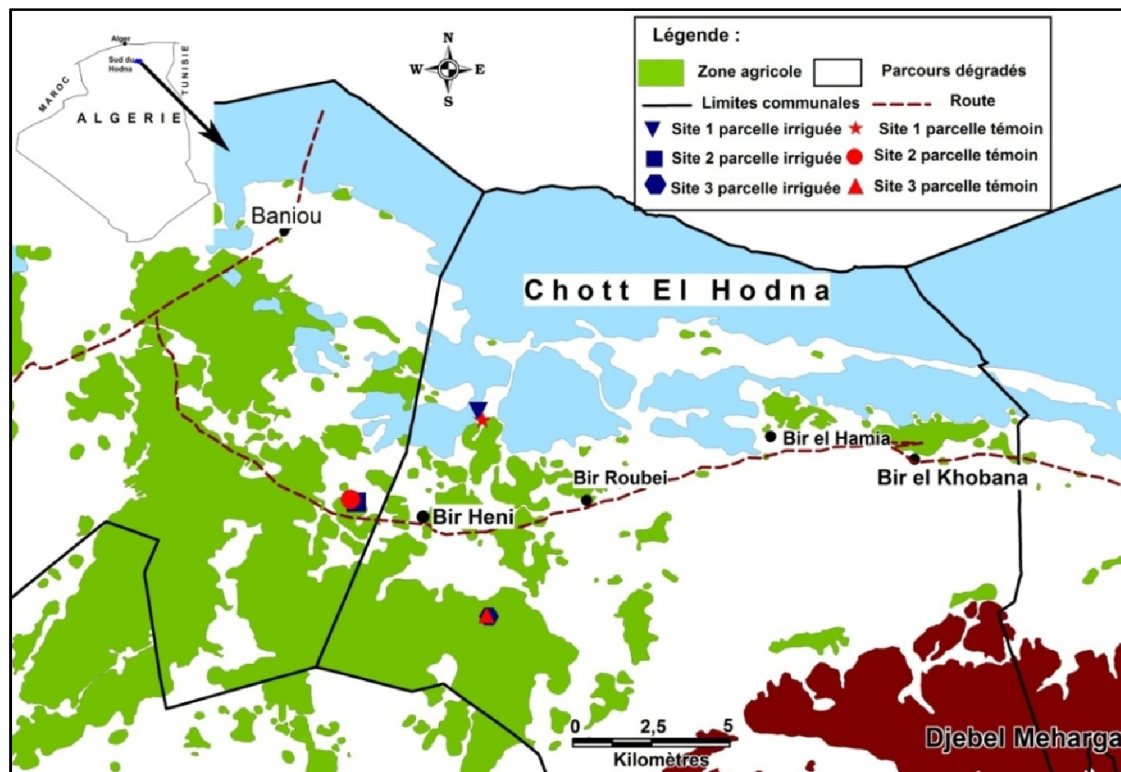


Fig.1. Localisation des fosses pédologiques des parcelles irriguées et des parcelles témoins adjacentes

Les échantillons du sol correspondants aux des différents horizons ont été utilisés. Nous nous sommes intéressés à la taille des sables dominante représentée par les sables très fins à moyens. Tout d'abord, si l'échantillon fait effervescence à l'acide, on le traite d'abord à l'HCl, pour le débarrasser des grains calcaires et ne pas risquer de confondre ceux-ci avec d'autres roches ou minéraux [14]. Le sol est lavé ensuite sous jet d'eau sur un tamis de 100 μm en frottant fortement avec les doigts pendant quelques minutes, pour le débarrasser des éléments fins. Les échantillons ainsi traités sont placés dans une étuve pour le séchage avant l'observation à la loupe. L'observation des sables a été réalisée à la loupe binoculaire. Le comptage des grains a été effectué le plus souvent sur 100 grains environ.

D'autres analyses de sol ont été réalisées, il s'agit du dosage du gypse par la méthode de chauffage proposée par Vieillefon [18], de la perméabilité sur échantillons remaniés [19], de la granulométrie par la méthode à la pipette Robinson et le calcaire total par le calcimètre Bernard [20].

7 RESULTATS ET DISCUSSION

7.1 ANALYSE STATISTIQUE GLOBALE

Dans la zone d'étude, la connaissance de la variation de la granulométrie des constituants minéraux revêt un intérêt capital. En effet, soumise à une érosion éolienne et une érosion hydrique d'une part, et subissant une pression anthropique intense (mise en culture en irrigué) [10], [21] d'autre part, l'évolution de ces sols méritent une attention particulière sachant que l'agriculture constitue un volet important du développement socio-économique de cette région.

L'analyse statistique des horizons des profils étudiés (Tableau 1) montre que la fraction sableuse est importante et marque la composition granulométrique de ces sols. En effet, la moyenne est de 59,6%. Les résultats révèlent que 78% des échantillons dépassent 50% de sable.

La fraction argileuse est faiblement représentée dans les échantillons de sol avec une moyenne de 9,2%. Par contre le limon fin est relativement bien représenté avec une moyenne de 19,65%. Si on considère la fraction argile plus limon fin, le tableau (1) indique une moyenne assez important de l'ordre de 26%. La présence de ces deux fractions en quantité significative est un signe de fertilité de ces sols. Il est ainsi utile d'étudier sa variation verticale au niveau du profil pédologique.

Tableau1. Statistiques descriptives des valeurs des fractions granulométriques

	Moyenne	Médiane	Minimum	Maximum	Ecart-type
Argile	9,20	8,5	0	22	6,78
Limon fin	19,65	17	0	67	18,01
Limon grossier	12,04	7	0	56	13,50
Sable fin	33,91	35	19	54	10,51
Sable grossier	25,65	27	1	66	16,11
Sables totaux	59,57	64	20	92	22,35
Argile+Limon fin	26,00	27	4	69	17,09

La matrice de corrélation entre les différentes fractions granulométriques (Tableau 2) permet de noter les relations suivantes :

- Une corrélation négative entre l'argile et le limon grossier.
- Une corrélation négative entre le limon fin et les sables.
- Une corrélation négative entre l'argile plus limon fin et les sables.
- Une corrélation positive entre l'argile plus limon fin et le calcaire total.
- Une corrélation négative entre les sables et le calcaire total.
- Pas de corrélation entre le limon grossier et l'argile plus limon fin.

De ce qui précède, on peut faire les remarques suivantes :

Dans les échantillons étudiés, l'augmentation de la fraction fine (argile et limon fin) coïncide avec la diminution des pourcentages des sables totaux et vis versa. Le calcaire évolue proportionnellement avec la fraction fine, ce qui suggère sa localisation dans cette fraction.

Tableau 2. Matrice de corrélation des fractions granulométriques

	Argile	Limon fin	Limon grossier	Sable fin	Sable grossier	Sables totaux	Argile+Limon fin	Calcaire total
Argile	1							
Limon fin	-0,41	1						
Limon grossier	-0,47	0,40	1					
Sable fin	0,26	-0,67	-0,59	1				
Sable grossier	0,18	-0,79	-0,58	0,39	1			
Sables totaux	0,25	-0,88	-0,69	0,74	0,90	1		
Argile+Limon fin	-0,03	0,93	0,25	-0,63	-0,79	-0,87	1	
Calcaire total	0,29	0,36	0,28	-0,58	-0,33	-0,51	0,51	1

7.2 VARIATION VERTICALE DES FRACTIONS GRANULOMETRIQUES

Les résultats de la variation verticale des sables totaux et de la fraction argile+limon fin sont reportés dans le tableau 3.

7.2.1 SITE 1

Mis à part certaines parties du chott affectées en surface par l'ensablement, le chott est un lieu de dépôt des éléments transportés par les cours d'eau.

a) Profil de la parcelle témoin

Il se présente sous trois horizons. Les pourcentages des sables totaux sont inférieurs à 21%. Ils enregistrent une diminution considérable par rapport aux autres sites. Les sables grossiers sont rares.

Les valeurs de l'argile sont négligeables. Les taux des limons sont très élevés (77 à 83%). Leurs teneurs sont relativement homogènes au niveau du profil.

b) Profil de la parcelle irriguée

Ce profil est localisé près d'un drain. Le sol était sous l'influence d'une nappe phréatique très salée. Le profil est formé de quatre horizons ; les deux derniers forment un encroûtement gypseux. Les microcristaux de gypse sont de la taille des sables ce qui influence sur la texture.

Les sables totaux varient de 24 à 83%. Le profil sableux est descendant, les sables augmentent avec la teneur en gypse.

7.2.2 SITE 2

Dans ce site, les profils pédologiques présentent plusieurs successions d'horizons (5 au total).

a) Profil de la parcelle témoin

Les pourcentages des sables totaux sont très importants, ils varient de 53 à 87%. Le profil sableux présente une onde au centre correspondant à une diminution des sables. La fraction argile+limon fin enregistre des valeurs allant de 7 à 34%. Le profil textural présente une onde au centre correspondant à une augmentation de cette fraction.

On note un noircissement au niveau des horizons médians témoignant d'une ancienne hydromorphie.

b) Profil de la parcelle irriguée

Les sables totaux varient de 52 à 75%. Le profil sableux représente une onde au centre correspondant à sa diminution. Les pourcentages de la fraction argile+limon fin oscillent entre 10 et 37%. Le profil textural présente une onde au centre qui coïncide avec une augmentation de ces fractions.

A la base de l'horizon 4, se présente une croûte calcaire de quelques cm d'épaisseur. On note aussi, comme dans le profil précédant, la présence d'un noircissement témoignant d'une ancienne hydromorphie.

L'augmentation de la fraction fine dans les deux profils du site 2 semble être en relation avec l'entraînement des particules fines en profondeur. Ceci est du certainement à la perméabilité élevée caractérisant ces matériaux sableux.

7.2.3 SITE 3**a) Profil de la parcelle témoin**

Les pourcentages des sables totaux (fins et grossiers) sont très importants au niveau du profil. Ils varient de 50 à 76%. Le profil textural sableux présente une onde au centre correspondant à l'abaissement des valeurs de sable. Les teneurs en argile+limon fin varient de 14 à 39%. Le profil textural de cette fraction présente une onde au centre témoignant de l'accroissement de la fraction fine.

Tableau 3. Variation des sables totaux et de a fraction argile+limon fin au niveau des profils pédologiques

Site 1 (profil témoin)			Site 1 (profil de la parcelle irriguée)		
Horizon (cm)	Sables	Argile+Limon fin	Horizon (cm)	Sables	Argile+Limon fin
0-15	21	27	0-13	24	42
15-40	20	69	13-73	36	52
40-128+	21	47	73-98	83	12
			98-123+	79	4
Site 2 (profil témoin)			Site 2 (profil de la parcelle irriguée)		
Horizon (cm)	Sables	Argile+Limon fin	Horizon (cm)	Sables	Argile+Limon fin
0-11	82	10	0-17	75	17
11-50	73	14	17-62	64	30
50-82	53	34	62-86	52	37
82-110	76	19	86-102	56	34
110-142+	87	7	102-122+	58	10
Site 3 (profil témoin)			Site 3 (profil de la parcelle irriguée)		
Horizon (cm)	Sables	Argile+Limon fin	Horizon (cm)	Sables	Argile+Limon fin
0-15	70	19	0-36	54	35
15-60	50	39	36-88	68	27
60-125+	76	14	88-138+	92	4

b) Profil de la parcelle irriguée

Les valeurs relatives en sables sont très importantes, ils varient de 54 à 92%. Le profil textural sableux est descendant. Les pourcentages de la fraction argile+limon fin oscille entre 4 et 35%. Le profil textural est ascendant.

On peut dire que dans le site 3, le sol est très sableux en profondeur. En surface, lorsqu'il est travaillé, la terre fine est ramenée en surface. Lors de la description morphologique du profil, on a constaté que la transition entre l'horizon 2 et 3 est graduelle avec la présence parfois de languettes de terre fine ce qui suggère un déplacement de ces éléments aux dépens des parties superficielles.

A travers les résultats précédents, on peut faire les constatations suivantes :

Les sols dans leur ensemble sont très riches en sable. Les pourcentages dépassent 50% et atteignent parfois 92%, exception faite pour le site du chott où les résultats révèlent des valeurs de sables totaux de l'ordre de 20% avec une raréfaction des sables grossiers quartzeux.

La diminution des sables correspond toujours à une augmentation de la fraction argile plus limon fin. Cet enrichissement semble être localisé dans les horizons médians où le profil textural marque une onde indiquant les valeurs les plus élevées.

Dans les horizons de surface des parcelles cultivées, la teneur en éléments fins est toujours supérieure à celle du témoin. Ceci est en fait lié au travail mécanique du sol qui ramène ces éléments fins en surface.

7.3 ORIGINE DES MATERIAUX DU SOL (MORPHOSCOPIE DES SABLES)

La détermination des différentes formes des grains de sable a été réalisée selon la nomenclature suivante [14] :

Non-usés (NU) : Presque toujours anguleux, à sommets ponctuels et arêtes tranchantes. Soit brillants, soit ternes.

Émoussés-luisants (EL) : Les sommets et les arêtes sont émoussés et brillants, fonctionnant comme un miroir convexe. Un œil exercé y reconnaît même l'image du filament de la lampe. Subanguleux à subarrondis. Résultat d'une longue usure par l'eau. Les fleuves ne donnent guère que des subanguleux, les petites plages récentes aussi ; sur les plages lacustres et surtout marines, à fort ressac, le façonnement aboutit à la longue à des subarrondis ou arrondis ; enfin par tourbillonnement dans des moulins karstiques ou autres, on peut arriver finalement à des arrondis-luisants et ronds-luisants.

Ronds-mats (RM) : Forme arrondie, à peine plus longue que large. Surface entièrement mate, du fait de marques de choc. Résultat de chocs dans l'air, sous l'effet du vent.

Les **Ronds-mats sales** Variété du groupe précédent, et qui s'en distingue (pas toujours facilement) par la présence de restes de ciment quartzeux ou ferrugineux, de grains doubles (deux grains accolés), de grains cassés. Ces formes n'ont pas été observées dans nos échantillons.

Les résultats retrouvés sont reportés dans le tableau 4. Ils comportent les pourcentages des formes des grains de sable quartzeux observés sous la loupe binoculaire.

7.3.1 CAS DU SITE 1

Au niveau du profil de la parcelle témoin, les émoussés luisants sont compris entre 57 et 68%. Les ronds mats varient entre 32 à 43%. Les non usés sont absentes. Au niveau du profil de la parcelle irriguée, les émoussés luisants oscillent entre 51 à 75% et les ronds mats entre 24 à 47%. Les non usés sont très faibles (0-2%).

On peut dire qu'en surface, on observe une abondance des émoussés luisants et des ronds mats. En profondeur, on note une augmentation des émoussés luisants contre une baisse des ronds mats ce qui peut être expliqué par une influence du transport par l'eau.

7.3.2 CAS DU SITE 2

Les résultats obtenus, indique qu'au niveau du profil de la parcelle témoin, les émoussés luisants varient de 36 à 83%. Les ronds mats oscillent entre 16 et 63%. Les non usés sont très faibles. Au niveau du profil de la parcelle irriguée, les émoussés luisants varient de 56 à 84%. Les ronds mats oscillent entre 16 et 42%. Les non usés sont rares.

On peut constater en surface une abondance des émoussés luisants et des ronds mats. En profondeur, Les émoussés luisants deviennent plus importantes ce qui met en évidence l'influence du transport par l'eau.

7.3.3 CAS DU SITE 3

Les résultats retrouvés montrent qu'au niveau du profil, les émoussés luisants et les ronds mats sont presque égaux. Au niveau du profil de la parcelle témoin, les émoussés luisants varient de 45 à 50%. Les ronds mats oscillent entre 51 et 55%. Les non usés sont rares. Au niveau du profil de la parcelle irriguée, les émoussés luisants varient de 49 à 50%. Les ronds mats oscillent entre 46 et 50%. Les non usés sont très faibles. Ses résultats supposent un façonnement mixte éolien et fluvial.

Des résultats précédents, on peut faire les commentaires suivants :

En surface, l'observation morphoscopique des sables révèle la présence des ronds mats et des émoussés luisants témoignant d'une origine mixte éolienne et hydrique. Ces résultats confirment une dynamique fluviale et une dynamique éolienne dans le sud du Hodna.

En profondeur, l'observation morphoscopique des sables révèle un accroissement des émoussés luisants notamment dans les sites 1 et 2 ce qui met bien en évidence l'importance du façonnement par l'eau dans une période antérieure dans ces milieux. Dans le site 3, la présence des ronds mats et des émoussés luisants indiquent un façonnement mixte.

Les profils témoins et les profils des parcelles irriguées présentent une allure générale semblable à l'exception des horizons de surface qui, soumis à un remaniement constant au niveau des parcelles irriguées, ramènent la terre des horizons médians sous l'effet du travail du sol. En surface, les ronds mats deviennent importantes ce qui suggère une action éolienne actuelle importante.

Tableau 4. Morphoscopie des sables

Site 1 (profil témoin)				Site 1 (profil de la parcelle irriguée)			
Horizon (cm)	RM	EL	NU	Horizon (cm)	RM	EL	NU
0-15	43,33	56,67	0	0-13	46,62	51,13	2,26
15-40	37,98	62,02	0	13-73	31,67	66,67	1,67
40-128+	31,58	68,42	0	73-98	23,96	75,00	1,04
				98-123+	26,71	73,29	0,00
Site 2 (profil témoin)				Site 2 (profil de la parcelle irriguée)			
Horizon (cm)	RM	EL	NU	Horizon (cm)	RM	EL	NU
0-11	62,6	35,77	1,63	0-17	42,27	55,67	2,06
11-50	51,02	46,94	2,04	17-62	38,37	60,47	1,16
50-82	17,51	81,92	0,56	62-86	26,67	71,85	1,48
82-110	20,39	77,67	1,94	86-102	16,22	83,78	0
110-142+	16,28	82,56	1,16	102-122+	17,65	80,88	1,47
Site 3 (profil témoin)				Site 3 (profil de la parcelle irriguée)			
Horizon (cm)	RM	EL	NU	Horizon (cm)	RM	EL	NU
0-15	54,6	45,4	0	0-36	45,71	50,48	3,81
15-60	53,53	45,52	0,95	36-88	49,42	48,84	1,74
60-125+	50,5	49,5	0	88-138+	49,57	48,72	1,71

Le Sud du Hodna était une zone de parcours où les nomades Hodnéens passaient l'hiver avant de se rendre en estivage au Nord sur les hautes plaines constantinoises. Au fil des temps, et suite à des considérations historiques et aux politiques agricoles développées, on assiste aujourd'hui à une amplification de l'érosion éolienne [21]. L'accroissement démographique dans cette région [22] et l'extension de l'agriculture dans ce milieu depuis quelques décennies ont réduit les superficies des parcours et par voie de conséquence ont augmenté le surpâturage et ont amplifié l'extension de l'ensablement [10], [23], [9]. Si l'agriculture a pu se développer dans ce milieu sableux c'est grâce aux crues des oueds qui permettent d'entretenir la fertilité du sol par les apports des éléments fins calcaires. Cependant, l'étude de la morphoscopie des sables a montré que les horizons de surface sont sujets à un apport éolien bien marquant par rapport aux horizons de profondeurs. En effet, Les labours et la jachère prolongée exposent le sol à l'érosion éolienne et la réduction des parcours, aux dépens de l'évolution des surfaces irriguées, favorise la surexploitation des maigres parcours déjà dégradés dans cette steppe sableuse ce qui peut compromettre la durabilité des aménagements hydroagricoles dans cette région.

8 CONCLUSION

Le sud du Hodna, région steppique de l'Algérie, est marqué par des conditions physiques sévères et par une anthropisation inquiétante. C'est une région venteuse où l'érosion éolienne pose de graves problèmes pour la mise en valeur. Elle se traduit dans l'espace par des accumulations dunaires qui ont été remises en mouvement par les hommes, par leurs actions de destruction de la végétation naturelle. Elle est parcourue aussi par des cours d'eau dont les crues influencent considérablement les caractéristiques du sol. L'étude des sols sur fosses pédologiques a montré d'une manière générale une prédominance de la texture grossière. Les crues rapportent les limons calcaires, qui entretiennent la fertilité des sols, et se trouvent entrainer dans les horizons médians à cause de la perméabilité élevée. Par la suite, dans les parcelles irriguées, le travail du sol favorise la remontée des ces éléments fins en surface. L'analyse morphoscopique des sables a révélé un apport mixte fluviale et éolien. La dynamique fluviale devient plus marquée en profondeur dans les sites 1 et 2 témoignant d'un façonnement par l'eau dans des périodes antérieures. Ce travail révèle aussi des signes d'une action éolienne actuelle importante en surface.

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La relation entre la gestion des connaissances et les technologies d'information et de communication

[The relationship between Knowledge management and information and communication technologies]

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ABSTRACT: This paper explores and reviews the ability of Information and Communication Technologies (ICTs) to improve the transferability of knowledge. The aim here is to look beyond knowledge management at a general level. By distinguishing between the types of knowledge, a more thorough understanding of knowledge transfer is sought, and in particular of the role of ITCs in this process. ICTs favor the transfer of knowledge that can be codified and reduced to data. Of central concern here is what role, if any; do ICTs have with the knowledge management? This paper raises issues concerning the relationship between knowledge management and Information technology and communication.

KEYWORDS: ICT Knowledge, tacit knowledge, explicit knowledge, TIC.

RESUME: Ce document explore et examine la capacité des technologies de l'information et des communications (TIC) afin d'améliorer la transférabilité des connaissances. Le but ici est de regarder au-delà de la gestion des connaissances à un niveau général. En distinguant entre les types de connaissances, une compréhension plus approfondie de transfert de connaissances est demandée, et en particulier du rôle des TIC dans ce processus. TIC favorisent le transfert des connaissances qui peuvent être codifiées et réduites à des données. Au centre des préoccupations, voici ce rôle, le cas échéant, Quel est le lien entre TIC et gestion des connaissances? Ce document soulève des questions concernant la relation entre la gestion des connaissances et de la technologie de l'information et de la communication.

MOTS-CLEFS: connaissance, connaissance tacite, connaissance explicite, ICT.

1 INTRODUCTION

Au sein d'une économie désormais basée sur la dématérialisation des échanges, la gestion des connaissances ou Knowledge Management s'est progressivement imposée comme discipline des sciences de gestion de l'organisation. Les différents auteurs ayant traité le sujet ont démontré l'importance de la valorisation des connaissances en tant que source de création de richesses pour l'entreprise. Les premières littératures sur la gestion des connaissances, se sont d'abord centrées sur la définition et les caractéristiques du management des connaissances. Il sera donc question de partir d'un essai de définition de l'assise théorique de cette étude. Ensuite, de clarifier ce qui est la connaissance, pour aboutir à une présentation assez précise du concept de gestion des connaissances et ses principales caractéristiques et ses différentes approches. Enfin, on va s'intéresser à préciser la relation entre TIC et management des Connaissances.

2 MATERIELS ET METHODES

2.1 L'ENJEU DES CONNAISSANCES DANS L'ENTREPRISE

Avant de procéder à une étude du concept de gestion des connaissances proprement dit, il convient tout d'abord de s'intéresser de manière approfondie à ce qu'est la connaissance, considérée de plus en plus aujourd'hui et selon le courant du Knowledge-Based View, comme une ressource clé ou ressource stratégique pour les entreprises (Dudezert, 2003). Les études portant sur la connaissance remontent à plusieurs siècles. En effet, tout au long de l'histoire, l'homme a été préoccupé par la connaissance et sa définition. Ainsi, de nombreux penseurs contemporains, ont cherché à comprendre le terme connaissance en donnant chacun des définitions, sans qu'aucun consensus n'ait pu être dégagé. Toutefois, chacune de ces définitions apporte une contribution non négligeable pour la compréhension de ce qu'est la connaissance en tant que ressource pour l'entreprise.

2.1.1 UN ESSAI DE DEFINITION DE LA NOTION DE CONNAISSANCE

La connaissance est un concept polysémique, il a fait l'objet de très nombreuses définitions. Nonaka, l'un des auteurs les plus cités dans le cadre de la gestion des connaissances, considère la connaissance comme « un processus humain dynamique de justification de croyances personnelles vers l'atteinte de la vérité » (Nonaka et Takeuchi, 1995). Dans la même optique, Davenport et Prusak considèrent que « Les connaissances sont un mélange fluide d'expériences vécues, de valeurs, d'informations contextuelles, dans la perspective d'un savoir-faire précis, qui forment un cadre permettant d'évaluer et d'intégrer de nouvelles expériences et de nouvelles informations » [6]. Ces définitions ressortent bien le caractère assez complexe qui réside dans la définition de la connaissance. A ce sujet, Davenport et Prusak arguent que « il ressort de cette définition que les connaissances ne sont pas quelque chose de clair et net. » [6]. Malgré cette complexité avérée par certains auteurs, d'autres définitions plus concrètes semblent simplifier, dans une certaine mesure, la compréhension de ce qu'est la connaissance. Ainsi, Aurelie Dudezert et Imed Boughzala définissent la connaissance comme « Le résultat temporaire d'une expérience humaine et d'une réflexion basées sur un ensemble de croyances. Elle réside dans des objectifs fictifs dans le cerveau des personnes et peut potentiellement être transformée en action. ». [2]

En effet, la littérature abondante sur le sujet montre qu'il est crucial, pour mieux cerner ce qu'est la connaissance, de la distinguer d'avec la notion d'information (Nonaka et Takeuchi, 1995). L'information est un moyen ou un matériau permettant de découvrir et de construire la connaissance. Elle affecte la connaissance en lui ajoutant quelque chose ou en la structurant. Ainsi, « L'information est un flux de messages, tandis que la connaissance est créée et organisée par le flux même de l'information, ancré sur l'engagement et la conviction de son titulaire » [28]. La connaissance est de ce fait intimement liée au processus d'apprentissage, d'éducation, de recherche et d'utilisation des compétences (Morad Diani, 2002). Tandis que pour la connaissance, les individus réalisent les fonctions : porteurs, créateurs et utilisateurs. Autrement dit, si la technologie est adaptée au traitement de l'information, le traitement de la connaissance est avant tout une activité humaine (Alexandre Perin, 2004). En définitive, une information est une donnée mise en contexte. Et une connaissance est une information comprise, c'est à dire assimilée et utilisée par un individu, qui permet d'aboutir à une action. Après ce tour de la littérature sur la définition de la connaissance, il est nécessaire afin d'affiner la compréhension sur ce concept, de s'intéresser aux différentes formes que peut revêtir la connaissance.

2.1.2 LA TYPOLOGIE OU CLASSIFICATION DES CONNAISSANCES

Le paragraphe précédent a fait état de l'importance accordée au concept de connaissance. Ce dernier a en effet été au cœur de nombreux débats. Il apparaît donc naturel qu'il en est découlé un nombre important de taxonomies toutes plus ou moins différentes les unes des autres. En se basant sur la littérature, cette étude va se limiter à la présentation de deux dimensions jugées incontournables dans l'élaboration de toute recherche sur la gestion des connaissances, comme c'est le cas pour le présent travail. Il s'agit de la dimension épistémologique qui oppose la connaissance tacite à la connaissance explicite et la dimension ontologique qui oppose les connaissances individuelles aux connaissances collectives.

Probablement, l'une des plus célèbres et des plus pertinentes classifications, la dimension épistémologique de la connaissance a fait l'objet de nombreux travaux (Polanyi, 1962 ; Nonaka, 1991; Nonaka et Takeuchi, 1995). Dans ses travaux, Michael Polanyi définit le caractère tacite de la connaissance en usant une expression désormais célèbre « we can know

more than we can tell »¹ (Polanyi, 1966). L'idée derrière cette expression est reprise plus tard par Nonaka, dans son célèbre livre sur la Création de la connaissance, qui considère la connaissance tacite comme une connaissance acquise par l'expérience, difficile à formaliser et à communiquer (Nonaka et Takeuchi, 1995). Autrement dit, il s'agit d'une connaissance qui est personnelle, spécifique à un contexte donné et difficile à articuler en un langage formel. Ainsi, Leonard et Sensiper (1998) décrivent les connaissances tacites comme étant cachées, intangibles, subjectives et spontanées puisque provenant directement de notre inconscient ou de notre subconscient (S. Boutelitan, 2005).

A l'opposé des connaissances tacites, les connaissances explicites sont celles qui peuvent être formellement articulées ou codées et qui de ce fait sont faciles à transférer et à partager. Ainsi, contrairement aux connaissances tacites, les connaissances explicites sont donc objectives et facilement accessibles (Hall et Andriani, 2003). Hall et Andriani ajoutent que, la connaissance explicite est la connaissance ayant été capturée dans un code ou une langue qui facilite la communication. Cela implique que les connaissances explicites peuvent être traitées par ordinateur, peuvent être facilement transmises de manière électronique et entreposées dans des bases de données (Nonaka & Takeuchi, 1995). Dans ce contexte et en accord avec Grant (1996) nous sommes enclins à considérer que la connaissance tacite est comparable au « savoir-faire »² tandis que la connaissance explicite est comparable au « savoir-propos ». Toutefois, bien qu'il existe une distinction claire entre les connaissances tacites et explicites, il convient de garder à l'esprit que ces deux types de connaissances restent complémentaires et interdépendantes, certains auteurs estiment dès lors que les connaissances tacite et explicite se constituent mutuellement.

La deuxième typologie fait référence à la dimension ontologique qui représente les différents niveaux de la connaissance à savoir : les connaissances individuelles opposées aux connaissances collectives (ou sociales). Par connaissances individuelles, il faut entendre ici l'ensemble des croyances d'un individu sur les relations de cause à effet entre des phénomènes, ou tout simplement le savoir créé par les individus.

A l'opposé, les connaissances collectives, parfois divisées en sous niveaux : le groupe, l'organisation et l'inter-organisation (Nonaka et Takeuchi, 1995), sont considérées comme les connaissances de l'organisation, ou mieux encore, comme les connaissances qui sont largement partagées et détenues par un grand nombre d'individus dans l'organisation. Il peut s'agir de routines, de pratiques etc..... Par exemple, le départ d'un individu est peu préjudiciable pour une entreprise. En revanche, le départ d'une équipe toute entière qui a développé des connaissances collectives spécifiques est très dangereux pour toute organisation.

Les deux dimensions de la connaissance (épistémologique et ontologique) présentées ci-dessus ont été au centre des analyses de Nonaka et Takeuchi dans le cadre de leur modèle de création des connaissances

2.1.3 LE MODÈLE DE LA CRÉATION DES CONNAISSANCES DE NONAKA ET TAKEUCHI

En pratique, force est de constater que les mises en œuvre opérationnelles du management des connaissances s'appuient largement sur les travaux de Nonaka et Takeuchi (1995) qui ont mis en avant le rôle essentiel de la connaissance et plus précisément celui des interactions entre connaissances tacites et explicites dans l'émergence de la connaissance organisationnelle.

¹ Traduction : *Nous pouvons connaître plus que nous pouvons dire.*

² Grant compares explicit knowledge to « know about » and tacit knowledge to « know-how »

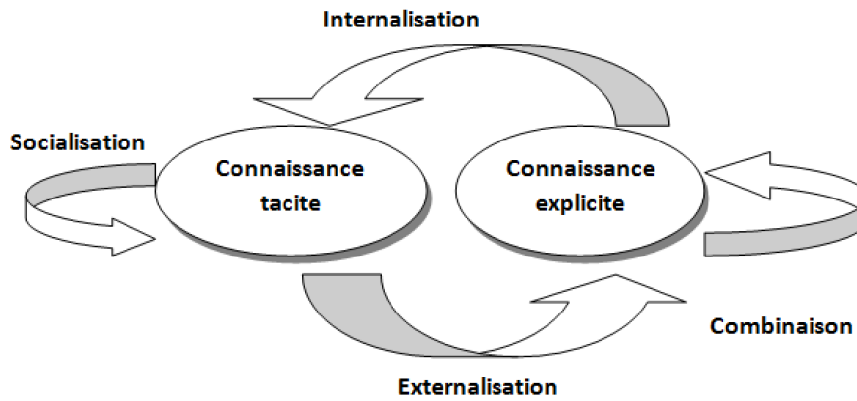


Fig. 1. La création des connaissances

Source : Nonaka et Takeuchi, 1995

La théorie de la création de la connaissance établie par Nonaka (1991) et popularisée par l’ouvrage de Nonaka et Takeuchi (1995) est sans doute l’un des modèles qui a le plus influencé le management des connaissances. En effet, à la suite de ses travaux sur les raisons de la performance du processus d’innovation dans les entreprises Japonaises dans les années 1980, Nonaka a émis l’idée de base de son ouvrage selon laquelle la connaissance naît de l’interaction entre connaissances tacites et connaissances explicites. Ainsi, cette interaction entre les deux types de connaissances appelée « processus de conversion de la connaissance. [30]

	Connaissance tacite	Connaissance explicite
Connaissance tacite	Socialisation	Extériorisation
Connaissance explicite	Intériorisation	Combinaison

Fig. 2. Les quatre modes de conversion de la connaissance

Source : Nonaka et Takeuchi, 1997

Le processus de création des connaissances commence par la Socialisation (conversion du tacite vers le tacite). Il correspond au processus de diffusion de connaissances tacites entre les individus au sein de l’organisation. Il s’agit donc de transmettre des modèles mentaux ou des compétences techniques. Au regard de la difficulté de transmission des connaissances tacites, Nonaka et Takeuchi soulignent que la clé pour acquérir une connaissance tacite c’est l’expérience partagée. Cette transmission peut très bien se faire sans échanges verbaux. En effet, la transmission d’un tour de main s’effectue généralement par l’observation, l’imitation et surtout la pratique. Dans la pratique, la socialisation consiste à capter des connaissances grâce à la proximité physique au sein de l’organisation et par l’intermédiaire d’interaction directe avec les clients et fournisseurs.

A la suite de la socialisation vient l’étape de l’Extériorisation (Conversion de la connaissance tacite en connaissance explicite par articulation de cette connaissance) L’extériorisation est un processus qui permet le passage de connaissances tacites en connaissances codifiées, sous la forme de concepts, modèles ou hypothèses. Contrairement à la phase de

socialisation dans laquelle l'interaction se fait principalement entre les individus, dans la phase d'extériorisation, l'interaction a lieu au sein des groupes où les individus deviennent une partie intégrante d'un groupe. Au sein du groupe, la modélisation d'un concept (l'extériorisation) est très souvent déclenchée par le dialogue et l'échange avec d'autres individus. Dans la pratique, cette transformation se présente sous forme d'articulation des connaissances tacites et de traduction du savoir tacite des clients et des fournisseurs dans une forme compréhensible.

Après la transformation des connaissances tacites en connaissances explicites, ces dernières doivent être diffusées au sein de l'organisation et combinées à d'autres connaissances préexistantes ou nouvellement externalisées : c'est l'étape de la Combinaison (conversion de l'explicite vers l'explicite). La combinaison est un processus de création de connaissances codifiées à partir de la restructuration d'un ensemble de connaissances codifiées acquises par différents canaux de communication. Ici l'interaction se fait au-delà du groupe et a lieu entre différents groupes au sein de l'organisation. Ce mode de conversion se manifeste dans la pratique à travers trois sous-processus importants à savoir : la capture et l'intégration de nouvelles connaissances ; la diffusion des connaissances explicites et l'édition ou la transformation des connaissances explicites.

Pour finir, l'Intériorisation (Conversion de la connaissance explicite en connaissance tacite par appropriation) vient clôturer le processus de conversion de la connaissance. Il s'agit du processus de conversion de connaissances explicites nouvellement créées en connaissances organisationnelles tacites sous la forme d'un modèle mental partagé. L'intériorisation suppose que les individus faisant partie d'une grande entité (le groupe et l'organisation), identifient les connaissances qu'ils jugent pertinentes pour eux, les mettent en pratique et les incarnent dans leur corps de connaissances tacites. Cette conversion est un processus d'apprentissage par la pratique et utilise divers supports tels les documents, les manuels, les procédures etc... L'intériorisation en clôturant le processus dynamique de conversion des connaissances dans l'organisation constitue donc un mécanisme de base dans le processus de création des connaissances au sein de l'organisation. En effet, la connaissance tacite nouvellement créée par internalisation devra ensuite être partagée entre les individus ce qui déclenchera donc la nouvelle spirale de la création des connaissances.

Ainsi, après avoir exploré la littérature sur ce qu'est la connaissance, ses différentes formes et ses principaux modes de transformation, il convient de s'intéresser au concept de gestion des connaissances proprement dit.

2.2 LE KNOWLEDGE MANAGEMENT OU GESTION DES CONNAISSANCES

Dans un contexte économique où la valeur ajoutée repose notamment sur l'échange et la production d'actifs immatériels, et où l'utilisation des technologies de l'information a conduit à une accélération de la circulation de l'information (on parle d'économie de la connaissance), les entreprises ont pris conscience de la nécessité de gérer leur capital savoir (connaissances, compétences...) (Aurelie Duzert et Immed Boughzala, 2003). Ainsi, on assiste depuis un peu plus d'une quinzaine d'années à l'apparition des démarches visant à optimiser le management de ces flux d'information, de connaissances : c'est l'ère du Knowledge management. Longtemps considéré comme un simple effet de mode, ce mouvement a évolué pour se constituer peu à peu en une discipline à part entière des sciences de gestion.

Le management des connaissances ou gestion des connaissances, issu de l'anglais Knowledge Management (KM en abrégé), est depuis plusieurs années au cœur des préoccupations des dirigeants d'entreprises qui ressentent de plus en plus le besoin de créer, partager et capitaliser les connaissances au sein de leur organisation. Comme tout concept nouveau, le management des connaissances a fait l'objet de nombreuses définitions plus ou moins claires et précises (Davenport, Prusak, Quintas, Earl,...).

Le management des connaissances, peut être défini comme l'ensemble des actions systématiques et organisées qu'une entreprise réalise pour obtenir une plus grande valeur des connaissances dont elle dispose (Davenport et Prusak, 1998). Pour certains, le management des connaissances est un « processus organisationnel permettant l'acquisition, la structuration, l'intégration et la diffusion de la connaissance des individus à travers l'organisation, en vue d'offrir une aide au travail et d'accroître l'efficacité organisationnelle » (Quintas et al. 1997). Il s'agit donc, suivant cette vision d'utiliser aux mieux les connaissances déjà existantes chez les individus de l'organisation, en s'assurant que ces connaissances soient partagées par les bonnes personnes au bon moment et au bon endroit afin qu'elles puissent prendre les bonnes décisions dans un but d'accroissement de l'efficacité organisationnelle. Autrement dit, c'est l'ensemble des actions systématiques et organisées qu'une entreprise réalise pour obtenir une plus grande valeur des connaissances dont elle dispose (Davenport et Prusak, 1998).

Suivant cette optique, le management des connaissances apparaît donc comme un processus de création de nouvelles connaissances à travers l'innovation continue (ce qu'on qualifie d'apprentissage organisationnel), qui est présentée dans la

littérature comme une source importante d'influence de la performance organisationnelle (Nonaka, 1991 ; Nonaka et Takeuchi, 1995 ; Davenport et Prusak, 1998).

Dans une autre approche, la gestion des connaissances s'entend comme un dispositif centré sur à ce que les spécialistes appellent « le capital intellectuel », source fondamentale de création de la valeur et du développement économique des entreprises. D'après Edvinsson L. et Malon M. S. (2007) c'est : « le processus à travers lequel les organisations génèrent de la valeur à partir de leurs actifs intellectuels, et des actifs fondés sur la connaissance. Le plus souvent, la génération de la valeur à partir de tel actif permet de les partager entre les employés, départements et même avec d'autres entreprises dans un effort de conseil de bonnes pratiques ». Dans la même approche l'organisation de coopération et du développement économique (l'OCDE) considère la gestion des connaissances comme « The management of intellectual capital ». Le capital intellectuel est composé de deux éléments fondamentaux, à savoir le capital humain et le capital organisationnel ou structurel. Le capital humain s'agit en fait, de l'ensemble des connaissances détenues par les membres de l'organisation. Quant au capital structurel, il rassemble les connaissances capturées et institutionnalisées au niveau de l'organisation. D'autres auteurs tel que Boisot M. (2005) voit ce concept sous un angle plus au moins technique, en tant que démarche qui permet de mettre en place des outils technologiques, tels que l'intranet, les outils du travail collaboratif, etc. permettant de repérer, archiver et enregistrer les connaissances. Par ailleurs le Club Informatique des Grandes Entreprises Françaises (CIGREF), définit le concept de la gestion des connaissances comme « un ensemble de modes d'organisation et de technologies visant à créer, collecter, organiser, stocker, diffuser, utiliser et transférer la connaissance dans l'entreprise ». Selon ce club, la connaissance est matérialisée par des documents, le capital intellectuel et les expériences des collaborateurs ou des experts d'un domaine.

La gestion des connaissances peut se définir aussi comme un « processus de capture et d'enregistrement de l'expertise collective d'une entreprise, quel que soit l'endroit où cette dernière réside, [...] puis de sa redistribution là où elle est susceptible de produire les meilleurs profits » [11]. Bref, le KM devrait assurer la capitalisation, le partage et la stimulation de la création des connaissances. En d'autres termes, réaliser les trois objectifs stratégiques d'une démarche KM (Ermine, 2004). En effet, la capitalisation consiste à stocker, préserver les "connaissances cruciales" c'est-à-dire celles qui ont de la valeur pour l'entreprise.

Le partage des connaissances ou knowledge sharing renvoie à une fertilisation des connaissances due à la superposition des différents savoirs des acteurs. La création des connaissances permet de favoriser la créativité des acteurs par la stimulation de la production des connaissances. En résumé, ce concept protéiforme peut donc être vu de façon général comme l'art de valoriser la richesse immatérielle d'une organisation. C'est « l'exploitation de la richesse immatérielle d'une société pour atteindre des objectifs d'affaires » [36].

Par ailleurs elle pourra collecter des informations concernant ses échecs : ceux-ci devront être capitalisés et enrichis ce qui permettra de ne plus reproduire les erreurs du passé.

Le management des connaissances n'est donc pas, par définition, une fin en soi, c'est un moyen donné aux entreprises d'accroître leur performance (Earl, 2001).

Après avoir défini la gestion des connaissances, nous allons maintenant voir la relation entre TIC et gestion des connaissances.

2.3 TECHNOLOGIE D'INFORMATION ET DE COMMUNICATION (TIC) ET MANAGEMENT DES CONNAISSANCES

Depuis les années 70-80, dans les pays développés, les TIC ont progressivement pris de l'ampleur pour être désormais omniprésentes dans le fonctionnement des entreprises et des organisations, tant publiques que privées. Cette introduction des TIC s'est effectuée par poussées successives, sans programme défini, mais simplement en suivant les innovations techniques et les succès commerciaux. L'objectif de l'introduction des TIC était la recherche de l'efficacité et de la rapidité dans l'accomplissement des tâches classiques de l'organisation.

La diffusion des TIC au sein de la société est devenue un objet central d'analyse pour les sciences sociales. D'une part, ces technologies accompagnent et sont porteuses de changements sociétaux. D'autre part, autour d'elles, s'organisent des phénomènes d'apprentissage, de coordination, de réorganisation, d'innovation, qui réinterrogent certains des fondements des sciences sociales.

Au-delà des aspects liés au traitement de l'information, les TIC sont un puissant moyen de mise en relation des individus et des groupes, qu'il s'agisse de communication interpersonnelle, d'échanges économiques, ou encore d'échanges ou de réception d'information. Les acquis des recherches passées convergent sur l'absence de déterminismes de nature purement technologiques, économiques ou sociaux et réfutent la mise en place d'un modèle économique, culturel ou social unique.

Depuis plusieurs années, les sciences sociales ont mis l'accent sur les changements organisationnels associés aux TIC. Eric Brousseau et Frédéric Moatty (2003) estiment que « D'une certaine manière, ces technologies peuvent être considérées comme la production endogène de systèmes économiques et sociaux où la division du travail s'est heurtée à des difficultés de coordination auxquels on a tenté d'apporter des réponses technologiques » [10].

Cela étant, pendant longtemps, les TIC ont été associés à des modèles organisationnels qui auraient été eux-mêmes techno-déterminés. Les technologies des années 60 et 70 auraient été porteuses d'une plus grande centralisation, tandis que celles des années 80 et 90 auraient produit l'effet contraire.

Toutefois, certains travaux mettent au contraire l'accent sur l'idée que les TIC s'adaptent à de nombreuses formes organisationnelles. Leur introduction dans les organisations s'accompagne de changements organisationnels qui suivent deux logiques.

Premièrement, les TIC permettent de contourner certaines contraintes organisationnelles et permettent donc aux organisations d'améliorer leur adaptation aux contraintes de leur environnement. Deuxièmement, les changements empruntent des trajectoires spécifiques découlant des particularités des processus d'appropriation, d'apprentissage et d'innovation.

L'étude de ces évolutions et adaptations spécifiques conduit à mieux appréhender les propriétés et les potentialités des mutations organisationnelles associées aux TIC.

Par ailleurs, il a toujours été question des performances effectives des TIC et le doute subsiste quant à leur contribution réelle à la productivité. On constate donc l'existence d'un paradoxe puisque d'un côté, la présence de l'outil informatique en entreprise est aujourd'hui généralisée et de l'autre côté, on a du mal à voir cet outil comme un levier de performance économique et organisationnelle et de transformation des techniques managériales. A partir de ce constat, il nous semble utile d'analyser la réalité de l'usage des technologies de l'information dans les entreprises et leur impact sur le management et la stratégie.

De manière générale, les travaux de l'observatoire Dauphine Cegos de l'e-management qui se poursuivent et ont fait l'objet d'un ouvrage coordonné par Michel Kalika, invitent à une réflexion sur plusieurs perspectives.

- Un effet de généralisation de la pénétration des TIC dans toutes les fonctions de l'entreprise est mis en évidence dans les résultats d'enquêtes. En France, et plus généralement dans les pays développés, ces outils sont banalisés du fait de la forte réduction des écarts entre les entreprises en termes d'équipement et d'usage.

- les TIC entraînent un bouleversement de deux dimensions essentielles de l'activité de tout individu, à savoir la relation au temps et à l'espace. Ce bouleversement doit être pris en compte par la réflexion managériale.

- La question de la surcharge informationnelle ne doit pas non plus être occultée : elle nécessite des réponses organisationnelles et individuelles pour éviter que les technologies produisent de l'excès d'information qui risque de tuer la communication.

Les TIC se situent au centre des préoccupations managériales tant sur le plan stratégique qu'organisationnel. Mais leur diffusion ne se fait pas sans créer de nombreux problèmes aux managers.

2.4 L'ENJEU STRATEGIQUE DES TIC

Nous considérons dans cette recherche que deux types de concepts expriment l'existence et la qualité du management stratégique dans une entreprise

Les discours sur l'émergence des TIC doivent cependant être confrontés aux pratiques effectives. L'analyse du sens et des enjeux que donnent les utilisateurs à leurs pratiques est ainsi un moyen essentiel pour révéler les modèles sociaux émergents. Ces analyses permettent de comprendre comment et pourquoi les individus et les groupes s'approprient (ou non) les technologies en les mettant au service de leurs intérêts et de leurs besoins de sociabilité, d'identité, d'autonomie ou d'échange, participant ainsi à la transformation des rapports sociaux ou à celle d'institutions comme la famille, l'éducation ou l'État, et plus largement, à l'évolution des modes de vie. La diffusion massive du téléphone mobile et l'extension de ses usages, par exemple ceux qui sont liés aux nouvelles offres des médias de masse, ne peuvent se comprendre sans la rencontre et la mobilisation d'une diversité d'acteurs y projetant leurs intérêts (économiques du côté de "l'offre" ; aspirations identitaires, besoins d'individualisation, de contact ou de mobilité du côté de la "demande") qui peuvent interagir de manière accélérée et inédite sur les contenus ou les technologies, redéfinissant de ce fait l'offre et ses relations à la demande. (Eric Brousseau, Frédéric Moatty, 2003, p6)

On trouve aussi, deux hypothèses qui constituent le fondement du concept d'alignement stratégique, proposé par Henderson et Venkatraman (1999). La première hypothèse est que la performance dépend directement de l'équilibre stratégique entre l'attitude concurrentielle de l'entreprise et sa structure administrative. La deuxième considère que cet équilibre est dynamique puisque l'alignement est censé être un processus permanent de changement et d'adaptation et non un événement. Partant de ces hypothèses, le levier critique n'est pas la technologie elle-même, mais la capacité d'utiliser cette dernière sur le plan concurrentiel. Aussi, Grant (2003) considère à cet effet que l'analyse de la valeur réelle pouvant être consécutive aux investissements en TI demande, de la part de l'entreprise, un alignement entre ses activités et les stratégies conséquentes en matière de TI.

Par conséquent, la stratégie d'alignement à un réseau conduit à une stratégie d'échange d'informations et à la mise en place d'une technologie de support. Lors des relations d'échanges entre partenaires, cette technologie entraîne des changements notables qui ont des conséquences à la fois sur l'économie et la gestion interne de l'entreprise, et sur sa stratégie de réseau (Middleton et Harper, 2004). Au total, l'alignement stratégique entraîne la transformation des relations inter-organisationnelles et en crée de nouvelles grâce aux partenariats, aux alliances et aux échanges informationnels. Ces relations permettent aussi la mise en place d'autres moyens de communication, de nouveaux produits et services, ce qui permet de mieux cibler les objectifs marketings (Henderson et Venkatraman, 1999).

Le concept d'alignement stratégique permet de décrire la cohérence entre les objectifs poursuivis et les objectifs de l'entreprise en général. Souvent, les spécialistes considèrent que la performance organisationnelle est le résultat de cette cohérence. Autrement dit, la performance organisationnelle serait la conséquence de la capacité du management de chaque entreprise à réaliser une structure interorganisationnelle adéquate par rapport à ses objectifs et à sa vision stratégique.

Considérant que la planification stratégique des SI conditionne le succès des investissements en TI, on peut dire qu'elle constitue un défi pour les directeurs informatiques.

La planification stratégique des SI est un processus d'identification de l'ensemble des applications informatiques permettant à l'organisation de réaliser son plan et d'accomplir ses objectifs (Gottschalk, 1997).

King et Teo (1997) résument les objectifs de la planification stratégique des SI en stipulant que celle-ci inclut l'ensemble des activités qui permettent d'identifier les opportunités stratégiques nécessaires à une utilisation appropriée des technologies de l'information, le but étant de soutenir les plans stratégiques de l'entreprise et de préserver une fonction SI efficace et efficiente.

2.4.1 SITUATION, ENVIRONNEMENT ET DISTRIBUTION DES CONNAISSANCES

La prise en compte de la situation et de l'environnement permet d'alléger la vision d'un acteur doté d'un système de représentation complexe des connaissances. Ainsi, dans les modèles de cognition située, l'action est ancrée dans le monde, et l'environnement (socialement construit) sert de guide pour l'action grâce aux repères cognitifs et sensoriels, aux contraintes ou aux aides qu'il fournit. Ces modèles sont ainsi particulièrement utiles dans les environnements technologiques complexes où les TIC tiennent une grande place et où l'environnement des utilisateurs a été conçu comme une ressource importante du pilotage de l'action. Les TIC jouent aussi un rôle dans le fonctionnement de réseaux d'acteurs. La production de logiciel libre correspond ainsi à une coproduction des connaissances dans un contexte où les frontières entre l'offre et la demande se redéfinissent. Les modèles de cognition distribuée entre différents acteurs (humains et machiniques) permettent d'alléger les hypothèses souvent irréalistes sur les connaissances ou la rationalité des usagers supposée illimitée alors qu'ils s'appuient de plus en plus sur leur environnement techno-cognitif. L'accent peut ainsi se déplacer sur les outils d'aide à la décision ou à la représentation des connaissances, sur les modifications de l'accès aux ressources documentaires, ou sur les apprentissages de la navigation dans des réseaux informationnels en transformation. Les modalités traditionnelles d'accès à la connaissance se transforment sous l'effet des technologies numériques qui aménagent des contacts inédits avec des interlocuteurs humains ou machiniques, soulignant l'importance de l'apprentissage sur le tas, de la multi modalité des usages et de la compétence dans leur articulation. (Eric Brousseau, Frédéric Moatty, 2003)

2.4.2 UNE INFRASTRUCTURE MODERNE AU SERVICE D'UNE ECONOMIE COMPETITIVE

Prenant l'exemple de la Tunisie, on trouve qu'elle a mis un plan d'action pour promouvoir les Technologies de l'Information et de la Communication. (Plan d'action 2013-2017)

Renforcer la coopération sectorielle

- Poursuivre la coopération dans le domaine des TIC pour l'instauration d'une société de l'information inclusive à l'échelle universelle y compris l'échange d'expériences et d'expertise en matière de réglementation sectorielle dans la perspective du rapprochement du cadre réglementaire avec celui de l'UE (par exemple par le Réseau Euro-Méditerranéen des Régulateurs - EMERG) ;
- Favoriser la coopération institutionnelle entre régulateurs/agences Européens et Tunisiens (l'Agence Nationale de Certification Électronique, l'Agence Nationale des Fréquences, l'Instance Nationale des Télécommunications), par exemple en intégrant l'ANCE dans les projets sur l'e-signature ;
- Développer la coopération dans le domaine de certification électronique, en commençant par le domaine de l'e-signature, et en évaluant les possibilités d'un échange d'expertise technique et/ou juridique ;
- Echange d'expériences dans le domaine de la sécurité et la confiance du numérique (cyber sécurité)
- Echange d'expériences et d'expertises afin de renforcer les capacités d'évaluation des marchés des télécommunications et les perspectives de croissance offertes par le commerce électronique;
- Développer une coopération plus avancée dans le domaine de la société d'information et de l'économie numérique sur les thèmes en commun, en prenant le Plan d'Action comme référence;
- Promouvoir le libre usage de l'internet, y compris un échange d'expertise et d'expérience sur les développements européens, internationaux et tunisiens, concernant les principes qui gouvernent l'internet
- Continuer à renforcer la compétitivité et les capacités du secteur des TICs en Tunisie
- Poursuivre et assurer la coopération relative aux réseaux de recherche et d'enseignement, en particulier dans le cadre du réseau régional méditerranéen (EUROMEDCONNECT), qui permet l'accès aux ressources électroniques spécifiques de recherche.

Développer l'infrastructure technologique

- Développer une société de l'information inclusive et favoriser la coopération, le développement des compétences et les échanges d'expériences dans les domaines liés aux développements des technologies de l'information dans le secteur public notamment en matière de restructuration des grandes applications de l'Etat dans le cadre d'un nouveau modèle économique se basant éventuellement sur la Technologie du Cloud Computing, l'Open Gov, l'Open Data et le SaaS « Software as a Service » ;
- Faciliter l'échanger d'expériences et d'expertises en matière de définition et mise en œuvre de normes et standards relatifs aux développements et à l'utilisation des technologies de l'information;
- Présentation et discussion de l'objectif tunisien de s'établir comme Hub régional de télécommunications et d'internet;
- Favoriser l'expansion du réseau TNT (Télévision Numérique Terrestre) à court terme et évaluer les perspectives de la TV terrestre à long terme.

3 CONCLUSION

La revue de la littérature a permis de dégager non seulement les grands axes de la gestion des connaissances ainsi que les pratiques y afférentes. Mais aussi le lien entre cette première et les TIC, qui sont nécessaire pour promouvoir la performance des entreprises.

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ETUDE DES EPIPHYTES DANS LA REGION ORIENTALE DU LAC- KIVU, CAS DE LWIRO ET SES ENVIRONS

[EPIPHYTE STUDY IN THE ORIENTAL REGION OF THE KIVU LAKE, ESPECIALLY LWIRO AREA AND HIS AROUND]

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ABSTRACT: This study has an objective to contribute at a study of the epiphytic plants in the eastern region of the Kivu Lake precisely in LWIRO area, South Kivu, Democratic Republic of Congo. The priority contribution was to make a list or to inventory the epiphytic plants and to elucidate some ecologic data which are been relevant at some simple observations. The phytosociologic and opportunist methods was been done to realize this study. This study stand out that 61 species split up into 34 families. The floristic analysis has show us the dominance of grass (57, 37%), the phanérophytes plants (40, 98%), the species of arbustive savanna (32, 78%), but also accidentals epiphytes (31, 14%). The frequency at *Erythrina abissinica* species was been the most important (0.3846) and *Pyrosia shimperi* was been the most species frequent on all phorophytes species (0.2197) and was been again the most frequent species on *Erythrina abissinica* (0.1538), the characteristic phorophyte. The altitudinal frequency shows large representativity between 1900m and 2000m. The similarity was weak and as for at the diversity, he was been note that the diversity was under the minima and the maxima i.d under 1.

KEYWORDS: Epiphytic, Lwiro, ecology account.

RESUME: Une étude d'inventaire d'épiphyte a été effectuée dans la région orientale du lac Kivu précisément à Lwiro et ses environs dans le Sud-Kivu, République Démocratique du Congo. Ce travail avait pour but d'inventorier premièrement les épiphytes et élucider quelques données écologiques relevant des observations simples. Pour y arriver, nous sommes servis de la méthode opportuniste mais aussi celui de relevé phytosociologique. Ce ci nous a conduit à des résultats tels que 61 espèces ont été récoltées et réparties en 34 familles et dont l'analyse floristique nous montre la dominance des herbes (57,37%), les phanérophytes (40,98%), les espèces des savanes arbustives (32,78%), mais aussi les épiphytes accidentelles (31,14%). La fréquence sur l'espèce *Erythrina abissinica* a été la plus grande (0.3846) et l'espèce *Pyrosia shimperi* était plus fréquente sur tous les phorophytes (0.2197) et était plus fréquente sur *Erythrina abissinica* (0.1538) phorophytes caractéristiques. La fréquence altitudinale montre une bonne représentation entre 1900m et 2000m (0.6593). La similarité a été très faible et qu'en tant à la diversité, il a été constaté que la diversité a été en dessous du minima et de maxima c à d en dessous de 1.

MOTS-CLEFS: Epiphytes, Lwiro, relevé écologique.

1 INTRODUCTION

Ce travail reprend les résultats de l'inventaire des plantes épiphytes à Lwiro et ses environs dans le territoire de KABARE, province du Sud- Kivu, République Démocratique du Congo. Ceci dit, il est bien connu que les épiphytes se retrouve un peu partout dans la nature, on peu dire d'ailleurs que la plus part d'elles font partie des groupes des espèces cosmopolites, surtout les plantes dites inférieures, les bryophytes, les sphaignes, etc. dont la plupart sont réparties mondialement.

Le mot épiphyte (du grec *ἐπί* « sur », *φύτον* « plante ») ; sont des plantes qui poussent en utilisant d'autres plantes comme support. Ces plantes ne sont pas parasites mais des organismes autotrophes photosynthétiques. Ces espèces sont caractérisées par leur capacité de pouvoir s'adapter et vivre sur les autres ou dans des endroits non lucide à leur développement.

Elles sont distribuées dans la zone intertropicale, plus particulièrement dans les forêts ombrophiles ; et bien aussi dans les régions tempérées où ils sont des bio-indicateurs de la qualité de l'air et d'un bon environnement.

Mais vu l'importance des écosystèmes tropicaux à l'échelle de la biodiversité biologique malgré leur fragilités et sensibilités face aux menaces qui lui est proliférai, et donc en évaluant le taux d'extinction d'espèce à plus de 37% à l'échelle de 2050(Thomas et al. ,2004), nous avons constante a travers une forte pression sur la végétation dans le site de notre étude, que ceci pourrait aller au-delà du taux précité.

La vulnérabilité guète surtout les espèces épiphytes dont leur existence conditionneraient la présence de leurs phorophytes qui sont les cibles de menace, alors que les épiphytes représentent un taux de 10% des plantes supérieures répertoriées sur la terre, et on a remonté le taux des épiphytes à un taux de 3,7% à l'échelle mondiale (Kress, 1986) mais le cas de la région risquerai d'être plus inquiétante à voir les taux de la déforestation. Ces plantes épiphytiques sont d'importance capitale dans la région tropicale, ils sont nécessaire pour le maintien de l'équilibre écologique.

L'épiphytisme est donc un phénomène important dans la nature car il joue un rôle crucial dans le maintien de chaine trophique et dans le maintien de la végétation mais très vulnérable et sensibles aux menaces qui sont proliférer par la déforestation. D'une manière générale, les épiphytes sont sensibles aux dynamiques éco-physiologiques entre les cycles du carbone et de l'eau, aux polluants et aux stress divers à l'inverse des plantes enracinées dans le sol, Feldmann (2011).

Elles ont fait l'objet de nombreuses études sur leur diversité, leur distribution et leur physiologie. Leur importance et leur localisation à des points-clés des flux d'eau et d'énergie dans les arbres, et en particulier de la canopée, sont à l'origine d'un rôle important sur les cycles minéraux et l'hydrologie des milieux. Ce sont aussi des ressources et des habitats importants pour la faune (Feldmann, 2011).

Disons que c'est un groupe écologiquement important dont bénéficierai une attention particulière surtout dans notre région ou leur étude sont presque inexistante.

La bibliographie antérieure montre une rareté des études sur les épiphytes dans cette partie de la région albertine à part les études d'inventaire floristique ne distinguant pas le statut écologique des espèces inventoriées. Les inventaires botaniques, il y en a eu dans la généralité et pas le moindre mais pas cela visant à donner une grande considération aux plantes épiphytes de cette partie orientale du lac Kivu ou à les particularisant.

Cette étude vise a apporte une contribution dans les inventaires botaniques en focalisant l'attention sur les épiphytes ; les connaître d'abord, identifier leur habitat c'est-à-dire les différents milieux ou types de forêt et les plantes qui leur servent de support, ensuite élucider les autres paramètres écologiques y relevant.

2 MATERIELS ET METHODE

Milieu d'étude

Le CRSN/Lwiro est situé entre 1750 et 2000m d'alt et entre 2°15' latitude Sud et 28°48' Longitude Est avec une superficie de 225 ha.150ha sont situé à 1750m d'alt et 75ha à 2000m d'alt ou se trouve la station de dégradation zoologique de Tshibati à 4km du centre.

Il est à 7km du Lac- Kivu, à 40 km de la ville de Bukavu à peu près sur l'axe routier Bukavu- Goma.

Du point de vue climatique, les données géo climatiques de la région prélevées par la station météorologique de Lwiro renseigne que la température moyenne annuelle de la région varie entre 19,9°C et 20°C avec une précipitation annuelle variant aussi entre 1500-2000mm/an.

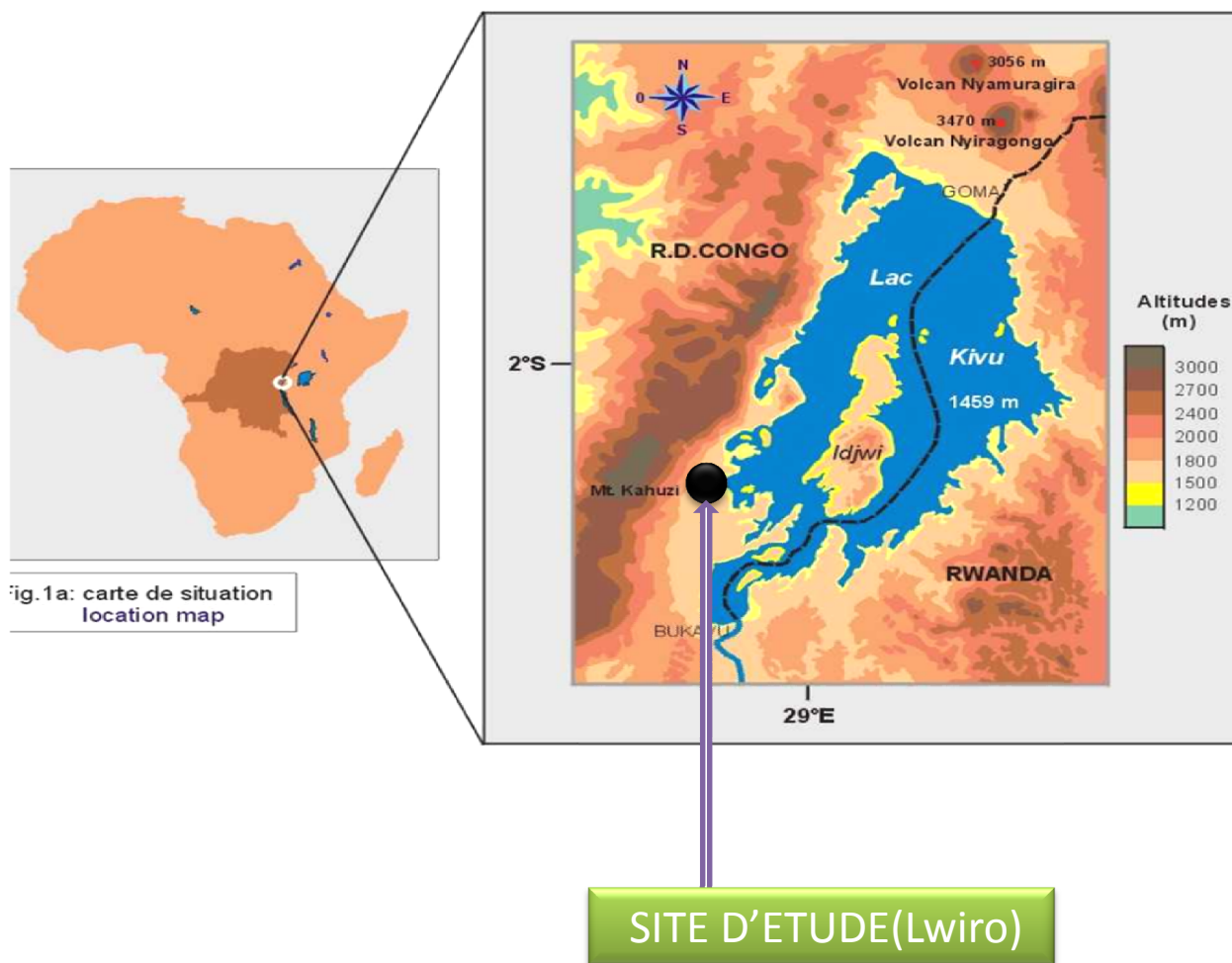


Fig. 1 : zones bordières du Kivu - orographie

Les matériels

Nous avons utilisés deux types de matériels dont les biologiques constituant les échantillons récoltés et gardés dans les collections de l'Herbarium de Lwiro et d'autres non biologiques constituent des presses, sécateur, sac, machette, GPS, Boussole, Carnet de terrain, Stylo, appareil photo.

Les méthodes

Les échantillons ont été récoltés à Lwiro et ses environs entre 1700m – 2200 m d'altitude dont nous avons subdivisé en deux tranches altitudinales et pour en arriver, nous avons utilisées deux méthodes.

La première méthode était de ramassage et consiste à passer n'importe où on pouvait trouver une plante épiphyte dans de milieux anthropisés se trouvant dans notre air assigné au présent travail.

La deuxième était la méthode de relevé phytosociologique qui nous aidait à relever différentes les fréquences des espèces épiphytes. Il est bien de signaler que les fréquences des familles et espèces d'épiphytes seulement était concerné.

Fréquence des taxons

La fréquence relative des Taxa (FreR) était trouvé en considérant le nombre des pieds dans un rayon de 10 mètres carrés pour chaque 250 mètres (data point) le long des transects où l'espèce est présente. Il en est de même pour la famille.

$$\text{FreR d'une espèce} = \frac{\text{Fre d'une espèce}}{\text{Somme de Fre de toutes les espèces}} \times 100$$

$$\text{FreR d'une famille} = \frac{\text{Fre d'une famille}}{\text{Somme de Fre de toutes les familles}} \times 100$$

Identification des espèces inventoriées et détermination des statuts biologiques.

On identifier premièrement sur terrain pour certaines espèces et les autres à partir de la confrontation avec ceux conservés à l'herbarium de Lwiro et enfin pour les autres, certains ouvrages des auteurs : AGNEW et al. (1996), FISCHER (2008), FISCHER (2010), BARTELS (1989), TROUPIN *et al.* (1983), TROUPIN (1985, 1988), LETOUZEY (1983).

Les types morphologiques des espèces étaient déterminés sur terrain en observant le port et l'aspect végétatif mature de la plante. Les formes suivantes ont été enregistrées selon qu'il s'agissait des plantes ligneuses : Arbre (A), Arbuste (Arb) et Liane (Lian) ou des herbacées ; Herbe annuelle (Han) et Herbe vivace (Hvi).

Pour ce qui est des types biologiques, la classification de RAUKIAER (1934) par LEBRUN (1947) aux régions tropicales in NYAKABWA (1982) nous ont permis d'identifier les types ci-après : les Microphanérophytes (Micph), Mésophanérophytes (Mesph), Phanérophytes grimpants (Phgr), Nanophanérophytes (Nanph), Chaméphytes cespiteux (Chces), Chaméphytes grimpants (Chgr), Thérophytes grimpants (Thgr), Thérophytes rampants (Thr) et Thérophytes prostrées (Thpr).

Quatre catégories de provenance ou des biotopes des plantes étaient signalées dans cette étude : les espèces des forêts secondaires (FoS), des savanes-arbustives (Sav-arb), des jachères (Jach) et celles des endroits cultivées (Cult).

Les types des épiphytes aussi en ont comptés 5 dont les épiphytes vraie (EV), les hémi-épiphytes (HE), les épiphytes accidentelles (EA), les espèces accidentelles (E AC) et enfin les Phorophytes (PH).

Analyse des données

L'analyse des données s'est basé d'abord sur l'analyse classique connue pour les types morphologiques, biologiques et des biotopes des espèces ensuite le logiciel EXCEL nous a aidé à encoder et aussi tracer les graphiques des types précités ci-dessus et enfin le logiciel PAST pour décoder la diversité et la similarité des espèces à partir des indices de Simpson, Shanon et le cluster analysis.

3 RESULTATS ET DISCUSSION

Etude floristique

Un total de 61 espèces des plantes ont été inventoriés et récoltés pendant nos enquêtes et a constitué le matériel biologique dont l'herbier de référence a été constitué et est conservé à herbaria de LWI en RDC. Les plantes inventoriées sont classées selon leur types morphologiques, biologiques des milieux de provenances et des types d'épiphytes. ces espèces sont repris dans le tableau 1. Ci- dessous.

NOMS SCIENTIFIQUES	T.B	T.M	T.H	Type d'EP.
ACANTACEAE				
1. <i>Assistasia gangetica</i> (L.)T.ANDERSON	HVi	Chces	FoS	EA
2. <i>Hypoestes triflora</i> ATS.	HVi	Chpr	FoS	EA
ARACEAE				
3. <i>Anthurium scherzerianum</i>	HVi	Tr	FoS	PA
4. <i>Monstera deliciosa</i> Liebm.	HVi	Tr	FoS	PA
AGAVACEAE				
5. <i>Agave cisale</i> L.	HVi	Grh	Cult.	PH
AMARANTHACEAE				
6. <i>Achyranthes aspera</i> L.	HVi	Cher	FoS	PA
7. <i>Cyathula shimperiana</i> HOCHST ex.MOQ.	Ha	Tpr	Cult.	PA

ARALIACEAE				
8. <i>Polyscias fulva</i> (HIERN).HARMS	A	MsPh	FoS	PH
ASPARAGACEAE				
9. <i>Dracaena arborea</i> L.	A	NPh	Cult.	PH
ASPLENIACEAE				
10. <i>Asplenium tenuicordatum</i>	HVi	Grh	Jach.	EV
11. <i>Asplenium linckii</i> Kuhn.	HVi	Grh	Jach.	EV
ASTERACEAE				
12. <i>Bidens pilosa</i> L.	Ha	Tsc	Cult.	EA
13. <i>Chrysanthemum</i> sp. L. C. Rich. in Pers	HVi	Tpr	Sav- Arb	HE
14. <i>Conyza sumatrensis</i> (RETZ) E.H. WALER	HVi	Cher	Cult.	EA
15. <i>Crassocephalum montuosum</i> (S- MORE) MILNE	Ha	Tsc	Jach.	PA
16. <i>Crassocephalum</i> sp.	Ha	Tsc	Sav- Arb	EA
17. <i>Helicrisum</i> sp.	HVi	Tpr	Sav- Arb	EA
18. <i>Gynura scandens</i> O.HOFFM.	Lian	Chr	Cult.	EA
19. <i>Tagetes minita</i> L.	HVi	Tpr	Sav-Arb	EA
BIGNONIACEAE				
20. <i>Markhamia lutea</i> (BENTH) SCHUM.	Arb	McPh	Cult.	PH
21. <i>Spathodea campanulata</i> P .DE BEAUV.	A	MsPh	FoS	PA
CAPRIFOLIACEAE				
22. <i>Sambucus mexicana</i> PREL ex A. DC.	S-Arb	NPh	FoS	PA
COMMELINACEAE				
23. <i>Commelina diffusa</i> BURN. F.	HVi	Chces	Cult.	EA
24. <i>Zebrina pendula</i> SCHNIZL.	HVi	Chr	FoS	EA
CUPRESSACEAE				
25. <i>Cupressus lusitanica</i> MILL.	A	Mcph	Cult.	PH
26. <i>Cupressus microcarpa</i> MILL.	A	NPh	Cult.	PH
EUPHORBIACEAE				
27. <i>Bridellia micrantha</i> (HOCHST) BAILLON	A	Mcph	Jach.	PH
28. <i>Erythrococca oleracea</i> PRAIN.	Lian	Chr	FoS	PA
FABACEAE				
29. <i>Erythrina abyssinica</i> DE WILD et TH. DUR.	A	NPh	Sav-Arb	PH
30. <i>Jaccaranda mimosifolia</i> D.DON	A	McPh	Cult.	PH
31. <i>Milletia dura</i> DUNN.	A	NPh	Sav-Arb	PH
LAMIACEAE				
32. <i>Leucas deflexia</i> HOOK.F	Ha	Chpr	Jach.	PA
33. <i>Salvia leucantha</i> CAV.	HVi	Tsc	Jach.	EA
LAURACEAE				
34. <i>Persea Americana</i> MILL.	A	MsPh	Cult.	PH
LILIACEAE				
35. <i>Chlorophytum sparsiflorum</i> BAKER.	Hvi	Gbu	Sav-Arb	HE
LAURANTACEAE				
36. <i>Euglerina</i> sp.	Lian	Phr	Jach.	EV
37. <i>Laurantus</i> sp.	Lian	Phr	Cult.	EV
MALVACEAE				
38. <i>Hybiscus diversifolius</i> JACQ.	HVi	Chpr	Sav-Arb	PA
MORACEAE				
39. <i>Ficus glomosa</i> DELILE.	Arb	Mcph	Sav-Arb	HE
40. <i>Ficus valis-choudea</i> DELILE	A	MsPh	FoS	PH
41. <i>Ficus verruculosa</i> WARB.	Arb	Nph	Sav-Arb	EA
MYRTACEAE				
42. <i>Eugenia uniflora</i> L.	S-Arb	Nph	Sav-Arb	EA

ORCHIDACEAE				
43. <i>Angraecum sp.</i> S.l	HVi	Grh	Sav-Arb	EV
44. <i>Calanthe corymbosa</i> LINDL	HVi	Grh	Sav-Arb	EV
45. <i>Calanthe sp.</i>	HVi	Grh	Sav-Arb	EV
PIPERACEAE				
46. <i>Piperomia reflexa</i> (L.f) A. DIERT	HVi	Cher	Sav-Arb	HE
PHYTOLACCACEAE				
47. <i>Phytolacca dondecandra</i> L'HERIT.	S-Arb	Phg	Cult.	PH
POACEAE				
48. <i>Setaria megaphylla</i> (Steud.)Th.Dur& Schinz	Ha	Chpr	Cult.	EA
49. <i>Melinis sp.</i>	HVi	Tces	Sav-Arb	HE
50. <i>Oplumenus bermannii</i> (L.)(RETZ) P.BEAUV.	Ha	Chr	FoS	PA
POLYGONACEAE				
51. <i>Rumex usambariensis</i> (ENGL.)DAMMER	HVi	Tsc	Sav-Arb	EA
POLYPODIACEAE				
52. <i>Drynaria volkensii</i> Hieron.	HVi	Grh	Sav-Arb	HE
53. <i>Pyrosia Schimper</i> L.	HVi	Grh	Sav-Arb	EV
PORTULACACEAE				
54. <i>Talium triangulare</i> (JACK WILDD).	Ha	Tpr	Cult.	EA
PROTEACEAE				
55. <i>Grevillea robusta</i> A. CUNN.	A	MsPh	Cult.	PH
ROSACEAE				
56. <i>Rubus cf. adolfi-friederici</i> ENGL.	S-Arb	NPh	Cult.	EA
RUBIACEAE				
57. <i>Pentas zanzibarica</i> (KLOTZSCH)VATKE	HVi	NPh	Jach.	EA
SOLANACEAE				
58. <i>Solanum americanun</i> DE WILD.	S-Arb	NPh	Cult.	PA
59. <i>Solanum angustispinosum</i> DE WILD	S-Arb	Nph	FoS	EA
TECTARIACEAE				
60. <i>Arthropteris orientalis</i> (Gmel) Posth.	HVi	Grh	Sav-Arb	EV
VERBENACEAE				
61. <i>Duranta erecta</i> L.	S-Arb	Nph	FoS	PA

Analyse Floristique

Ce tableau 1. Ci-dessus nous a permis d'analyser :

1. Les types morphologiques

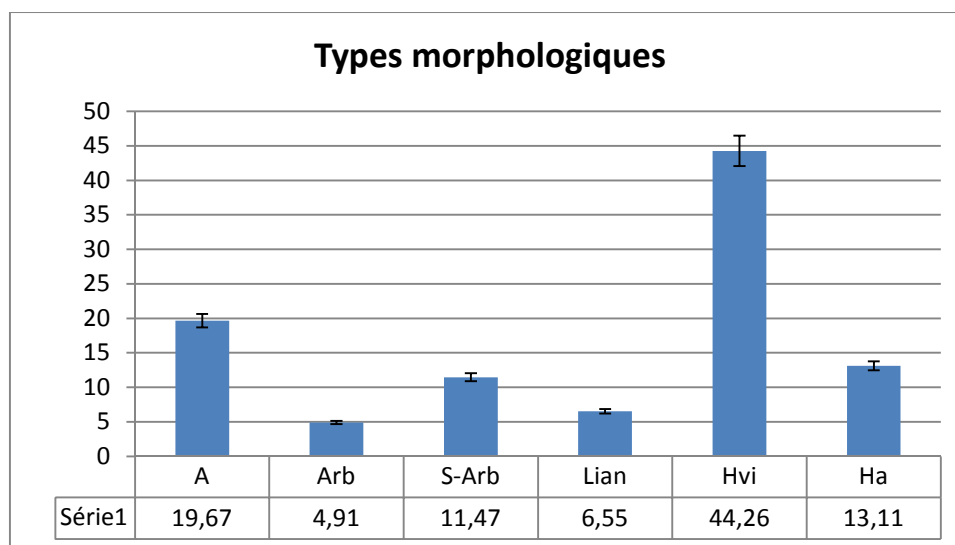


Fig.2 : représentation des types morphologiques.

Cette figure montre que la flore inventoriée était essentiellement dominée par les herbes avec un taux de 57.38%, cette situation se traduit par le fait d'avoir inventorié les plantes épiphytes qui ne sont d'autre que les plantes herbacées et seulement certain de leur phorophytes.

2. Les types biologiques

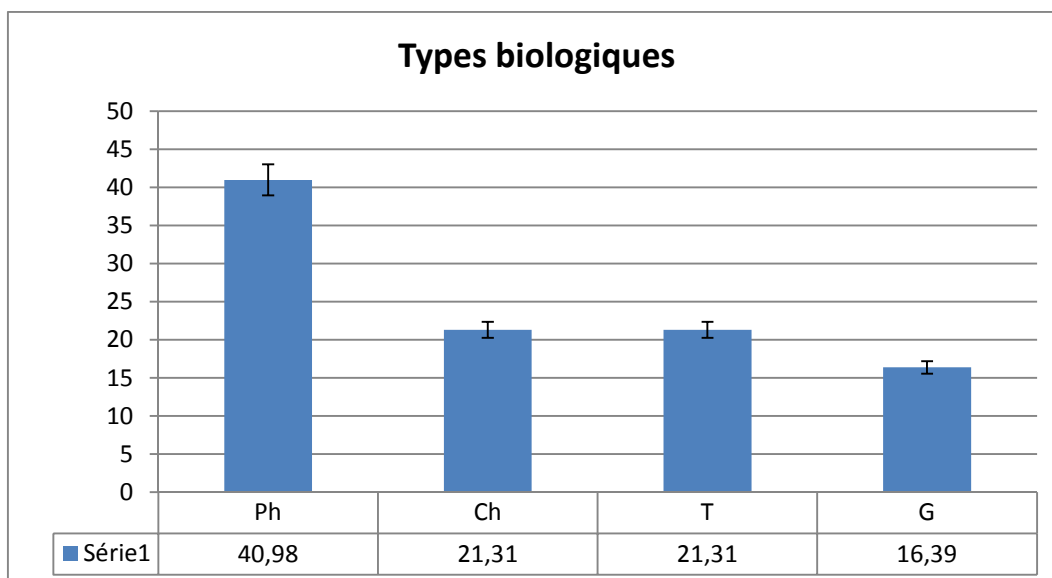


Fig. 3 : représentation des taux de types biologiques

Il est claire ici que les phanéropytes ont fortement dominés sur les autres types avec 40,98% et ceux-ci sont suivis par les chaméphytes et thérophytes avec tous 21,31%.

3. Types de provenances et de biotopes

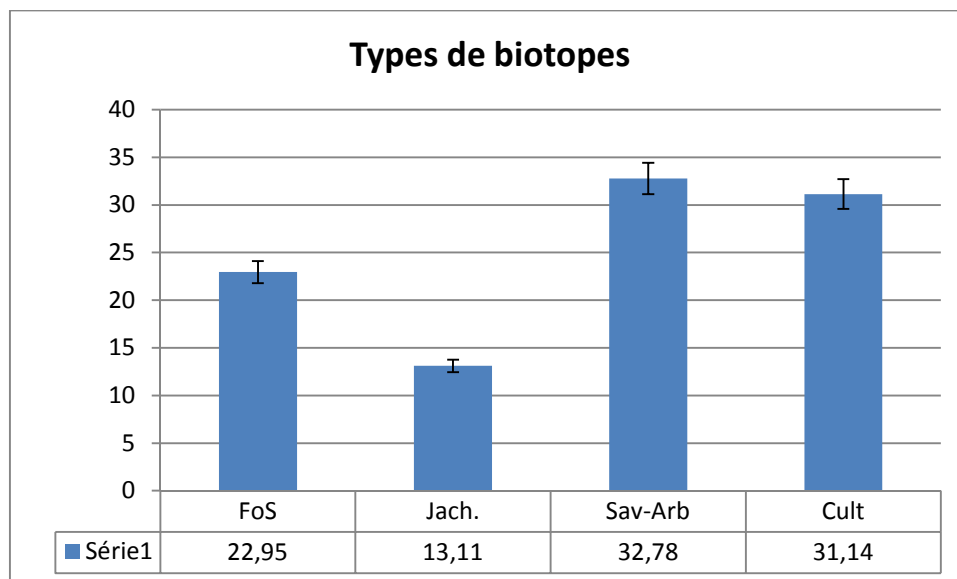


Fig.4 : représentation de types de biotopes

Les types de biotopes représentés ci-dessous dans la figure montrent que les espèces de savane arbustive étaient presque égales aux espèces de culture (32,78% ; 31,14%) et les autres s’en est suivi.

Cet état de chose montre que la partie a été fortement anthropisée mais qu’il y a un espoir petit à petit d’une reconstitution d’une forêt secondaire à 2000m d’altitude selon notre constant et si du moins les choses restaient telles qu’elles sont.

4. Les types d’épiphytes

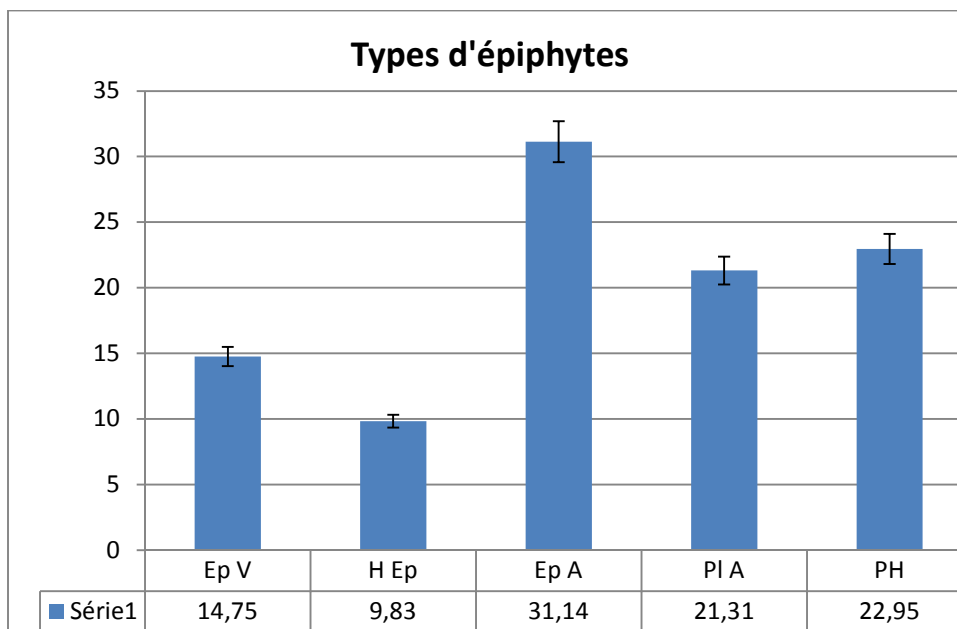


Fig. 5 : représentation des types d'Epiphytes

Cette figure montre aussi que ce sont les épiphytes accidentelles qui ont primés dans cette partie (31,14%) mais aussi les phorophytes qui les portaient (22,95%) et les plantes accompagnatrices (21,31%).

Ce propos continuent à affirmer ceux dont énoncer ci-haut du faite que les habitats de vraies épiphytes sont déjà détruits, il ya maintenant prolifération des épiphytes accidentelles qui ne jouent pas vraiment le vraie rôle des épiphytes.

Analyse des Strates d'épiphytisme sur les phorophytes

Selon la stratification que nous avons faite, nous avons trouvés que la strate 1 comprise entre 0-2m et la strate 2 comprise entre 2-4 ont été trop sollicitées par les espèces c.à.d. avec 38 et 35 présences et que donc nous supposons que les tranches les plus sollicitée dans la région sont cela comprise entre 0-2 et 2-4 et donc la majorité des espèces inventoriées sont des espèces d'ombre.

Analyses multi variées et Phytosociologiques.

a) Les analyses phytosociologiques n'ont tenus que compte aux calculs des fréquences des espèces épiphytes et il en est décollé que l'espèces *Erythrina abissinica* était plus fréquenté plus que les autre avec 35 présences soit une fréquence de 0.3846 et l'espèce *Pyrosia shimperi* était très fréquente sur elle avec 14 présences soit une fréquence de 0.1538, mais aussi il faut signaler que la grande proportion de la fréquence de cette espèces a été constante dans la partie allant entre 1900m et 2000m. les autres suivaient avec des faibles proportions. Pour les espèces épiphytes, c'est toujours *Pirosia shimperi* qui était largement fréquente sur tous les phorophytes inventoriés et sa fréquence était évalué à 0.2197 avec une présence de 20.

Présences des espèces selon la subdivision altitudinale entre 1750m et 2000m

- ✓ De 1750 à 1900 : zone fortement anthropisée avait eu 31 présences soit une fréquence de 0.3406.
- ✓ De 1900 à 2000: la présence était de 60 Soit une fréquence de 0.6593.

b) Les analyses multi variées :

- Indices de diversité

Les divers indices de diversité sont donnés dans le tableau 2 ci-dessous considérant les indices de Shannon et Simpson :

Tableau 2. Représentation des indices des Shannon et Simpson

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25
Shannon_H	0.6837	0	0	1.099	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6365	0	0	0.6931	0	1.099	0	1.309
Simpson_1-D	0.3704	0	0	0.6667	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4444	0	0	0.5	0	0.6667	0	0.7083

T26	T27	T28	T29	T30	T31	T32	T33	T34	T35	T36	T37	T38	T39	T40	T41	T42	T43	T44	T45	T46	T47	T48	T49	T50
0	0	0.6616	0	0.6365	1.099	0	0.6365	0	0	0	0	0	0	0	1.561	1.332	0.9557	0	0.673	0.6365	0	0	0	0
0	0	0.4688	0	0.4444	0.5278	0	0.4444	0	0	0	0	0	0	0	0.7778	0.72	0.5714	0	0.48	0.4444	0	0	0	0

Selon les résultats ci-haut représentés, nous avons vu que la diversité était en dessous de 1 alors qu'il est bien connu selon la règle que une fois $H = 0$ tous les individus appartient à la même espèce. Pour notre cas, nos résultats montrent qu'on est entre 0 et 1 et donc les individus appartenait à la même espèce et aussi chaque espèce est au moins représentée par un individu.

Pour Simpson, la variation est de 0 à 1, nous a permis de dire que l'on est en dessous du minima et les maxima de la diversité, selon règle qui précise que de 1 à 2 nous sommes dans le minima et 2 au-delà, c'est maxima. Ceux – ci montrent presque la même chose chez Shanon qu'à Simpon c'est-à-dire que leur diversité étaient tous en dessous de 1.

➤ La similarité a été évaluée à partir du cluster analysis et on en a eu ce qui suit dans la fig. 6 :

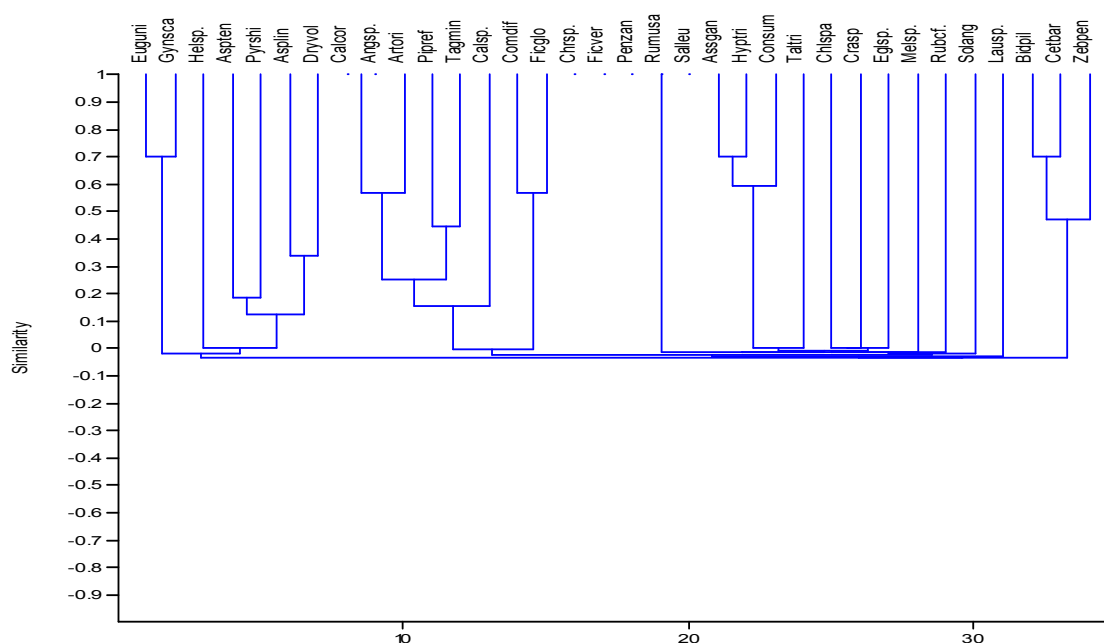


Fig. 6 : Cluster de Similarité entre espèce

Les similarités sur l'ensemble des espèces est faible, mais on ne peut pas n'est pas signalé quelque particularité par exemple celui de *Eugenia uniflora* et *Gynura scandens* qui ont presque 75% de similarité suivie des autres.

4 CONCLUSION

61 espèces ont été inventoriées et réparties en 34 familles ou celui des *Asteraceae* dominaient sur les autres avec 8 espèces.

Ce ci nous a permis de remarquer une faible proportion des épiphytes du faite que les groupes représentatifs connus ne sont pas fortement représentés. Les fréquences des espèces renforcent cette hypothèse du faite qu'on a remarqué presque une faible diversité des espèces sur les phorophytes.

On a traduit ceci par un déséquilibre hydrostatique et de climat fortement perturbé durant ces dernières années.

Mais aussi il a été remarqué une très grande représentativité des espèces au niveau de 2000m et donc cela montre une grande diversité des épiphytes dans le temps dans cette région mais fortement dégradé actuellement.

Et bien nous recommandons une gestion durable et rentable de peu de relique que ça soit lambeau forestier ou quelque pied d'espèce rélictuelle qui nous reste actuellement pour espérer encore une petite stabilité climatique dans la région durant ces quelques années avenir.

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The role of the parity and the age in acquisition of Toxoplasmosis among pregnant women in Rabat - Morocco-

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ABSTRACT:

Objectives: This retrospective study was undertaken between 2008 and 2009 to assess the seroprevalence of Toxoplasmosis among pregnant women and the role of the parity, the age and the abortion presence or absence in acquisition of infection *pregnant women* at the National Institute of health in Rabat in Morocco.

Methods: Specific *T. gondii* IgG and IgM were measured by Enzyme-Linked Immunosorbent Assay (ELISA). Datation of the infection was carried out by avidity test. All existing data for every pregnant woman were collected from medical report.

Results: Among 1169 pregnant women of different age diagnosed, 47% were found to be IgG seropositive including 1,5 % of IgM seropositive. The use of IgG avidity test allowed to exclude recent infection among 72,2 % of IgM positive sera. The result of bivariate analysis revealed that the age and parity influenced significantly the seroprevalence rate, whilst the existence of previous spontaneous abortion did not have any significant statistical correlation with the positivity of toxoplasmosis.

Conclusion: This study showed that 53 % pregnant women were susceptible to *T. gondii* and considered to be at high risk for toxoplasmosis during pregnancy. However, the follow-up of pregnancy and Counselling of pregnant women remains essential of the prevention of congenital toxoplasmosis.

KEYWORDS: Toxoplasmosis; Pregnant women; ELISA, Age, Parity, Morocco.

1 INTRODUCTION

Toxoplasma gondii is a well known parasitic zoonosis that is causative agent for stillbirths, eye problems and mental retardation in the children of women who acquire primary infection during pregnancy [1]. Seroprevalence rate of toxoplasmosis in pregnant women varies among different countries, it's depends on the geographic area and lifestyle. Until now, all risk factors for contract the disease are not yet known. However, in Europe, the *Toxoplasmosis* infection can be due to undercooked meat [2]. In Central America and in other developed countries, toxoplasmosis prevalence may be related to socioeconomic status and frequently the presence of stray cats especially climate for the survival of oocysts. In Morocco, according to a cross-sectional study in the Rabat region, toxoplasmosis has been attributed primarily to soil contact and lack of knowledge about the disease [3]. Consideration of the latter as a risk factor for acquiring toxoplasmosis requires monitoring and attention towards this opportunistic infection.

Moreover, serological screening for toxoplasmosis in Morocco was still considered a biological test not required by Doctors. From 2006, National Health of Morocco had developed a *Decree 2519-05; 30 Chaabane 1426 (BO no 5384 of 05 January 2006)* recommended without obligation, the serological screening systematic of toxoplasmosis for pregnant women.

The impact of toxoplasmosis on the health of mother and newborn should not be neglected. The surveillance of toxoplasmosis is mainly based on research of antibodies *IgG* and *IgM T. gondii*. The screening of the disease must be diagnosed early during pregnancy in order to detect early the seroconversion. This latter is manifested when the pregnant women develop antibodies to *T. gondii*, they "seroconvert" from antibody-negative to antibody-positive. It is also mentioned with the significant increase of antibodies *IgG* titers with the presence of antibodies *IgM*. The date of seroconversion can be determined by the avidity test which allows to exclude toxoplasmosis among women under 20 weeks for their pregnancy.

Given the importance of the disease, we felt it appropriate to update the data on the prevalence of toxoplasmosis in the pregnant population in Rabat region and its surroundings and to complete our exploration of other factors influencing the occurrence of toxoplasmosis, such as age of patient, parity and the presence or absence of a history of abortion.

2 STUDY POPULATION

This retrospective survey was carried out between January 2008 and December 2009 on 1169 pregnant women admitted in toxoplasmosis laboratory in National Institute of Hygiene in Rabat at their first prenatal care visit. All existing data for every pregnant woman were collected from medical report such as; age of patient, parity and the history of abortion

3 SEROLOGICAL TEST

Serum samples were tested for both IgG and IgM *T. gondii* antibodies by using commercial kits by ELISA test (Biorad). Both kits used and the results were interpreted as suggested by the manufacturer. Samples were considered IgG reactive when the antibody concentration was greater than or equal to 9 UI/ml, non-reactive when the concentration was less than 6 UI/ml and undetermined when the concentration was between 6 and 9 UI/ml. For IgM, the results are expressed qualitatively. Samples that was reactive to both anti-*T. gondii* IgG and IgM were confirmed acute infection using an IgG avidity test by ELISA (Platelia Toxo IgG Avidity Kit (Biorad)). An low index of avidity below 0.4 does not exclude a recent primary infection of less than 20 weeks while high index avidity or equal to 0.5 can be excluded. In case of intermediate index of avidity (≥ 0.4 and <0.5), an assay on a second sample was recommended.

4 STATISTICAL ANALYSIS

Data files were entered and performed on Epi-Info 2007 (version 3.4). Bivariant analysis was used to assess the relationship between *Toxoplasma* seropositive and different risk factors such as age, parity and history of abortion. The chi-square test was used to evaluate significant differences of infection rate in pregnant women of different age; p values for significance were set at $p < 0.05$.

5 RESULTS

An total of 1169 pregnant women were studied, the average age of these women was 28.9 ± 6.2 years. Among these women 47% (CI 95%: 44 % - 49,8 %) were positive for IgG antibodies and 1,53 % were positive for IgM antibodies (Table I) . Of the 18 patient who were positive by IgM antibodies, 13 had a high index of avidity of *Toxoplasma* and 5 patients had low or intermediate avidity.

Data from the evaluated risk factors that could be associated with the serological results for anti-*T. gondii* antibodies are presented in Table II. Variables such as age group and parity, showed a significant association ($p < 0,05$) with the presence of IgG antibodies. In the contrast the history of abortion was not statistically significant ($p > 0,05$).

Stratified analysis to determine whether there is a relationship between the parity and exposure to infection toxoplasmosis according to age showed that multiparous women who age exceeds 27 years are more often infected ($p < 0.05$) (Table III). In contrast, women under 27 years old, the relationship between exposure of nulliparous women and the occurrence of toxoplasmosis is absent ($p > 0.05$). However, the Chi square interaction is not significant ($X^2 = 2.43$, $p > 0.05$), so that age is neither a confounder nor an effect modifier when it is associated with parity considered susceptible to infection ($p > 0.05$).

6 DISCUSSION

The *T. gondii* IgG prevalence of 47% found in this study is comparable with results of a study in the same area study in which 50,6% of pregnant women were seropositive for IgG to toxoplasmosis [4]. Unfortunately, there is no recent published study concerning this prevalence within general population in our country. Among the first studies of seroprevalence of toxoplasmosis in Morocco made include that of Mekouar et al. (1972) [5] reported a prevalence rate of 52%. Then, twelve years after an investigation by Guessous et al. (1984) within 200 pregnant women in the region of Casablanca were about the same rate of Toxoplasmosis infection and are 51.5% [6]. Until recently, El Mansouri et al reported in their study in the Rabat region, a 50.6% rate of *Toxoplasma* infection among pregnant women [4]. In comparison with our results, it appears that the seroprevalence of toxoplasmosis was decreased by 4% in the study area. This decline could be probably related to a decrease

in the frequency of transmission of the parasite telluric where contact with soil was the greatest risk factor associated with *T. gondii* infection in the Rabat region [3]. Moreover, improved lifestyle including food hygiene can contribute positively to the decline in toxoplasmosis prevalence.

Despite the lower prevalence of toxoplasmosis observed in the study area, the rate remains high compared to the neighbouring Mediterranean countries, like Setif-region Algeria with 32% [7]. This variation in the seroprevalence rate depends on the difference risk factors for acquiring the disease. In Algeria, Chouchan et al. (2008) showed a significant association between the consumption of undercooked meat and acquisition of *Toxoplasma* antibodies. While in Morocco, Laboudi et al. (2009) reported that contact with the ground and illiteracy were considered the main risk factors of contracting toxoplasmosis.

Although the number of cases of IgM reactivity observed in 18 women (1.5%), the detection of this immunoglobulin can not be used as a reliable marker of acute infection [8]. Thus, the contribution of avidity test appears to be effective and reliable tools of excluding infection of less than 4 months [9]. Indeed, application of the avidity test (IgG) in 18 (1,5 %) reactive IgG and IgM sample allowed to exclude a recent infection in 72.2% (13/18) pregnant women.

When considering age group, the prevalence of IgG antibodies in our study population increased with age (from 40 years). These results statistically significant ($p < 0.05$) were already observed in 2007 by El Mansouri et al. (2007). Similar observation has been advanced by Berger et al in France who reported that toxoplasmosis infection increases linearly with age [10]. This can be explained by the increase of exposure to infection sources throughout life.

There was no significant association of *T. gondii* infection with the existence of a history of spontaneous abortion. In the contrast, it was statistically significant with the parity. It was also not significant in the study carried out by Breurec et al. (2004). This is probably related to age because multiparous women are generally older than nulliparous women [11]. However, the stratified analysis performed to search for possible relationship between seropositivity for toxoplasmosis and parity for age was inferred that the age does not affect the relationship between gender and infection by *T. gondii* ($p > 0.05$). Therefore, the prevalence increases with the number of pregnancies regardless of age. A study in Brazil between 1997 and 1999 showed that pregnancy makes women more susceptible to protozoa [12].

7 CONCLUSION

This study revealed that 47% seropositivity for IgG antibodies for toxoplasmosis in pregnant women. However, 53% of women studied were susceptible during pregnancy. Therefore, data from this study could be used to argue for the establishment of a mandatory screening and serological surveillance of seronegative pregnant women of all ages, and must encourage decision-makers to review the legislation in Morocco that ignores the psychological and physical discomfort endured by these mothers as well as the financial burden imposed by the cost of diagnosis and travel to research laboratory specialist for further biological test.

8 TABLEAUX

Table 1. Prevalence of anti- *Toxoplasma gondii* IgG and IgM antibodies obtained in pregnant women in Rabat region Morocco between 2008 -2009

Antibodies anti- <i>T. gondii</i>	Prevalence n (%)	CI 95%
IgG(+) IgM (-)	530 (45,33)	
IgG(+)IgM (+)	18 (1,53)	
Total IgG(+)	548 (46,87)	44,0% - 49,8%
IgG(-) IgM (+)	3 (0,25)	
IgG(-) IgM (-)	618 (52,86)	
Total IgG(-)	621(53,12)	50,2% - 56,0%

Table 2. Seroprevalence of toxoplasmosis according to age, parity and history of abortion among pregnant women in Rabat region between 2008 - 2009

	Serology		χ^2	<i>p</i>
	Seropositivity (%)	Seronegativity (%)		
Age (years)				
17-24	137 (42,7)	184 (57,3)	12,42	<i>P</i> <0,05
25 - 29	141 (43,8)	181 (56,2)		
30 - 34	141 (51,5)	133 (48,5)		
35 - 39	86 (47,0)	97 (53,0)		
40 - 48	43 (62,3)	26 (37,7)		
Parity			6,52	<i>p</i> <0,05
Nulliparous	239(43,0)	317(57,0)		
pauciparous(1-2 P**) / multiparous (≥ 3P**)	267(50,2) / 42(51,9)	265(49,8) / 39(48,1)		
Abortion			1,36	NS*
NA***=0 / NA ≥ 1	428 (47,8) / 120 (43,8)	467 (52,2) / 154 (56,2)		

* NS : No significant, ** : Pregnancy, ***NA : Number of abortion

Table 3. Stratified analysis according to the parity among pregnant women living in Rabat region (2008-2009)

	Seropositivity (%)	Seronegativity (%)	OR*	CI**	<i>P</i>
Age = 17 – 26			1,03	0,67 - 1,58	0,86
women Nulliparus	138 (41,2)	197 (58,8)			
women Multiparus	50 (42)	69 (58)			
Age = 27 – 36			1,31	0,92– 1,87	0,11
women Nulliparus	86 (44,8)	106 (55,2)			
women Multiparus	187(51,7)	175(48,3)			
Age = 37-48			1,12	0,50 - 2,50	0,78
women Nulliparus	15 (51,7)	14 (48,3)			
women Multiparus	72 (54,5)	60 (45,5)			

Chi square of interaction: 0,76 ; *P* = 0,68; *OR : Odd ration, **CI : Confidence Interval

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Valorisation of whey: Bioethanol production by free and immobilized yeasts

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ABSTRACT: The lactose in cheese whey is an interesting substrate for the production of bulk commodities such as bio-ethanol, due to the large amounts of whey surplus generated globally. In the present context of increasing demand for energy and biofuel, the microbial synthesis of ethanol using industry waste materials has gained recent importance. The present study deals with the ethanol production from whey—a dairy waste by using potential thermotolerant immobilized yeasts isolates in free and immobilized state. Two species of thermotolerant yeasts strains, *Candida inconspicua*, *Candida xylopsoci* and standard culture of *K. marxianus* were used for bioethanol production. Of the selected thermotolerant yeast species, *Candida inconspicua* W16 exhibited the maximum production of ethanol (3.9 ± 0.02 v/v) on immobilization as well as in free State (1.9 ± 0.08 % v/v) within 72 h using whey as a substrate. The experiment revealed that the thermotolerant yeast *Candida inconspicua* is efficient in bioethanol production from whey, when it is immobilized.

KEYWORDS: bioethanol, whey, lactose, immobilized cells, free cells

1 INTRODUCTION

Cheese whey is a greenish-yellow liquid product from the cheese-making process. Because of its high organic content with high BOD, whey dumped directly to the environment is causing serious contamination problems [1;2;3]. To overcome these complications intense recent research attempts try to deal with the problem focusing on the development of technologies that employ whey as raw material to produce feeds or chemicals of added value [4]. So, the whey its liquid remaining after milk fat and casein have been separated from whole milk, is one of the major disposal problems of the dairy industry, and demands simple and economical solutions. Also, whey represents about 85–95% of the milk volume and retains 55% of milk nutrients. Among the most abundant of these nutrients are lactose (4.5– 5% w/v), soluble proteins (0.6–0.8% w/v), lipids (0.4–0.5% w/v) and mineral salts (8–10% of dried extract).

Whey represents an important environmental problem because of the high volumes produced and its high organic matter content. Whey exhibits a biochemical oxygen demand (BOD) of 35,000 ppm and a chemical oxygen demand (COD) of 68,000 ppm [5]. The search for a satisfactory solution for disposal of the unutilized whey produced in the manufacture of cheese remains an area of intense concern for the dairy industry. Although adequate technology is available to recover selectively

and concentrate the nutritious protein portion of cheese whey, no widely accepted method has been developed to utilize the lactose portion. Since conventional waste treatment systems are costly, the ideal solution would entail converting the lactose to a marketable product to defray the operating costs and possibly recover the initial capital outlay. One alternative often proposed is to ferment the lactose into ethanol for use as a fuel or chemical feedstock. In subsequent research, we have contributed to the conversion of lactose from whey polysaccharides for value in high-energy substances. Also, we have made a production of biogas from the effluent in other studies [6;7;8].

High ethanol productivity and reduced energy demand have been two important aspects of most alcoholic fermentation research. To achieve them several techniques have been developed including continuous culture, cell immobilization, cell recycle through sedimentation or membrane retention and two stage reactor systems. Application of immobilized yeast cell is the recent technology used to improve the economics of ethanol production from whey. Immobilization is the technique for the physical or chemical fixation of cells, enzymes or other proteins onto a solid support, into a solid matrix or retained by a matrix in order to increase their stability and make possible their repeated or continued use. The immobilized microbial cell can be reused for a long time and transferred simply by draining; fermentation process can be controlled more easily. The immobilization of microorganisms used for ethanol production by attachment to water-insoluble materials has drawn considerable attention [9;10;11]. Using immobilized cells, different bioreactor configurations were reported with variable success rate. The study on the physiology of immobilized cells and development of non-invasive measuring techniques have remarkably improved our understanding on microbial metabolism under immobilized state. *Saccharomyces cerevisiae* was immobilized in Hollow-Fiber Membrane Bioreactors for ethanol production by following the method of Inloes [12].

In this study, the ethanol production by free and Ca-alginate immobilized cultures of the thermotolerant yeast was compared. It was found that initial yields produced by the immobilized culture lagged behind those produced by cultures in free suspension. However, in subsequent batch-feed experiments it was demonstrated that the ethanol producing ability of the immobilized preparation increased with successive feeds, while production by the free suspension reduced significantly [12]. Since the first report of successful application of immobilized cells in industrial applications, several research groups worldwide have attempted whole-cell immobilization as a viable alternative to conventional microbial fermentations. The advantages associated with the production of ethanol at temperatures higher than those used in conventional systems include reduced operating costs with respect to maintaining growth temperature in large-scale systems, reduced risk of contamination, increased rate of productivity and ease with which the product may be recovered, particularly at the later stages in batch and fed batch reactor systems [13]. Other advantages may include biocatalyst recycling and rapid product separation [14].

The utilization of cheese whey as a fermentation substrate to produce bio-ethanol is an effort to supply bio-ethanol demand as a renewable energy. The present work was therefore carried out to apply immobilization technology for the production of ethanol from whey using thermotolerant yeast cells.

2 MATERIALS AND METHODS

2.1 SUBSTRATES

The substrate is obtained from rejection of the dairy industry in Rabat / Salé. This substrate was stored at 4 ° C until use. The experiments were also performed on solutions of pure lactose which has been obtained by mixing D-Lactose (Sigma-Aldrich Ltd) with distilled water.

2.2 MICROORGANISMS

Microorganisms used in this work are: *Kluyveromyces marxianus*, *Candida inconspicua* and *Candida xylopsoci*.

Kluyveromyces marxianus was obtained from the National Collection of Microorganisms (LB FSDM; Laboratory of Biotechnology, Faculty of Science DharLMehraz, Fes, Morocco).

The lactose fermenting isolates thermotolerant yeasts (*Candida inconspicua* and *Candida xylopsoci*) were isolated by Eloutassi et al. (LB FSDM, study not yet published).

2.3 CULTURE MEDIUM

The cultivation of yeast was performed in a 2 liter bioreactor with a working volume of 1.2L. It contains yeast extract (2.5 g l^{-1}), ammonium sulphate $(\text{NH}_4)_2\text{SO}_4$ (0.25 g l^{-1}), magnesium sulfate MgSO_4 (0.025 g l^{-1}), glycerol (0.5 ml), the pectin (0.625 g l^{-1}), disodium phosphate $\text{Na}_2 \text{HPO}_4$ (15 g l^{-1}), monosodium phosphate $\text{NaH}_2 \text{PO}_4$ (0.7 g l^{-1}), the pH adjusted to 7 with NaOH (2.5M).

2.4 FERMENTATION

The fermentation was performed in 500 ml Erlenmeyer flasks. The useful volume of fermentation is 200 ml containing whey permeate pretreated [6;7] as carbon source supplemented with yeast extract (2.5 g l^{-1}), $(\text{NH}_4)_2 \text{HPO}_4$ (0.25 g l^{-1}), MgSO_4 ($7\text{H}_2\text{O}$) (0.025 g l^{-1}) and NaH_2PO_4 (13.8 g l^{-1}). This medium is then inoculated with Microorganisms (0.2 g / l dry weight), and then incubated at 30°C with stirring (50 rev / min).

2.5 IMMOBILIZATION OF YEAST CELLS FOR ETHANOL PRODUCTION

The calcium alginate gel-entrapping method was used in the present study [15]. *Candida inconspicua* W16, *Candida xylopsoci* W23 and standard culture of *K. marxianus* cells were immobilized with alginate. Pre-cultured cells (of different dry weight) were each mixed with 50 ml 2.5% Na alginate solution. The resulting mixture was added drop-wise to 150ml 2% CaCl_2 solution to make cell-embodied beads. CaCl_2 solution was gently stirred at room temperature during the process. The mean diameter of the resulting Ca-alginate gel beads was about 2.8 mm.

2.6 REMOVAL OF FERMENTATION INHIBITORS

The removal of fermentation inhibitors (hydroxymethyl furfural) are removed by the method described by Coté [16]. Precipitation of these compounds is carried out by increasing the pH of the hydrolyzate to 9 with the calcium hydroxide ($\text{Ca}(\text{OH})_2$), then neutralized with sulfuric acid (H_2SO_4 , 2N).

2.7 PRODUCTION OF BIOETHANOL

The production of bioethanol was done using immobilized thermotolerant yeast fermentation by following the method outlined by Roukas [16]. Batch immobilized cell fermentation and free cell fermentation was performed at 37°C in 500-ml Erlenmeyer flasks. Ten percent (20-mg dry wt) free cells or 20% (w/v) beads carrying immobilized cells were added to 100 ml of whey fermentation medium as the inoculum. Whey (5.0% w/v lactose) was supplemented with specific amount of nutrients (ammonium sulphate (0.25% w/v), yeast extract (0.5% w/v), phosphorus salt (0.5% w/v) and 1% v/v corn steep liquor), pH of whey was adjusted to 5.0. Fermentation was carried out at 37°C . The level of ethanol in all the flasks was estimated at every 24 h time interval of incubation and change in pH during bioethanol production was also analyzed.

2.8 LACTOSE ESTIMATION

Residual lactose was estimated according to the method of Picric acid method Perry [17].

2.9 ETHANOL ESTIMATION

Ethanol was estimated by the dichromate colorimetric method, which is based on the complete oxidation of ethanol by dichromate in the presence of sulphuric acid to form acetic acid [18].

3 RESULTS AND DISCUSSION

After different treatment techniques, the dairy waste processing industry (Rabat/Salé) consist essentially of water, lactose, proteins, minerals and fat (Table 1).

Table 1: Composition of Whey [6;7;8].

constituents	Whey (g/kg)
dry matter	60
Lactose	385
proteins	82.5
Minerals - ash	40.9
Organic acids	10,2
fat matter	2,1

Analysis of ethanol production was carried out in the immobilized and non immobilized thermotolerant yeast strains, respectively. The results obtained from these experiments were shown in Fig. 1 and 2 which showed the comparison between ethanol production by immobilized and non immobilized yeast cells.

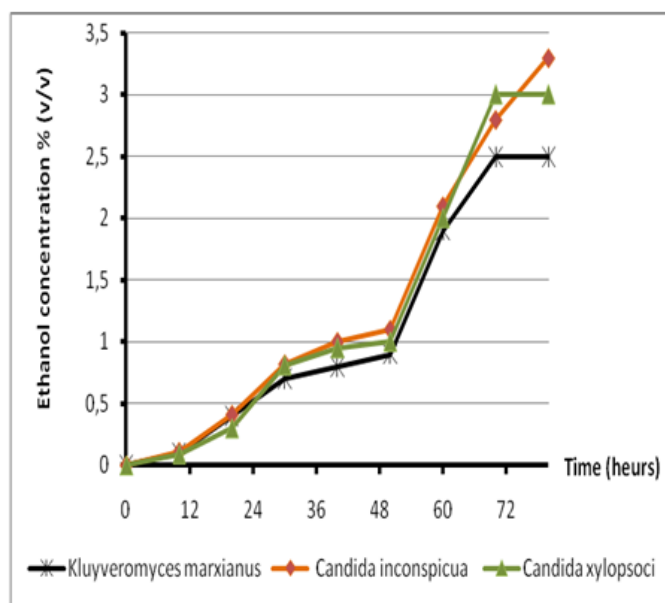


Fig. 1 Ethanol production by immobilized thermotolerant yeast strains from whey

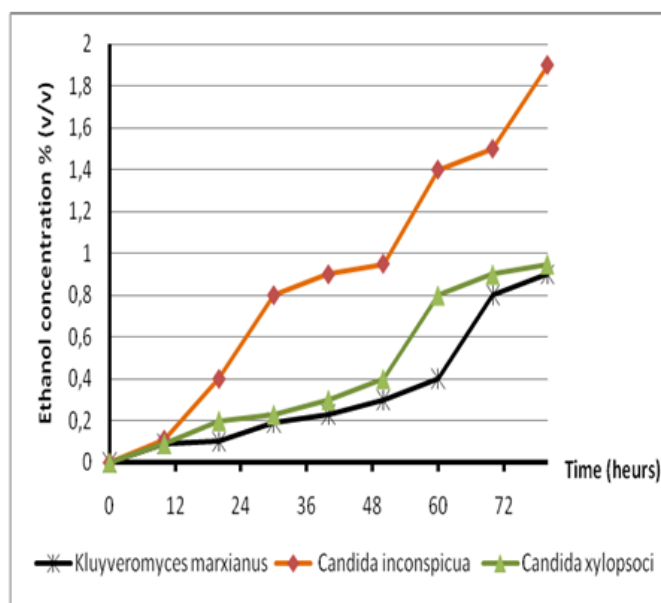


Fig. 2 Ethanol production by non-immobilized thermotolerant yeast strains from whey

Alcohol is a source of energy used for heating, cooking, lighting and as a motor fuel. Many researches are at progress in finding an alternative fuel through biological ways. The thermotolerant microorganism would be a potential source of alcohol production. Therefore, this investigation was aimed to study the feasibility of utilizing the thermotolerant yeast for ethanol production.

Among the selected thermotolerant yeast isolates *Candida inconspicua*, *Candida xylopsoci* and *Kluyveromyces. Marxianus*. *Candida inconspicua* showed maximum production of alcohol. It was $3,9 \pm 0.2\%$ v/v and $1.9 \pm 0.08\%$ v/v under immobilized and non immobilized conditions respectively; moreover, the sugar utilization concentration was lower in case of non immobilized yeast strains than immobilized yeast strains (Fig. 3 and 4).

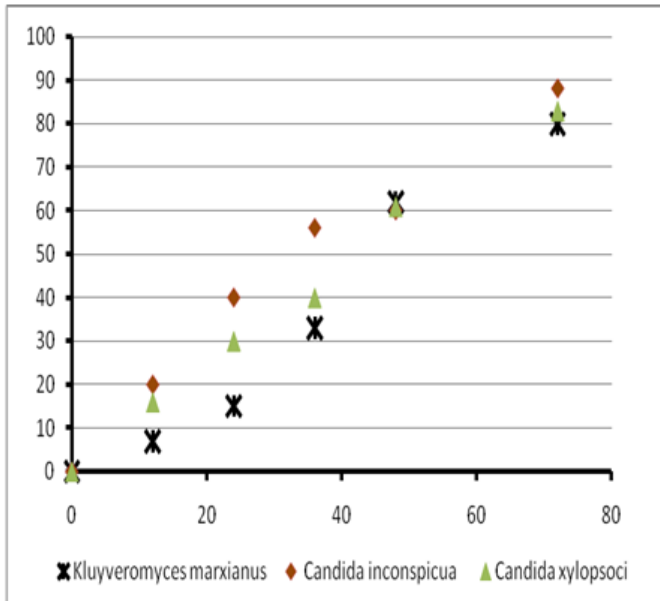


Fig. 3 Lactose utilization by immobilized thermotolerant yeast strains from whey

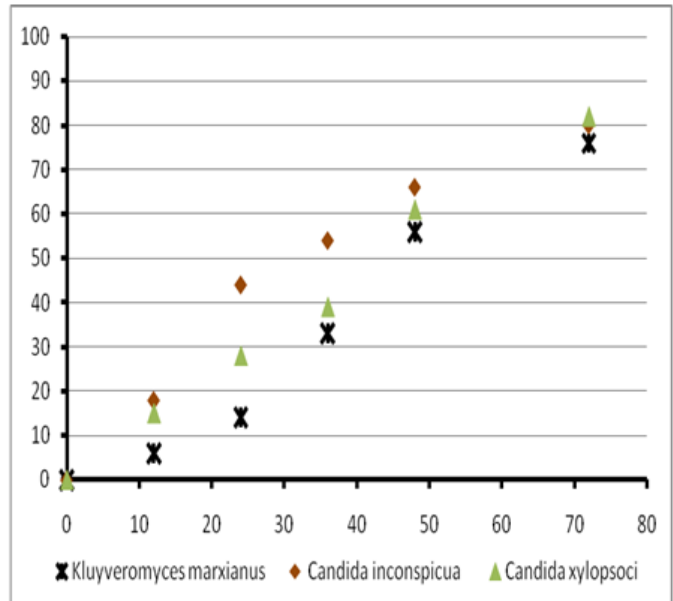


Fig. 4 Lactose utilization by non-immobilized thermotolerant yeast strains from whey

There are many studies on bioethanol production from yeast fermentation [19;20;21] produced ethanol using *Trichoderma viride* and thermotolerant yeast *Kluyveromyces marxianus*. *S. cerevisiae* is capable of converting only hexose sugars to ethanol.

The most promising yeasts that have the ability to use both pentose and hexose sugars are *Pichia stipitis*, *Candida shehatae* and *Pachysolan tannophilus*. Significantly higher fermentation and ethanol yield were obtained from immobilized cells compared to free cells under similar conditions [10;11;22].

This ability of immobilized yeast cells to produce more ethanol than free cells yet remains to be explained but it may be due to the fact that immobilized cells contains significantly higher percentage of saturated fatty acids compared to the free cells which leads to greater ethanol tolerance in the immobilized cells, and hence greater survival and productivity [22,23].

High temperature alcoholic fermentation of whey was carried out by Kourkoutas [9] using *Kluyveromyces marxianus* IMB3 yeast. Delignified cellulosic material (DCM) was used for immobilization of yeast cell. They reported that ethanol yield was nearly 7.3 g l⁻¹ ethanol at the end of 72 h of fermentation at pH 4.5 and temperature 45°C.

4 CONCLUSION

The use of immobilized thermotolerant yeast cells can help to overcome the problems/cost associated ethanol production from whey. Among the selected thermotolerant yeast strains and standard culture of NCDC 39, *Candida inconspicua* W16 thermotolerant yeast strain showed the maximum ethanol production (3.9±0.02 v/v) within 72 h in immobilized state as well as in free cell state (1.9±0.08% v/v). *Candida inconspicua* is a potential yeast strain for producing ethanol production from whey.

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Syndrome d'Ogilvie post-césarienne : à propos d'une observation et revue de la littérature

[Ogilvie's syndrome after cesarean section: A case report and revue of literature]

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ABSTRACT: Ogilvie's syndrome is a rare postsurgical complication. The high mortality rate after caecal perforation explains the seriousness of this clinical situation. The early diagnosis is made by plain abdominal X-ray and abdominal scanner. Conservative treatment is usually effective and surgery should be reserved for complicated cases or refractory to conservative treatment. We report a case of Ogilvie's syndrome after cesarean section. A case is reported clinical evolution of a chronic colonic obstruction disease after cesarean section which has been treated by conservative methods as Prostigmine® (néostigmine) and colonic lavement so.

KEYWORDS: Ogilvie's syndrome; Post-partum; Cesarean section; Colonic pseudo-obstruction; Intestinal occlusion.

RESUME: Le syndrome d'Ogilvie ou pseudo-obstruction colique est une complication chirurgicale rare. La mortalité élevée de ce syndrome après perforation cœcale en fait toute sa gravité. Le diagnostic doit être précoce et repose principalement sur la radiographie de l'abdomen sans préparation en plus de la TDM. Le traitement médical est efficace dans la majorité des cas, la chirurgie devant être réservée aux complications et aux cas réfractaires au traitement conservateur. Nous rapportons un cas de syndrome d'Ogilvie après césarienne. Cette observation rapporte l'évolution clinique d'une pseudo-occlusion colique aiguë survenue en post césarienne traitée médicalement par la Prostigmine® (néostigmine) associée au lavement colique à répétition.

MOTS-CLEFS: Syndrome d'Ogilvie; Post-partum; Césarienne; Pseudo-obstruction colique; Occlusion intestinale.

INTRODUCTION

Le syndrome d'ogilvie ou pseudo-obstruction aiguë du colon est une pathologie rare, décrite pour la première fois par ogilvie en 1948 [1]. Il s'agit d'une dilatation massive et aiguë du côlon sans obstacle mécanique. Il se manifeste par un tableau d'occlusion intestinale aiguë basse, il survient habituellement chez l'homme de la soixantaine ayant une maladie systémique associée. Chez la femme, la césarienne apparaît comme étant la condition la plus pourvoyeuse de ce syndrome [2] [3]. Dans ce cas, le diagnostic est difficile. L'occlusion colique en rapport avec ce syndrome est souvent mise sur le compte d'un iléus post opératoire prolongé. L'évolution spontanée se fait vers la perforation caecale avec péritonite stercorale et/ou vers un tableau de mégacolon toxique avec une mortalité non négligeable jusqu'à 45 % [2] [4]. A ce stade le pronostic devient sombre et la mortalité est élevée. Nous rapportons un nouveau cas de syndrome d'ogilvie post césarienne survenant chez une femme de 41 ans. Le tableau clinique était celui d'une occlusion intestinale basse ; l'évolution était heureusement favorable.

CAS CLINIQUE

Madame K.M est une septième geste quatrième pare avec trois enfants vivants (deux avortements spontanés à 2mois et une MFIU à 6mois) de 41 ans, ayant comme antécédents cholécystectomie il y'a 10 ans, une césarienne en 2009 et un diabète familial. Il s'agit d'une grossesse monofoetale évolutive, hospitalisée à 30 semaines d'aménorrhée (SA) + trois jours pour diabète gestationnel suite à une HGPO à 75g du glucose pathologique, équilibrée sous insuline sans retentissement ni maternel ni foetal, et au cours de cette hospitalisation une hypertension gravidique a été diagnostiquée d'où la mise en place d'un traitement antihypertenseur : ALDOMET 500mg/8h avec un bon équilibre sans retentissement. Le contrôle après sa sortie, du diabète et du l'HTA resté sans anomalie jusqu'à 35SA, ou elle a été ré hospitalisée pour équilibre diabétique devant un cycle glycémique perturbé sous insuline. La patiente restée hospitaliser jusqu'à 37SA+4J où elle a été césarisée pour diabète gestationnel sur utérus cicatriciel, donnant naissance à un garçon, APGAR 10/10, bien portant, pesé 3500g.

À j2 post-césarienne la patiente n'a pas repris son transit et présentait un météorisme abdominal important avec douleurs abdominales diffuses. Les bruits hydro-aériques (BHA) sont présents, sans émission de gaz. Ces douleurs sont mises sur le compte de la reprise du transit et traitées médicalement par antispasmodiques et laxatifs, et la patiente est laissée à jeun. Malgré l'instauration d'un traitement symptomatique avec hydratation électrolytique, et mise en place d'une sonde nasogastrique, la symptomatologie ne s'améliorait pas. Un ASP (cliché sans préparation) a été réalisé objectivant une distension colique sans niveau hydroaériques. **[Fig. 1]** (ASP)



Fig. 1. (ASP) : un ASP (cliché sans préparation) a été réalisé objectivant une distension colique sans niveaux hydro-aériques.

A j3 post-césarienne, une tomodensitométrie abdominopelvienne était alors réalisée retrouvant une distension majeure de la totalité du côlon. Pour éliminer une origine organique, une opacification rétrograde aux hydrosolubles était réalisée, confirmant l'absence d'obstacle soit intrinsèque ou extrinsèque et pas de souffrance intestinale ni d'épanchement

abdominal [Fig.2]. (TDM) Mais vu l'aggravation des douleurs abdominales et l'augmentation très marquée du météorisme, avec défense à la palpation abdominale. Devant cet abdomen chirurgical, un bilan sanguin préopératoire est prélevé et une laparotomie en urgence a été réalisée pour suspicion d'un volvulus de sigmoïde, l'exploration chirurgicale n'a pas objectivée d'anomalies pas d'obstacle ni volvulus ni épanchement intra abdominal ni souffrance intestinale ; donc le diagnostic de syndrome d'Ogilvie a été confirmer.

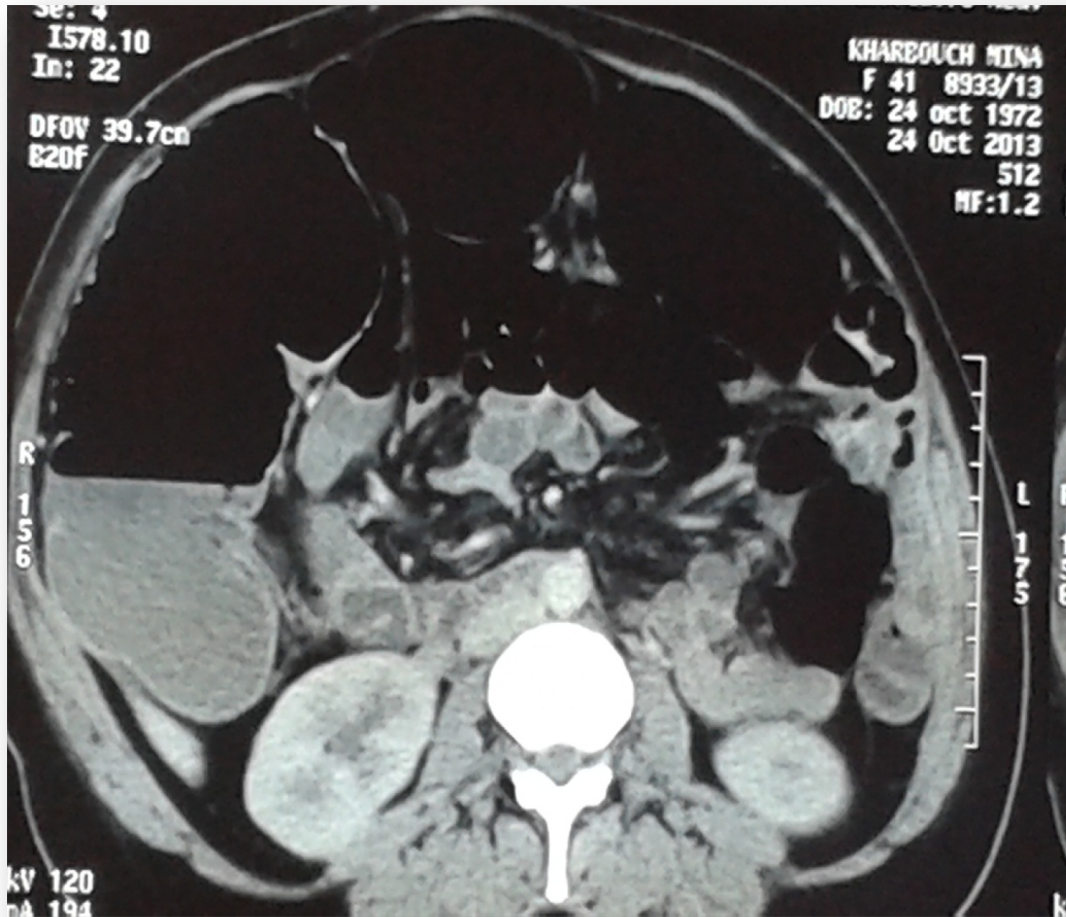


Fig. 2. (TDM) : Dilatation massive du côlon. Aspect scannographique de la dilatation colique. Scanner : la dilatation colique.

À J1 post opératoire (soit j5 post césarienne), la patiente est de nouveau algique, son abdomen est ballonné. Un traitement par Prostigmine® (néostigmine) est mis en place à raison d'une ampoule en intramusculaire à la posologie de 0,05 mg / kg en IV (ampoule à 0,5 mg/ml) soit une ampoule chaque huit heures pendant 48heures.

A J2 post opératoire, la patiente est toujours à jeun. On note une amélioration de son état clinique. On réalise une radiographie de l'abdomen sans préparation (ASP) par jour, ainsi que l'examen abdominal tous les jours. Ces éléments permettent la surveillance de l'amélioration de la colectasie, et avec elle du ballonnement abdominal.

A J3 post opératoire, l'état clinique est rassurant : une reprise progressive de l'alimentation liquidienne est autorisée, le traitement par Prostigmine® est arrêté. . Une surveillance régulière par ASP est poursuivie. Une colonoscopie diagnostique a été réalisée qui n'a pas objectivé d'anomalies à part une hypertrophie sphinctérienne. L'évolution est marquée par une bonne amélioration avec reprise du transit normal dans une semaine.

DISCUSSION

Rarement idiopathique, le syndrome d'Ogilvie survient le plus souvent chez des patients atteints de maladies viscérales graves ou venant de subir une intervention chirurgicale (surtout chirurgie pelvienne ou thoracique), la distension colique, totale ou segmentaire est toujours progressive, en l'absence d'un traitement approprié, elle entraîne une ischémie intestinale et la possible perforation diastasique du coecum quand le diamètre viscéral atteint 9 à 12 cm. En cas de perforation, la mortalité est très élevée 40-50% [2] [4]. Chez la femme, la césarienne apparait comme étant l'intervention la plus fréquemment associées au syndrome d'ogilvie [4] [5] [6] [7] cependant ce syndrome a été également décrit au cours des accouchements normaux[8]. L'Étiopathogénie [9][10] n'est actuellement pas totalement élucidée, la plupart des auteurs reconnaissent la dilatation aiguë comme conséquence d'une altération de l'innervation autonome du colon, par déficit du parasympathique sacré [3][14] responsable d'une atonie du colon distal, ce qui provoque une obstruction fonctionnelle, identique à celle qui se manifeste dans la maladie de Hirschprung, avec la différence que l'histologie révèle la présence de cellules ganglionnaires normales au niveau du plexus mésentérique. Une théorie vasculaire est proposée par d'autres auteurs, le mécanisme initial serait une baisse de la perfusion splanchnique au cours d'un bas débit général chez des malades souvent poly vasculaires et fragiles. Des théories hormonales mettent en cause les prostaglandines E qui stimulent la couche musculaire circulaire du colon. Des facteurs médicamenteux ou métaboliques viennent souvent s'ajouter aux précédents, les traitements neurotropes sont souvent mis en cause en raison de leurs effets anti cholinergiques. La symptomatologie est celle d'une occlusion intestinale aiguë basse ; d'installation rapide (un à deux jours) ou plus lente (3 à 7 jours) ; chez notre patiente la symptomatologie est apparue dans les 48 heures.

Le tableau clinique est rarement typique d'une occlusion intestinale basse la distension abdominale et le météorisme étant les signes les plus constants , les bruits hydro-aériques sont normaux ou augmentés l'état général est conservé ;les autres signes habituels de l'occlusion intestinales tels que les nausées , les vomissements ,la fièvre et l'arrêt des matières ne sont pas toujours présents [5] ;tandis que l'apparition d'une douleur de la fosse iliaque droite doit faire suspecter une perforation caecale [11].Les examens biologiques sont peu contributifs cependant une hyperleucocytose est retrouvées dans 27% chez les patientes non compliquées et dans 100% dans les perforations caecales [5] .L'abdomen sans préparation est l'examen radiologique le plus fiable. Il montre une distension colique globale du coecum à la jonction recto sigmoïdienne ; ou partielle surtout au niveau du coecum, les niveaux hydro aériques sont inconstants, chez notre patiente l'ASP a montré quelques niveaux hydro-aériques type coliques intéressant la région caecale et colique droite. Le respect des haustrations coliques ainsi que l'inconstance des niveaux hydro-aériques sont en faveur d'un obstacle fonctionnel [9] ce qui doit déjà orienté vers le diagnostic de syndrome d'ogilvie. La mesure du diamètre caecal apparait comme le meilleur indice prédictif d'une perforation caecal ; lowman et Davis avait défini le seuil de 9cm [12] alors que vaneck et al n'avaient observé de perforation avant 12 cm [2].Cependant l'ASP est peu contributive en terme de perforation car la présence de pneumopéritoine est physiologique jusqu'à cinq jours après la laparotomie. La tomодensitométrie (TDM) abdominale n'a intérêt que dans l'élimination de certains diagnostic différentiel tels qu'un obstacle mécanique ; un volvulus du sigmoïde, le fécalome ou la péritonite. Le traitement du syndrome d'ogilvie dépend essentiellement de l'état général de la patiente et du diamètre caecal à l'ASP, le but de ce traitement est de réduire la distension colique afin d'éviter la complication la plus redoutable qui est la perforation et la péritonite stercorale. En dessous de 9-12cm le traitement médical doit être réalisé en première intention ; au-dessus de ce seuil le traitement par méthodes invasives s'impose, le traitement chirurgical n'est indiqué que dans les formes compliquées et en cas d'échec du traitement médical. Le traitement médical associe le jeûne, la mise en place d'une sonde nasogastrique, la rééquilibration des désordres hydro électrolytiques, et la pose d'une sonde rectale.

On utilise aussi des para sympathicomimétiques comme la Prostigmine à la posologie de 0,05 mg/kg en IV (ampoule à 0,5 mg/ml) ; son utilisation exige une surveillance clinique et électrocardioscopique étroite ainsi qu'une seringue d'atropine a côté [5][8][13]. L'Erythromycine peut être également utilisée, décrite pour avoir un effet stimulant sur la motilité colique [13]. La colonoscopie est à la fois diagnostique, thérapeutique et pronostique [14][5][8][13]. Elle permet d'apporter la preuve de l'absence d'obstacle ; de réaliser une exsufflation colique en montant une sonde rectale ; et de vérifier l'intégrité de la muqueuse colique. C'est ce qui a été réalisé par notre équipe de gastro-entérologues.

D'autres possibilités thérapeutiques ont été décrites comme l'anesthésie péridurale, les infiltrations splanchniques et le lavement à la gastrografine [5] [15][13].Weber et al ont rapporté trois cas de syndrome d'ogilvie post césarienne [5] ,la première a bénéficié d'un traitement médical simple avec retour rapide à la normale ;la deuxième a bénéficié d'une exsufflation colonoscopique après échec du traitement médical ;la troisième malade a aussi bénéficié d'une colonoscopie exuflative après l'absence d'amélioration sous le traitement médical et la péridurale ;donc ces auteurs concluent que le traitement médical doit être privilégié au dépend du traitement chirurgical qui doit être laisser pour les complication telle que la perforation. Roux et al [9] tirent les mêmes conclusions en 2009.Mainguay et al [10] rapportent deux cas compliqués de

perforations coecales ayant nécessité une intervention chirurgicale en urgence type coecotomie avec colostomie transverse de décharge et suture de la séreuse.

CONCLUSION

Le syndrome d'Ogilvie est une entité rare ; il doit être évoqué chez la femme qui présente un syndrome occlusif avec météorisme important en post partum ; il constitue une urgence de prise en charge du fait du risque de perforation caecale et de la péritonite stercorale.

L'ASP constitue l'examen clé pour faire le diagnostic et pour chercher les signes de pré perforation .Le traitement repose essentiellement sur les mesures médicales ainsi que la colonoscopie exuflative, cependant le traitement chirurgical peut s'avérer obligatoire en cas de complication.

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Spectral Analysis of the Photoionization of Atomic Hydrogen in Intense High-Frequency Laser Field: Numerical Simulation

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ABSTRACT: The present work aims at analyzing the dynamics of the photoionization process of a hydrogen atom -modelling a single active electron atom- interacting with intense high-frequency laser pulses. The choice of the numerical approach to be used for solving the time-dependent Schrödinger equation (TDSE) of an atom in a laser field is based on the fact that when the intensity of a femtosecond laser get higher, the electron after it reaches the continuum starts behaving as a free electron oscillating in the laser field, which leads to a strong oscillations in the electronic wave function, and then could affect the stability in numerical solutions of TDSE. Therefore a highly stable numerical methods are required for solving the TDSE of an atomic hydrogen in intense laser pulses, for this reason, we chose to use the three-point finite difference method for the spatial discretization of the wave function and the standard Peaceman-Rachford scheme coupled to an inverse iteration procedure for the function's propagation in time. Once the wave function obtained, a spectral analysis of the ejected electron based on the use of a window operator is performed to calculate the probability of ionization of a hydrogen atom by a high frequency laser field.

KEYWORDS: Spectral Analysis, Photoionization, Atomic Hydrogen, High-Frequency, Laser, Numerical Simulation.

1 INTRODUCTION

The study of the interaction of intense laser fields with atomic systems is subject of interest since the invention of laser since the early 60s. The development of high-power pulsed lasers during the past two decades has enabled us to reach of higher intensities to 10^{14} W/cm² and with pulse durations of a few femtoseconds (10^{-15} s). With such characteristics, the interaction of an intense laser fields with an atomic system leads to non-linear process where a large number of photons can be emitted or absorbed. Agostini et al. [4] discovered in 1979 that at sufficiently high intensities ($I > 10^{11}$ Wcm⁻²), the ejected electron can absorb photons in excess of the minimum number required for ionization to occur. This phenomenon is called "above-threshold ionization" (ATI). "). In the late 1980s the experimenters observed another phenomenon of noble gases interacting with intense, short-pulse laser fields: it is the high-order harmonic generation (HHG) [4,5].

So far, most theoretical efforts have been focused on solving the problem of a hydrogen atom, or more generally, a single-active-electron atomic system in a strong laser field for which exact calculations can be performed. As for multi-electron systems the theoretical calculations remains only an approximation.

The numerical treatment of the interaction of the hydrogenic atom with the intense, high frequency laser fields can not be treated within the framework of perturbation theory due to the interaction fields, which becomes comparable to the Coulomb field of hydrogen. Therefore, non-perturbative methods are required to explain most of the experimental observations. It is necessary in this case to solve the time-dependent Schrödinger equation (TDSE), which is usually found in non-perturbative theories. At the end of the interaction, our system is represented by the final wave function obtained from the numerical resolution of the TDSE, the analysis of the spectra of the ejected electrons whose ATI peaks were observed, can help us to calculate easily the probability of ionization of H(1s) by linearly polarized laser pulses.

2 CHARACTERISTICS OF THE LASER FIELD

The chosen laser field is characterized by its electric field $\vec{E}(\vec{r}, t)$ of peak amplitude $E_0 = 5 \cdot 10^{-3} \text{ a.u.}$ of frequency $\omega_0 = 0.57 \text{ u.a.}$ (corresponding to a period of $T_L = 2\pi/\omega_0 = 11.02 \text{ u.a.} \approx 0.25 \text{ fs}$) and modulated by an envelope $f(t)$. The total duration of the pulse t_{max} is defined by the following expression: $t_{\text{max}} = n_{\text{cycle}} T_L$, where n_{cycle} is the number of optical cycle of the laser field.

For a linearly polarized laser pulse, the electric field can be written in the dipole approximation as

$$\vec{E}(\vec{r}, t) = E_0 f(t) \sin(\omega_0 t) \vec{e}_z \quad , \quad (1)$$

where \vec{e}_z represents the polarization vector and $f(t)$ defines the temporal profile of the laser pulse (envelope), which is chosen to be trapezoidal. It rises linearly over five optical cycles, remains constant for thirty cycles then it is ramped linearly down over the final five cycles:

$$f(t) = \begin{cases} \frac{t}{5 \cdot T_L} & \text{si } 0 < t < 5 \cdot T_L \\ 1 & \text{si } 5 \cdot T_L < t \leq 35 \cdot T_L \\ -\frac{t}{5 \cdot T_L} + 8 & \text{si } 35 \cdot T_L < t < 40 \cdot T_L \end{cases}$$

The temporal evolution of the electric field defined with the expression (1) is then given in the following figure:

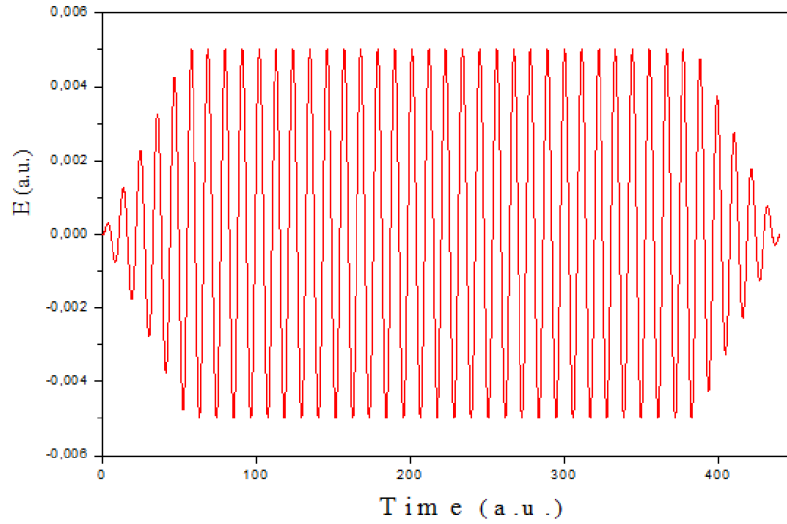


Figure 1: Temporal evolution of the electric field of the laser pulse with a frequency of $\omega_0 = 0.57 \text{ a.u.}$ (the photon energy of 15.5 eV) and a peak amplitude $E_0 = 5.10^{-3} \text{ a.u.}$ (Corresponding to a peak intensity of $8.77 \times 10^{11} \text{ W/cm}^2$) for 40 optical cycles (trapezoidal envelope)

3 NUMERICAL APPROACH

In addition to the analytical methods, different numerical methods have been developed to describe the interaction of the laser field with the active electron. Our numerical approach is to solve numerically the time-dependent Schrödinger equation (TDSE) in a non-perturbative way, namely

$$i \frac{\partial}{\partial t} \psi(\vec{r}, t) = (H_0 + H_{int}) \psi(\vec{r}, t), \quad (2)$$

where H_0 is the time-independent, non-relativistic field-free atomic Hamiltonian, which is written as follows:

$H_0 = E_c + E_p = -\frac{1}{2} \Delta - \frac{1}{r}$, with E_c the kinetic energy of the electron, and E_p the potential energy. The term H_{int} represents the time-dependent Hamiltonian describing the interaction of the atom with the laser field given by $\vec{E}(t) \cdot \vec{r}$ in length gauge or $\vec{A}(t) \cdot \vec{p}$ in velocity gauge with $\vec{E}(t)$ defined in (1) is the electric field of the laser and $\vec{A}(t)$ is the potential vector.

If we limit ourselves to laser pulse linearly polarized along the z-axis, the magnetic quantum number m of the electron is conserved, the time-dependent Schrödinger equation describing the atom in a laser field in the length gauge is given by (in atomic units)

$$i \frac{\partial}{\partial t} \psi(\vec{r}, t) = \left\{ -\frac{1}{2} \left(\frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial}{\partial r} \right) + \frac{1}{r^2} \bar{L}^2 \right) - \frac{1}{r} - E_0 z f(t) \sin(\omega_0 t) \right\} \psi(\vec{r}, t), \quad (3)$$

where the position \vec{r} is expressed using the spherical coordinates (r, θ, φ) .

We can separate the radial part of the wave function from its angular part by expanding it in spherical harmonics

$$\psi(r_i, \theta, \varphi, t) = \sum_{\ell=0}^L \Phi_{\ell}(r_i, t) Y_{\ell}^0(\theta, \varphi), \quad \Phi_{\ell}(r_i, t) = \frac{R_{\ell}^i(t)}{r_i} \quad (4)$$

The finite difference representation at three points can be employed for a discretized representation of the kinetic energy, the field-free Hamiltonian H_0 becomes

$$\begin{aligned}
 H_0 \mathcal{W}(r_i, \theta, \varphi, t) &= \frac{1}{r_i} \sum_{\ell} Y_{\ell}^0(\theta, \varphi) \left\{ -\frac{1}{2(\Delta r)^2} (c_i R_{\ell}^{i+1}(t) + c_{i-1} R_{\ell}^{i-1}(t) - 2d_i R_{\ell}^i(t)) + \left(\frac{\ell(\ell+1)}{2r_i^2} - \frac{1}{r_i} \right) R_{\ell}^i(t) \right\} \\
 &= \frac{1}{r_i} \sum_{\ell} Y_{\ell}^0(\theta, \varphi) (H_0 R(t))_{\ell}^i
 \end{aligned} \tag{5}$$

with $r_i = (i - 0.5)\Delta x$ and the coefficients c_i and d_i are defined by [6]

$$c_i = \frac{i^2}{i^2 - 1/4}, \quad d_i = \frac{i^2 - i + 1/2}{i^2 - i + 1/4}.$$

We see that the Hamiltonian matrix H_0 is diagonal in the angular momentum quantum number ℓ and is tridiagonal in the grid index i , therefore the non-zero elements are given by

$$H_{0,\ell,\ell'}^{i,i} = \delta_{\ell,\ell'} \begin{cases} -\frac{c_i}{2(\Delta r)^2} & i = i+1 \\ -\frac{c_{i-1}}{2(\Delta r)^2} & i = i-1 \\ \frac{d_i}{(\Delta r)^2} + \frac{\ell(\ell+1)}{2r_i^2} - \frac{1}{r_i} & i = i \end{cases} \tag{6}$$

Substituting Equations (4) and (5) into the TDSE (3), we find that

$$i \frac{\partial R_{\ell}^i(t)}{\partial t} = (H_0 R(t))_{\ell}^i + \sum_{\ell'} H_{\ell\ell'} R_{\ell'}^i(t), \tag{7}$$

with $H_{\ell\ell'}$ are the matrix elements of the interaction Hamiltonian

$$H_{\ell\ell'} = \langle Y_{\ell}^0(\theta, \varphi) | H_{int} | Y_{\ell'}^0(\theta, \varphi) \rangle \tag{8}$$

The interaction Hamiltonian in the length gauge is given by

$$H_{int} = -zE(t) = -E(t)r \cos \theta, \tag{9}$$

θ is the angle between the vector r and the z-axis.

The matrix elements of the interaction Hamiltonian in the angular momentum basis is given by

$$\begin{aligned}
 \langle \ell 0 | H_{int} | \ell' 0 \rangle &= -E(t)r_i \langle \ell 0 | \cos \theta | \ell' 0 \rangle \\
 &= -E(t)r_i \left(\frac{\ell+1}{\sqrt{(2\ell+1)(2\ell+3)}} \delta_{\ell',\ell+1} + \frac{\ell}{\sqrt{(2\ell+1)(2\ell-1)}} \delta_{\ell',\ell-1} \right), \\
 &= -\delta_{\ell',\ell} E(t)r_i \begin{cases} a_{\ell}, & \ell' = \ell+1 \\ a_{\ell-1}, & \ell' = \ell-1 \end{cases}
 \end{aligned} \tag{10}$$

where the coefficients a_{ℓ} are given by

$$a_{\ell} = \frac{\ell+1}{\sqrt{(2\ell+1)(2\ell+3)}} \tag{11}$$

This matrix H_{int} is then tridiagonal in the angular momentum quantum number ℓ and diagonal in the grid index i .

Substituting Equation (9) into Equation (6), we can then rewrite the TDSE in the form

$$i \frac{\partial R_\ell^i(t)}{\partial t} = -\frac{1}{2(\Delta r)^2} (c_i R_\ell^{i+1}(t) + c_{i-1} R_\ell^{i-1}(t) - 2d_i R_\ell^i(t)) + \left(\frac{\ell(\ell+1)}{2r_i^2} - \frac{1}{r_i} \right) R_\ell^i(t) - E_0 r_i f(t) \sin(\omega_0 t) \{ a_\ell \delta_{\ell', \ell+1} + a_{\ell-1} \delta_{\ell', \ell-1} \} R_\ell^i(t) \quad (12)$$

Since both the matrix H_0 and the matrix $H_{int}(t)$ are tridiagonal, we can use the implicit method of Peaceman-Rachford, which consists in replacing the differential equation by two discretized equations (tridiagonal) used for periods $\frac{\Delta t}{2}$, namely

$$R_\ell^i(t + \Delta t) = \left[I + iH_0 \frac{\Delta t}{2} \right]^{-1} \left[I + iH_I \frac{\Delta t}{2} \right]^{-1} \left[I - iH_0 \frac{\Delta t}{2} \right] \left[I - iH_I \frac{\Delta t}{2} \right] R_\ell^i(t) \quad (13)$$

Let $\left[I - iH_0 \frac{\Delta t}{2} \right] \left[I - iH_I \frac{\Delta t}{2} \right] R_\ell^i(t) = \chi_\ell^i(t) \quad (14)$

$$\underbrace{\left[I + iH_0 \frac{\Delta t}{2} \right]}_{tridiagonale} \xi_\ell^i(t + \Delta t) = \chi_\ell^i(t) \quad (15)$$

Using the Routine Tridag for solving a tridiagonal system, we can calculate $\xi_\ell^i(t + \Delta t)$.

Finally we must solve the following system to find $R_\ell^i(t + \Delta t)$

$$\underbrace{\left[I + iH_I \frac{\Delta t}{2} \right]}_{tridiagonal} R_\ell^i(t + \Delta t) = \xi_\ell^i(t + \Delta t) \quad (16)$$

In our simulations, we took $\Delta r = 0.1 a.u.$, $\Delta \tau = 0.1 a.u.$ and the ground state of the hydrogen atom $R_\ell^i(t = 0) = 2r_i e^{-r_i}$ as the initial state of the system.

4 SPECTRUM OF THE EJECTED ELECTRON

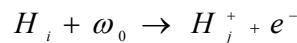
4.1 WINDOWS OPERATOR TECHNIQUE

For laser intensities of about 10^{12} W/cm^2 , the ejected electron can absorb a number of photons in excess of the minimum number required for ionization; by having a number N of photons absorbed, then additional photons S above the threshold, the bounded electron thus acquired a kinetic energy equal to

$$E_c = (N + S) \hbar \omega_0 - |E_i| \quad (17)$$

where E_i is the ionization energy, that is the minimum energy required for the electron initially located in the ground state ($n = 1$) to be no longer bound to the atom.

In our case, a linearly polarized photon, having an energy of $\omega_0 = 0.57 a.u. > E_i = \frac{e^2}{8\pi a_0 \epsilon_0} \approx 0.5 a.u.$, remove the electron from the hydrogen atom, therefore the dominant ionization process will be photoionization ($N = 1$), it can be summarized by the following reaction



At the end of the pulse laser, i.e. at time t_{\max} , our atomic system was represented by final-state wave function $\psi_f(r, t_{\max})$ from which we can deduce the energy spectrum of the ejected electrons by using an adequate method, which does not require the computation of all the eigenstates of the system. It is based on the use of a window operator $\hat{F}(E_k, n, \gamma)$ [7]:

$$\hat{F}(E_k, n, \gamma) = \frac{\gamma^{2^n}}{(E_k)^{2^n} + \gamma^{2^n}}, \quad (18)$$

with n is the order of the window operator, and γ is the parameter, which determines the spectral width of the window, i.e. the energy resolution of the analysis. A good value of γ should not be too big if you want to be able to extract information such as ATI spectrum peaks.

Using the window operator (see Eq. 18) we can determine the energy spectrum of photoelectrons ejected from hydrogen, such as the total probability of finding the electron energy (in the final state) within the interval $E_k \pm \gamma$

$$P(E_k, n, \gamma) = \langle \psi_f | \frac{\gamma^{2^n}}{(H_0 - E_k)^{2^n} + \gamma^{2^n}} | \psi_f \rangle, \quad (19)$$

$$= \langle \chi | \chi \rangle$$

with

$$|\chi\rangle = \frac{\gamma^{2^{n-1}}}{(H_0 - E_k)^{2^{n-1}} + i\gamma^{2^{n-1}}} |\psi_f\rangle \quad (20)$$

To satisfy a good energy resolution, we choose $n = 2$ [6], thus equation (20) becomes

$$[(H_0 - E_k)^2 + i\gamma^2] |\chi\rangle = \gamma^2 |\psi_f\rangle \quad (21)$$

$$\underbrace{[(H_0 - E_k) + \sqrt{i}\gamma]}_{\text{tridiagonal}} \underbrace{[(H_0 - E_k) - \sqrt{i}\gamma]}_{\text{tridiagonal}} |\chi\rangle = \gamma^2 |\psi_f\rangle \quad (22)$$

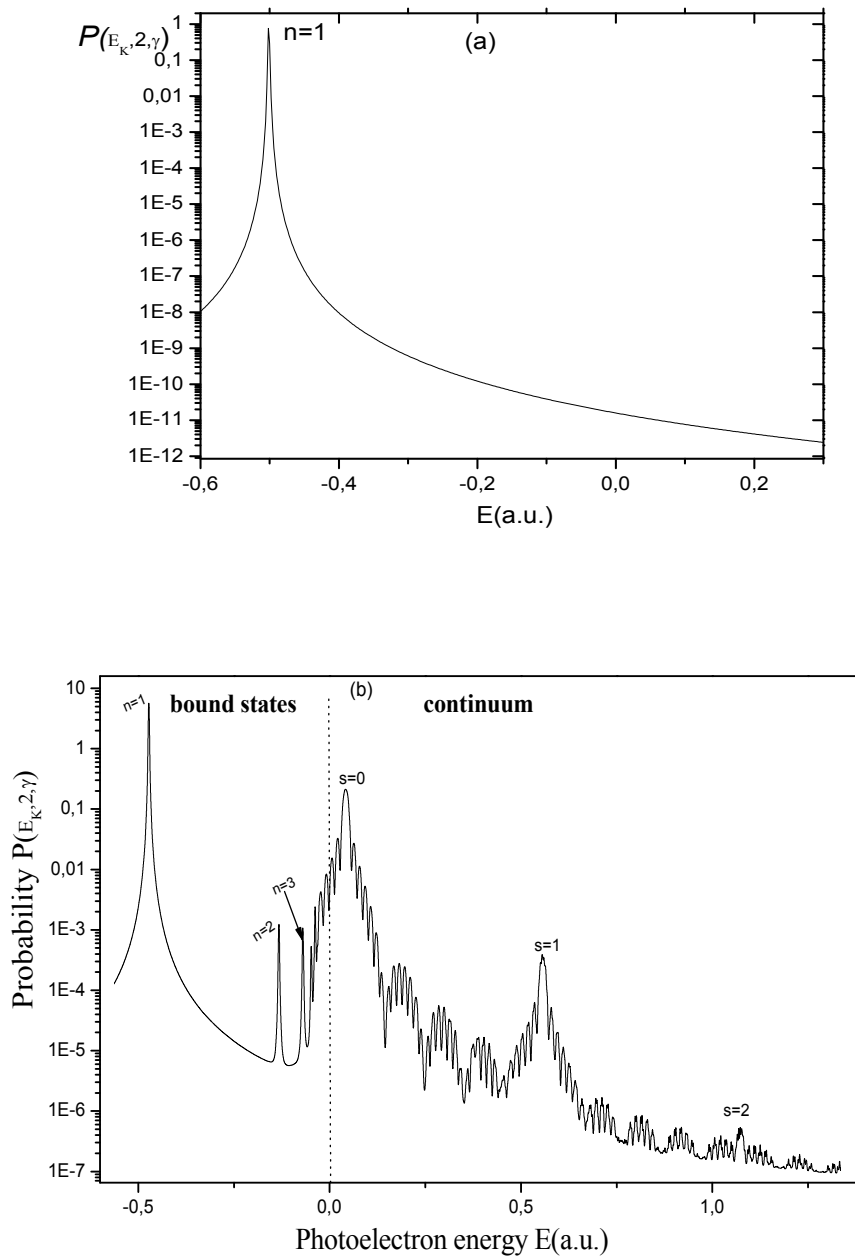


Figure 2: Probability $P(E_k, n, \gamma)$ for $n = 2$, $\gamma = 10^{-3}$ a.u., in Logarithmic scale as function of the photoelectron energy. We use $L_{\max} = 8$ and a forty-cycle laser pulse of photon energy $\omega_0 = 0.57$ a.u. and maximum amplitude : (a) $E_0 = 0$ a.u. (b) $E_0 = 5.10^{-3}$ a.u..

Figure (2) shows the probability $P(E_k, n, \gamma)$ on a logarithmic scale. Peaks whose energy $E < 0$ correspond to the bound states of the atom, while in the continuum, there is well positioned three peaks at 0.0699 a.u., 0.639 and 1.209 a.u. respectively, which are separated by one photon energy $\omega_0 = 0.57$ a.u. This agrees fairly well with the expected theoretical value. Indeed, the first peak of the spectrum corresponds to the ionization of hydrogen from its 1s ground state by absorbing

a photon of energy $\omega_0 = 0.57 \text{ a.u.}$, while the second and third peaks are related to the ATI. The widths and shapes of these peaks are consistent with the Fourier transform of the laser pulse shape, as is expected if no resonance enhancement is involved.

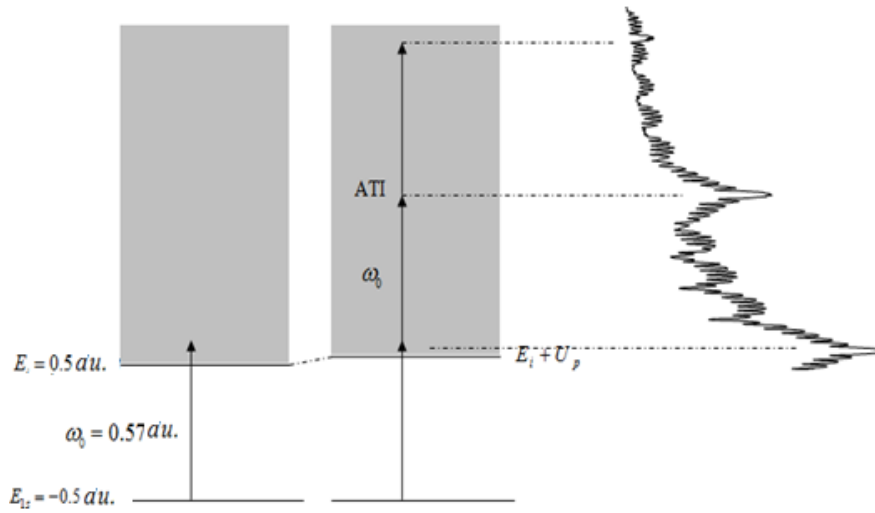


Figure 3: Shifting of ATI peaks due to ponderomotive effects, which cause an increase in the ionization potential value.

The ATI peak position is seen to shift with a value of U_p toward lower energies which results in a change in the ionization potential of the atom. U_p can be interpreted as the cycle-averaged kinetic energy of a quivering electron in a laser and can be written in a.u. as:

$$U_p = \frac{I(W/cm^2)}{4\omega^2(a.u.)I_0(W/cm^2)}, \quad (23)$$

with $I_0(W/cm^2) = 3.5 \times 10^{16} W/cm^2$.

The kinetic energy of the ionized electron (17) can be rewritten as follows

$$E_c = (N+S)\hbar\omega_0 - (|E_i| + U_p) \quad (24)$$

This last expression shows that the released electron energy depends not only on the number of the absorbed photons, but also on the value of the field at its release. Therefore, the ATI peaks have a certain width $\Delta E \simeq 2 \times 10^{-2} \text{ a.u.}$ (the photon energy divided over the length of the pulse), this value is in good agreement with those extracted from Figure (2).

5 PROBABILITY OF TOTAL IONIZATION

We can calculate the total ionization probability from the ATI spectrum:

$$\begin{aligned} p_{ion} &= \int_0^{E_{max}} \frac{dP(E)}{dE} dE = \int_0^{E_{max}} \rho(E) dE \\ &\approx \sum_k \rho(E_k) \Delta E_k \end{aligned}, \quad (25)$$

where $\rho(E_k)$ is the probability density of finding the electron ejected with an energy close to E_k .

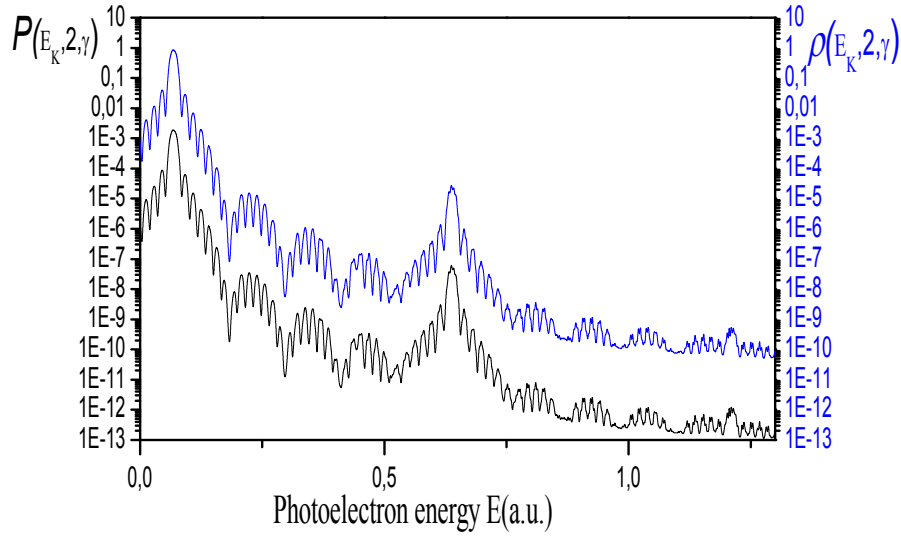


Figure 4: probability density of the free electrons $\rho(E_k, 2, \gamma)$ (blue) and the probability $P(E_k, n, \gamma)$ (black), with a spectral width $\gamma = 10^{-3}$ and with the same laser pulse parameters $(\omega_0, E_0, n_{c.o.})$ as in Fig. (2).

In our system there is only one electron that is involved in the process, the final state can then be developed in the basis of eigenvectors of H_0 :

$$|\psi_f\rangle = \sum_{|\ell\rangle} c_\ell |\ell\rangle + \int_{e>0} de c(e) |e\rangle \quad (26)$$

Thus we can write $P(E_k, n, \gamma)$ (Equation 19) as a sum over the bound states and an integrand over the continuum:

$$P(E_k, n, \gamma) = P_\ell + P_c \\ = \sum_{|\ell\rangle} |c_\ell|^2 \hat{F}(E_k - E_\ell, n, \gamma) + \int_{e>0} de |c(e)|^2 \hat{F}(E_k - e, n, \gamma) \quad (27)$$

It corresponds to the total probability of locating the electron either in the bound states of the atom or in the states of the continuum.

In the region $E > 0$, equation (27) becomes:

$$P(E_k, n, \gamma) \approx \int_{e>0} de |c(e)|^2 \hat{F}(E_k - e, n, \gamma) \quad (28)$$

If the value of γ is chosen small enough such that $c(e)$ does not change too much on a large area of energy [5], (28) can be written [8]:

$$\begin{aligned}
 P(E_k, n, \gamma) &\approx |c(E)|^2 \int_{e>0} de \hat{F}(E_k - e, n, \gamma) \\
 &= |c(E)|^2 \frac{\pi}{n} \operatorname{csc}\left(\frac{\pi}{2n}\right) \gamma
 \end{aligned} \tag{29}$$

This formula makes the link between the probability density $|c(E)|^2$ and the probability $P(E_k, n, \gamma)$:

$$\rho(E_k, n, \gamma) = \frac{P(E_k, n, \gamma)}{\frac{\pi}{n} \operatorname{csc}\left(\frac{\pi}{2n}\right) \gamma} \tag{31}$$

We can then convert the ATI spectrum in a probability density, by using equation (31) the conversion factor is then

$\frac{\pi}{2} \operatorname{csc}\left(\frac{\pi}{4}\right) \gamma$ (for $n = 2$). The ionization probability (Equation 27) p_{ion} can be approximated by the following formula:

$$p_{ion} \approx \frac{1}{\frac{\pi}{n} \operatorname{csc}\left(\frac{\pi}{2n}\right) \gamma} \sum_k P(E_k, n, \gamma) \Delta E_k \tag{32}$$

As part of our calculation, the expression (32) gives us a probability of ionization 0.013983 au, this value is close to that calculated from the projection of the final wave function on the bra of the initial (fundamental) state $\langle \varphi_{1s} |$ such as:

$$p_{ion}(t) \approx 1 - \left| \langle \varphi_{1s} | \psi(t) \rangle \right|^2 \tag{33}$$

we notice from Figure (5), that at the end of the interaction $p_{ion} \approx 1 - P_{n=1} = 0.01397 \text{ a.u.}$

A second procedure for calculating the total ionization probability is given by calculating the total probability for an electron to remain in the bounded states after the interactions:

$$P_{\text{états liés}} = \sum_n \left| \langle \varphi_n | \psi(t_{\max}) \rangle \right|^2 \tag{34}$$

the total probability of ionization of the system is:

$$p_{ion} = 1 - P_{\text{états liés}} \tag{35}$$

Using Figure (2), we can easily extract the amount of probability for each bound state $P_{\text{états liés}}$ such as: the result for $n = 1$ is in good agreement with that of the ground state population at the end of the interaction $\left| \langle \varphi_n | \psi(t_{\max}) \rangle \right|^2$, while the contributions of $n \geq 2$ are found to be of 10^{-7} u.a. of magnitude, which allows us to neglect them in our study.

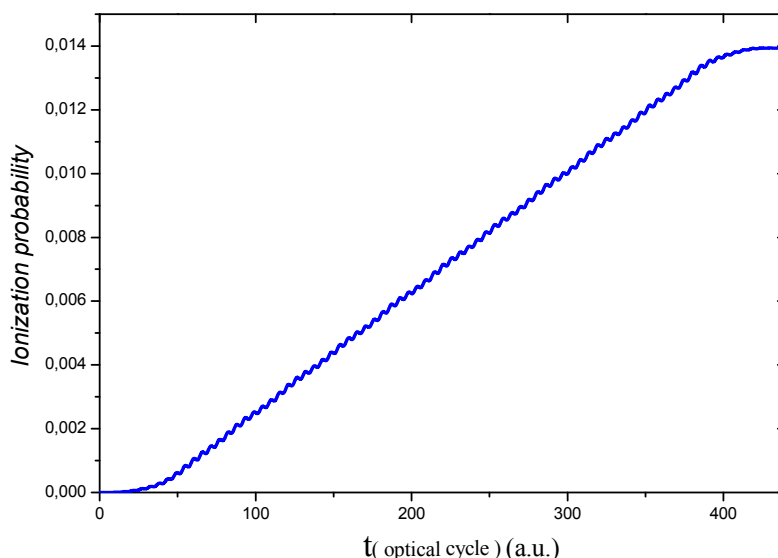


Figure 5: Ionization probability, $1 - \left| \langle \varphi_{1s} | \psi(t) \rangle \right|^2$, versus time for the same laser field parameters as above.

6 CONCLUSION

We have presented numerical methods that we have used to solve the time dependent Schrödinger equation for a hydrogen atom in presence of a strong and short laser field. The obtained wave function was analyzed in energy by means of a window operator which allowed us to analyze the energy spectra of the ejected electron. We observed typical ATI peaks separated by one photon energy and we evaluated the probability of the photoionization of the hydrogen in such extreme conditions.

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Relationship between Resilience and Life Satisfaction among Nomadic

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ABSTRACT: The purpose of the study was to explore the level of resilience and life satisfaction among nomadic. The sample consisted of 100 nomadic (50 males nomadic, 50 females nomadic) belonged to the different profession, age; martial status were taken from Multan and Bahwalnagar. The resilience scale and the life satisfaction scale was used to measure the level of resilience and life satisfaction respectively. Statistical analysis indicated that the resilience and life satisfaction was positively correlated. The results indicated that there was significant difference among males nomadic have higher level of life satisfaction as compared to females nomadic, but there was no significant difference that females nomadic have higher level of resilience as compared to males nomadic. Further findings indicated that there were no significant differences that working nomadic have higher level of resilience and life satisfaction as compared to nonworking nomadic. Another finding indicated that there were no significant differences married nomadic have higher level of resilience and life satisfaction among unmarried nomadic.

KEYWORDS: resilience, life satisfaction.

1 INTRODUCTION

1.1 RESILIENCE

“Resilience simply stated, is positive adaptation in response to adversity” (Waller, 2001). Resilience in psychology refers to the idea of an individual’s ability to cope with stress and adversity. This coping may result in the individual “bouncing back” to a previous state of normal functioning, or experience the exposure of adversity to produce a “steeling effect” and function better than expected. Resilience can indicate a capacity to resist a sharp decline in functioning even though a person temporarily appears to get worse (Masten, 2009).

Resilience is basically a two-dimensional construct which is concerning the exposure of adversity and the positive adjustment outcomes of that adversity. It is different from strengths or developmental assets which are a characteristic of an entire population, regardless of the level of adversity they face Under adversity, assets function differently like a good school, or parental monitoring, have a more influence in the life from a poorly resourced background than one from a wealthy home with other options for support, recreation, and self-esteem (Luthar & Cicchetti, 2000).

These two-dimensional construct can be described by two judgments: one about a "positive adaptation" which is considered behavioral or social competence or success at meeting any particular tasks at a specific life stage, and the other about the "significance of risk adversity" which can be defined as any risks associated with negative life conditions that are related to adjustment difficulties, such as poverty, children of mothers with schizophrenic, or experiences of disasters. Resilience is a process and not a trait of an individual (Masten & Obradovic, 2006).

1.2 CONCEPTS AND TERMINOLOGY OF RESILIENCIES

Resilience is a term derived from the physics of materials that has been applied in ecology, developmental psychology and psychiatry. In materials science, resilience refers to the ability of something to return to its original form after having been bent or compressed (Laurence & Kirmayer, 2009). In organism biology, resilience refers to the capacity of the individual organism to respond to physiological challenges by restoring and maintaining bodily mechanisms. For ordinary fluctuations or small challenges, the body has mechanisms to restore balance (Mcewan, 1998). In psychology, Resilience refers to the idea of an individual's tendency to cope with stress and adversity. This coping may result in the individual bouncing back to a previous state of normal functioning, or using the experience of exposure to adversity to produce a "steeling" effect and function better than expected future exposure to disease (Masten, 2009).

Ecological views of resilience emphasize the ability of natural systems to respond to a stress or challenge by self-correcting processes that restore pre-existing patterns and populations of plants and animals. Ecosystems show resilience through three broad mechanisms: buffering disturbances to reduce their impact, Self-organization to maintain crucial system functions, and learning or adaptation (Abel, Stepp & Trostler, 2003).

According to Smith & Ward (2009) developmental psychologists have adopted a more interactional view, seeing resilience in the interactions of children with their caretakers or peers. Researchers have suggested that these individual-centered models because they tend to ignore the larger social and cultural context in which individual development and adaptation takes place. In psychiatry, the concept of resilience emerged from clinical observations and recognized that many children do well despite very difficult childhood experiences (Rutter, 2001).

According to Holling (2001) there are different types of systems which have different structures and processes, but there are some general features of the dynamics of systems that are relevant to understanding resilience. At this abstract level, resilience is "the capacity of a system to absorb disturbance and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks" (Waller, Okamoto, Hankerson & McIntyre, 2002).

Resilience reflects the ability of individuals to maintain stable mental function even though they experience risk factors. These risk factors are related to poor or negative outcomes. For example, poverty, low socioeconomic status, and mothers with schizophrenia are coupled with lower academic achievement and more emotional or behavioral problems. These positive outcomes are attributed to some protective factors, such as good parenting or positive school experiences (Masten, Best & Garmezy, 1990).

1.3 COMMUNITY RESILIENCE

According to Allen (1999) communities foster individual resilience. "Community resilience" has two interpretations. Firstly, it may look at how people overcome stress, trauma and other life challenges by drawing from social networks and cultural resources embedded in communities. Secondly, it may consider the ways in which communities themselves exhibit resilience, responding to stresses and challenges in ways that tend to restore their functioning.

Resilience of the community itself involves the dynamics of the social response to challenges that threaten to damage or destroy the community. These dynamics may involve adaptations and adjustments of individuals, groups and organizations with the community as well as interactions of the whole community with its surrounding environment, including especially other social, economic and political entities (Masten, 2001).

Resilience has been described in terms of an outcome, such as a child who grows up in poverty but despite the odds stays in school and experiences academic achievement. There are different types of resilience both in terms of pathways and outcomes, individuals may apply specific abilities to achieve different desired outcomes (Benard, 2007).

1.4 PATTERNS OR STRATEGIES OF INDIVIDUAL RESILIENCE

The studies on resilience described four patterns or strategies of individual resilience: Firstly, The dispositional pattern is characterized by features of self-worth, sense of mastery and self-efficacy, as well as constitutional features such as

intelligence, health, appearance, and temperament. Secondly, the relational pattern reflects the person's ability to seek comfort, support or inspiration from others (Polk, 1997).

Thirdly, the situational pattern involves approaching circumstances using appropriate cognitive skills and problem solving abilities. Finally, the philosophical pattern emphasizes the role of personal beliefs, the construction of meaning and self-knowledge in enhancing life experience. Resilience is the result of individuals being able to interact with their environments and the processes that either promote well-being or protect them against the overwhelming influence of risk factors (Zautra, Hall & Murray, 2010).

1.5 STEPS FOR BUILDING RESILIENCE

There are some steps or strategies which build resilience in individual and showing that resilience can be built and learned, it's not just an innate ability. These seven steps for building resilience include:

Learning the ABCs: To recognize the impact of your 'in the moment' thoughts and beliefs on behavioral and emotional consequences of adversity. Thinking traps recognizing the errors in thinking we are often unaware of; for example, jumping to conclusions. Detecting icebergs building an awareness of the deep-seated beliefs we have of how the world works and how this can impact upon our emotions and behavior (Ungar, 2008).

Challenging beliefs: It is a process by which the breadth and thus accuracy of our understanding of events can be enhanced, leading to more effective and sustained problem-solving behaviors. Putting it in perspective learning to stop the spiraling of catastrophic thinking and turn it into realistic thinking. Real-time resilience putting it all into practice in the moment; this skill is reliant on mastering the others and offers a 'fast skill' which does not rely on having the time to think through a resilience reaction in depth (Jackson & Watkin, 2004).

Calming and focusing: Finding ways to step back from adversity create breathing space and think more resiliently. Resilience is not a simple linear causal process in which limited to the strength that leads directly to a good developmental outcome; instead, resilience involves interactions among multiple processes or strategies giving rise to alternate constant input to maintain, or they may be self-sustaining of the development. Resilience often involves tradeoffs, in which something is gained and something lost. Resilience has models which recognize the risk and protective factors that is linked and interact to creating a situations of greater risk or greater protection (Waller, 2001).

1.6 KEY DIMENSIONS OF RESILIENCE

Resilience is not static, but rather a dynamic outcome resulting from the interaction of risk and protective factors that reside both within and outside the individual. Resilient individuals should not be identified as "stress-resistant" and superhuman in their ability to handle stress. Resilience does not convey a form of invulnerability to the individual. Resilient individuals who are able to function competently remain vulnerable to negative outcomes if their situation changes (Cicchetti & Garmezy, 1993).

A circumstances within and outside the individual change so does their corresponding potential for resilience. There are multiple domains to the construct of resilience, such as social, academic/work, and relational these domains of resilience are connected to an individual's developmental level and change as one grows and transitions through various developmental life stages. Resilient functioning in one domain does not guarantee resilient functioning in another domain. Inconsistency across domains suggests that resilience is not an all-or-none phenomenon (Tusaie & Dyer, 2004).

1.7 MODEL OF RESILIENCE

Richardson and Waite (2002) propose a resiliency model that describes how individuals can be resilient in facing adversity. According to the resiliency model, when an individual experiences adversity, they may experience little to severe disruption in his/her life. Four possible outcomes can occur when the individual reintegrates the disruption. First, the individual might reintegrate back to the homeostasis, the comfort zone. That is, the individual returns to the same levels of functioning as before experiencing the event, they did not gain any skills, knowledge, strengths, or competence from the experience.

Second, the individual might reintegrate the disruption with resiliency. The individual has gained some skills, knowledge, strengths, or competence from the process of coping with the event that, in turn, increases the individual's abilities to cope with life adversity in the future. Third, the individual may reintegrate with loss. They reintegrates to a lower level of functioning than before experiencing the event. They have fewer protective skills or traits after experiencing the event and

experience a loss of self-esteem or withdraw from social relationship. Fourth, the individual may reintegrate with dysfunctional strategies such as becoming alcoholic, committing suicide (Ungar, 2008).

1.8 LIFE SATISFACTION

Satisfaction is a Latin word that means to make or do enough. Satisfaction with one's life implies contentment with or acceptances or the fulfillment of one's wants and needs for one's life as a whole. In essence, life satisfaction is a subjective assessment of the quality of one's life, because it is inherently an evaluation judgment of life satisfaction. Life satisfaction has a large cognitive component (Sousa & Lyubomirsky, 2001).

Accordingly to the individual's overall life satisfaction reports are based upon personal comparisons between self determined criteria and perceived life circumstances. Similarly, life satisfaction refers to a person's subjective evaluation of the degree to which his/her most important needs, goals and wishes have been fulfilled (Frisch, 1998).

1.9 LIFE SATISFACTION AND RELATED CONCEPTS

Life satisfaction is used with a number of related concepts. Life satisfaction has been defined as a cognitive evaluation of the quality of a person's overall life or with specific aspect of life such as family, friends and community (Pavot, Diener, Colvin & Sandvik, 1991). It probably serves as the umbrella under which other terms are covered.

Quality of life: The concept of quality of life is frequently used to describe "the good life" within several disciplines such as economy, sociology, psychology, medicine, and health-care. The contents and specific measures of quality of life vary both between and within disciplines (Bishop, Frain & Tschopp, 2008). Quality of life as an individuals perceptions of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns (Frain, Berven, Chan & Tschopp, 2008).

Well-being It is sometimes referred as "subjective well-being and social psychological well-being (George, 2000).

1.10 DISTINCTION FROM CREATED CONSTRUCTS

Life satisfaction vs. subjective well being: According to Deiner and his colleague (2002), subjective well being or happiness has both an affective (i.e. emotional) and a cognitive (i.e. judgment) component. The effective component consists of low frequently an individual reports experiencing positive and negative affect. Life satisfaction is considered to be the cognitive component of this broader construct.

Life satisfaction vs. life domain: Researcher differentiate between life domain satisfaction with specific areas of an individual's life such as work, marriage, and income, where judgments of global. Life satisfaction is much broader consisting of an individual's comprehensive judgment of her life (Sousa & Lyubomirsky, 2001).

Personal strength for life satisfaction: Now you are aware of your unique strength, he question is how to take advantage of them, to bring you happier, more fulfilling life. Your goal is here to unique talents and strength to your advantage by using them each and every day. This may take some thing creativity, but its your advantage to focus on your strength (Sosusa & Lyubomirsky, 2001).

1.11 ELEMENTS OF LIFE SATISFACTION

The vast majority of researches on life satisfaction investigate the extent to which various elements which is the predictor of life satisfaction. However, the researcher are not able to perform he true experiments by randomly assigning participant to demographic group (e: g gender, income, age) all of this research has been correlation much of the work has focused on the objective determines of life satisfaction (Kahneman, Deiner & schwarz, 1999).

Culture: Before describing the research on the cultural influence, we must revisit the question of whether life satisfaction can be measured across the cultures. Fortunately, satisfaction appears to be a universal terms, and cross cultural researches have not had any defaulting translating measure of life satisfaction into any different language. People from different cultural are able to distinguish b/w such term as 'happiness', "satisfaction with life", "best possible life", and "worst possible life" and there does to be the linguistics bias (Kahneman, Deiner & schwarz, 1999).

Employment: An individual's employment status regardless of income', appears to predict life satisfaction, such that the employed report significant diminished satisfaction compared with employed when gender is taken into account, it appears

that employment is more strongly associated with life satisfaction than women. This finding is not surprising, given that there is less cultural pressure on women to work outside the home (Deiner & Biswas, 2002).

Education: Overall, researcher has found small correlation b/w education and life satisfaction. However, the correlation appears to disappear when income and occupation are satisfactory controlled. That is the relationship b/w education and life satisfaction is probably due to the fact that higher level of education is associated with higher incomes. Education also appears to be more highly related life satisfaction for individual's with lower incomes and in poor nations. Perhaps poorer persons obtained greater satisfaction from education because the achievement surpasses their expectation of what is attainable influence life satisfaction (Carson, 1978).

Age: Life satisfaction generally remained stable throughout the life span, showing just a slight increasing trend between the ages of 20 and 80 years. Accommodative coping does tend to increase with age. Alternatively, as women age, they may achieve goals with greater frequency (i.e. family, career success, and financial comfort) moving closer to their ideal self. Life satisfaction levels across the life span are that people have an extraordinary capacity to adapt to significant life changes (Deiner & Biswas, 2002).

Social relationship: Human relationship doubles our joys and has our sorrows. Many studies have supports this contention. High level of social support have been shown to be strongly associated with high level of in western nations, marriage appears to be even more predictive of life satisfaction than relationship with friends and family. In addition to the number of social contacts, it appears that gender is a factor in the quality of intimate relationships as well. Women tend to provide greater and more meaningful support than men. That is, both women and men report that their friendships with women are more intimate, nurturing, and supportive than their friendships with men (Pinquart & Soresen, 2000).

According to Veenhoven, (1996) life-satisfaction can be fairly well measured, they consider how satisfied people are with life and to determine the extent to which their judgments may differ. They are described the four pattern of life satisfaction.

1.12 THEORIES OF SATISFACTION

Life satisfaction is prompted by the hope of finding ways to create greater happiness for a greater number for this purpose the researches may confirm theories of satisfaction which imply that the improvement in living conditions does not reduce discontent.

Life satisfaction is relative: According to Veenhoven (1995b) this theory evaluate life assumes that satisfaction is the result of a comparison between life-as-it-is to conceptions of how-life-should-be. Standards of how-life-should-be are seen to draw on perceptions of what is feasible and on comparison with others. These standards of comparison are thought to vary. These imply that it is not possible to create lasting satisfaction; neither at the individual level, nor the societal level.

At the individual level, this theory predicts that satisfaction is a short lived phenomenon. People would be satisfied when life comes close to ideal, but as people come closer to the ideal they would tend to set higher demands and hence end up as dissatisfied as before. At the societal level, this theory implies that average satisfaction tends to neutral as well (Heady, & Veenhoven, 1989).

If satisfaction and dissatisfaction balance out in the lives of individual citizens, the average in the country cannot be far from zero. The empirical evidence for the theory that life-satisfaction is relative. One implication of this theory is that changes in living conditions, from good to bad, or vice versa, will have no lasting consequences for life-satisfaction (Veenhoven, 1994b).

Life satisfaction is a trait: This theory suggests that the hope of creating greater happiness for the greater number is futile, holds that satisfaction is a fixed disposition. This theory figures at the individual level as well as the societal level. The individual level variant sees satisfaction as a personal trait, a general tendency to like or dislike things. This tendency can stem from an inborn temperament as well as early experience. This trait is believed to shape the perception of life-experiences (as well as the overall evaluation of life. Improvement of living conditions will not result in greater satisfaction with life (Veenhoven, 1995).

Life satisfaction does not appear to be a stable trait. The results can be summarized as follows: Firstly, life-satisfaction does not remain the same over a period of time; particularly not over the length of a lifetime. Secondly, life-satisfaction is not insensitive to change in living conditions. Thirdly, satisfaction is not entirely an internal matter. It is true that evaluations of life are influenced by personal characteristics and collective orientations. The societal variant of this theory assumes that tendency to like or dislike life is part of a common national-character. Some cultures would tend to have a gloomy outlook on life, whereas others are optimistic (Veenhoven, 1994).

1.13 NOMADIC

The word “nomad” is etymologically identical with “pastoralism”, and derives from a Greek term *nomas* meaning “to pasture” (wandering shepherd). “Pastoralism”, in turn derives from the Latinic term *pastor* and refers to raising livestock.

Semi-nomads: Those who raise herds and have one or more permanent dwellings and often engage in small-scale agriculture. Nomadic people are communities of who move from one place to another, rather than settling permanently in one location. Many cultures have traditionally been nomadic, but nomadic behavior is increasingly rare in industrialized countries. Nomadic cultures are having three categories: hunter-gatherers, pastoral nomads, and peripatetic nomads (Sutherland, 1986).

Hunter-gatherers: Nomadic hunting and gathering, also known as foragers moved from campsite to campsite, following game and wild fruits and vegetables. Hunting and gathering was the ancestral subsistence mode of Homo, and all modern humans were hunter-gatherers until around 10,000 years ago. The invention of agriculture, hunter-gatherers was displaced by farming or pastoralist groups in most parts of the world. Only a few contemporary societies are classified as hunter-gatherers, and many supplement, sometimes extensively, their foraging activity with farming and/or keeping animals. Mostly they are present in Africa, Americas, Asia, Australia, Europe, India (Ender & Morton, 2002).

Pastoral nomads: They are nomads moving between pastures. Nomadic pastoralism is thought to have developed in three stages that accompanied population growth and an increase in the complexity of social organization. Nomadic pastoralism seems to have developed as a part of the secondary products revolution, also began using animals for their secondary products, for example, milk and its associated dairy products, wool and other animal hair, hides and consequently leather, manure for fuel and fertilizer, and traction. Pastoralism is a mixed economy with a symbiosis within the family. Agropastoralism is when symbiosis is between segments or clans within an ethnic group. True Nomadic is when symbiosis is at the regional level, generally between specialized nomadic and agricultural populations (Vigo, Julian, 2005).

Patterns of Pastoralist: Societies most often have matrilineal descent patterns and are male dominated. Men usually make the important decisions and own the animals, while women primarily care for children and perform domestic chores. Compared to pedestrian foraging societies, the economic and political power of most pastoralist women is very low. However, the division of labor is based primarily on gender and age in both foraging and pastoralist societies (Oberfalzerova, Alena, 2006).

Peripatetic minorities: They are mobile populations moving among settled populations offering a craft or trade. Each existing community is primarily endogamous, and subsists traditionally on a variety of commercial and/or service activities. All or a majority of their members were itinerant, and this largely holds true today. Migration generally takes place within the political boundaries of a single state these days (Kaushik, 2008).

Each of the peripatetic communities is multilingual; it speaks one or more of the languages spoken by the local sedentary populations, and, additionally, within each group, a separate dialect or language is spoken. Peddling and the sale of various goods were also practiced by men and women of various groups, such as the Jalali, the Pikraj, the Shadibaz, the Noristani, and the Vangawala. Many Biblical characters, such as Abraham, Isaac, Jacob, Moses, David and others, lived a nomadic lifestyle. A nomad lived in tents and traveled from location to location in search of water and pastures for their livestock (Vigo, Julian, 2005).

1.14 LIFE STYLE OF NOMADS

The Wilderness The home of the nomad was the wilderness often dry and arid but with an occasional oasis, river, water basin and pastures. The nomad lived in home in the wilderness They also knew the area which he traveled in very well and where all the water sources were, where pastures were located at different times of the year and all the landmarks which directed they travels (Rao & Casimir, 2003).

Possessions The nomad lived a very simple life and because of their constant travels they could not carry a great amount of supplies and equipment. His major possession is the tent made of goat hair, the poles, stakes and ropes for supporting the tent, a curtain to divide the tent into two parts (male and female sides) and a carpet for the floor. The nomad’s wealth was measured by the size of his flocks and herds which supplied him with most of his needs including milk, meat, skin, hair for tents, horns for trumpets and liquid containers and many other odds and ends (Schaetti, 2000).

Family: A nomadic camp consisted of about 25 to 50 members. Any less and it would be difficult to protect the family and any more would be difficult to feed. Usually the oldest member of the family was the head, or chief, of the clan. The

remainder of the clan would consist of brothers, sons, nephews and grandsons as well as their wives. Each clan was an independent entity with the chief as judge and ruler (Rao & Casimir, 2003).

Social Activities: The men would often gather together, usually at meal times, to discuss past events, needs, locations and other details of operating the camp. The women gathered together to prepare foods, make clothing and make tent repairs. Story telling was probably one of the most important forms of entertainment. The older members of the clan would tell the stories of their history to the children in order to pass on the experiences of the tribe and clans to the next generation. One of the major responsibilities of the clan is to provide hospitality to anyone who comes to them. This may be a member of a related clan or even an enemy of another tribe. In both cases it was the responsibility of the clan to provide food, shelter and protection as long as they were within their camp (McLachlan, 2005).

Religion: The religion of the nomads is very different from the understanding of religion. The whole of the nomad's life was his religion. They very existence was dependent upon rain he understood that his life was in God's hands at all times. The nomad saw the power, justice, love and mercy of God in all things and covertly all of his activities, from eating to making shelter, were seen as a service to God. The nomad lived in harmony with his surroundings and understood as being one with God who created all things. In short, his life was one long prayer to God (Hall, 1996).

Resilience is the capacity to withstand stress, and happiness is an emotional state reflecting positive feelings. A number of studies have examined the relationship between positive emotions and resilience. Multiple methodologies e.g., self-report, observation and longitudinal studies demonstrate that resilient individuals are characterized by positive emotionality. They have an energetic approach to life, and are curious and open to new experiences (Masten, 2001). Studies showed that resilient individuals use positive emotions to achieve effective outcomes such as humor, creative exploration, relaxation and optimistic thinking (Anthony, 1987).

The relationship between life satisfaction and the 24 character strengths appears to be consistent across the general population and college students. Park, Peterson, and Seligman (2006) examined the relationship between life satisfaction and the 24 character strengths with on-line participants. They found that Hope, Zest, Gratitude, Curiosity, and Love were most strongly related to life satisfaction. However, the relationships between life satisfaction and Humility/Modesty, Appreciation of Beauty and Excellence, Creativity, Open-Mindedness, Love of Learning, and Prudence were weak.

Ratnagar (2004) studied on nomads and writes that even rural economies cannot be reduced to agricultural production; "The livestock input, extent of nomadic or agro pastoralist, or specialized pastorals takes on a special relevance in times of drought or famine. Pastoralist production can also impinge on urban economies when it comes to markets and trading for meat, leather products or wool. According to Rao (2006), South Asia has the world's largest nomadic population. Nowhere else is there such a variety of creatures systematically herded nor is the diversity of peripatetic professions to be matched. The relation between pastoralists with settled groups have a significant impact on trade, for political processes, as well as for detribalization.

1.15 RATIONALE AND OBJECTIVES OF STUDY

Through the resilience and life satisfaction in this study identify the coping strategies and satisfaction with life among nomadic. Resilience has impact on life satisfaction. Recently few studies have done on the resilience and life satisfaction. Life satisfaction is positively related to many personal characteristics and protective factors for resiliency. It is reasonable to assume that people who adapt well to changes/demands in the environment, experience less negative emotions in the face of adversities, and possess characteristics related to both resiliency and life satisfaction are more likely to be content or satisfied with their overall life. Both resilience and life satisfaction are positively related with the extrovert personality. Resiliency significantly predicted life satisfaction; people who have a higher level of resilience will gain benefits in many life domains from their positive state of mind, including larger social rewards, superior work outcomes and more activity, energy, satisfaction with their life (Gardiner, 2006). Life satisfaction was positively related to hope, self-esteem, self-efficacy, locus of control, and seeking social support. Hope, self-esteem, self-efficacy, locus of control, and seeking social support are protective factors for resiliency. Therefore, the present study hypothesizes that there is a relationship between life satisfaction and resiliency (Bailey & Snyder, 2007). The purpose of the study is to assess the level of resilience and life satisfaction among nomadic.

Main objectives of the study are as under:

1. To check the relationship of resilience and life satisfaction among nomadic.
2. To assess the level of resilience among nomadic.
3. To investigate the level of life satisfaction among nomadic.
4. To study the effect of different variable (gender, marital status, profession) on main scales (resilience & life satisfaction).

2 LITERATURE REVIEW

Garmezy (1973) was the first person who published the first research findings on resilience. In his research he used epidemiology which is the study of who gets ill, who doesn't, and why, to uncover the risks and the protective factors which is now help to define resilience Garmezy & Streitan (1974) then created tools to look at systems that support development of resilience. Werner (1971) was one of the early scientists to use the term resilience in the 1970s. She studied a cohort of children from Kauai. Kauai was quite poor and many of the children in the study grew up with alcoholic or mentally ill parents, she noted that the children who grew up in very bad situations, two-thirds exhibited destructive behaviors in their later teen years, such as chronic unemployment, substance abuse.

Resilient children and their families had traits that made them different from non-resilient children and families. Resilience emerged as a major theoretical and research topic from the studies of children of schizophrenic mothers in the 1980s. The results showed that children with a schizophrenic parent may not obtain comforting care giving compared to children with healthy parents, and such situations had an impact on children's development. Some children of ill parents perform well (Werner, 1982). Resilience refers to a class of phenomena characterized by good outcomes in spite of serious threats to adaptation or development. Resilience has been characterized as the ability to bounce back and cope effectively in the face of difficulties, to bend, but not break under extreme stress, and to maintain equilibrium following highly aversive events. Resilience describes that people who are expected to adapt successfully even though they experience risk factors that 'stack the odds' against them experiencing good development (Masten & Reed, 2002).

Resilience is a multidimensional concept. The concept of resilience is different from recovery. Resilience denotes the ability to maintain competent functioning in the face of adversity whereas recovery suggests a return to normal functioning after a period of disruption. It is believed that there is no single means of maintaining competent functioning in the face of adversity but rather multiple pathways to resilience has been defined in a number of ways (Bonanno, 2004).

Research on the relationship between life satisfaction and resiliency is consistent. Fredrickson, et al. (2003) found that resiliency was correlated to life satisfaction. Life satisfaction also was significantly related to resiliency. Resilient students' levels of life satisfaction were significantly higher than those of low-resilient students. King (2000) concluded that not only was resiliency positively related to life satisfaction among individuals experiencing divorce, but also resiliency significantly predicted life satisfaction.

According to Luthar & Cicchetti (2000) describe resilience as "a construct connoting the maintenance of positive adaptation by individuals despite experience of significant adversity." Resilience is described as the capacity for successful adaptation, positive functioning or competence despite high-risk status, chronic stress, or severe trauma (Egeland, Carlson, & Stroufe, 1993).

Life-satisfaction is the degree to which a person positively evaluates the overall quality of life as-a-whole. In other words, how much the person likes the life that they lead? Life-satisfaction is one of the indicators of 'apparent' quality of life. Together with indicators of mental and physical health, it indicates how well people thrive. High satisfaction suggests that the quality of life, in the population concerned, is good. Low satisfaction marks serious shortcomings with life means that something is wrong (Veenhoven, 1984).

The line of research is rooted in 18th century Enlightenment thinking. From this perspective, the purpose of existence is life itself, rather than the service of King or God. Self-actualization and happiness become central values. Society itself is seen as a means for providing citizens with the necessities for a good life. In the 19th century, this conviction manifested itself in the Utilitarian Creed that the best society is one which provides 'the greatest happiness for the greatest number' (Saris, Veenhoven & Scherpenzeel, 1996).

The first survey studies which used measures of life-satisfaction were performed in the USA in the 1960's. The emphasis at that time was on mental health. The results from some of this research appeared in books by Gurin (1960) and Bradburn (1969). In the 1970's, life-satisfaction was a central theme in several American Social Indicator studies. Landmark books were published by on life-satisfaction (Campbell, Converse & Rodgers, 1976).

In the 1980's the first large-scale longitudinal survey on life-satisfaction was performed in Australia by Heady and Ruut Veenhoven. Recently a bibliography has appeared, which includes 2475 contemporary studies on subjective appreciation of life. This bibliography is part of the 'World Database of Happiness,' which also involves the ongoing cataloguing of new data on life-satisfaction and its correlates (Veenhoven, 1993).

Life satisfaction is a personal judgment about how satisfied an individual is with his/her current life compared to his/her own standard, a standard not imposed by any external sources (Diener, Emmons, Larsen, and Griffin 1985). Life satisfaction appears related to positive characteristics. Cafasso (1998) found that there was no relationship between resiliency and life satisfaction. That is, resilient individuals' levels of life satisfaction did not differ significantly from non-resilient individuals.

Bailey & Snyder (2007) studied on life satisfaction and finding indicated that life satisfaction was positively related to hope, self-esteem, self-efficacy, locus of control, and seeking social support. Hope, self-esteem, self-efficacy, locus of control, and seeking social support are protective factors for resiliency. Therefore, the present study hypothesizes that there is a relationship between life satisfaction and resiliency.

Usually nomads do not rely on agriculture, with some exceptions. In Sudan, all nomads depend on domesticated animals of various species, as dictated by ecological conditions. Some nomads engage in small-scale agriculture at fixed points or along their migration routes. However, their main income is derived from their animals. Among some tribes, some nomadic groups have a permanent dwelling, for temporary and occasional use (Ender & Morton, 2002).

Nomads cooking supplies and equipment consisted of bags made of skins for carrying food reserves such as grains and dried fruits, a few utensils such as spoons, knives and bowls and a grinding mill for making flour out of grains. He also carried some harvesting supplies such as sickles and mattocks to gather crops when available. For defense he also carried weapons such as the bow and arrow, spears and knives. Many of his weapons were used for other purposes such as butchering knives, mattocks and the tent poles which were sharp at one end for spears (Mclachlan, 2005).

The nomad term varies from country to country. It was the groups of people who for one reason or another had to move in pursuit of their livelihood, and did not have a fixed dwelling. Being nomadic does not imply wandering aimlessly. They are experts at maximizing the use of rangelands, a capability demonstrated by numerous research studies (Galaty & Johnson, 1990).

The reach of nomadic pastoralist is immense. While nomadic is perhaps most widespread today in far-flung, remote and unpopulated regions, it is also found in more crowded and developed regions. Some nomadic populations occupy remote regions, environmentally marginal and distant from centers of civilization and power, but other nomadic pastoral populations like the Bakkarwals, Gaddis and Gujjars migrate through regions of agricultural settlements and pass, and even stop at, major cities and towns (Galaty and Johnson, 1990).

Rao and Casimir (2003) write that in times when settlements were few, roads limited, and communication over long distances rare, nomads were seen to be the carriers of news, goods and resources from other societies. Nomadic itself emerges from an environmental and cultural context and may or may not be exclusively practiced.

3 METHODOLOGY

3.1 PARTICIPANTS

The sample consisted of 100 nomadic (50 nomadic female and 50 nomadic males). Nomadic males and females were taken from the different areas of Multan. Participants were taken through the purpose sampling. They were belonged to different age, gender and socioeconomic status.

3.2 INSTRUMENTS

The following scales were used to accomplish the objectives of the study:

3.3 THE RESILIENCE SCALE

The Resilience Scale (RS) was used to measure the level of resilience of the participants (Wagnild & Young, 1993). The Resilience scale used to measure five characteristics which included: equanimity, self-reliance, perseverance, meaningfulness of life, and existential aloneness between nomadic males and females. Which is based on the 7 point Likert Scale indicate the extent to which you agree or disagree with the following statements. It comprised on 25 items with 7 preferences or option :(

Strongly Disagree, Disagree, slightly disagree, Strongly Agree, agree, slightly agree, neutral).The high levels of resilience Scores are considered 147-175.

3.4 THE SATISFACTION WITH LIFE SCALE

The Satisfaction with Life Scale (SWLS) is a measure of life satisfaction developed by (Diener, Emmons, Larsen & Griffin, 1985) Life satisfaction is distinguished from affective appraisal in that it is more cognitively than emotionally driven. Life satisfaction can be assessed specific to a particular domain of life (e.g., work, family) or globally. The SWLS is a global measure of life satisfaction. It is based on the 5 point scales. The 5 point scales assesses the degree of agreement or disagreement of the individual. It is comprised on the 5 items. The score range from 31 – 35 high score which denote the extremely satisfied, 5 - 9 score range is low score denote the extremely dissatisfied.

3.5 OPERATIONAL DEFINITION

The resilience: The term resilience operationally defines as the mean score of the respondents on the resilience scale. High score indicated the higher level of resilience.

Life Satisfaction: The term life satisfaction operationally defines as the mean score of the respondents on life satisfaction scale. High score indicated the higher level of life satisfaction.

3.6 PROCEDURE

The booklet including consent from with demographic variable sheet was given to the nomadic males and nomadic females. Nomadic males and females were taken from different areas of Multan and Bahwalnager. There were no specific place where nomadic lived. Therefore, it was difficult to approach nomadic people. The language of nomadic people have changed in different place because of the variation in their languages it was difficult to fill the questionnaires. They were given the brief introduction of the purpose of the study and were assured that information would be kept confidential and will only be used for statistical enumeration. Necessary explanation was provided to the respondents to make the questionnaire easy and understandable. Statistical analysis was done by using SPSS. Descriptive and inferential statistics was computed for this data obtained from the participant.

4 HYPOTHESIS

1. Resilience is positively correlated with life satisfaction.
2. Females nomadic have higher level of resilience as compared to males nomadic.
3. Females nomadic have lower level of life satisfaction as compared to males nomadic.
4. Married nomadic have higher level of resilience as compared to unmarried nomadic.
5. Unmarried nomadic have higher level of life satisfaction as compared to married nomadic.
6. Working nomadic have higher level of resilience as compared to non working nomadic.
7. Nonworking nomadic have higher level of life satisfaction as compared to working nomadic.

5 RESULTS AND DISCUSSION

5.1 RESULTS

Table 1. Correlation coefficients for scores of resilience and life satisfaction among nomadic

Scale	The resilience	Life satisfaction
The resilience	1	.389***
Life satisfaction	.389***	1

Note: $p^* > 0.05$

Result depicted in the table 1 is to be found that there is strong positive correlation between resilience and life satisfaction.

Table 2. Mean, Standard deviation, t and p value on the score of resilience among male and female nomads.

Groups	N	Mean	S.D	T	p
Male	50	103.2800	24.83664	-.763	.447
Female	50	106.6600	19.07088		

Note. N=100.df =98, p<0.05

The result of the table 2 shows that there is no significant difference among males and females nomadic (t=-.763, df= 98, p<0.05). The result does not support our hypothesis that females nomadic have higher level of resilience as compared to males nomadic.

Table 3. Mean, Standard deviation, t and p value on the score of life satisfaction among male and female nomads.

Groups	N	Mean	S.D	t	p
Male	50	17.8000	5.93502	-3.140	.002
Female	50	21.5200	5.91173		

Note. N=100.df =98, p*>0.05

The result of the table 3 shows that there is significant difference among males and females nomadic (t=- -3.140, df= 98, p<0.05). The result does support our hypothesis that females nomadic have lower level of life satisfaction as compared to males nomadic.

Table 4. Mean, Standard deviation, t and p value on the score of resilience between married and unmarried nomads.

Groups	N	Mean	S.D	t	p
Married	54	103.90	24.11550	-.519	.605
Unmarried	46	106.2174	19.65731		

Note. N=100.df =98, p<0.05

The result of the table 4 shows that there is no significant difference among married an unmarried and nomadic (t= --.519, df= 98, p<0.05). The result does not support our hypothesis that married nomadic have a higher level of resilience as compared to unmarried nomadic.

Table 5. Mean, Standard deviation, t and p value on the score of life satisfaction between married and unmarried nomads.

Groups	N	Mean	S.D	t	p
Married	54	18.8889	6.54640	-1.357	.178
Unmarried	46	20.5652	5.66334		

Note. N=100.df =98, p<0.05

The result of the table 5 shows that there is no significant difference among married an unmarried and nomadic (t= - 1.357, df= 98, p<0.05). The result does not support our hypothesis that unmarried nomadic have higher level of life satisfaction as compared to married nomadic.

Table 6. Mean, Standard deviation, t and p value on the score of resilience between working and non working nomads.

Groups	N	Mean	S.D	t	p
Working	43	104.9245	25.25702	.014	.989
Non working	57	104.8605	18.67591		

Note. N=100.df =98, p<0.05

The result of the table 6 shows that there is no significant difference among working and non working nomadic (t=- .014, df= 94, p<0.05). The result does not support our hypothesis that working nomadic has higher level of resilience as compared to non working nomadic.

Table 7. Mean, Standard deviation, t and p value on the score of life satisfaction between working and non working nomads.

Groups	N	Mean	S.D	t	p
Working	43	18.7547	6.176059	-1.359	.177
Non working	57	20.4884	6.26164		

Note. N=100,df =98, p<0.05

The result of the table 7 shows that there is no significant difference non working and working nomadic (t= -1.359, df= 94, p<0.05). The result does not support our hypothesis that non working nomadic has higher level of life satisfaction as compared to working nomadic.

5.2 DISCUSSION

This research was undertaken to investigate the role of resilience and life satisfaction among nomadic. The purpose of the study was to find out the relationship of resilience and life satisfaction and their impact on nomadic. The finding regarding to the effect of different demographic variables including gender, martial status, profession and age have significant effect on the level of the resilience and life satisfaction among nomadic.

The concept of resilience refers o he capacity of individual to cope well under adversity. Resilience is better understand as the opportunity and capacity of individual to navigate their way to psychological, social, cultural and physical resource that may sustain their well being and capacity individually and collectively experience meaning full ways (Unger, 2008). Different researches suggested that resilience and life satisfaction was associated with personality. Life satisfaction refers to the person’s subjective, global evolution of the positively of his/her life as whole or specific life domain (Diner,Suh, Lacus & simth, 1999).

The 1st hypothesis pertaining to the correlation of resilience and life satisfaction was supported by the findings. In this way there was positive correlation between resilience and life satisfaction. Individual with high level of resilience cope the life adversity well and have a higher level of life satisfaction. Resilience was positively correlated to the life satisfaction. Resilient individual level of life satisfaction was higher than those of resilient individual (Fredrickson, 2002).

The 2nd hypothesis was that females nomadic will be a higher level of resilience as compared to the males nomadic. Findings of the result do not support that females nomadic have higher level of resilience as compared to males nomadic. Norms and cultural was impact on the resilience, but he results of the study do not support the hypothesis cause of rejection of hypothesis can be the cultural differences.

The 3rd hypothesis was that males nomadic will be a higher level of life satisfaction as compared to the females’ nomadic. Findings of the results support that females nomadic have lower level of life satisfaction as compared to males nomadic. Pinquart and Sorsen (2000) found additional support for the assertion that men and women derive satisfaction from different sources. Life satisfaction was more highly related to income for men than for women. The finding of the results was suggested that life satisfaction vary by gender.

The 4th hypothesis was that married nomadic have higher level of resilience as compared to the unmarried nomadic. But the results of the study do not support that married nomadic have higher level of resilience as compared to the unmarried nomadic. Married persons report lower level of resilience than persons who have never been married or have been divorced, separated or widowed. the hypothesis cause of rejection of hypothesis can be the cultural variation.

The 5th hypothesis was that unmarried nomadic will be a higher level of life satisfaction as compared to the married nomadic. Satisfaction with life seems to birelated to marital status. Women who are married or live with partners were more satisfied with life than those who are single, separated, widowed and divorced.Unmarried adults attribute being single to both barriers and choices. Men desire marriage more than do women and the never married want to marry more than the divorced (Bailey & Synder, 2007).

The 6th hypothesis was that Working nomadic will be a higher level of resilience as compared to nonworking nomadic. Poverty has been long focused on resilience. The poor household identify the family and social support, respectful, attitudes, and behaviors of services provides an opportunity to engage in actively that bolster the resilience (Derse & varda, 2009).

The 7th hypothesis was that non working nomadic will be a higher level of life satisfaction as compared to working nomadic. But the result of the study do not support that non working nomadic have higher level of life satisfaction as compared to working nomadic. From additive models of overall quality of life, was derived about the relationships among work family conflict, work leisure conflict, job satisfaction, family satisfaction, leisure satisfaction and global life satisfaction

were non significant among non working (Deiner & Biswas, 2002). The hypothesis cause of rejection can be the cultural variation.

6 CONCLUSION

The purpose of the present study was to investigate the level of resilience and life satisfaction among nomadic. Statistical analysis indicated that resilience is positively correlated to life satisfaction. Results further disclosed that there is no significant difference found in that males nomadic have higher level of resilience as compared to females nomadic, but there was significant difference found in that females nomadic have lower level of life satisfaction as compared to males nomadic. An interesting findings regarding marital status was that there was no significant difference found in that married nomadic have a higher level of resilience as compared to unmarried nomadic. Results further indicated that there was no significant difference found in that unmarried nomadic have higher level of life satisfaction as compared to married nomadic. Another findings regarding profession indicated that there was no significant difference found in that working nomadic have higher level of resilience as compared to non working nomadic. Further findings also indicated that there was no significant difference regarding non working nomadic has higher level of life satisfaction as compared to working nomadic.

7 LIMITATIONS AND SUGGESTIONS

1. As the sample was taken from only the Multan and Bahwalnager, so the results can not be generalized to all people of the whole countries.
2. Time limit for conducting this whole study is limited to get the results requires.
3. Sample techniques were not the best representative of sample taken.
4. The researcher found some difficulties in collection of the data that most of the people showed non cooperative behaviors.
5. The scale was difficult to understand for illiterate people.
6. In order to generalize the results, a much longer and nationally representative sample should be used and convenient random sample should be avoided.
7. In order to obtain more accurate results and lesson the possibilities of errors
8. Few variable age, education etc also be taken into account and result should be analysis on the basis of there variable as well.

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Application de plan de Plackett Et Burman dans le criblage des paramètres agissants sur le processus d'hydrodistillation de Thym du Maroc (*Thymus vulgaris L.*)

[The application of Plackett and Burman design in screening the parameters acting on the hydrodistillation process of Moroccan thyme (*Thymus vulgaris L.*)]

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ABSTRACT: Thyme, *Thymus vulgaris L.*, is an herb widely used throughout the world. It is, without doubt, one of the most popular plants in Morocco. For the purpose of examining the factors affecting the extraction of the essential oil of this plant by hydrodistillation, a screening study by Hadamard matrix type Plackett and Burman was conducted. After an appropriate choice of six factors, sixteen experiments lead to a mathematical model of first degree connecting the response function (yield) to factors. Later than the realization of the experiments and data analysis, we concluded that five factors have a significant effect on the hydrodistillation process, namely: the extracting time, the harvest period, the individuality effect, the mass plant/water ratio and the temperature of heating. As for the drying of plant material, it presents a statistically negligible effect.

KEYWORDS: *Thymus vulgaris L.*, hydrodistillation, factors, screening, Plackett and Burman design, yield.

RESUME: Le thym, *Thymus vulgaris L.*, est une herbe médicinale largement utilisée à travers le monde. Elle est, sans doute, l'une des plantes les plus populaires au Maroc. Dans le but du criblage des facteurs qui influent sur l'opération d'extraction de l'huile essentielle de cette plante, une étude de criblage par matrice d'adamard de type Plackett et Burman a été menée. Après un choix approprié de six facteurs, 16 expériences ont conduit à un modèle mathématique du premier degré reliant la fonction de réponse (rendement) aux facteurs. Après la réalisation des expériences et l'analyse des données, nous avons conclu que cinq facteurs ont un effet significatif sur le procédé d'hydrodistillation, à savoir: le temps de traitement, la période de récolte, l'effet d'individualité, le rapport matière végétale/Eau et la température de chauffage. Quant au séchage des feuilles, il présente un effet statistiquement négligeable.

MOTS-CLEFS: *Thymus vulgaris L.*, hydrodistillation, facteurs, criblage, plan Plackett et Burman, rendement.

1 INTRODUCTION

Les plantes aromatiques et médicinales représentent une valeur considérable pour l'économie marocaine. En 2010, les exportations de plantes aromatiques et médicinales en produits semi-transformés ont augmenté à 900 millions de DH. Quant aux importations, elles ont dépassé les 600 millions de DH. De plus, les chiffres de l'Office des changes ne tiennent pas compte de la consommation locale, qui est estimée à près de 400 millions de DH, commercialisés par les herboristeries, parapharmacies et autres magasins spécialisés dans les produits du terroir [1]. Parmi ces plantes, il y a le Thym.

Thymus vulgaris L. est un arbuste à feuilles persistantes appartenant à la famille des *Lamiacée*. Il est indigène de l'Europe du sud, on le rencontre depuis la moitié orientale de la péninsule ibérique jusqu'au sud-est de l'Italie, en passant par la façade méditerranéenne française [2], [3]. Il est maintenant cultivé partout dans le monde comme thé, épice et plante médicinale [4].

L'essence du thym est souvent rapportée comme étant parmi les huiles essentielles les plus actives [5], [6].

Le thym possède de nombreuses activités biologiques telles que l'effet antispasmodique, antimicrobien, antibactérien, antiviral, antioxydant et activité fongicide, anti-inflammatoire, antiseptique, carminatif [5], [7], [8].

Ainsi, il est primordial de comprendre les effets des facteurs qui agissent sur le processus d'hydrodistillation vu leur lien étroit avec l'amélioration du rendement en huile essentielle. Afin d'atteindre cet objectif, nous avons procédé par l'application des techniques statistiques telles que les plans d'expérience pour rendre cette amélioration de plus en plus accessible. Ces méthodes, qui permettent l'expérimentation dans un nombre minimal d'expériences [9], donnent la possibilité de faire un criblage des facteurs, du plus influant au moins influant, et permettent aussi d'optimiser les conditions opératoires afin d'atteindre le meilleur résultat possible.

Dans cet article, nous avons fait un criblage des facteurs agissant sur l'opération d'hydrodistillation de *Thymus vulgaris* L. Nous nous sommes servis des plans de criblage dont les plus connus pour des facteurs à 2 niveaux sont les matrices d'Hadamard ou de Plackett et Burman [10]. L'expérimentation a consisté à mettre en évidence les effets de certains facteurs sur la réponse étudiée [11].

L'utilisation des plans d'expériences dans l'analyse et l'optimisation du processus d'hydrodistillation a été évoquée par plusieurs auteurs. Certains ont utilisé d'autres types de plans tels que les plans factoriels complets [11], [12], [13]. D'autres sont passés directement à l'optimisation en se servant des plans surface de réponse [14], [15], [16].

Le choix des plans de criblage pour notre étude au lieu des plans factoriels complets est basé sur le nombre des facteurs étudiés qui est égale à six. Ce nombre, élevé par rapport aux facteurs des études qui ont utilisé un plan factoriel complet, va entraîner une augmentation du nombre des essais ($2^6=64$ essais). Quant aux plans de surface de réponse, ils sont utilisés généralement pour l'optimisation. Cette dernière reste loin de notre objectif dans ce stade, qui est celui de comprendre l'effet de chacun des facteurs sur le processus d'hydro distillation. L'étude d'optimisation viendra en perspective et va porter seulement sur les facteurs ayant une influence sur le processus d'hydrodistillation. Dans notre cas, un plan de criblage de type Plackett et Burman est mieux préconisé.

2 MATÉRIEL ET MÉTHODES

2.1 MATÉRIEL VÉGÉTAL

Les plantes de *Thymus vulgaris* L. ont été cueillies à partir du jardin de l'institut national des plantes médicinales et aromatiques de Taounat.

2.2 MATÉRIEL D'EXTRACTION

L'appareil utilisé pour l'hydrodistillation est de type Clevenger [17] selon le protocole recommandé par la pharmacopée Française [18]. Il est constitué d'une chauffe ballon, un ballon de 1L, une colonne de condensation de la vapeur (réfrigérant) et un collecteur en verre qui reçoit les extraits de la distillation. L'huile essentielle obtenue est conservée au réfrigérateur dans un flacon en verre brun fermé hermétiquement à 4 °C et à l'ombre.

2.3 PLAN DE PLACKETT ET BURMAN

A propos d'un processus ou d'un phénomène, les premiers problèmes auxquels les plans d'expériences peuvent apporter de l'information sont ceux de criblage des paramètres. Une étude de criblage peut être définie comme une étape permettant de repérer rapidement, dans un grand nombre (k) de facteurs, ceux qui sont effectivement influents sur un processus dans un domaine expérimental fixé. Cette étude permettra de déterminer le "poids" de chaque niveau de chaque facteur, pour ensuite les classer par ordre d'importance.

Les matrices d'expériences de criblage les plus connues sont les matrices d'Hadamard [19] ou matrices de Plackett et Burman pour lesquelles le nombre de simulations est proche du nombre de facteurs étudiés [20]. Ces plans sont des matrices à colonnes orthogonales composées uniquement des valeurs +1 ou -1 [21] et pour laquelle la matrice d'information $X'X$ est telle que : $X'X = NI_N$ avec, I_N : matrice identité d'ordre N [22]. Ces plans sont le plus souvent saturés et le modèle mathématique est un modèle sans interactions [23].

Le plan de Plackett et Burman est un plan factoriel fractionné, et l'effet principal d'une telle conception peut être simplement calculé comme la différence entre la moyenne des mesures effectuées au niveau haut (+1) du facteur et la moyenne des mesures effectuées au niveau bas (-1). Cela permet la détermination de l'effet de chaque facteur. Un grand contraste coefficient positif ou négatif indique qu'un facteur a un grand impact sur la réponse; tandis qu'un coefficient proche de zéro signifie qu'un facteur a peu ou n'a pas d'effet [24].

2.4 DOMAINE EXPERIMENTAL DES FACTEURS ET REPONSES

Le choix des facteurs et leurs niveaux de variations a été effectué en tenant compte des limites expérimentales du fonctionnement, et en considérant les données de la littérature sur les conditions de l'Hydrodistillation [25] et les études précédentes [12], [13], [14], [15], [16].

Les facteurs susceptibles d'affecter le rendement en huile essentielle se divisent en deux catégories :

- Des facteurs continus ou quantitatifs:

- Le Temps de l'opération d'hydrodistillation compris entre 150 min et 210 min
- le rapport entre la matière végétale et l'eau dans le ballon de distillation : ce facteur varie entre 100/1200 et 100/400 (g/ml).
- La température de chauffage qui est directement liée au flux de vapeur sortant du ballon chauffé donc au débit de condensation. Afin de tester ce paramètre, deux températures de chauffage sont utilisées 250° et 350°.

- Des facteurs qualitatifs:

- La période de récolte du matériel végétal qui prend les deux modalités : Moitié du mois de juillet et moitié du mois de septembre.
- Le séchage des plantes étudiées avec les deux modalités : plante fraîche et plante séchée. Le séchage des plantes se fait dans l'ombre pendant 8 jours.
- L'effet du changement de l'individu traité : nous avons étudié deux pieds différents, donc nous avons les modalités "individu 1" et "individu 2"

Le Tableau 1 montre les six facteurs qui ont été étudiés simultanément afin de quantifier l'effet de chacun d'entre eux sur l'opération d'hydro-distillation.

La réponse étudiée est le rendement en huile essentielle de *Thymus vulgaris L.* qui se traduit par l'expression:

$$R_{HE}(\%) = \frac{M_{HE}}{M_s} \times 100$$

Avec : M_{HE} = La masse de l'huile essentielle (g), M_s = La masse de la matière végétale sèche (g) and R_{HE} = Le rendement en huile essentielle (%).

2.5 MATRICE D'EXPERIENCES

Puisque nous avons six facteurs, le plan d'expérience sera une matrice de 8 expériences. Pour plus de précision, nous avons dupliqué le plan choisi, ce qui mène donc à une matrice de 16 essais.

2.6 MODELE MATHEMATIQUE ET ANALYSE STATISTIQUE

Le modèle mathématique résultant est un polynôme d'ordre 1 tel que:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + \varepsilon$$

Avec:

Y: Le rendement en huile essentielle (réponse).

b_0 représente la valeur moyenne théorique de la réponse.

b_1, b_2, b_3, b_4, b_5 et b_6 : Les effets principaux des facteurs X_1, X_2, X_3, X_4, X_5 et X_6 , respectivement

ε : Le terme d'erreur.

La qualité du modèle ajusté a été exprimée par le coefficient de détermination R^2 , et sa signification statistique a été vérifiée par un test F (analyse de variance) au niveau de signification de 5%. Autrement, Le R^2 mesure la proportion de la variation totale de la réponse moyenne expliquée par la régression, en fait, c'est la corrélation entre la réponse observée et prédite, et il est souvent exprimé en pourcentage en multipliant par 100 [26].

Les carrés moyens (MS) sont obtenus comme suit:

$$MS = SS/DF$$

Où SS est la somme des carrés de chaque source de variation et DF est le degré de liberté.

Le rapport entre la régression carré moyen (MSR) et le carré moyen résiduel (MSr), $F_{ratio (R/r)}$, a été utilisé afin de vérifier si le modèle était statistiquement significatif [12].

La valeur F explique de façon adéquate la variation des données autour de leur valeur moyenne, en plus, les effets des facteurs estimés sont vrais [27], [28].

Les coefficients du modèle ont été considérés comme significatifs pour des valeurs de $p < 0,05$. La signification statistique des coefficients de modèle a été déterminée en utilisant le test t (seuls les coefficients significatifs avec $p < 0,05$ sont conservés).

Durant cette étude, nous avons utilisé les logiciels de conception et de traitement des plans d'expériences NemrodW [29].

3 RÉSULTATS

Les valeurs de réponse observées avec les différentes combinaisons des six variables étudiés sont répertoriées dans Tableau 2.

3.1 VALIDATION STATISTIQUE DU MODELE RETENU

D'après le tableau de l'analyse de la variance (Tableau 3.), nous pouvons conclure que la régression explique bien le phénomène étudié puisque la signification du risque ($p\text{-value} < 0.0001\%$) est inférieure à 0.05. Bien évidemment, le calcul de $F_{Ratio(R/r)}$ (26.77) a montré qu'il est presque huit fois supérieur à la valeur de $F_{(0.05;6,9)}$ au niveau de confiance de 95% qui est égale à 3.37.

Comme règle pratique, le modèle est statistiquement significatif si la valeur de F calculée est au moins de trois à cinq fois plus grande que la valeur théorique [30].

En outre, le modèle ne présente pas un défaut d'ajustement. Cela signifie qu'il fait moins d'erreurs que l'expérimentation puisque la signification du risque ($p\text{-value} = 0,08$) est supérieure à 0.05. Le calcul de $F_{Ratio(LOF/PE)}$ qui est égale à 3,90 a montré qu'il est inférieur à la valeur de $F_{(0.05;1,8)}$ au niveau de confiance de 95% qui est égale à 5.32. Le coefficient de corrélation $R^2 = 94.7\%$ est très suffisant. La valeur donne une bonne concordance entre les valeurs expérimentales et prévues du modèle adapté.

Le graphe (Fig. 1) montre que la courbe des valeurs observées en fonction des valeurs prévues a parfaitement l'allure d'une droite.

3.2 ÉTUDE DES EFFETS DES FACTEURS

Les effets principaux des six variables étudiés sont montrés dans le tableau 4.. Chaque coefficient est associé aux valeurs de t et p-value. Les valeurs de t sont employées pour déterminer la signification des coefficients de régression de chacun des paramètres ; et les valeurs de p sont définies comme plus petit niveau d'importance menant au rejet de l'hypothèse nulle [12]. En général, plus la grandeur de t est élevée, plus p value est petit, et plus le terme correspondant de coefficient est significatif [31].

La valeur de la constante b_0 est égale à 1.74. Cette valeur ne dépend d'aucun facteur. Les résultats du tableau 4. montrent que seul le facteur b_6 n'a pas d'influence sur l'opération d'hydrodistillation, puisque les 5 autres facteurs ont des significations des risques (P-value) inférieures à 0.05. Ces résultats sont plus clairs sur les deux graphes (Fig. 2) des effets des facteurs et leurs pourcentages de contribution dans la variation de la réponse étudiée (Rendement).

3.3 MODELE POSTULE

Le modèle mathématique statistique qui représente la réponse en fonction des variables les plus influents est:

$$Y = 1.74 + 0.032X_1 - 0.023 X_2 + 0.065X_3 - 0.019X_4 - 0.062X_5 + \varepsilon$$

L'erreur expérimentale (ε) a été calculée à partir des écarts types des réplifications des expériences et nous avons trouvé qu'elle a la valeur de 0.032.

4 DISCUSSIONS

4.1 PARAMÈTRES STATISTIQUEMENT NÉGLIGEABLE

4.1.1 SÉCHAGE

La figure 3 montre qu'il y a une petite augmentation dans le rendement en passant des plantes fraîches aux plantes séchées. Ce résultat est similaire à ceux trouvés pour d'autres plantes telles que *Rosmarinus officinalis L.* [32] et *Tetraclinis articulata* [33], qui ont prouvé que le séchage pendant une semaine entraîne une remarquable augmentation du rendement. Sauf que dans notre cas, cette augmentation n'est pas statistiquement significative.

Le test t pour le coefficient b_6 a montré que ce facteur n'a aucune influence sur le fonctionnement de l'hydrodistillation, car son risque de signification (P-value= 0.123) est de plus de 0,05.

4.2 PARAMÈTRES STATISTIQUEMENT NON NÉGLIGEABLES

4.2.1 TEMPS DE TRAITEMENT

Les deux graphes (Fig. 2) montrent que le temps (facteur b_3) est le facteur le plus influent sur l'opération d'hydrodistillation avec un coefficient de 0.065. Il contribue tout seul par 41.64% dans la variabilité de la réponse étudiée. Bien évidemment, le temps influe directement sur l'opération d'hydrodistillation, et son impact a été prouvé par plusieurs auteurs [12], [13], [14], [15], [16].

4.2.2 PÉRIODE DE RÉCOLTE

La période de récolte vient en seconde place avec un coefficient de -0.062 et une contribution de 37.73%. Ce résultat indique que le rendement est plus important en moitié du mois de juillet par rapport à celui inventorié en moitié du mois de septembre. Ces résultats sont conformes à ceux reportés par d'autres auteurs [34], [35], qui montrent que les meilleurs rendements d'huile essentielle de *Thymus vulgaris L.* correspondent au début de la phase de floraison, ce stage qui se déroule au cours du mois de juillet.

4.2.3 EFFET DE L'INDIVIDUALITÉ

L'effet de l'individualité est le troisième facteur qui affecte l'opération d'hydrodistillation avec un coefficient de 0.032 et une contribution de 10.13% dans la variabilité du rendement. Le signe négatif montre que le passage de l'individu 1 à

l'individu 2 dans la réalisation des essais entraîne une baisse dans le rendement en huile essentielle. Ce changement d'un individu a des facteurs tels que l'âge de la plante [36], le stade de croissance de ses organes [37], ou même à des facteurs génétiques [38].

4.2.4 RAPPORT ENTRE LA MATIÈRE VÉGÉTALE ET L'EAU

Un autre facteur qui a montré une influence significative sur le rendement a été inventorié : il s'agit bien évidemment du rapport entre la matière végétale et l'eau dans le ballon de distillation. Ce facteur a un coefficient de -0.023 et une contribution de 5.29 %. Le signe moins indique que le passage du niveau min (qui est le rapport 1/12) au niveau max (qui est le rapport 1/4) entraîne une baisse dans le rendement en huile essentielle. Plusieurs études ont montré que l'augmentation du rapport entre la matière végétale et l'eau entraîne une diminution du rendement [12], [14]. Cette diminution est expliquée par le fait qu'une quantité élevée de matière dans l'eau empêche la vapeur d'eau formée dans la partie inférieure du réservoir de monter dans le tube de condensation, ce qui provoque une diminution du rendement [39].

4.2.5 TEMPÉRATURE DE CHAUFFAGE

Avec un coefficient de -0.019 et une contribution de 3.43 seulement, la température de chauffage est le dernier facteur ayant un effet significatif sur le rendement. Son augmentation entraîne une augmentation dans le débit de condensation, cette augmentation a un effet négatif sur le rendement. En effet, une grande augmentation du débit de condensation induit une diminution du temps de séjour du condensat dans le décanteur et ne laisse pas le temps aux huiles essentielles d'être séparées du liquide [40]. Ces résultats s'accordent parfaitement avec ceux obtenus par d'autres auteurs [11], [12], [39].

5 TABLEAUX ET FIGURES

Tableau 1. Facteurs et leurs niveaux réels et codés

Facteurs	Niveaux	Unités	Variables codés	Niveaux codés
Effet de l'individualité	Individus 1		X1	-1
	Individus 2			1
Ratio Matière/Eau	1/12		X2	-1
	1/4			1
Temps	150	Min	X3	-1
	210			1
Température de chauffage	250	°C	X4	-1
	350			1
Période de récolte	Moitié juillet		X5	-1
	Moitié septembre			1
Séchage	Fraiche		X6	-1
	Séchée			1

Tableau 2. Plan d'expériences du processus d'hydrodistillation de *Thymus vulgaris L.* avec les réponses enregistrées pour chaque essai

N°Exp	Effet de l'individualité	Ratio Matière/Eau	Temps	Température de chauffage	Période de récolte	Séchage	RDT
1	1	1	1	-1	1	-1	1.77
2	1	1	1	-1	1	-1	1.79
3	-1	1	1	1	-1	1	1.80
4	-1	1	1	1	-1	1	1.86
5	-1	-1	1	1	1	-1	1.68
6	-1	-1	1	1	1	-1	1.71
7	1	-1	-1	1	1	1	1.68
8	1	-1	-1	1	1	1	1.69
9	-1	1	-1	-1	1	1	1.58
10	-1	1	-1	-1	1	1	1.59
11	1	-1	1	-1	-1	1	1.99
12	1	-1	1	-1	-1	1	1.91
13	1	1	-1	1	-1	-1	1.71
14	1	1	-1	1	-1	-1	1.71
15	-1	-1	-1	-1	-1	-1	1.77
16	-1	-1	-1	-1	-1	-1	1.74

Tableau 3. Analyse de la variance pour le modèle postulé

Source de variance	Ddl	Somme des carrés	Carré moyen	Rapport F	p-value
Modèle	6	0,16375	0,027292	26.7748	<0,0001
Résidus	9	0,009225	0,001025		
Total	15				
Défaut d'ajustement	1	0,003025	0,003025	3,9032	0,0836
Erreur pure	8	0,0062	0,000775		
Erreur total	9	0,009225			
R ²	94,60%				

Tableau 4. Effets des coefficients du modèle qui relie la réponse aux facteurs

Nom	Coefficient	Effect	Ecart-Type	Ratio t	Prob
Constant	b0	1.749	0.008	220.48	< 0,0001 ***
Effet de l'individualité	b1	0.032	0.008	4.03	0,00303 **
Ratio Matière/Eau	b2	-0.023	0.008	-2.92	0,0167 *
Temps	b3	0.065	0.008	8.18	< 0,0001 ***
Température de chauffage	b4	-0.019	0.008	-2.35	0,0420 *
Période de récolte	b5	-0.062	0.008	-7.79	< 0,0001 ***
Séchage	b6	0.013	0.008	1.69	0,123

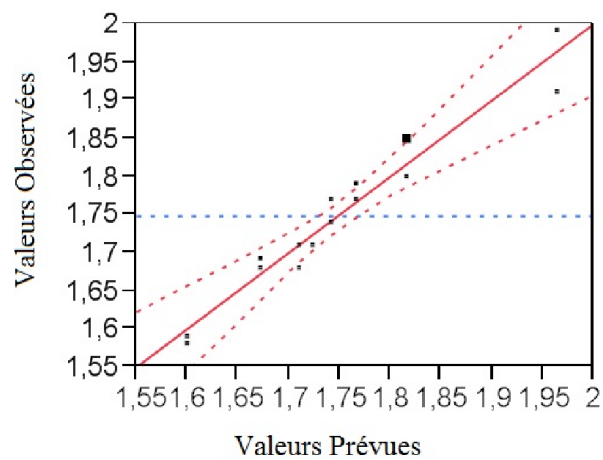


Fig. 1. Courbe des valeurs observées en fonction des valeurs prévues

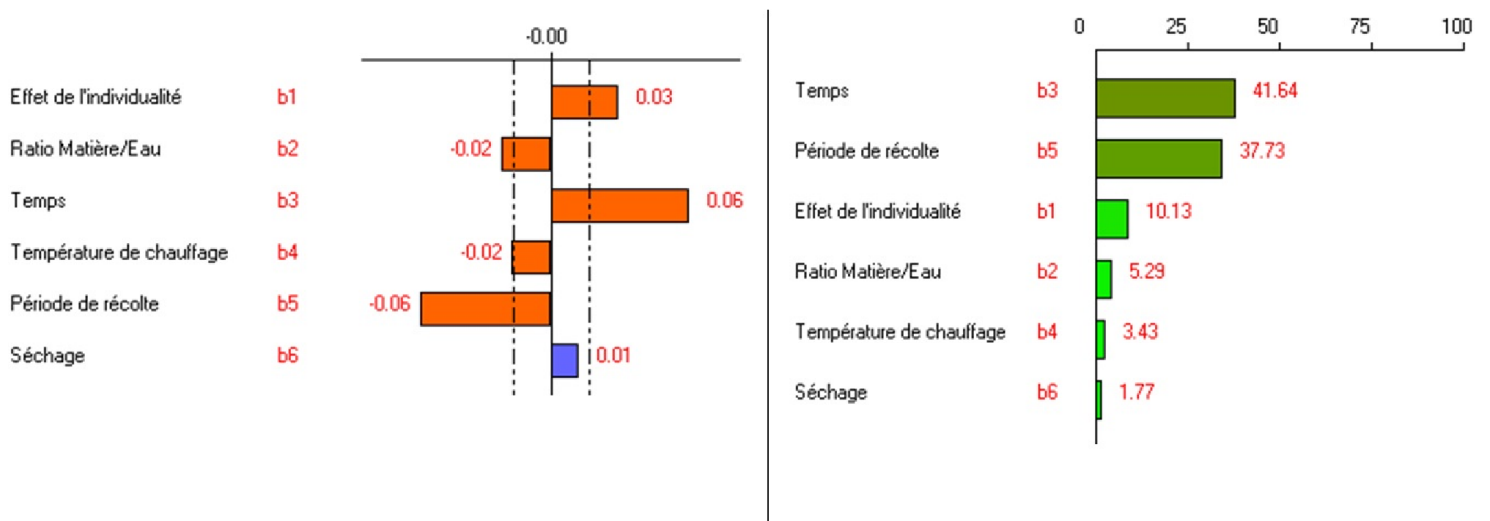


Fig. 2 A gauche: graphe des effets des facteurs, à droite: graphe qui montre le pourcentage de contribution de chacun des facteurs dans la variation de la réponse étudiée

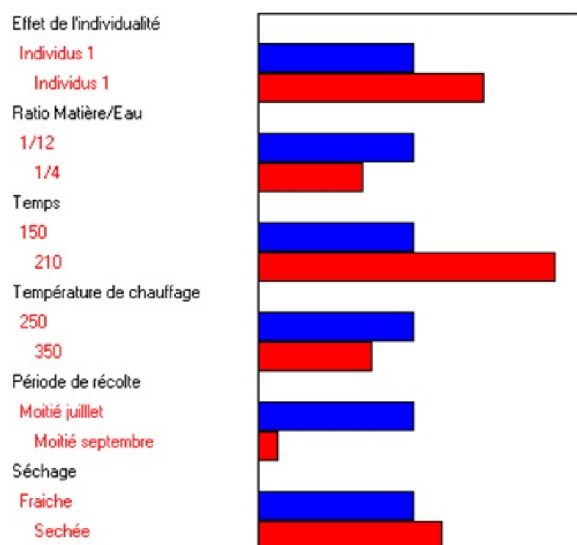


Fig. 3. Variation de la réponse en fonction de chacun des paramètres

6 CONCLUSION

Dans cette étude, nous avons pu évaluer l'effet des conditions opératoires sur le rendement en huile essentielle de *Thymus vulgaris L.*, en utilisant comme stratégie la méthodologie des plans d'expériences. Les résultats montrent clairement que la conception expérimentale est une méthode appropriée pour faire le criblage des facteurs agissant sur l'opération d'hydrodistillation de la plante étudiée. Le plan de Plackett et Burman qui a été appliqué a conduit à un modèle du premier ordre dont les coefficients significatifs sont statistiquement relatifs aux facteurs les plus influents sur la réponse. Après la validation statistique du modèle obtenu, nous sommes passés à l'analyse des effets. Ainsi, ce modèle a permis, d'une part, de montrer que le temps de l'hydrodistillation, la période de récolte, l'effet de l'individualité, le rapport entre la matière végétale et l'eau et la température de séchage du ballon sont tous des facteurs qui influent sur l'hydrodistillation, ces facteurs ont tous des effets significatifs sur le rendement (0.065, -0.062, 0.032, - 0.023, - 0.019 Respectivement). D'autre part, ce modèle a démontré que, même si le séchage entraîne une légère augmentation dans le rendement, cette augmentation est jugée négligeable puisqu'elle est non significative statistiquement.

Afin de compléter cette étude, une étude d'optimisation doit être mise en jeu. Elle consistera à chercher les conditions opératoires optimales susceptibles de garantir un meilleur rendement, et ce, par l'utilisation d'un autre type de plans d'expériences conçu pour ce type d'études, Soit les plans d'optimisation de type surface de réponse en agissant sur les facteurs opératoires continus jugés influents par l'étude de criblage, tels que le temps, le rapport entre la matière végétale et l'eau et la température de séchage.

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Détermination théorique des distances interatomiques, des fréquences de vibration, des constantes de force et des enthalpies de formation de l'intercalation de l'anion carbonate dans l'hydroxyde double lamellaire [Zn-Al-CO₃] par les méthodes semi-empiriques AM1, PM3 et par la méthode DFT B3LYP/6-311G

[Theoretical determination of interatomic distances, vibration frequencies, force constants and enthalpies of formation of the intercalation of the carbonate anion between layers of the layered double hydroxide [Zn-Al-CO₃] using the semi-empirical methods AM1, PM3, and the DFT B3LYP/6-311G method]

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ABSTRACT: In this work we used the AM1 and PM3 semi-empirical methods, together with density functional theory (DFT) B3LYP 6-311G, to determine the structure and position of the carbonate anion intercalated between layers of the zinc and aluminum layered double hydroxide [Al-Zn-Co₃] at ambient temperature. We calculated interlayer distances, vibration frequencies, force constants and enthalpies of formation. We showed that at ambient temperature the CO₃²⁻ anion is intercalated in the interlayer space by the formation of hydrogen bonds with water molecules. The results obtained using these three methods are compared to those obtained experimentally and those obtained using the Hartree-Fock STO-3G method.

KEYWORDS: bond order, Hartree-Fock, hydrogen bond, interlayer distance, interlayer space, strong bond.

RESUME: Dans ce travail, nous avons utilisé les méthodes semi-empiriques AM1 et PM3, ainsi que la méthode de densité fonctionnelle DFT B3LYP 6-311G, pour déterminer la structure et la disposition de l'anion carbonate intercalé entre les feuillets de l'hydroxyde double lamellaire de zinc et d'aluminium [Al-Zn-CO₃] à température ambiante. Nous avons calculé les distances interfoliaires, les fréquences de vibration, les constantes de force et les enthalpies de formation. Nous avons montré qu'à température ambiante l'anion CO₃²⁻ est intercalé dans l'espace interlamellaire par la formation des liaisons hydrogène avec des molécules d'eau. Les résultats obtenus par ces trois méthodes sont comparés à ceux obtenus expérimentalement et à ceux déterminés par la méthode de Hartree-Fock STO-3G.

MOTS-CLEFS: distance interfoliaire, espace interlamellaire, Hartree-Fock, liaison forte, liaison hydrogène, ordre de liaison.

1 INTRODUCTION

Les hydroxydes doubles lamellaires ou composés de forme hydrotalcite ont la formule générale $[M_{1-x}^{II}M_x^{III}(OH)_2]^{x+}[A_{x/m}^{m-}nH_2O]^{x-}$ [1]. Ces composés ont une notation abrégée de la forme $[M^{II}-M^{III}-X]$ [2], où M^{II} est le cation métallique divalent (Ca²⁺, Mg²⁺, Zn²⁺, Co²⁺, Ni²⁺, Cu²⁺, Mn²⁺, Fe²⁺ ...) , M^{III} le cation trivalent (Al³⁺, Cr³⁺, Fe³⁺, Co³⁺, Ni³⁺, Mn³⁺ ...) et X l'anion interlamellaire (HO₃⁻, HPO₄²⁻, Cl⁻, CO₃²⁻, NO₃⁻, SO₄²⁻ ...) [3].

La charge du feuillet est $\gamma=x$ quand M est divalent, $\gamma=2x-1$ quand M est monovalent et $\gamma=2x$ quand M est tétravalent. La structure des feuillets est une association coplanaire d'octaèdres M(OH)₆ qui forment des feuillets hydroxylés de formule M(OH)₂ de type brucite. La coexistence de cations divalents et trivalents dans ces feuillets entraîne un excès de charge positive contrebalancé par l'insertion d'espèces anioniques et des molécules d'eau dans le domaine interfoliaire [4].

Dans cette étude, nous nous sommes intéressés à la détermination des propriétés chimico-physiques de l'intercalation de l'anion carbonate CO₃²⁻ dans les feuillets de l'hydroxyde double lamellaire [Zn-Al-CO₃]. L'utilisation des méthodes semi-empiriques AM1 et PM3 et de la méthode de densité fonctionnelle DFT B3LYP/6-311G ont contribué à la prédiction des distances interlamellaires, des fréquences de vibration, des constantes de force et des enthalpies de formation [5]. Les résultats obtenus par ces méthodes de calcul seront comparés à ceux obtenus par l'expérience, afin d'établir le rapport entre les études théoriques et expérimentales, et de choisir la méthode théorique convenable.

2 MÉTHODES DE CALCUL THÉORIQUE

L'optimisation des distances interatomiques des molécules étudiées à température ambiante, la détermination des fréquences de vibration, des constantes de force et des enthalpies de formation sont obtenues par l'utilisation des méthodes quantiques semi-empiriques AM1 et PM3, et par la méthode de densité fonctionnelle DFT B3LYP/6-311G, implantées dans le logiciel Gaussian 09 [6].

3 RÉSULTATS ET DISCUSSION

3.1 ÉTUDE STRUCTURALE DE L'ANION CO₃²⁻ LIBRE

Les distances interatomiques de l'anion carbonate CO₃²⁻ déterminées par les méthodes théorique AM1, PM3 et DFT B3LYP/6-311G sont données dans le Tableau 1. Ce tableau montre que les trois liaisons (C₁-O_{*x*}) sont identiques, ce qui confirme que la structure de l'anion carbonate CO₃²⁻ est un triangle équilatéral [7]. Elle appartient au groupe ponctuel de symétrie D_{3h} (Fig. 1). La théorie des groupes prévoit six fréquences de vibration fondamentale qui se répartissent suivant la représentation: $\Gamma_{\text{vib}}=A_1'+A_2''+E'+E''$.

Ces fréquences de vibration sont: ν_1 qui correspond à la vibration de valence symétrique non dégénérée active en Raman, ν_2 qui correspond à la vibration de déformation antisymétrique non dégénérée active en infrarouge, ν_3 qui correspond à la vibration antisymétrique doublement dégénérée active en Raman et en infrarouge, et ν_4 qui correspond à la vibration symétrique doublement dégénérée active en Raman [8] (Tableau 2).

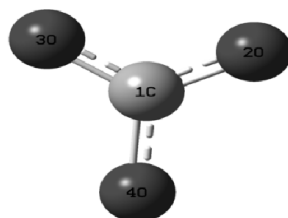


Fig. 1. Représentation de l'anion carbonate libre CO₃²⁻

NB: 1C dans le schéma correspond à C1 dans le texte et dans le tableau 1, 2O à O2 et ainsi de suite.

Tableau 1. Distances interatomiques optimisées de l'anion CO_3^{2-} (Å)

	AM1	PM3	DFT B3LYP/6-311G	Hartree-Fock STO-3G
$\text{C}_1\text{-O}_2$	1,297	1,292	1,336	1,33
$\text{C}_1\text{-O}_3$	1,297	1,292	1,336	1,33
$\text{C}_1\text{-O}_4$	1,297	1,292	1,336	1,33

Les distances interatomiques calculées par la méthode DFT B3LYP/6-311G sont comparables à celles obtenues par la méthode Hartree-Fock STO-3G [9].

Les fréquences de vibration correspondant à ν_1 , ν_2 , ν_3 et ν_4 calculées par la méthode DFT B3LYP/6-311G sont comparables aux fréquences de vibration de la même molécule CO_3^{2-} à l'état libre obtenues par l'expérience [10]. Nous pourrions conclure que la méthode DFT B3LYP/6-311G est plus fiable que les méthodes semi-empiriques AM1 et PM3.

Tableau 2. Fréquences de vibration de l'anion CO_3^{2-} à l'état libre (cm^{-1})

	Expérimentale	AM1	PM3	DFT 3BLYP/6-311G
ν_1	-	1313	1139	1088 (980)
ν_2	879	766	763	838 (754)
ν_3	1415	1887	1716	1607 (1446)
ν_4	680	605 604	505	656 (589)

3.2 ÉTUDE STRUCTURALE DE L'ESPACE INTERLAMELLAIRE

Pour étudier l'intercalation de l'anion carbonate CO_3^{2-} entre les feuillets de l'hydroxyde double lamellaire, nous supposons qu'il existe deux types de structure [11]. Généralement les molécules de la forme XY_3 peuvent avoir deux orientations [10]: la liaison C-O est soit perpendiculaire, soit parallèle aux feuillets de l'hydroxyde double lamellaire (respectivement modèles (a) et (b) dans la Figure 2). Pour déterminer les valeurs de la distance interlamellaire, nous avons utilisé uniquement la méthode DFT B3LYP/6-311G (Tableau 3).

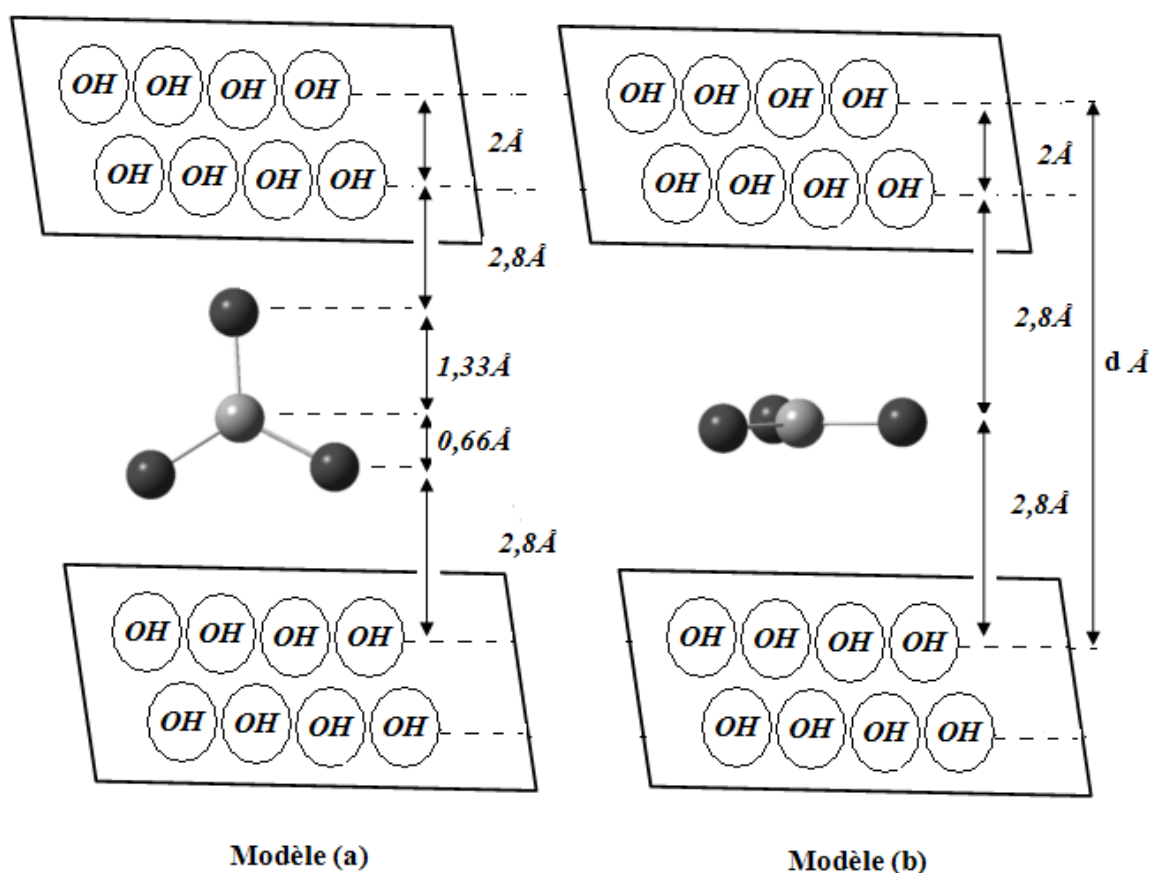


Fig. 2. Représentation schématique des dispositions possible de l'anion CO₃²⁻ entre les feuillets de l'hydroxyde double lamellaire

Tableau 3. Comparaison entre la distance interlamellaire dans l'anion CO₃²⁻ calculée par la méthode DFT B3LYP/6-311G et celle obtenue par l'expérience

	Modèle (a)	Modèle (b)
Distance d calculée (Å)	9,59	7,6
Distance d expérimentale (Å)	7,57	
Erreur absolue (Å)	2,03	0,04
Erreur relative (%)	26,85	0,52

D'après des études antérieures [12], [13] la distance entre deux groupements hydroxyles situés selon l'axe c du même feuillet est de 2 Å, tandis que la distance entre l'anion et le feuillet est de 2,80 Å.

Nous constatons que seul le modèle (b) donne une valeur de la distance interlamellaire comparable à celle obtenue par l'expérience [9], c'est à dire que l'anion carbonate CO₃²⁻ est inséré entre les feuillets de l'hydroxyde double lamellaire de sorte que les liaisons C-O soient parallèles aux feuillets.

La distance interlamellaire déterminée par l'expérience est de 7,57 Å [9]. Celle calculée par la méthode DFT B3LYP/6-311G est de 9,57 Å dans le modèle (a) et de 7,6 Å dans le modèle (b). Nous pouvons donc conclure que l'anion CO₃²⁻ est lié à l'hydroxyde double lamellaire selon le modèle (b). Dans ce cas l'anion serait lié soit à l'atome du zinc par des liaisons fortes soit aux molécules d'eau par des liaisons hydrogènes.

3.3 L'ANION CO_3^{2-} LIÉ PAR DES LIAISONS FORTES

Pour mettre en évidence ce type de réarrangement nous avons proposé deux modèles: modèle (c) et modèle (d) (Fig. 3)

- Modèle (c): l'anion CO_3^{2-} est supposé être lié à un atome de zinc selon une symétrie C_{2v} .
- Modèle (d): l'anion CO_3^{2-} est supposé être lié à un atome de zinc selon une symétrie C_s .

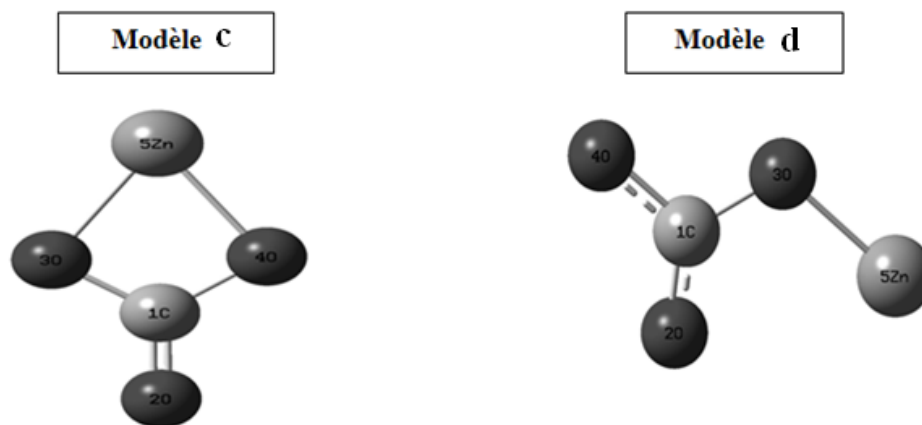


Fig. 3. Illustration des modèles (c) et (d)

Pour vérifier lequel des deux modèles proposés est valable, nous avons calculé par les méthodes quantiques AM1, PM3 et DFT B3LYP/6-311G les distances interatomiques (Tableau 4) et les fréquences de vibration (Tableau 5). Ces fréquences de vibration de l'anion CO_3^{2-} intercalé entre les feuillets de l'hydroxyde lamellaire peuvent être comparées à celles obtenues par l'expérience [10] (Tableau 6). Afin de compléter l'étude nous avons calculé aussi les constantes de force de la liaison Zn-O et les ordres de cette liaison (Tableau 7). (NB: Les constantes de force ont été calculées uniquement par la méthode DFT B3LYP/6-311G.)

Tableau 4. Distances interatomiques optimisées des modèles (c) et (d) (Å)

	Modèle (c)			Modèle (d)		
	AM1	PM3	DFT B3LYP/ 6-311G	AM1	PM3	DFT B3LYP/ 6-311G
C_1-O_2	1,225	1,208	1,228	1,286	1,306	1,348
C_1-O_3	1,357	1,378	1,406	1,316	1,306	1,346
C_1-O_4	1,357	1,378	1,407	1,286	1,273	1,297
Zn_5-O_3	1,978	1,902	1,936	2,245	2,357	2,151
Zn_5-O_4	1,978	1,902	1,936	-	-	-

Tableau 5. Fréquences de vibration calculées pour les modèles (c) et (d) (cm^{-1})

	Modèle (c)			Modèle (d)		
	AM1	PM3	DFT B3LYP/ 6-311G	AM1	PM3	DFT B3LYP/ 6-311G
ν_1	1193	1206	827	1192	1206	826
ν_2	760	960	706	760	675	706
ν_3	1398	1985	1657	1398	1985	1658
ν_4	671	653-675	705	625-671	960	733

Tableau 6. Fréquences de vibration de l'ion CO₃²⁻ dans différents composés de référence (cm⁻¹)

	CaCO ₃ (calcite)	CaCO ₃ (aragonite)	[Co(NH ₃) ₄ CO ₃]Cl	[Co(NH ₃) ₄ CO ₃]Br
v ₁	-	1080	1030	1070
v ₂	879	866	834	850
v ₃	1429-1492	1504-1492	1593-1265	1453-1373
v ₄	706	711-706	760-673	756-678

Tableau 7. Constantes de force et ordres de la liaison Zn-O

	Modèle (c)	Modèle (d)
Constante de force de liaison (mdyn/Å)	0,557	0,565
Ordre de liaison N	0,269	0,271

Nous constatons que les longueurs de liaison C₁-O_x du modèle (c) varient toutes par rapport aux longueurs de liaison de l'anion CO₃²⁻ à l'état libre. En particulier les distances des liaisons C₁-O₃ et C₁-O₄ augmentent lorsque l'anion carbonate CO₃²⁻ est lié à l'atome de zinc, tandis que la longueur de la liaison C₁-O₂ diminue. Cette modification pourrait être due à l'abaissement de symétrie, qui passe de la symétrie D_{3h} à la symétrie C_{2v}. Nous remarquons aussi dans le modèle (d) que toutes les distances de liaison C₁-O_x varient et en particulier que la longueur de la liaison C₁-O₃ augmente par rapport à la longueur de la même liaison de l'anion CO₃²⁻ à l'état libre. Cette modification pourrait être expliquée par l'abaissement de la symétrie D_{3h} à la symétrie C_s. Dans les deux modèles, il y a un abaissement de symétrie, qui pourrait entraîner des modifications des fréquences de vibration. Pour confirmer la validité de ces deux modèles, nous avons calculé les constantes de force et nous avons déduit les ordres de la liaison Zn-O dans les deux modèles proposés en appliquant la relation de Siebert [14].

$$N = 0,57 \frac{f_r}{f_1} + 0,43 \sqrt{\frac{f_r}{f_1}} \quad \text{avec} \quad f_1 = 7,2 \frac{Z_A Z_B}{n_A^3 n_B^3}$$

avec N: ordre de la liaison, Z: nombre atomique, f_r: constante de force de la liaison A-B et n: nombre quantique principal.

Les valeurs de l'ordre de liaison des modèles proposés sont de l'ordre de 0,5 (tableau 7), ce qui prouve qu'on peut exclure l'hypothèse d'une liaison forte de l'anion CO₃²⁻ avec les feuillettes de l'hydroxyde double lamellaire. Donc les deux modèles (c) et (d) ne peuvent exister: il est plus probable que l'anion CO₃²⁻ soit lié aux molécules d'eau par des liaisons hydrogènes.

3.4 L'ANION CO₃²⁻ LIE PAR DES LIAISONS HYDROGENES

La liaison hydrogène s'établit entre les atomes d'hydrogène des molécules d'eau et les atomes d'oxygène de l'anion CO₃²⁻. Dans cette étude, nous présentons trois cas (Fig. 4) pour déterminer la configuration la plus stable. Nous avons calculé l'enthalpie de formation de chaque système en utilisant les méthodes AM1, PM3 et DFT B3LYP/6-311G (Tableau 8).

Tableau 8. Enthalpies de formation (ΔH_f^o, kcal/mol)

	AM1	PM3	DFT B3LYP/6-311G
(CO ₃ ,1H ₂ O) ²⁻	-136,142	-138,996	-213431,671
(CO ₃ ,2H ₂ O) ²⁻	-221,601	-221,298	-261427,745
(CO ₃ ,3H ₂ O) ²⁻	-305,432	-300,455	-309417,499
CO ₃	-48,778	-52,835	-165426,568
H ₂ O	-59,226	-53,350	-47951,600

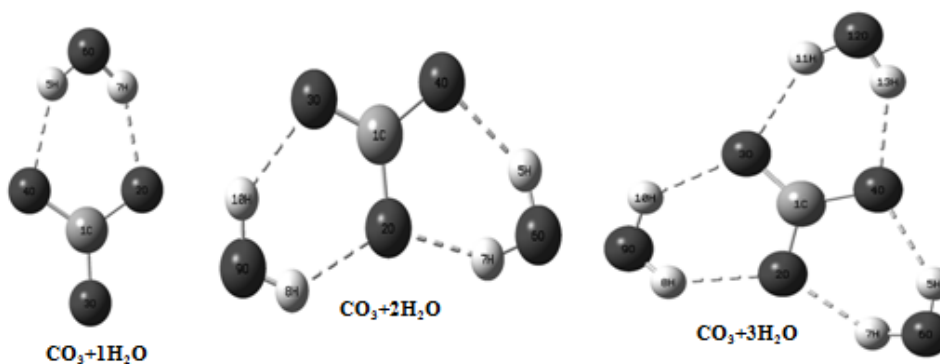
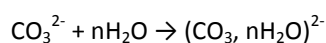


Fig. 4. Illustration des édifices proposés

La formation des liaisons hydrogènes se traduit par la réaction suivante:



avec $\Delta H_f^\circ = \Delta H_f^\circ(\text{CO}_3^{2-}, n\text{H}_2\text{O}) - \Delta H_f^\circ(\text{CO}_3^{2-}) - n\Delta H_f^\circ(\text{H}_2\text{O})$.

La valeur expérimentale d'enthalpie de formation de H_2O est de $-57,79$ kcal/mol [15]. Nous avons tracé les courbes de variation d'enthalpie de formation en fonction du nombre de molécules d'eau liées à l'anion carbonate CO_3^{2-} obtenues par les trois méthodes quantiques citées. Les résultats obtenus par ces trois méthodes sont semblables (Fig. 5), c'est à dire que l'énergie mise en jeu dans l'association entre ces espèces chimiques diminue avec le degré d'hydratation. Cette décroissance correspond à la formation des édifices chimiques de plus en plus stables, le plus stable étant celui dans lequel l'anion carbonate CO_3^{2-} est lié à trois molécules d'eau.

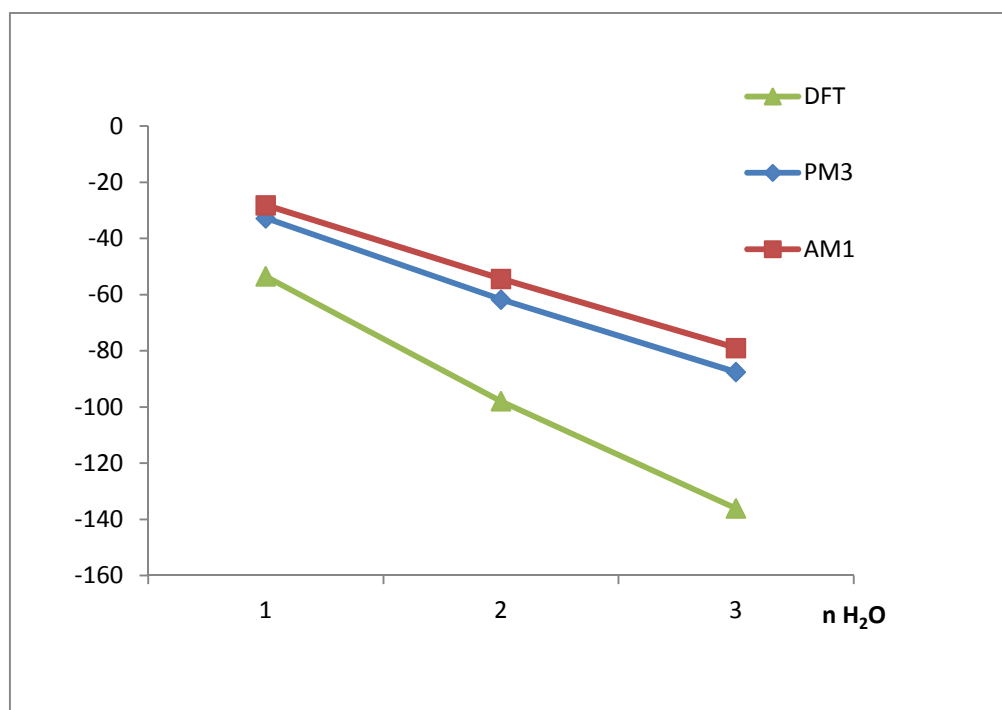


Fig. 5. Variation de ΔH° , en fonction du nombre de molécules d'eau liées à l'anion

4 CONCLUSION

Les calculs théoriques par les méthodes semi-empirique AM1 et PM3 et par la méthode de densité fonctionnelle DFT B3LYP/6-311G des distances interatomiques de l'anion carbonate CO₃²⁻ intercalé entre les feuillets hydroxylés [Zn-Al-CO₃], des fréquences de vibrations, des constantes de force et de l'enthalpie de formation ont montré que les anions carbonates sont liés avec des molécules d'eau par l'intermédiaire des liaisons hydrogène à raison de trois molécules d'eau par chaque anion carbonate CO₃²⁻. La comparaison des distances interatomiques et des fréquences de vibration montre que la méthode de densité fonctionnelle est plus fiable que les méthodes semi-empirique AM1 et PM3.

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Evaluation of Different On-farm Compost Quality & their Role in Made Tea Productivity and Development of Acid Tea Soils

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ABSTRACT: A study was conducted at Maud T.E., Assam, India as part of FAO-CFC-TBI Project (2008-09 to 2012-13) to evaluate the quality of on-farm compost produced under different composting method and its effectivity on soil quality development. Comparative nutrient content in terms of N + P₂O₅ + K₂O was highest in Novcom compost (3.98 %) followed by Biodynamic (3.56 %), Vermi (3.16 %) and Indigenous (2.96 %) compost. But comparative evaluation of microbial population (total bacteria, fungi, actinomycetes, ammonifiers, nitrifiers and phosphate solubilizing bacteria) in all the compost samples revealed distinctly different status of Novcom compost as compared to the rest. In case of vermi, Biodynamic and Indigenous compost, microbial population varied between 10⁷ to 10¹² c.f.u. where as that of Novcom compost varied from 10¹² to 10¹⁶ c.f.u. The comparatively high microflora population in Novcom compost could be due to its intense biodegradation process, which led to their natural generation within compost heaps. Post compost application effectivity assessment revealed that Soil Development Index (SDI) was highest in case of Novcom compost treated plots (SDI : 57.83) followed by plots receiving Biodynamic (SDI : 28.22), Indigenous (SDI : 27.82) and Vermi (SDI : 23.36) compost respectively. Positive and significant (r = 0.54**) correlation of SDI with crop yield indicated that it can be used as an effective tool to judge the soil quality in relation to crop performance as well as to assess the competence of soil management programme.

KEYWORDS: Novcom , Biodynamic, Vermi, Compost Quality Index, Soil Development Index.

1 INTRODUCTION

Emerging threat in crop sustenance is the basic concern of present day agriculture, primarily due to degradation of soil quality leading to lower crop yield and quality and the resultant depressed input– output ratio. To restore soil quality, application of organic soil amendment has become obligatory; The primary role of organic amendments is to rejuvenate the soil by creating a favourable soil–plant–microbial environment, in addition to improving the physical properties of the soil. In other words, to make the soil system live for healthy plant growth [1]. But most of the organic manures have poor nutrient content as a result crop yield is unsatisfactory. Moreover, poor microbial status and lack of stability/ maturity/ phytotoxicity evaluation fails to assure soil regeneration deemed necessary for restoration of the desired crop sustainability [2]. At the same time, high cost of compost (considering its N content) renders application of organic soil amendment economically unviable (even if recommended quantity is not considered). Moreover, there is no clear perception among the agricultural community regarding the quality parameters that are ultimate regulators of compost effectivity [3].

However, to enable affordability at farmers level on a large scale, the quantitative requirement and unit cost has to be mitigated, which can be well attended only through application of good quality, stable and mature compost [4]. Such compost in turn can be derived only from an effective composting/ biodegradation process. Good quality compost manufactured through an accurate aerobic digestion process acts as food source and shelter for beneficial microbes that

produce antibiotics along with antagonistic microorganisms that compete with plant pathogens, prey on and parasitize pathogens. Quality of compost becomes all the more important in the context of problematic soils like acid tea soils. In acid tea soils, availability of nutrients in soil solution is hindered as well as mono crop toxicity creates a hostile soil environment restricting the natural proliferation of soil micro flora [5]. So, to maintain equilibrium soil environment as well as ensure sustained crop production quality of compost is the most component for consideration [6]. Hence, the present study aims at the quality evaluation of on-farm compost prepared from different biodegradation process as well as their post application effectivity on soil quality development.

2 MATERIALS AND METHODS

2.1 STUDY AREA

The study was done as M.Sc. Project work, using data support from FAO-CFC-TBI project entitled 'Development, Production and Trade of Organic Tea', which was conducted at Maud tea estate (Assam) from 2008-09 to 2012-13. Analytical work was done partly in the Dept. of Agricultural Chemistry and Soil Science (Calcutta University) and at Inhana Biosciences laboratory, Kolkata. Young tea plantation (3 years) was taken for the study and the treatments were placed as per randomized block design with three replications and individual plot size of 0.01 ha. Different compost viz. Vermicompost (VC), Biodynamic (BD), Indigenous (FYM) and Novcom (NOV) compost were prepared with garden weeds and cow dung and applied (incorporated in soil) at a rate to supply 75 kg Nitrogen per hectare for plant uptake for 3 consecutive years.

2.2 PREPARATION OF DIFFERENT COMPOST

On-farm available green matter comprising common garden weeds viz. *Mikania micrantha*, *Ageratum houstonianum*, *Axonopus compressus*, *Digitaria setigera* Roth, *Clerodendrum viscosum* Vent., *Scoparia dulcis* Linn., *Paspalum longifolium* Roxb etc. were used for making four different types of compost viz. vermi compost, Indigenous compost or Farm Yard Manure (FYM), Biodynamic compost and Novcom compost; as per their standard processes (described below) at Maud tea estate in Dibrugarh, Assam (India). Vermicompost was produced within a period of 75 days, the biodegradation period for Indigenous and Biodynamic compost was 90 days while that for Novcom compost was 21 days. Twelve heaps were made for each type of compost.

2.2.1 VERMI COMPOST PREPARATION AT MAUD TEA ESTATE

Raw materials used: Common garden weeds viz. *Mikaniamicrantha*, *Ageratum houstonianum*, *Axonopus compressus*, *Digitaria setigera* Roth etc. and cow dung at 60 : 40 ratio was used for making compost.

Earth worm: 4000 4500 earth worms (*Esenia foetida*) were required for each layer comprising about 600 to 650 kg of raw materials.

Vermi shed and Vermi compost pit : A plastic shed with bamboo structure was made for protecting the vermi pit from direct sunlight as well as rainfall. A vermi compost pit was prepared measuring 15 ft. in length, 4 ft. in breadth and 4 ft. in height. Base of the pit was soled with bricks followed by a sand layer. At the top of sand bed, thick cow dung slurry was sprayed.

Preparation of Vermi Compost:

At a selected upland chopped green matter and cow dung was stacked in a heap measuring 10 ft. in length, 6 ft. in breadth and 4 ft. in height. Proper watering was done, so that decomposition was initiated. This was kept for about 20 to 25 days and frequent watering was done till the materials were semi decomposed and temperature of the heap came down. Then the materials were ready for using in the vermi pit. The semi decomposed raw materials were transferred into the vermi pit and vermi was added layer wise in the specific quantity. Watering on regular basis was done to keep the vermi pit moist. The vermi compost was ready in 40 to 50 days time.

2.2.2 BIODYNAMIC COMPOST PREPARATION AT MAUD TEA ESTATE

Raw materials used: Common garden weeds viz. *Mikania micrantha*, *Ageratum houstonianum*, *Axonopus compressus*, *Digitaria setigera* Roth etc. and cow dung at 70 : 30 ratio was used for making compost.

Preparation of Biodynamic Compost: At first 2 kg Cow Pat Pit (CPP) was mixed with some water and kept for 4-6 hours. After that at least 30 ltr. of water was added to it and stirred well. A plain land facing east- west direction was chosen for better effectivity. After cleaning the land, the soil was moistened by spraying water on the surface. A 15 ft. long bamboo strip was placed in the middle of the land with the help of two bricks. Two 2 ft. long bamboo strips (lying across) were placed at every 2ft. interval on the main strip. Dry grasses were spread over the bamboo structure (up to 6 inches height) and watered to make it wet. A layer of cow dung (about 3 inches thick) was made next and water was sprayed on it. 2 ltr. CPP mixture was sprayed on the layer. The processes of layering with grasses and cow dung were repeated until the height was raised up to 2 ft. Then a layer of fresh green matter was made over it (about 4 inches height) and 15 kg CaO was broadcasted on top of the layer. The process of layering with grass and cowdung was again repeated until the height of the heap reached to about 4 ft. The top layer of the heap was made of cow dung. 3 holes were made on the heap and some CPP mixture was poured in those holes. After that CPP mixture was used to moisten the heap. Concentrated cow dung slurry was prepared by mixing a certain amount of soil with cow dung and the entire heap was plastered by it.

Method for preparation of CPP : A structure 1.5 ft. in length x 1.5 ft. in breadth x 1 ft. in height was made using bricks and the inner wall was pasted with fresh cow dung. The bottom of the structure was not lined with bricks. The pit was filled with fresh firm cow dung, eggshells and basalt dust was inserted into the dung (for 20kg of manure 65gms crushed eggshells and 166gm basalt dust was used) and spaded for an hour, next jaggery solution (100gm jaggery and one liter water) was sprinkled over it. After gently patting the cow dung six holes, 2 inches deep were made in it, followed by incorporation of Biodynamic preparations (1gm each of 503- 506 and 1ml of 507). Fresh jute sack was placed over the pit to maintain moisture and to avoid excessive drying. The mixture was aerated once during a month with a garden fork. CPP gets ready in 60 days.

2.2.3 INDIGENOUS COMPOST (FYM) PREPARATION AT MAUD TEA ESTATE

Raw materials used: Common garden weeds viz. *Mikania micrantha*, *Ageratum houstonianum*, *Axonopus compressus*, *Digitaria setigera* Roth etc. and cow dung at 70 : 30 ratio was used for making compost.

Preparation of Indigenous compost: At a selected upland and flat area chopped green matter was spread to make a base layer measuring 15 ft. in length and 4 ft. wide. Green matter was chopped down to 1/2" Size and placed evenly till 1 ft. followed by a layer of cow dung. The process was repeated till the heap reached a height of about 5 ft. The heap was covered with clay mud. The heap was demolished and upturned once the height reduced below 4 ft. and reconstructed to a height of about 5 ft. Compost was ready in 3 months time.

2.2.4 NOVCOM COMPOST PREPARATION AT MAUD TEA ESTATE.

Novcom compost was prepared through Novcom composting method (Developed by an Indian Scientist, Dr. P. Das Biswas, Founder Director of Inhana Biosciences. Novcom composting method is a part of Inhana Rational Farming (IRF) Technology developed by Dr. P. Das Biswas is a complete package of practice for organic cultivation primarily conceptualized from Indian Mythology and Vedic Philosophy) using Novcom solution. The compost under this process is prepared within 21 days using green matter and cow dung as a raw materials.

Raw materials used: Common garden weeds viz. *Mikaniamicrantha*, *Ageratum houstonianum*, *Axonopus compressus*, *Digitaria setigera* Roth etc. and cow dung at 80 : 20 ratio was used for making compost.

Novcom solution: Biologically activated and potentized extract of Doob grass (*Cynodon dactylon*), Bel (*Sida cordifolia* L) and common Basil (*Ocimum basilicum*).

Total requirement of Novcom solution: Total 250 ml Novcom solution is required for 1 ton of raw materials (100 ml on day 1 followed by 75 ml each, on day 7 and day 14).

Preparation of Novcom compost:

Day 1 : At a selected upland and flat area chopped green matter was spread to make a base layer measuring 10 ft. in length, 5 ft. in breadth and 1 ft. in thickness. This layer was sprinkled thoroughly with diluted Novcom solution (5 ml/ ltr. of water) and over this layer, a layer of cow dung (3 inches in

thickness) was made followed by a second layer of chopped green material, once again 1 ft. in thickness. The green matter layer was once again sprinkled with diluted Novcom solution (5 ml/ ltr. of water) and the process was continued till

the total height reached to about 6 ft. After construction of each layer of green matter it was compressed downward from the top and inward from the sides for compactness.

Day 7 : On the 7th day compost heap was demolished and churned properly. The material was next laid layer wise and after making each layer diluted Novcom solution (5 ml/ ltr.) was sprinkled thoroughly as done on 1st day. After seven days the volume of the composting material decreased due to progress in decomposition process. Hence, to once again maintain the heap height to about 6 ft.; the length and breadth of the heap was maintained at 6 ft. x 6 ft. respectively. The heap was once again made compact as described earlier.

Day 14 : The same process was repeated as on day 7 and to maintain heap height to about 6 ft., the length and breadth of the heap was further reduced to 6 ft. x 4 ft. respectively.

Day 21 : The composting process was complete and compost was ready for use.

2.3 ANALYSIS OF COMPOST SAMPLES

12 Compost samples (3 samples from 3 compost heaps of individual type) Physicochemical properties of compost viz. moisture content, pH, electrical conductivity and organic carbon were analyzed according to the procedure of Trautmann and Krasny [7]. The total N, P and K in compost were determined using the acid digestion method [8]. Estimation of bacteria, fungi and actinomycetes was performed using Thornton's media, Martin's media and Jensen's media respectively, according to standard procedure [9]. Stability tests for the compost (CO₂ evolution rate, phytotoxicity bioassay test/germination index) were performed according to the procedure suggested by Trautmann and Krasny [7]. Cress (*Lepidium sativum* L.) seeds were used for the phytotoxicity bioassay test.



Fig 1 : Erection of Novcom Compost Heap with green matter and cow dung, monitoring of heap temperature and final measurement of compost heap size at Maud Tea Estate under FAO-CFC-TBI Project.



Fig 2 : Large scale Novcom compost preparation at Maud T.E. under FAO-CFC-TBI Project.



Fig 3 : Transportation and application of Novcom compost at Maud T.E. under FAO-CFC-TBI Project.



Fig 4 : Corresponding Author along with Ms Joelle Kato, Programme Manager, IFOAM, Germany inspecting Novcom compost heaps produced at Maud Tea Estate under FAO-CFC-TBI Project.



Fig 5 : Dr. P. Das Biswas, developer of IRF Organic Package of Practice with Ms Joelle Kato, Programme Manager, IFOAM, Germany discussed about young tea management under FAO-CFC-TBI Project.

Compost Quality Index (CQI) was calculated as per the methodology [10], which is represented by the following equation:

$$\text{Compost Quality Index (CQI)} : \frac{\text{Log}_{10} \{ \text{NV}_{\text{NPK}} \times \text{MP} \times \text{GI} \}}{\text{C/N ratio}}$$

Where NV_{NPK} = Total nutrient value in terms of total (N+P₂O₅+K₂O) percent.

MP = log₁₀ value of total microbial population in terms of total bacteria, total fungi and total actinomycetes.

GI = Germination Index.

Classification of compost as per Compost Quality Index

Compost Quality Index (CQI)	Compost Quality Classification
> 2.00	: Poor
2.00 – 4.00	: Moderate
4.00 – 6.00	: Good
6.00 – 8.00	: Very Good
8.00 – 10.00	: Extremely Good

2.4 ANALYSIS OF SOIL SAMPLES

Samples from 0 to 50 cm soil depth were collected from all the experimental plots before compost application in 2011-12 and one year after in 2012-13. The soil samples were divided into two parts, one part was kept in the refrigerator at 4°C for doing microbial analysis; the other part was air dried, ground in a wooden mortar and pestle and passed through 2 mm sieve. The sieved samples were stored separately in clean plastic containers. Soil physico-chemical, fertility and microbial properties were analyzed as per standard methodology [9]. Estimation of bacteria, fungi and actinomycetes was done as per plate counting method using Thornton's media, Martin's media and Jensen's media respectively according to the procedure outlined by [9]. Total phosphate solubilizing bacteria (PSB) count was also done as per plate counting method using Pikovskays's media [9].

The analytical values of the selected parameters before initiation of study in 2011 and one year after compost application (i.e. in 2012) were then used as per the following formula [11] to calculate soil quality index for different treatments.

$$\text{Soil Development Index (SDI)} = \frac{a}{n^2} \left\{ \sum_{n=1}^n \frac{100(X_1 - C_1)}{C_1} + \frac{100(X_2 - C_2)}{C_2} + \dots + \frac{100(X_n - C_n)}{C_n} \right\}$$

Where X = Soil Quality parameters after Experimentation; C = Value of individual Soil Quality Parameter before Experimentation ; a = no. of Soil Quality Parameters showing increased over initial value.

3. RESULTS AND DISCUSSION

3.1 ANALYSIS OF COMPOST QUALITY

To evaluate the comparative end product quality under different composting process viz. Vermi (VC), Biodynamic (BD), Indigenous (IC) and Novcom (NOV) composting method, final compost samples were evaluated for 35 different quality parameters. Under this study compost samples collected from Maud tea estate, Assam and analyzed for physicochemical properties, microbial population, stability, maturity and phytotoxicity parameters.

3.1.1 PHYSICAL PARAMETERS OF THE COMPOST SAMPLES

All the compost samples appeared dark brown in colour with an earthy smell, deemed necessary for mature compost [12]. Average moisture in compost samples were varied from 45.23 to 58.78 percent, which may be placed in the high value range (40 to 50) [13]. Bulk density of the compost samples (0.55 to 0.71 g/cc,) were almost within the standard range (0.4 to 0.7 g/cc) [14]. Porosity of the compost samples ranged from 49.21 to 60.22 percent (Table 1A). Water holding capacity values were 215.15, 212.04, 231.21 and 197.24 percent respectively in case of VC, BD, IC and NOV compost samples may be placed in the high value range (standard range of 100 to 200 with preferred value of >100) as [13]. The water holding capacity may be attributed to the abundance of humus particles in the compost [7] and higher water holding capacity may indicate presence of higher humus type materials in the samples. Application of compost with higher water holding capacity helped in retaining soil moisture during the dry months [15].

3.1.2 PHYSICOCHEMICAL PARAMETERS OF THE COMPOST SAMPLES

The predominant use of compost is to mix it with soil to form a good growing medium for plants, for which pH forms an important criteria of consideration . pH value were 6.81, 7.42, 7.14 and 7.52 respectively in case of VC, BD, IC and NOV compost indicate that Biodynamic and Novcom compost samples were well within the stipulated range (7.2 to 8.5) for good quality and mature compost [16]. The soluble salt concentration (reflected by the electrical conductivity values) is an important parameter, which indicates the nutrient status of compost. Very high concentration of soluble salts in the plant growth medium is detrimental to germinating seeds and to plant growth, whereas very low electrical conductivity value indicates low nutrient status / poor quality compost. Electrical conductivity value of all the compost samples were ranged between 1.47 and 2.02 dSm⁻¹, indicating its high nutrient status at the same time being safely below (< 4.0 dSm⁻¹) the stipulated range for saline toxicity as per USCC, 2002 [13]. However comparatively higher EC value in case of Novcom compost may indicate comparatively higher nutritional status within the compost (table 1A).

Table 1A : Quality parameters of different compost (Pooled data of 3 samples from each type of compost).

Sl. No.	Parameter	Analytical Value			
		Vermi compost	Biodynamic compost	Indigenous compost	Novcom compost
Physical Parameters					
1.	Moisture percent (%)	51.42	54.2	45.23	58.78
2.	Bulk density (g/cc)	0.71	0.62	0.58	0.55
3.	Porosity (%)	51.08	49.21	51.46	60.22
4.	WHC ¹ (%)	215.15	212.04	231.21	197.24
Physicochemical Parameters					
5.	pH _{water} (1 : 5)	6.81	7.42	7.14	7.52
6.	EC (1 :5) dS/m	1.51	1.62	1.47	2.02
7.	Total Ash Content (%)	52.14	49.05	50.26	52.32
8.	Total Volatile Solids (%)	47.86	50.95	49.74	47.68
9.	Organic carbon (%)	26.59	28.31	27.63	26.49
10.	CEC (cmol(p+) kg^{-1})	146.87	187.65	168.98	198.45
11.	CMI ²	1.96	1.73	1.82	1.98
12.	Sorption capacity index	5.52	6.63	6.12	7.49
Fertility Parameters					
13.	Total nitrogen (%)	1.71	1.84	1.68	2.16
14.	Total phosphorus (%)	0.67	0.70	0.59	0.81
15.	Total potassium (%)	0.78	1.02	0.69	1.01
16.	C/N ratio	15.55	15.38	16.45	12.26

¹WHC : Water holding capacity; ²CMI : Compost mineralization index

The organic matter in compost is a necessary parameter for determining the compost application rate, to obtain sustainable agricultural production. Organic carbon content in all the compost samples ranged between 26.49 and 28.31 percent, qualifying not only the criteria for field application (16 to 38) as per the range suggested by USCC (2002) [13] but also the standard suggested value of >19.4 percent [17] for nursery application. Ash content of the compost samples varied from 49.05 to 52.32 percent while volatile solids ranged from 47.68 to 50.95 percent. CEC is one of the most important properties of compost and is usually closely related to fertility. The CEC of compost indicates the relative presence of organic colloids, having high exchange capacity in the range of 100 to 200 meq/100g of compost. Cation exchange capacity of different compost samples ranged between 146.87 and 198.45 cmol (p+)kg⁻¹, where the higher value obtained in case of Novcom compost followed by biodynamic and indigenous compost. Compost mineralization index (CMI) expressed as ash content/ oxidizable carbon indicated the ready nutrient supplying potential of compost for plant uptake [11]. The CMI values of the compost samples were varied from 1.73 to 1.98 indicate that all the values obtained complied the standard range (0.79 to 4.38) [18]. Sorption capacity index, reflected the degree of maturity of specific humic compounds [19] and in compost samples varied within 5.524 and 7.492 once again qualifying the criteria(>1.7) for well humified compost as described [20].

3.1.3 NUTRIENT CONTENT IN THE COMPOST SAMPLES

Although 36 different nutrients are required for plant growth, but the macronutrient (N, P, and K) contribution of compost is usually of major interest [21]. Among the different macronutrients, availability of nitrogen to the plants is most complex. Nitrogen may be present in two significant inorganic forms NO₃⁻-N and NH₄⁺-N. Immature compost will contain more ammonium-nitrogen than mature compost. The inorganic nitrogen forms are immediately available source for absorption by plants while the availability of the organic form depends on how rapidly the microorganisms break down the compost [22]. The total nitrogen content in the compost samples ranged between 1.71 and 2.16 percent, which was well above the reference range (1.0 to 2.0 percent) suggested by [23, 24]. The highest content of Nitrogen (2.16 percent) obtained in case of Novcom compost might indicate higher fixation of atmospheric N within compost heap during Novcom composting process [1]. Total Phosphate (0.59 to 0.81 percent) and total potash content (0.69 to 1.02 percent) were also higher than the

minimum suggested standard (0.6 to 0.9 percent and 0.2 to 0.5 percent respectively) by [23, 24]. Total phosphate content was found to be highest in Novcom compost (0.81 percent) followed by Biodynamic compost (table 1B).

Table 1B : Quality parameters of different compost (Pooled data of 3 samples from each type of compost).

Sl. No.	Parameter	Value			
		Vermi compost	Biodynamic compost	Indigenous compost	Novcom compost
Ready Nutrient Supplying Potential					
17.	Water soluble carbon (%)	0.201	0.158	0.301	0.342
18.	Water soluble inorganic N (%)	0.067	0.093	0.064	0.137
19.	Water soluble organic N (%)	0.042	0.036	0.057	0.071
20.	Organic C/N ratio	4.79	4.39	5.28	4.82
21.	Humification ratio	0.008	0.006	0.011	0.013
Microbial Parameters (per gm moist soil)					
22.	Total bacterial count ³	57 x 10 ¹²	69 x 10 ¹²	53 x 10 ¹²	67 x 10 ¹⁶
23.	Total fungal count ³	29 x 10 ¹⁰	34 x 10 ¹²	54 x 10 ¹¹	34 x 10 ¹⁶
24.	Total actinomycetes ³ count	18 x 10 ¹⁰	23 x 10 ¹¹	23 x 10 ¹¹	17 x 10 ¹⁴
25.	Total ammonifiers ⁴	5.4 x 10 ⁷	5.9 x 10 ⁸	2.42 x 10 ⁸	2.2 x 10 ¹²
26.	Total nitrifiers ⁴	23 x 10 ⁷	31 x 10 ⁷	13 x 10 ⁷	3.1 x 10 ¹²
27.	Total PSB ⁴	17 x 10 ⁸	22 x 10 ¹⁰	19 x 10 ¹⁰	11 x 10 ¹²
28.	MBC ⁴ (%)	0.48	0.87	0.56	1.01
Stability Parameters					
29.	CO ₂ evolution rate (mgCO ₂ -C/g OM/day)	1.98	2.31	2.56	3.92
Maturity & Phytotoxicity Parameters					
30.	NH ₄ ⁺ - Nitrogen (%)	0.024	0.032	0.015	0.027
31.	NO ₃ ⁻ - Nitrogen (%)	0.043	0.061	0.049	0.11
32.	Nitrification Index	0.56	0.52	0.31	0.25
33.	Seedling emergence (% of control)	94.34	96.44	90.14	106.52
34.	Root elongation (% of control)	92.84	98.72	94.37	102.31
35.	Germination index (phytotoxicity bioassay)	0.88	0.95	0.85	1.09

³Count in MPN method.;⁴MBC : Microbial biomass carbon

(0.70 percent). However total potash content was highest in case of Biodynamic compost (1.02 percent) closely followed by Novcom compost (1.01 percent). Hence, the analytical value obtained may indicate intense biodegradation in case of Novcom compost resulting in minimum loss and appreciation of initial value (in case of N) contribute to the comparatively higher nutrient in the final compost samples (Fig 6) as also observed by [10, 3, 25, 26].

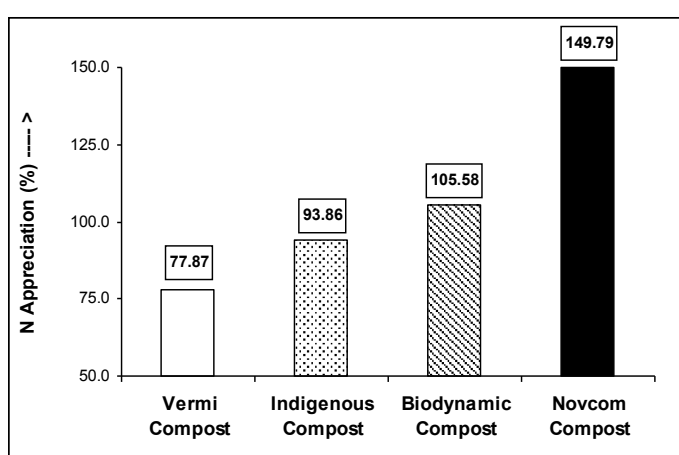


Fig 6 : Appreciation of total N value in final compost under different composting methods at Maud T.E.

The finding might provide an indirect indication of the fixation of atmospheric N within the compost heap by the autotrophic micro organisms generated during the composting process [1]. According to de de Bertoldi *et al* [27,28], an increase in the population of N-fixing bacteria in the later phase of composting, can be attributed to the increase in the value of total N in compost, despite volatilization (primarily) losses from compost heap during biodegradation.

The ideal C/ N ratio of any mature compost should be about 10, as in humus; but it can be hardly achieved in composting

[29]. However, of greater importance is its critical value (C/N ratio 20), below which further decomposition of compost in soil did not require soil nitrogen, but released mineral nitrogen into the soil [30]. C/N ratio varied from 12 : 1 in case of Novcom compost and 17 : 1 in case of Indigenous compost indicate all the compost samples were mature and suitable for soil application.

3.1.4 Ready nutrient supplying potential of the compost samples.

The water soluble forms of carbon and nitrogen representing the plant available forms, increased during compost maturation phase [31, 32]. In the different compost samples water soluble carbon, varied from 0.158 to 0.342 percent, water soluble inorganic nitrogen ranged from 0.064 to 0.137 percent while water soluble organic nitrogen varied between 0.036 and 0.071, percent. Organic C/N ratio in compost water extract is considered to be one of the important index for compost maturity [16, 33, 15]. The values (4.39 : 1 to 5.28 : 1) obtained for compost samples were almost within the stipulated range of 5:1 to 6:1 as proposed by [34, 33].

3.1.5 MICROBIAL PARAMETERS OF COMPOST SAMPLES

Most organic substrates draw an indigenous population of microbes from the environment [25]. In case of open-air composting processes, further colonization occurs naturally within compost material during heap construction as well as turning of heap [35]. The microbial population (in order of 10^{16} cfu in case of total bacteria, total fungi and total actinomycetes count) in Novcom compost samples was significantly higher (at least 10^4 to 10^6 cfu times) than the population obtained in case of compost samples (Table 1B). The population of ammonifiers, nitrifiers and phosphate solubilizing bacteria (PSB) was also evaluated and varied between 5.4×10^7 & 2.2×10^{12} , 13×10^7 & 3.1×10^{12} and 17×10^8 & 11×10^{12} respectively. The population of ammonifiers, nitrifiers and phosphate solubilizing bacteria (PSB) was also distinctly higher in the Novcom compost as compared to the other compost as also observed by Bera *et al*, [11]. Such high microbial status of Novcom compost was also of special significance considering that they were not exogenous inoculation but self-generated during Novcom composting process. In this context, of special significance is the high population of nitrifiers within Novcom compost, which might indicate that nitrites have been transformed into nitrates, an indicator of a high degree of compost stabilization [36]. At the same time comparatively higher nitrogen converters in the compost samples may influences in the comparative higher appreciation of the nitrogen value within Novcom compost sample. Measurement of the microbial biomass is considered as an indicator of bio-maturity [30]. The values obtained for the different compost samples (0.48 to 1.01) were well within the critical limit of < 1.7 percent for compost maturity/ stability [37].

3.1.6 STABILITY, MATURITY AND PHYTOTOXICITY PARAMETERS OF COMPOST SAMPLES

Stability of compost sample indicated the status of organic matter decomposition and is a function of biological activity. Hence, microbial respiration formed an important parameter for determination of compost stability [38]. Mean respiration or

CO₂ evolution rate of all composts (1.98 to 3.92 mg/day) was more or less within the stipulated range (2.0 - 5.0) for stable compost [7, 39]. The value obtained was also in close conformity to the respirometry stability class rating of U.S Composting Council (2002) for compost stability [40]. Free ammonia released from decaying organic matter inhibited seed germination [41, 42, 43] delayed shoot growth [44] and root elongation processes. Analytical interpretation of all the compost samples revealed that it satisfied the critical limit (< 0.04 %) for NH₄⁺- N [45] and (> 0.03 %) for NO₃⁻- N [46]. The nitrification index (ratio of NH₄⁺- N/ NO₃⁻-N) ranged between 0.25 and 0.56, which was in optimum conformity with the standard reference range (0.03 to 18.9) for compost maturity [34, 13]. Most importantly the ratio was even much below the stipulated safety limits (< 7.14) for application in Nursery beds [17].

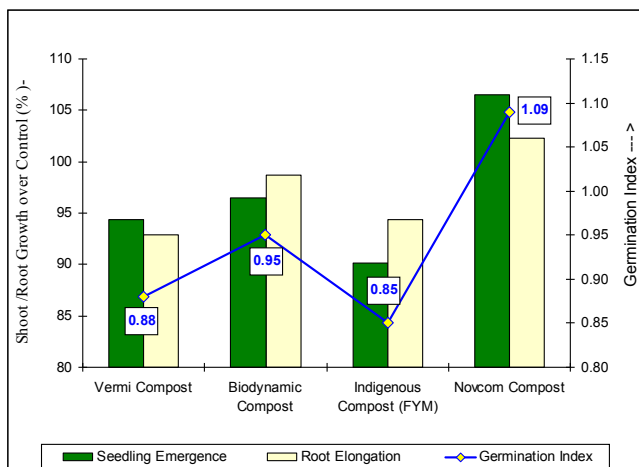


Fig 7 : Comparative study of Seedling Emergence, Root Elongation and Germination Index in different compost prepared at Maud T.E.

The phytotoxicity bioassay test, as represented by germination index provided a means of measuring the combined toxicity of whatever contaminants may be present [47]. The test value indicated that total absence of any phytotoxic effect in Vermi compost, Biodynamic compost, Indigenous compost and Novcom compost (fig 7) as per the standard value of 0.8 to 1.0 [7]. At the same time germination index value of >1.0 as obtained in case of Novcom compost indicated not only the absence of phytotoxicity [48] in the compost but moreover, it confirmed that the compost enhanced rather than impaired germination and radical growth [7].

3.1.7 FORMULATION OF COMPOST QUALITY INDEX (CQI)

In order to classify the different types of compost, four specific quality parameters (which were combination of one or more properties that regulate the nutrient mineralization from compost as well as its post soil application effectivity) were taken up to formulate Compost Quality Index (CQI) as per the formula [10]

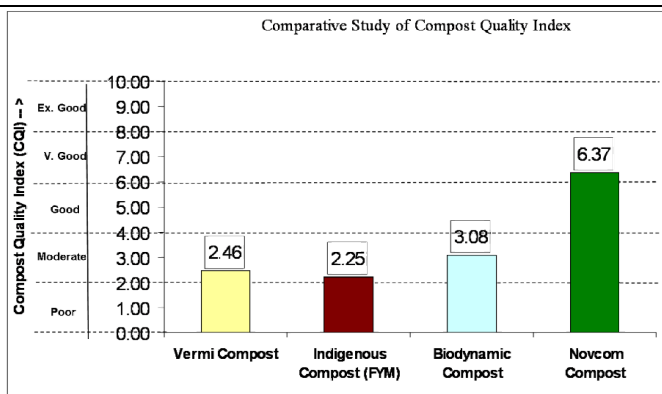


Fig 8 : Quality rating of different compost as per Compost Quality Index.

Average CQI values obtained for different types of compost (Fig 4) revealed highest rating of Novcom compost (average CQI: 6.37) followed by Biodynamic compost (average CQI: 3.08), vermicompost (average CQI: 2.46) and Indigenous compost (average CQI: 2.25) (fig 8). Evaluation of end product quality indicated that though all the compost samples attained the desired stability and maturity Novcom compost was found to exhibit relatively higher potential as compared to the other composts especially in terms of it's high content of self-generated microbial population.

3.1.8 ECONOMICS OF COMPOST PREPARATION UNDER DIFFERENT COMPOSTING PROCESS

Economics of the compost preparation under different composting method has been calculated with the data provided by the Garden authority, Maud T.E. As per the calculation unit cost of compost preparation is lowest in case of Novcom compost (Rs 0.96/- per kg) followed by Indigenous compost (Rs. 1.15/- per kg), Biodynamic compost (Rs. 1.24/- per kg). The cost of Vermi compost preparation was highest among the composting method and the unit cost was Rs. 2.09/- per kg (Table 2). Variation in unit cost of total NPK in the end product under different composting methods was given in fig 9

Table 2 : Comparative evaluation of cost component under different composting method.

Parameters	Vermi compost	Biodynamic Compost	Indigenous Compost	Novcom compost
Size of heap	300 cft	240 cft	480 cft	360 cft
Time of composting	60-75 days	80 – 90 days	80 – 90 days	21 - 30 days
Recovery percent	49.23	57.73	51.11	69.11
Mandays required/heap	6.5	6.5	9.0	13.2
Raw materials for heap construction.	2600 kg	2200 kg	2700 kg	4500 kg
Cost of raw materials/heap	Rs 800/-	Rs. 655/-	Rs. 780/-	Rs. 1275/-
Cost of other component /heap	Rs. 1290/-	Rs 435/-	-	Rs. 525/-
Cost of mandays/heap	Rs. 579/-	Rs. 579/-	Rs. 801/-	Rs. 1175/-
Total cost/kg	Rs. 2.09/-	Rs. 1.24/-	Rs. 1.15	Rs. 0.96/-

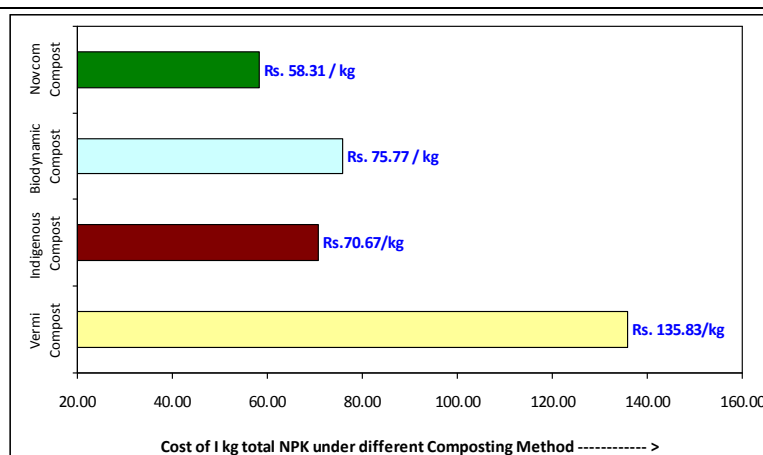


Fig 9 : Variation in unit cost of macro nutrients in the end product under different composting methods at Maud T.E., Assam.

Along with compost quality, cost of compost is the most important criteria for its adoption by the tea planters, considering that cost of soil input comprises 60 to 80 percent of the total expense made on inputs. Cost of 1 kg NPK was lowest in case of Novcom compost (Rs. 58.31/kg) followed by Indigenous compost (Rs. 70.67 /kg), Biodynamic compost (Rs. 75.77/kg made tea) and vermi compost (Rs. 135.83/ kg made tea). The comparatively higher cost of vermi compost is perhaps the most limiting factor towards its large scale application.

3.2 ANALYSIS OF SOIL QUALITY DEVELOPMENT

3.2.1 VARIATION IN PHYSICO-CHEMICAL AND FERTILITY PARAMETERS OF SOILS

Variation in physico-chemical and fertility parameters of soils in terms of pH, electrical conductivity, organic carbon, cation exchange capacity and available NPKS were studied before and one year post application of compost (Table 4). The soils of all the experimental plots were moderately acidic in reaction pH varying from 4.60 to 4.82 which was within the recommended soil pH (5.0-5.6) for tea cultivation [49]. After application of compost, pH of the soil samples was found to increase as compared to their control counterpart. Though the increase in pH value with application of compost is not so much significant (percent increase varied within 0.29 to 0.57 percent except in control plots), but it will be important with respect to the conventional garden, where increase of soil acidity was often noticed after application of chemical fertilizers

which needs corrective management in regular basis. According to the observation of Oh et. al. [50] application of heavy nitrogen (N) caused serious soil acidification (77% of 70 tea fields having pH below 4.0) Thus, increase in soil pH after application of compost is important, as very low pH is often harmful for the tea plants. Low pH led to the increased uptake of nutrient elements like Fe, Mn, Al etc., which could prove toxic to tea in the long run [51]. Besides this low pH of soils is known to reduce the population of earthworms, which are essential for biological activities in tea soils, especially where soil rejuvenation is sometimes not possible for even as long 100 years.

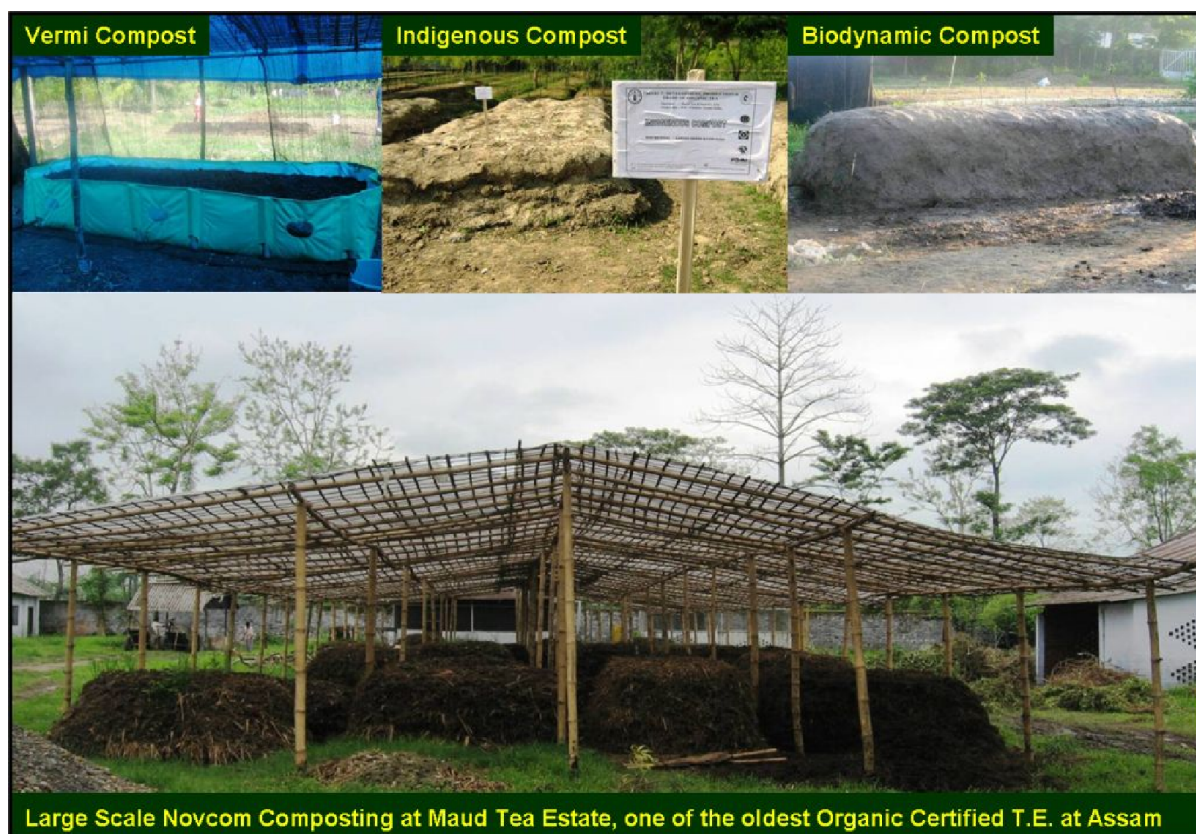


Fig 10: Different compost prepared using garden weeds as raw material in Maud Tea Estate, Dibrugarh, Assam under FAO-CFC-TBI Project.



Fig 11 : Prof. A. K. Dolui and Prof. R. K. Sarkar of Calcutta University inspecting the tea plantation at Maud T.E., Assam under FAO-CFC-TBI Project.

Electrical conductivity (EC) of the soil (except in salt affected problematic soil) reflects the fertility of the soil. EC value of the experimental plots increases with the application of compost might be the indication of release of nutrient from compost sources in soil. The CEC of the soil samples were of low to medium range (according to the range suggested by Ilaco, [52] varying between 10.59 and 12.01 $\text{cmol (p}^+ \text{)kg}^{-1}$). Increase in the CEC value was noticed with the application of compost and the percent increase was highest with Novcom compost applied experimental plots followed by Indigenous, Vermi and Biodynamic compost applied experimental plots. Increasing trend of CEC value in the different experimental plots over control post compost application indicated the upliftment of soil fertility with application of compost (table 3).

Table 3: Variation of Soil Physico-chemical and Fertility Parameters in Acid Tea Soils under different Compost Application at Maud Tea Estate, Assam.

Soil Quality Parameters	Treatment Plots				
	Control Plots	Vermi Compost Applied Plots	Biodynamic Compost Applied Plots	Indigenous Compost Applied Plots	Novcom Compost Applied Plots
pH (H ₂ O)	4.61 (4.60)	4.57 (4.60)	4.66 (4.67)	4.75 (4.78)	4.67 (4.70)
EC (dSm ⁻¹)	0.024 (0.024)	0.022 (0.023)	0.033 (0.034)	0.045 (0.046)	0.046 (0.047)
CEC cmol(p+)kg ⁻¹	10.63 (10.67)	11.98 (12.14)	10.86 (10.98)	11.69 (11.87)	11.83 (12.02)
Org. C (%)	0.74 (0.74)	1.00 (1.07)	1.09 (1.11)	1.21 (1.23)	1.22 (1.25)
Av. N (kg ha ⁻¹)	299.8 (296.3)	401.8 (405.1)	399.4 (408.0)	410.3 (414.7)	413.2 (427.3)
Av. P ₂ O ₅ (kg ha ⁻¹)	29.9 (28.0)	47.7 (50.6)	52.4 (55.8)	42.2 (46.1)	60.6 (66.4)
Av. K ₂ O (kg ha ⁻¹)	143.0 (139.8)	176.5 (177.3)	177.7 (180.0)	190.4 (194.1)	183.5 (193.4)
Av. SO ₄ ²⁻ (kg ha ⁻¹)	18.3 (19.5)	36.1 (38.2)	39.0 (40.2)	41.2 (41.8)	43.8 (47.8)

The organic carbon content in the experimental plots ranged from 0.73 to 1.26 percent and except control in all the cases, increase in soil organic carbon is noticed with application of compost. The percent increase in the organic carbon varied within 1.52 to 2.56 except in control plots and there is not too much variation in percent organic carbon increase among the compost treated experiment plots. Available- N status in soils of the experimental plots were medium [53] and ranged between 286.7 and 412.3 kg ha⁻¹. Except in control plots, the available- N status was found to increase in the different experimental plots after application of compost and the percent increase was highest (3.42 percent) in case of Novcom compost applied plots in comparison to others. The availability of phosphorous is one of the most limiting factors in acid tea soils as the available phosphate gets fixed with Fe³⁺ and Al³⁺ ion in acid atmosphere, thereby remaining unavailable for plant uptake [54]. Therefore, increase in the availability of phosphate in acid tea soil is the most challenging task. Available phosphate in the experimental plots were of medium status [53] and ranged between 28.3 and 61.2 kg ha⁻¹. After one year of compost application, available phosphate status increased in the different experimental plots (except in control plots), which might indicate the positive influence of the compost towards higher availability of phosphate in acid tea soils. The effect might be due to the application of compost in soil, which reduced the capacity of soil minerals to fix P and increased its availability through release of organic acids [55, 56]. Available potash varied within 140.2 and 194.3 kg ha⁻¹ in the experimental plots. After compost application slight increase in potash status was observed in almost all the experimental plots (with few exceptions). Similar post compost application effects were also obtained by several workers [56, 57].

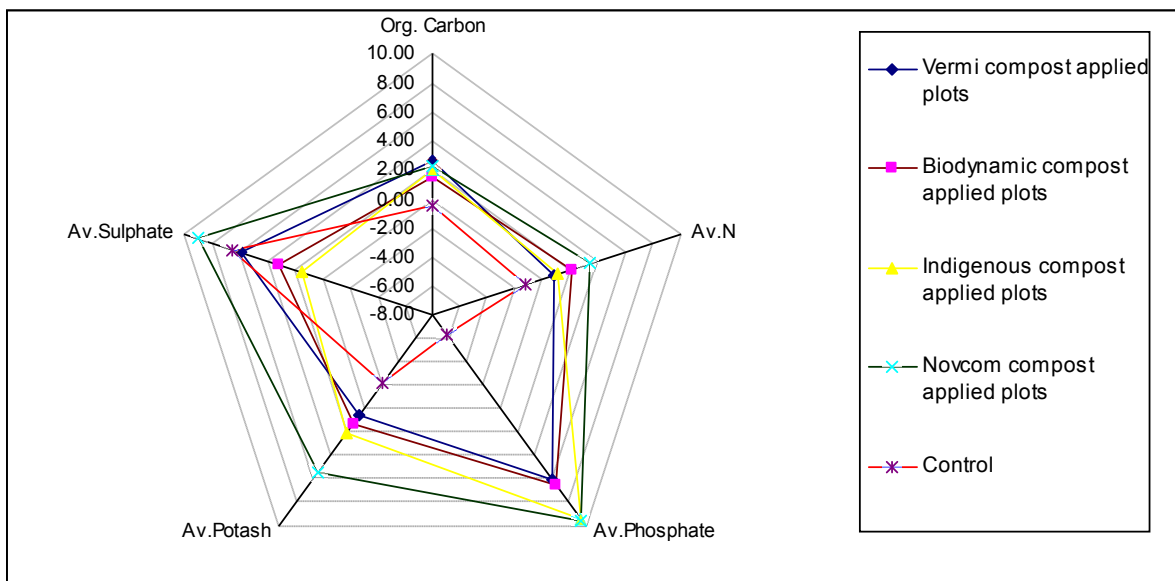


Fig 12 : Cobweb Polygons (Spider Diagrams) for displaying comparative change in soil fertility post application of different compost at Maud Tea Estate, Assam.

Available sulphate varied between 16.5 and 47.6 kg ha⁻¹ in the experimental plots. After one year of compost application, available sulphate status increased slightly in all the experimental plots, which indicated the favourable influence of compost towards higher sulphate availability in acid tea soils. Trend of availability of major soil nutrients (NPKS) after compost application indicated that maximum increase was noticed in totality in case of Novcom compost applied experimental plots (4.81 percent) followed by Biodynamic and Indigenous compost applied experimental plots (2.32 and 1.85 percent respectively). These developments might be due to the high quality as well as very high self generated microbial status of Novcom compost resulting positive influence in activating soil nutrient dynamics in comparatively speediest way.

3.2.2 VARIATION IN SOIL MICROBIOLOGICAL PARAMETERS

Microbial activity is probably the most important factor that controls nutrient re-cycling in soil. Microorganisms participate in disintegration and decomposition processes leading to the release of nutrients trapped in plant and animal debris, rock and minerals as well as synthesize and release hormones that are essential for plant growth [58]. Soil microbial population in terms of total bacteria, fungi, actinomycetes and phosphate solubilizing bacteria (PSB) were studied for the different treatment plots in order to assess changes in their population before and one year post compost application (table4). The results obtained are given (log₁₀ values) in table 6. In general, soil microbial population (irrespective of any specific type) was found to increase

Table 4: Variation of Soil Microbial Population in Acid Tea Soils under different Compost Application at Maud Tea Estate, Assam.

Soil Quality Parameters	Treatment Plots				
	Control Plots	Vermi Compost Applied Plots	Biodynamic Compost Applied Plots	Indigenous Compost Applied Plots	Novcom Compost Applied Plots
Total Bacterial Count	6.324 (6.409)	8.242 (8.472)	8.111 (8.440)	8.071 (8.301)	8.071 (8.595)
Total Fungal Count	4.448 (4.483)	4.898 (5.013)	4.687 (4.967)	4.813 (5.027)	4.882 (5.039)
Total Actenomyces Count	4.464 (4.399)	5.010 (5.056)	4.760 (4.914)	4.669 (4.773)	4.808 (5.270)
Total Phosphate Solubilizing bacterial Count	4.418 (4.326)	4.966 (5.119)	4.943 (5.029)	4.919 (5.050)	5.013 (5.384)

in post application (one year) of organic soil inputs in all the treatment plots, with few exceptions. Similar observation was made by other workers [59] in their study, post application of organic soil amendments in soil. However increase in microbial pollution with application was found to be highest in case of Novcom compost applied plots with respect to other compost applied plots which might be due to the very high self generated microbial population in the Novcom compost. It was significant in terms of regeneration of soil microflora in acid tea soils. Development of soil microbial population with application of Novcom compost was also observed by several workers [3, 60, 61, 62]

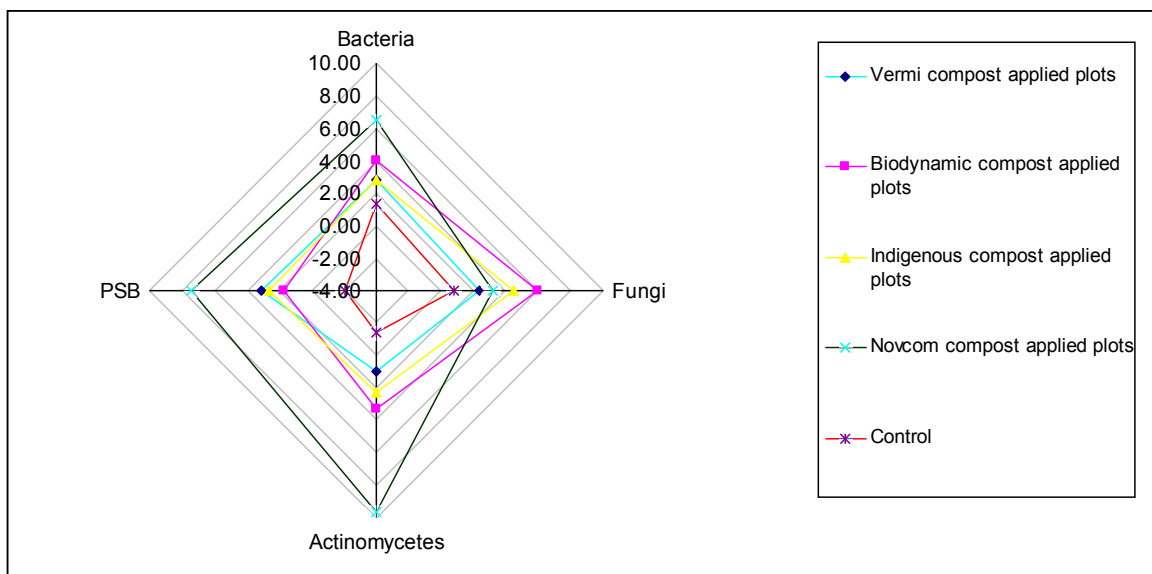


Fig 13 : Cobweb Polygons (Spider Diagrams) for displaying comparative change in soil microbial population post application of different compost at Maud Tea Estate, Assam.

3.3 CROP RESPONSE UNDER DIFFERENT COMPOST APPLICATION

Crop response in terms of green leaf production (Fig 8) in different experimental plots with the application of different compost was recorded (during 2011-12) and it was highest in case of Novcom compost applied experimental plots (9627 kg/ha) followed by Vermicompost (9208 kg/ha), Indigenous (8474 kg/ha) and Biodynamic (8356 kg/ha) compost applied Plots (fig. 14). Crop yield in the Novcom compost applied plots were 31.45 % higher than that of Control plots followed by others.

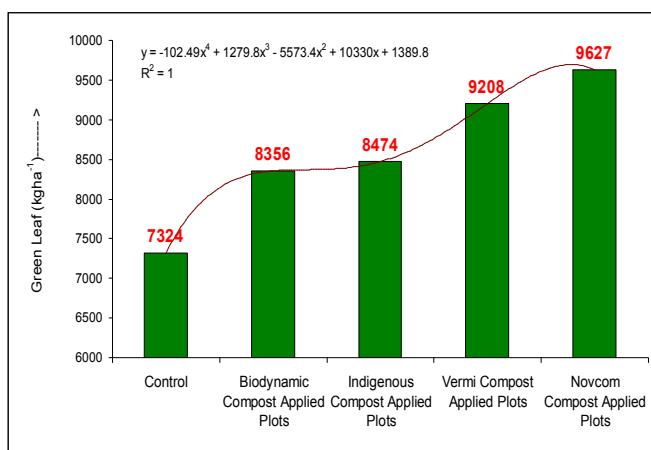


Fig 14 : Crop yield of new tea plantation (2+ year age) in terms of green leaf under application of different compost at Maud T.E.



Fig 15 : Young Tea Plantation in the Novcom compost applied plots at Maud T. E.

Information on relative agronomic effectiveness (RAE) of tea plantation under various available organic soil inputs could assist in selection of proper input thereby leading to economic crop production. Relative Agronomic Effectiveness (RAE) i.e. comparative effectivity of different treatments with respect to the best performer (Novcom compost in this case) [63], indicated that only one treatments i.e. vermin compost applied plots scored highly (RAE: 81.78 %) while rest all others obtained values lower than 50 percent.

3.4 INTERRELATION BETWEEN CROP YIELD AND SOIL QUALITY PARAMETERS.

To evaluate the interrelationship between crop response and soil quality parameters, total 12 soil parameters (analyzed during this study) were correlated with crop yield and 10 soil quality parameters were found to be positively and significantly correlated crop yield. As per the data revealed from table 7, crop yield was positively and significantly correlated with organic carbon (0.648***), CEC (0.501*), available N (0.536*), available P₂O₅ (0.590**), available potash K₂O (0.469*), available SO₄ (0.585**), total bacterial count (0.607**), total fungi count (0.615*), total actinomycetes count (0.694***) and PSB (0.646**). The study indicated that improvement of these soil quality parameters might influence the crop performance and regular application of quality compost helped to improve soil quality (table 5).

Table 5 : Correlation coefficient between Yield and soil quality parameters.

	pH	0.050		Av. K ₂ O	0.469*
	EC	0.356		Av. SO ₄ ²⁻	0.585**
Crop Yield	Org. C	0.648**	Crop Yield	Bacteria Count	0.607**
Vs	CEC	0.501*	Vs	Fungi Count	0.615**
	Av. N	0.536*		Actinomycetes count	0.694***
	Av. P ₂ O ₅	0.590**		PSB	0.646**

*** Significant at 1% level; ** Significant at 5 % level; *Significant at 10 % level

3.5 RELATIONSHIP AMONG DIFFERENT SOIL QUALITY PARAMETERS

Relationship among soil quality parameters are given in table 8. Soil pH is one of the important components of soil quality. Especially in acid soil, minor change in soil pH affects nutrient availability. Soil pH was positively and significantly correlated with electrical conductivity (0.745***), organic carbon (0.645***), available potash (0.623**) and available-sulphate (0.486*). Soil CEC was also highly and positively correlated with available nutrient and microbial population.

Significant and positive correlation among soil available nutrient and soil microbial population (table 6) indicated their role in the availability of soil macro nutrients and the phenomenon in acid tea soil has a significant impact on crop productivity.

Table 6 : Correlation coefficient among different soil quality parameters.

Soil Quality Parameters	pH	CEC	Org. C	Av. N	Av. P ₂ O ₅	Av. K ₂ O	Av. SO ₄ ²⁻	Bacteria	Fungi	Actino
CEC	0.285									
Org. C	0.645**	0.725***								
Av. N	0.464	0.734***	0.944***							
Av. P ₂ O ₅	0.280	0.592**	0.830***	0.857***						
Av. K ₂ O	0.623**	0.709***	0.970***	0.956***	0.792***					
Av. SO ₄ ²⁻	0.486*	0.693***	0.930***	0.939***	0.865***	0.938***				
Bacteria	0.372	0.732***	0.905***	0.977***	0.869***	0.906***	0.914***			
Fungi	0.397	0.743***	0.857***	0.945***	0.792***	0.901***	0.862***	0.931***		
Actino ¹	0.078	0.704***	0.720***	0.842***	0.882***	0.751***	0.831***	0.846***	0.831***	
PSB ²	0.307	0.715***	0.828***	0.907***	0.855***	0.894***	0.925***	0.887***	0.919***	0.931***

*** Significant at 1% level; ** Significant at 5 % level; *Significant at 10 % level;¹Actino : Actenomyces, ²PSB : Phosphate solubilizing bacteria.

Hoorman and Islam [64] in their study indicated role of microbes in the availability of soil nutrients. Higher inter-relationship among different soil quality parameters indicates all these function in a harmonized mananer and a comprehensive approach towards soil development can bring the desire effectivity in a short time frame.

3.6 DEVELOPMENT OF SOIL QUALITY INDEX

Soil quality is the capacity of a soil to maintain key ecological functions in order to sustain yield and improve plant health. A fertile soil provides essential nutrients for plant growth and supports a diverse and active biotic community [65]. Soil quality index is a concept to express the overall soil development by quantifying the extent of development of different soil quality indices for easy understanding of the end-users [66]. The soil quality index should be easy to formulate, understandable and must reflect the extent of soil management undertaken and at the same time correlate with crop response.

In case of tea plantations, where there may be significant heterogeneity in the soil character of individual sections, assessment of Soil Quality Index (SQI) can help in the identification of priority areas, which if attended effectively might significantly influence the productivity of entire garden. The SQI was developed using soil physicochemical, fertility and biological parameters. Total 12 soil quality parameters viz. soil pH, EC, organic carbon, C.E.C, Available NPKS, total bacteria, fungi and actinomycetes were analyzed and only those parameters were selected which were significantly correlated with crop yield. The selected 10 quality parameters were organic carbon, available NPKS, total bacteria, fungi and actinomycetes. The analytical values of the selected parameters before initiation of study in 2011 and one year after compost application (i.e. in 2012) were then used as per the following formula [66] to calculate soil quality index for different treatments.

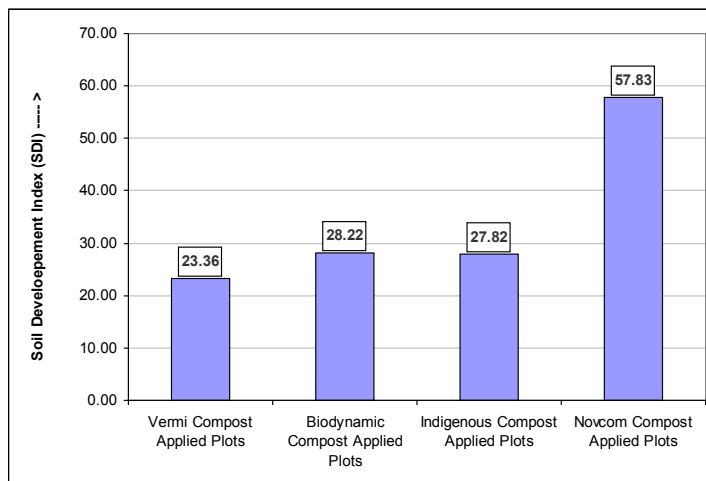


Fig 16: Development of soil quality as indicated by Soil Development Index (SDI) under application of different types of compost.

Soil quality index was highest in case of Novcom compost treated plots (SQI : 57.83) followed by plots receiving Biodynamic (SQI : 28.22), Indigenous (SQI : 27.82) and Vermi (SQI : 23.36) compost (Fig. 9). Soil quality index of Novcom compost applied plots was significantly higher than that of next best performer, which indicated higher potential of Novcom compost over other compost in terms of effective organic soil management in a speedy manner. The finding was further corroborated with crop performance data which showed highest crop yield in the Novcom compost applied plots.

3.7 CORRELATION OF SOIL DEVELOPEMENT INDEX WITH CROP PERFORMANCE

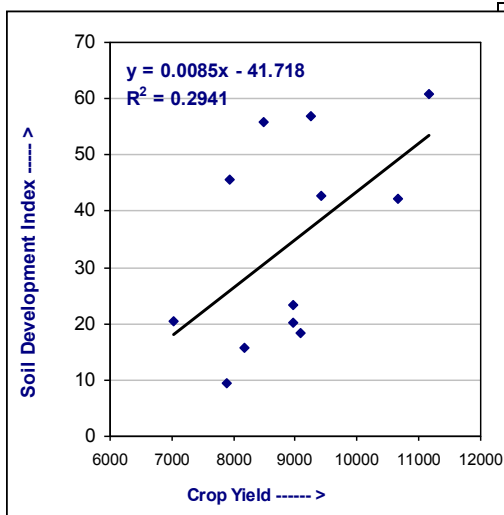


Fig 17 : Relationship between Soil Development Index (SDI) and Crop Yield.



Fig 18 : Microbial Analysis in the Laboratory of Inhana Biosciences as a part of MSc. Project.

Soil development index (SDI) will be representative only if it correlates with respective crop performance. The positive and significant ($r = 0.542^{**}$) correlation of soil quality index with crop performance as obtained in the study, indicated that it can be used as an effective tool to judge the soil quality in relation to crop performance as well as to assess the competence of

the soil management programme undertaken for achieving the desired soil development, especially in acid tea soils. The trend line in the figure 10 also showed a close relationship between soil quality index and crop response.

4. CONCLUSION

Organic soil management is slowly becoming a necessary compulsion not only for organic conversion but also to restrict productivity depletion under chemical farming practice. Organic soil management will be successful only if the focus is shifted from quantitative to qualitative approach. The qualitative approach starts with the selection of good quality organic inputs through laboratory assessment of quality using standard protocol. At the same time development of soil quality index to measure the effectivity of organic management can help in practical assessment and justification of the qualitative approach. In the present study the result indicated that compost helps to improve soil quality and quality of compost played an important role in soil quality development leading to higher crop response.

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A New Approach to Understand the Fundamental Cause of Gravity, and Time Dilation in Special and General Relativity

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ABSTRACT: In present article, the 'space' is considered as a physical entity, and the gravity is discussed as a consequence of equal and opposite interaction between 'mass' and the 'space' around every mass. In order to explain the cause of gravity, a very new concept of *root force* is introduced as a fundamental nature of 'mass' and the 'space' both. The unit of root force is $(\sqrt{m} \sqrt{kg/s})$ or square root of newton. It is learnt that may be, it is a *root force* which gives mass to every particle and make existence possible. The exact nature of *root force* is beyond current understanding of physics. Another new concept of *super-vacuum* (absolute emptiness) is also introduced in this paper. This concept is essential to understand the importance of the 'space'. It is concluded that 'mass' and 'space' shares equal and opposite interaction, which causes gravitation. And magnitude of root force causes time dilation.

KEYWORDS: Gravity, Root force, the 'space', Super-vacuum.

1 INTRODUCTION

Gravity is the most fundamental phenomenon of our universe, and still it is one of the most elusive concepts to understand [1, 2]. Even greatest minds in physics have failed to explain the cause of gravity. The reason for this elusiveness of gravity is probably lies in our ignorance. Something very special, something very fundamental is being ignored.

Right from the beginning of human understanding, it is assumed that the 'space' around us, or in which every mass moves, is infinite, and is there forever. We think that the 'space' around us, around every object, is inert and it has no special role to play. It is a human nature — more common, more ordinary is a thing — less we think about it. The 'space' around us, around every mass is extremely ordinary thing, and therefore we do not think about it at all. We take this 'space' granted. We ignore the concept of the 'space'. And as a result, we failed to understand the importance of it.

If we think our universe as a beautiful painting; the 'space' is a *paper* or a *canvas* on which the creator created his painting. Without paper/canvas or any two dimensional surface, one cannot create a painting. Similarly, without the concept of three dimensional 'space', the universe cannot be created. The 'space' itself is one of the most essential constituent of our universe. It is the 'space', which provides the ultimate structure to our universe. **The 'space' is there so that 'mass' can move inside it. The 'space' is there so that 'mass' can stay in state of 'mass' inside it.** We failed to consider the 'space' as a physical entity. Probably it is our ignorance towards the 'space' because of which we do not comprehend the most fundamental force of nature — Gravity.

2. A NEW APPROACH TO UNDERSTAND THE CAUSE OF GRAVITATION

2.1 ROOT FORCE

Root force is a very new thought for physics. It maybe something which makes existence possible.

Root force is an inherent property or fundamental nature of 'mass' and the 'space' both. Normally, force exerted by one mass over other mass is regular force which is measured in newton. This regular force is seen as a movement or deflection of one body or both bodies. However, **force exerted by 'mass' over 'space' – and – 'space' over 'mass' is a root force.** Unlike regular force, we cannot see or feel root force but it is there. It is probably a root force which gives mass to every particle and makes existence possible. The exact nature of root force is beyond current understanding of physics. The unit of root force is $\sqrt{m}kg/s$ or square root of newton (\sqrt{N}).

Root force can be classified into two kinds: i) mass force and ii) space force. In order to understand the nature of mass force and space force, at this point, it is assumed that every mass itself is a 'mass force' and the 'space' itself is a 'space force'.

2.2 FIRST LAW FOR GRAVITATION

Every 'mass' – and the 'space' around every mass, exerts equal and opposite root force on each other.

This equal and opposite interaction between 'mass' and the 'space' – is fundamental cause for universal gravitation.

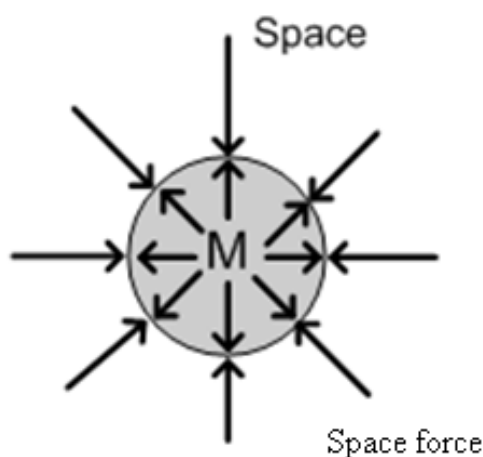


Fig 2.1

Every 'mass' exerts internal root force i.e. mass force in outward direction. The 'space' around that mass however, always exerts equal amount of root force i.e. space force in opposite direction. The result this equal and opposite interaction – is gravity.

When the 'space' exerts equal and opposite root force on mass (as a reaction to mass force), it creates a *gravitational slope* around that mass. When other mass enters in gravitational slope (or sloped space), follows the direction of slope. This notion is quite similar to the *gravitational field*. However, this paper intends to give cause for such gravitational field/slope. Mechanism of gravity is explained in section 2.4 in this paper.

The first law can be interpreted as follows...

**The Space completes the mass,
And the Mass completes the space.**

2.3 SECOND LAW FOR GRAVITATION

Root force exerted by the ‘space’ on any ‘mass’ from any given point in space (point relative to given mass) is directly proportional to that mass and inversely proportional to the distance between the mass and that *space point*.

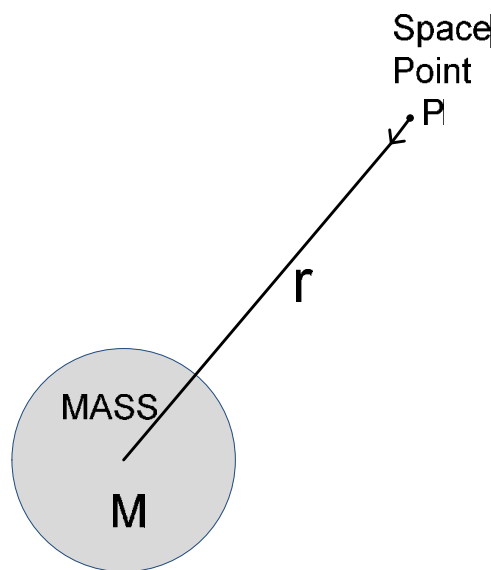


Fig 2.2

Let's have any mass **M** in the ‘space’, and *space point* **P**, any point in space at relative distance **r** from that mass (fig 2.2).

Therefore, root force/space force (**f/N**) at point **P** is given by

$$f/N \propto \frac{M}{r}$$

$$f/N = \frac{SM}{r}$$

Where **S** is constant for space force ... $S = 8.169 \times 10^{-6} \text{ m}^{3/2} \text{ kg}^{-1/2} \text{ s}^{-1}$... (Square root of **G**)

2.4 MECHANISM OF GRAVITY

2.4.1 WHY THINGS FALL DOWN?

The ‘space’ around the earth exerts equal and opposite root force on earth as a reaction to earth’s mass force. When the ‘space’ exerts root force on earth, it creates a gravitational slope around the earth. This gravitational slope of the ‘space’ can be assumed as a flow of water. A piece of a paper thrown in flowing water will follow the direction of water. (Not exactly but) In somewhat similar manner, when other body enters into this gravitational slope, it follows the direction of the slope. The

direction of this slope is the direction of root force exerted by the 'space' i.e. towards the center of earth. It is the 'space' itself because of which things fall down and earth has no direct relationship with it. Whenever physicists encounter the term \sqrt{g} or $\sqrt{-g}$ in their equations, probably they are dealing with this gravitational slope i.e. root acceleration of the 'space' itself. Gravitational slope of the 'space' on surface of earth is directly proportional to square root of mass of earth and inversely proportional to radius of earth. On surface, its value is about $3.13\sqrt{m/s}$. There is no need of another body to understand the gravity.

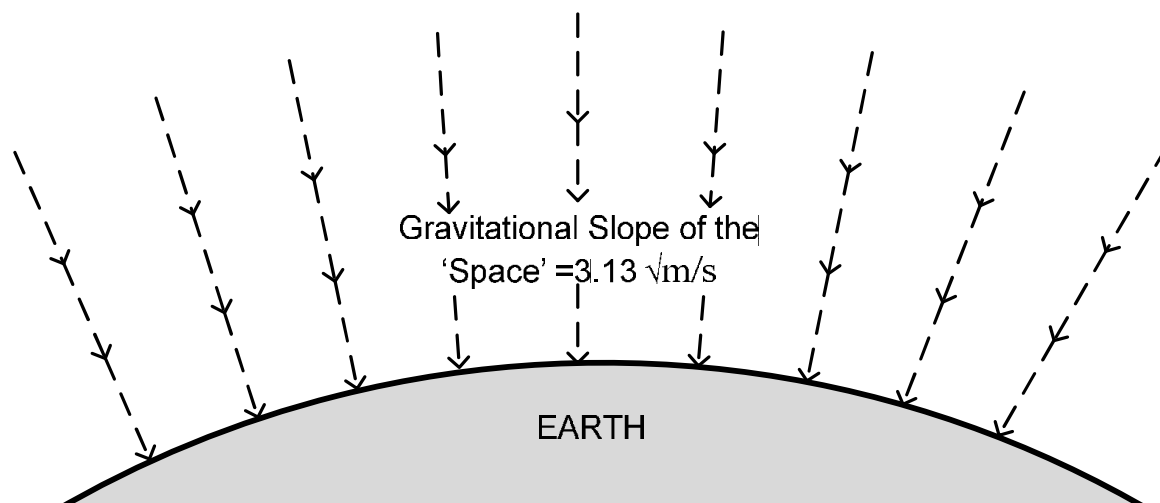


Fig 2.3

2.4.2 EXPLANATION FOR NEWTON'S LAW

Let's have two masses m_1 and m_2 in the 'space' separated by distance 'r' (Fig 2.4). The 'space' around those masses exerts equal and opposite root force on those masses as reaction to their mass forces. While exerting root force, the 'space' creates gravitational slope around those masses. As both masses are in gravitational slope of each other, the sloped 'space' pushes them towards each other. It is the 'space' itself brings both masses closer.

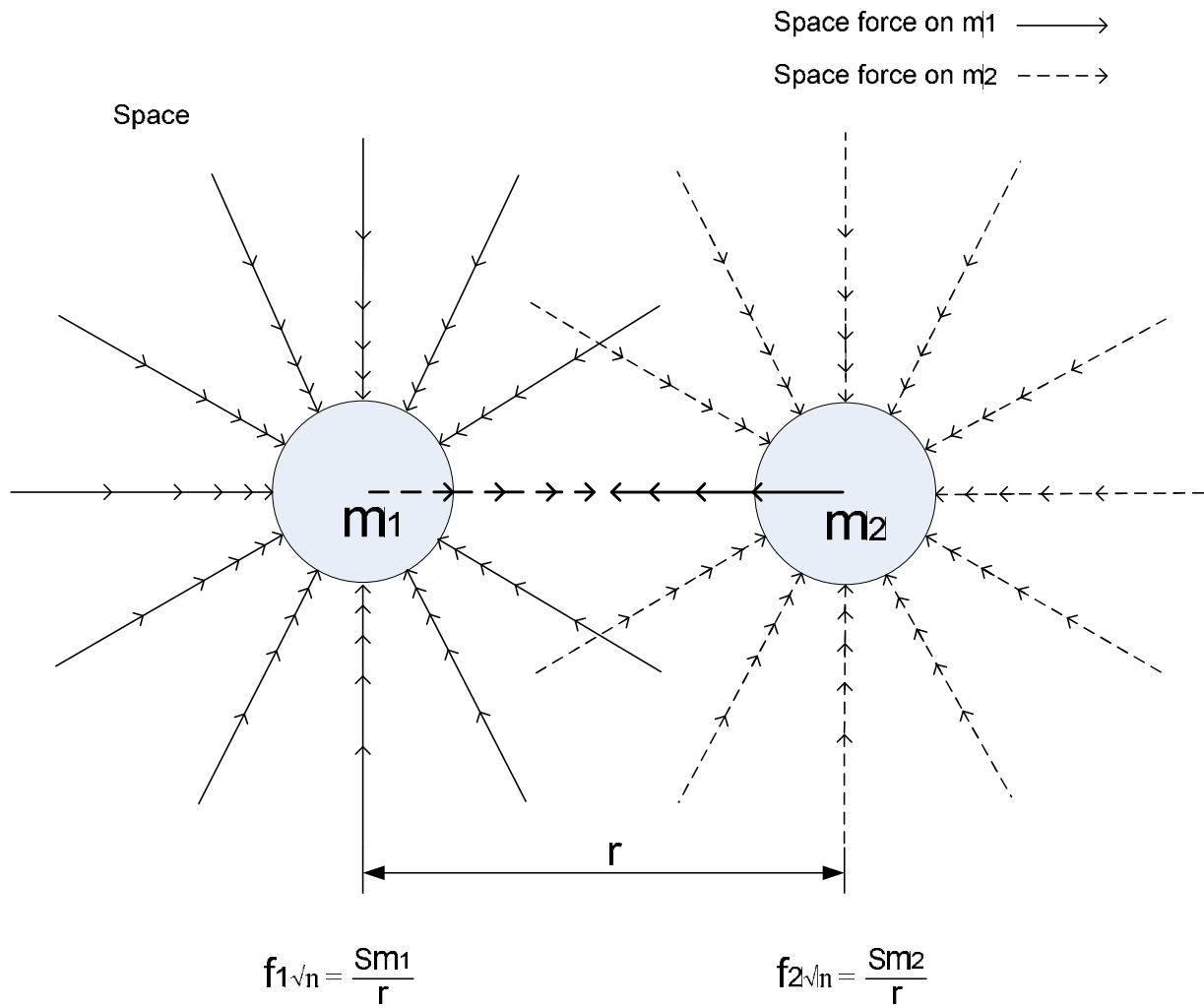


Fig 2.4

By second law of gravitation: root force on body **m1** at distance **r** is-

$$f_{1\sqrt{n}} = \frac{Sm_1}{r}$$

Root force on body **m2** at distance **r** is-

$$f_{2\sqrt{n}} = \frac{Sm_2}{r}$$

Therefore combine force i.e. gravitational force (**F_N**) on these two bodies is given by

$$F_N = f_{1\sqrt{n}} \times f_{2\sqrt{n}}$$

$$F_N = \frac{Sm_1}{r} \times \frac{Sm_2}{r}$$

$$F_N = \frac{S^2 m_1 m_2}{r^2}$$

$$F_N = \frac{G m_1 m_2}{r^2}$$

3. SUPER-VACUUM AND BIG BANG.

3.1 SUPER-VACUUM

Super-vacuum is a thing where root force exerted by the 'space' (i.e. space force) is absent. In other words: *Super-vacuum is an absolute emptiness*. It is a thing or a place where even the 'space' does not exist. The perception of super-vacuum is essential for one very special reason — it tells us importance of the 'space'.

3.2 BIG-BANG, SINGULARITY AND MASS-SPACE CONVERSION

The big bang theory is a widely accepted theory for the origin and evolution of our universe. It proposes that the universe expanded around 13.8 billion years ago from an extremely hot and dense state known as singularity. In this section, the probable cause of expansion of singularity is discussed shortly.

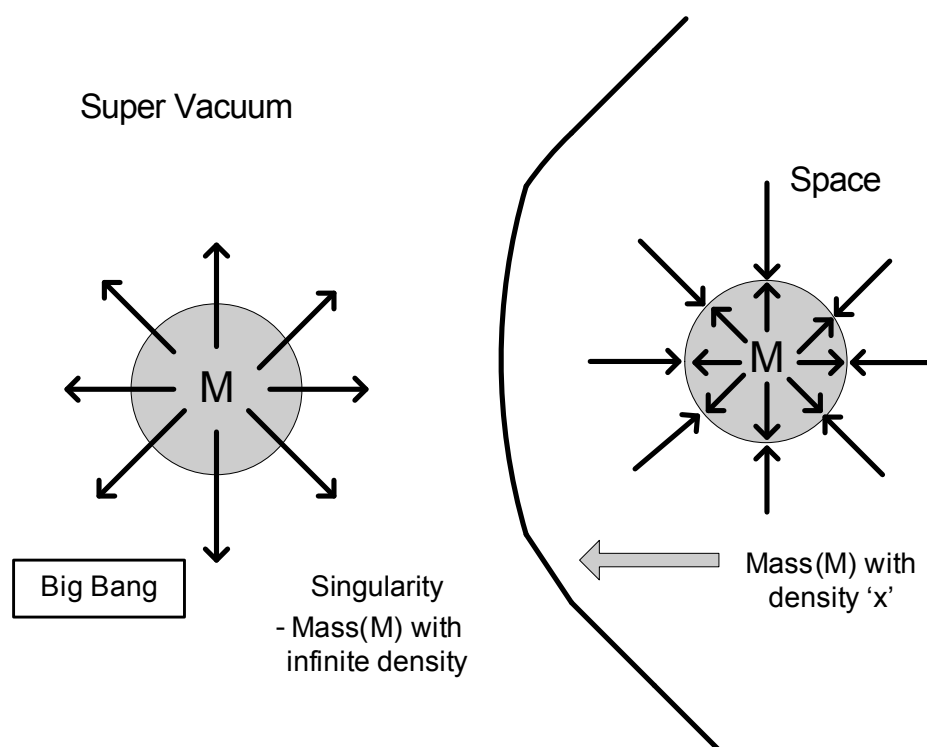


Fig 3.1

When any mass in the 'space' (fig 3.1- at right) enters into super-vacuum (left in fig 3.1), as there is no 'space' in super-vacuum, volume of that mass becomes zero, and therefore density of that mass becomes infinite. This is a state of singularity. As there is no space force to prevent the mass force exerted by mass, the mass expands with great speed, and gives a birth to new universe. As the 'space' is also created with an expansion of mass, probably mass and the 'space' both are forms of the same thing (energy), and may be are inter-convertible.

4. PROBABLE CAUSE OF TIME DILATION IN SPECIAL AND GENERAL RELATIVITY

4.1 TIME DILATION IN SPECIAL RELATIVITY

One of the important properties of the *space* is — it has its own braking mechanism and a speed limit for any mass travelling through it at relatively high speed. Time slows down for the mass which is travelling at relatively high speed. It happens because space exerts more root force on the mass at higher speed. In a reaction to that root force exerted by mass is also increases. This is nothing but relative increase in mass at higher speed (Fig. 4.1)

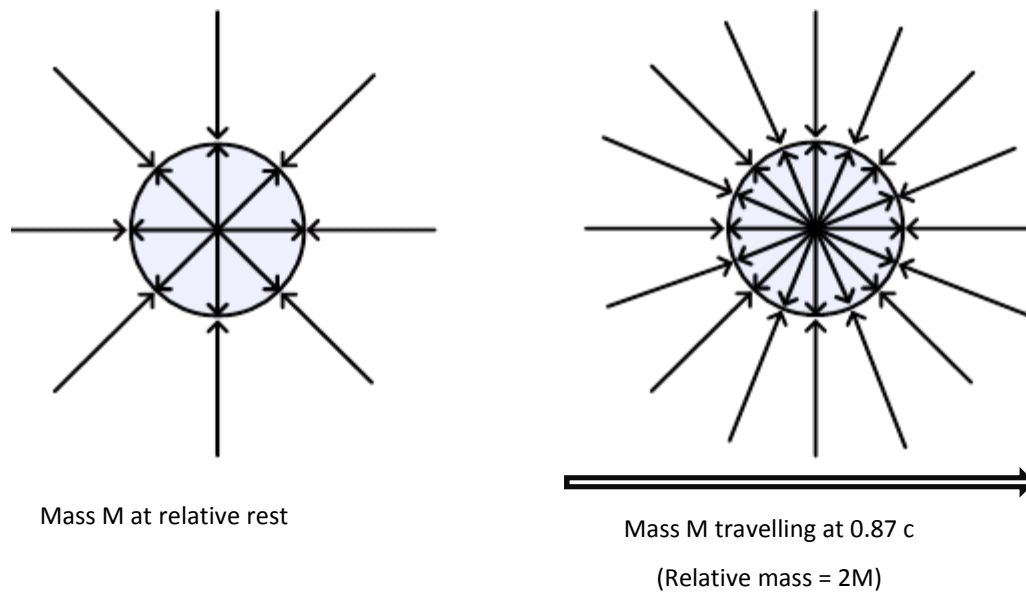


Fig. 4.1

Relative speed of time is inversely proportional to root force exerted by mass and space on each other. It means at more root force time will run more slow. At relatively higher speed, space exerts more root force on mass. The result is reactionary mass force increases and relative time slows down.

Time is equally associated with to mass and space both. Therefore it would be wrong just to use the word *space-time*. Either we should say *mass-time* and *space-time* both, or we use words *mass* and *space* as it is, and assume that *time* is equally and fundamentally associated with both.

4.2 TIME DILATION DUE TO GRAVITY (GENERAL RELATIVITY)

Time will run a lot slower on the surface of neutron star than to the surface of earth. The reason is the same as in special relativity. At more root force exerted, time will run more slowly. The only difference is — in special relativity time runs slow because of root force exerted by space on moving mass, whereas in general relativity time runs slow because of root force exerted by heavy mass on space.

5. CONCLUSION

Gravity is probably a consequence of equal and opposite interaction between 'mass' and the 'space' around every mass. When space exerts root force on mass, it creates gravitational slope around that mass. When other mass enters in that gravitational slope, follows the direction of the slope. Therefore, gravity can be defined as *a slope of a space at any given point in the 'space'*, where the space point is at relative distance from given mass. There is no need of another body to understand the gravity. As the 'space' does all the work, mass has no direct relationship with gravity (i.e. things falling down).

I conclude this paper with following cause statements:

- 1) Gravity is *the* fundamental consequence of *existence*.
- 2) Gravity is a result of equal and opposite interaction between mass and space.
- 3) Every mass and space around that mass produce equal and opposite root force on each other. This root force is fundamental cause of universal gravitation. The unit of root force is square root of newton.
- 4) Relative speed of time is inversely proportional to root force exerted by mass and space on each other. It means at more root force exerted by any of the entity (mass or space), time will run more slow.
- 5) Space completes the mass. And mass completes the space.

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UNDERSTANDING EMOTION REGULATION AND CHILD ABUSE IN ADOLESCENCE

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ABSTRACT: The present study aims to assess the child abuse and emotion regulation among orphan and non-orphan school adolescents residing in Jammu city. A purposive sample of 200 school going adolescents (100 from orphan schools and 100 from non-orphan schools) from Jammu, with an age range of 13-16 years was collected. Consent from guardians and assent from adolescents were taken. In conclusion, study demonstrated that the emotion regulation of orphan and non – orphan adolescents fall in the **poor** spectrum as observed from the manual comparatively. The mean value of emotion regulation of non-orphan adolescent boys & girls is slightly better than emotion regulation of orphan boys and girls. Child abuse of orphan adolescents and non- orphan adolescents differ significantly from each other. Orphan boys are more abused than non-orphan boys and abuse of non- orphan girls is more abused than orphan girls. Orphan boys are more abused than orphan girls but the non-orphan girls are more abused than non- orphan boys.

KEYWORDS: Child Abuse, Emotion Regulation Difficulties, Orphan, Non-orphan.

INTRODUCTION

Child abuse is a major public health epidemic. Nearly one million children become documented victims of abuse or neglect annually, and countless more go unnoticed. Rates of abuse vary across studies and subtypes with varying prevalence estimates for neglect (11.8% to 13.7%), physical abuse (15.8% to 28.4%), and sexual abuse (3.3% to 32.3%), but there are no estimates for emotional abuse due to ongoing debate about its operational definition. More than half of all maltreated youth experience more than one type of abuse, with the highest rates of comorbidity in cases involving emotional abuse. One in 3 abused children is under the age of 4 years, with the highest victimization risk for children who are less than 1 year of age. The direct and indirect costs of maltreatment, including chronic mental and physical health problems, total 56 billion dollars per annum in the United States alone. Over the past 40 years, a corpus of empirical literature has documented the deleterious impact of child maltreatment on cognitive, affective, physiological, emotional, and interpersonal functioning across the life span.

Thus, traumatic stress leads to emotional dysregulation. Emotional dysregulation, has been defined as difficulties in controlling the influence of emotional arousal on the organization and quality of thoughts, actions, and interactions. Individuals who are emotionally dysregulated exhibit patterns of responding in which there is a mismatch between their goals, responses, and/or modes of expression.

Factors of child abuse leading to difficulty in emotional regulation:

Physical abuse	Sexual abuse	Emotional abuse	Neglect	Exploitation
Emotional Dysregulation Outcomes <ul style="list-style-type: none"> - Increased somatization - Increased paranoid inaction - Psychoticism - Impairment of mental health - Depression - Onset of mental disorders - Anxiety - Self blame - ADHD - Suicide Ideation - Self harm - Attempted suicide 	Emotional Dysregulation Outcomes <ul style="list-style-type: none"> - Feeling sad or Hopeless - Depression - Passive coping - Impairment of mental Health - Intermittent explosive Disorder - PTSD - Mood disorder - Obsessive- compulsive - Loss of memory - Attention impairment - Shame - Dissociation - Psychoticism - Suicide ideation - Suicide attempt 	Emotional Dysregulation Outcomes <ul style="list-style-type: none"> - Anxiety - Depression - Anger-hostility - Low self- esteem - Common mental disorder - Anger - Fear - Hopelessness - Suicidal ideation - Attempted suicide - Self harm - Runaway impulse 	Emotional Dysregulation Outcomes <ul style="list-style-type: none"> - Onset of Mental disorders - Suicide ideation - Attempted suicide 	Impacts on education <ul style="list-style-type: none"> - Non-school attendance - Dropping out of school Employment <ul style="list-style-type: none"> - Debt bondage - Unpaid wages - Long hours Mental health <ul style="list-style-type: none"> - PTSD - Depression - Low self-esteem - Stigma
Physical health outcomes <ul style="list-style-type: none"> - Eating disorders - Pain disorders - Irritable bowel Syndrome - Functional Dyspepsia - Stomach pain - Shortness of breath - Chest pain - Dizziness 	Physical health outcomes <ul style="list-style-type: none"> - Genital-urinary symptoms - Shortness of breath - Chest pain - Dizziness - Had ever been drunk - Problem drinking - Vomit or take laxatives - Premarital sex 	Physical health outcomes <ul style="list-style-type: none"> - Psychosomatic disorder. 	Physical health outcome <ul style="list-style-type: none"> - Current alcohol use - Problem drinking - Multiple partners (>3) 	Physical health outcome <ul style="list-style-type: none"> - Have ever drank alcohol - Have ever smoked tobacco - STIs - HIV/AIDS - Unwanted pregnancy - Abortion

Past literature provides immense proof for the poor mental health and emotional dysregulation emerged as a key predisposing factor to sexual risk behavior among orphans and non-orphans. Poverty was associated with lack of food, poor housing, school dropout, and engaging in income generating activities, all of which increase their vulnerability to child maltreatment (transactional sex, early marriage, sexual experimentation, and the eventual consequences of increased risk of unintended pregnancies and STI/HIV). Juma et.al (July, 2013)

Nizami (2012 Jan) revealed that tens of thousands of orphans are suffering from trauma and other stress related disease including depression, sleeplessness and nausea due to the ongoing conflict in Jammu and Kashmir. On the impact of the conflict on the young minds, the survey has found that about two fifth of all the orphans (39%) often complained of headache and 29% had fever occasionally, while 9% had muscle pain and few also felt nausea (4%) and crams (3%). The survey found that many orphans experienced various symptoms of trauma- primarily as a result of conflict and the physical and social environment that they were experiencing. Forty percent of all the orphans showed signs of nervousness 21 percent were very silent, around 20 percent had depression , 16 percent reportedly had mood swings, 21 percent were very impatient 12 percent complained of sleeplessness and irritability and 11 percent had withdrawal symptoms.“ on the whole around 5% of all the orphan has faced some kinds of physical abuse such as having guns pointed at them, being openly

threatened by militants or the army/ police being accused of providing support to the Fighting sides and being to capture parents or as human shields harassed because of that being illegally detained and interrogated being forced to live outside the house or in hiding (includes in forest without any protection being physically assaulted and hurt, being used as bait to capture parents or as human shields)", the survey states.

In an alarming trend, most of the children living in orphanages in Kashmir suffer from psychiatric and emotional disorders including depression, a survey has revealed. 60 percent of children had severe loneliness, 25.7 percent had moderate loneliness while as 15 percent had little or no loneliness. (Masoodi, Srinagar, Dec 2011)

Complex trauma involves chronic or repeated, typically early-onset exposure to two or more of the following forms of trauma exposure: sexual, physical or emotional abuse, domestic violence, or neglect, as well as severe caregiver impairment and school/community violence (Kisiel et al., 2009). A national sample of over 2,200 children in child welfare found that over 70% met exposure criteria for complex trauma (Greeson et al., 2011).

The study was to examine a model of factors that place psychiatrically hospitalized girls at risk for non-suicidal self-injury (NSSI). The role of familial and peer interpersonal difficulties, as well as emotional dysregulation, were examined in relationship to NSSI behaviors. Participants were 99 adolescent girls (83.2% Caucasian; M age = 16.08) admitted to a psychiatric hospital. Structural equation modeling indicated the primacy of emotional dysregulation as an underlying process placing adolescents at risk for NSSI and mediating the influence of interpersonal problems through the family and peer domains. When family and peer relationships were characterized by conflict and lack of support for managing emotions, adolescents reported more dysregulated emotion processes. Family relational problems were directly and indirectly related to NSSI through emotional dysregulation. The indirect processes of peer relational problems, through emotional dysregulation, were significantly associated with NSSI frequency and severity. The findings suggest that the process by which interpersonal difficulties contribute to NSSI is complex, and is at least partially dependent on the nature of the interpersonal problems and emotion processes. **(Adrian et.al April 2011)**

The study examined associations between child sexual abuse (CSA), adult sexual victimization, and emotion regulation difficulties in a sample of 168 incarcerated women. Approximately 50 % of the sample reported CSA, 54% reported adult sexual victimization, and 38% reported sexual revictimization (i.e., CSA and adult victimization). Revictimized women reported significantly greater difficulties with several facets of emotion regulation when compared to singly victimized and non-victimized women. Interestingly, singly victimized women did not demonstrate greater emotion regulation deficits when compared to non-victims. Findings suggest that the negative impact of victimization experiences on adult emotion regulation abilities may be cumulative. Further, they highlight the potential importance of assessing and targeting emotion regulation difficulties among child abuse and adult sexual victimization survivors. (Kate, Scalora et.al July 2011)

Nair, Ramohanan, Ramadevi, Nair, Ghosh, Leena [2009] studied parents in Kerala, 1668 mothers aged 18-49. This interview focused primarily on disciplinary practice 62% mother reported using severe verbal discipline and 50% of mothers reported using severe physical abuse. Results suggest a high prevalence of normative and abusive practices in community with mothers playing a prime role in disciplining the child.

Major findings of Ministry of Women and Child Development, Government of India 2007 :

It has very clearly emerged that across different kinds of abuse, it is young children, in the 5-12 year group, who are most at risk of abuse and exploitation.

Physical Abuse

- i. Two out of every three children were physically abused.
- ii. Out of 69% children physically abused in 13 sample states, 54.68% were boys.
- iii. Over 50% children in all the 13 sample states were being subjected to one or the other form of physical abuse.
- iv. Out of those children physically abused in family situations, 88.6% were physically abused by parents.
- v. 65% of school going children reported facing corporal punishment i.e. two out of three children were victims of corporal punishment.
- vi. 62% of the corporal punishment was in government and municipal school.
- vii. The State of Andhra Pradesh, Assam, Bihar and Delhi have almost consistently reported higher rates of abuse in all forms as compared to other states.
- viii. Most children did not report the matter to anyone.
- ix. 50.2% children worked seven days a week.

Sexual Abuse

- i. 53.22% children reported having faced one or more forms of sexual abuse.
- ii. Andhra Pradesh, Assam, Bihar and Delhi reported the highest percentage of sexual abuse among both boys and girls.
- iii. 3. 21.90% child respondents reported facing severe forms of sexual abuse and 50.76% other forms of sexual abuse.
- iv. Out of the child respondents, 5.69% reported being sexually assaulted.
- v. Children in Assam, Andhra Pradesh, Bihar and Delhi reported the highest incidence of sexual assault.
- vi. Children on street, children at work and children in institutional care reported the highest incidence of sexual assault.
- vii. 50% abuses are persons known to the child or in a position of trust and responsibility.
- viii. Most children did not report the matter to anyone.

Emotional Abuse and Girl Child Neglect

- i. Every second child reported facing emotional abuse.
- ii. Equal percentage of both girls and boys reported facing emotional abuse.
- iii. In 83% of the cases parents were the abusers.
- iv. 48.4% of girls wished they were boys.

A UNICEF study carried out in excombatants in Somalia found high psychiatric morbidity and evidence of psychological effects of prolonged conflicts situations in high proportion of sample of 10,000 children. There is near total disruption of mental health services in the country. [Srinivasa, Mutrthy and Lakshminarauana 2006].

Montgomery and Spand [2005] conducted study on asylum seekers in Denmark who were either did nor did not obtain permission to stay in Denmark. Shortly after arrival in Denmark the parents of 1311 middle children answered structure interview on their exposure to organized violence and their mental health. Half of children had tortured parents in both groups about 2/3 suffered from anxiety and about 30% from sleep problems and children whose families did not later on get residence permit more often appeared sad or miserable [43.8%versus 27.9%]

Milner et.al (2000) revealed that physical maltreatment risk in a community sample, selected preexisting schema (external locus-of-control orientation, inappropriate developmental expectations, low empathic perspective-taking ability, and low perceived attachment relationship to child) were expected to predict child abuse risk beyond contextual factors (parenting stress and anger expression). Based on 115 parents' self-report, results from this study support cognitive factors that predict abuse risk (with locus of control, perceived attachment, or empathy predicting different abuse risk measures, but not developmental expectations), although the broad contextual factors involving negative affectivity and stress were consistent predictors across abuse risk markers.

A study in Hong kong has also shown that beating is a widely used form of child discipline (samuda 1988) physical punishment such as spanking has been used as a form of child discipline by almost all parents. A study with aim to test whether alexithymia mediates the relationship between childhood maltreatment and self injurious beahviour [SIB] in college women. The sample was comprised of 100 female undergraduate students. Child Trauma Questionnaire[CTQ] and self injurious behaviour Questionnaire were used which assessed the lifetime frequency six methods of superficial self injury.Results support a link between a history of childhood maltreatment and SIB among college women and the hypothesis that alexithymia mediates this relationship.

AIM

To assess the child abuse and emotion regulation of orphan and non- orphan adolescents belonging to Jammu city.

OBJECTIVES OF THE STUDY

- To assess emotion regulation of orphan and non-orphan school going adolescents belonging to Jammu district
- To assess child abuse of orphan and non-orphan school going adolescents belonging to Jammu district.

HYPOTHESES

- i. There will be no significant difference in emotion regulation of orphan adolescents and non – orphan adolescents.
- ii. There will be no significant difference in emotion regulation of orphan adolescent's boys and non – orphan adolescent's boys.

- iii. There will be no significant difference in emotion regulation of orphan adolescent's girls and non – orphan adolescent's girls.
- iv. There will be no significant difference in emotion regulation of orphan adolescent's boys and non – orphan adolescent's girls.
- v. There will be no significant difference in emotion regulation of orphan adolescent's boys and orphan adolescent's girls.
- vi. There will be no significant difference in emotion regulation of non- orphan adolescent's boys and non – orphan adolescent's girls.
- vii. There will be no significant difference in child abuse of orphan adolescents and non – orphan adolescents.
- viii. There will be no significant difference in child abuse of orphan adolescent's boys and non – orphan adolescent's boys.
- ix. There will be no significant difference in child abuse of orphan adolescent's girls and non – orphan adolescent's girls.
- x. There will be no significant difference in child abuse of orphan adolescent's boys and non – orphan adolescent's girls.
- xi. There will be no significant difference in child abuse of orphan adolescent's boys and orphan adolescent's girls.
- xii. There will be no significant difference in child abuse of non- orphan adolescent's boys and non – orphan adolescent's girls.

METHOD:

Sample:- In the present study the sample consisted of 200 school going adolescents. The sample of 100 school going adolescents belonged to orphan community. Other 100 school going adolescents were non orphan belonged to Jammu city. All participants were in the age range of 13-16 years.).

- **Variables:-**

The following variables were studied in the present research:-

(a) Independent variable:

- Sex ie boys & girls
- Orphan and non –orphan adolescents

(b) Dependent variable:

- Difficulty in emotion regulation scale scores (DERS)
- Child Trauma scores (CTQ)

Tools:-

- Difficulty in emotion regulation scale [DERS] by Gratz and Romer(2004). This scale is consisted of 36 items . This test assesses clinically relevant difficulties in the emotion response (with a particular emphasis on negative emotion). The test–retest reliability over a period of 4 to 8 weeks in a sample was found 0.88. The construct and predictive validity of DERS scores population has also been found.
- Child Trauma questionnaire [CTQ] was designed by Berstein and Fink (1998). This scale is consisted of 28 items. Reliability coefficients ranged from satisfactory to excellent, with highest for the sexual abuse scale (median=0.92) and the lowest for the physical correlation between 1st and 2nd testing were high emotional Abuse r= 0.80, physical Abuse r= 0.80, sexual Abuse r= 0.81, emotional Neglect r= 0.81, physical Neglect r= 0.79 Overall r= 0.86. All types of maltreatment assessed by the CTQ were significant associated with psychological disturbance, results supporting the concurrent validity of the CTQ.

Procedure:-

Data was comprised of 200 school going adolescents (100 orphan adolescents ie 50 orphan boys and 50 orphan girls and 100 non-orphan adolescents ie 50 non-orphan boys and 50 non- orphan girls). Data was collected, individually by regular visits. Parents/school consent was taken and adolescents assent was also taken verbally. Participants were told that their results were kept confidential.

RESULTS AND DISCUSSION:-

Table 1: Showing the critical ratio on emotion regulation of orphan adolescents and non– orphan adolescents.

Categories of adolescents	Mean	S.D	CR Ratio	Level of Significance
Emotion regulation of Orphan adolescents	98.09	12.53	0.053	Not significant
Emotion regulation of Non - Orphan adolescents	101.65	13.4		

The C.R between Emotion regulation of orphan adolescents and non – orphan adolescents came out to be 0.053, *which* is not significant. This shows that both the groups do not differ significantly from each other. Thus hypothesis is accepted.

Table 2: Showing the critical ratio on emotion regulation of orphan adolescent's boys and non – orphan adolescent's boys.

Categories of adolescents	Mean	S.D	CR Ratio	Level of Significance
Emotion regulation of Orphan boys	100.52	11.87	0.52	Not significant
Emotion regulation of Non -Orphan boys	102.3	15.40		

The C.R between Emotion regulation of orphan adolescent's boys and non – orphan adolescent's boys came out to be 0.52, *which* is not significant. This shows that both the groups do not differ significantly from each other. Thus hypothesis is accepted.

Table 3: Showing the critical ratio on emotion regulation of orphan adolescent's girls and non – orphan adolescent's girls.

Categories of adolescents	Mean	S.D	CR Ratio	Level of Significance
Emotion regulation of Orphan adolescent girls	95.66	12.80	0.028.	Not Significant
Emotion regulation of Non -Orphan adolescent girls	101	11.13		

The C.R between Emotion regulation of orphan adolescent's boys and non – orphan adolescent's boys came out to be 0.028, *which* is not significant. This shows that both the groups do not differ significantly from each other. Thus hypothesis is accepted. The mean value shows that emotion regulation of non-orphan adolescent girls is better than orphan adolescent girls.

Table 4: Showing the critical ratio on emotion regulation of orphan adolescent's boys and non – orphan adolescent's girls

Categories of adolescents	Mean	S.D	CR Ratio	Level of Significance
Emotion regulation of Orphan adolescent boys	100.52	11.88	0.83.	Not significant
Emotion regulation of Non -Orphan adolescent girls	101	11.12		

The C.R between Emotion regulations of orphan adolescent's boys and non – orphan adolescent's girls came out to be 0.83, *which* is Not significant. This shows that both the groups do not differ significantly from each other. Thus hypothesis is

accepted. The mean value shows that Emotion regulation of non -orphan adolescent girls is better than orphan adolescent boys.

Table 5: Showing the critical ratio on emotion regulation of orphan adolescent’s boys and orphan adolescent’s girls.

Categories of adolescents	Mean	S.D	CR Ratio	Level of Significance
Emotion regulation of Orphan adolescent boys	100.52	11.88	0.0519	Not significant
Emotion regulation of Orphan adolescent girls	95.66	12.80		

The C.R between Emotion regulation of orphan adolescent’s boys and orphan adolescent’s girls came out to be 0.0519, which is not significant . This shows that both the groups do not differ significantly from each other. Thus hypothesis is accepted. The mean value shows that Emotion regulation of orphan adolescent boys is better than orphan adolescent girls.

Table 6: Showing the critical ratio on emotion regulation of non- orphan adolescent’s boys and non – orphan adolescent’s girls.

Categories of adolescents	Mean	S.D	CR Ratio	Level of Significance
Emotion regulation of non-Orphan adolescent boys	102.3	15.39	0.349	Not significant
Emotion regulation of Non-Orphan adolescent girls	101	11.13		

The C.R between Emotion regulation of non- orphan adolescent’s boys and non – orphan adolescent’s girls came out to be 0.349, which is not significant. This shows that both the groups do not differ significantly from each other. Thus hypothesis is accepted. The mean value shows that Emotion regulation of non- orphan adolescent boys is better than non-orphan adolescent girls.

Table 7: Showing the critical ratio on child abuse of orphan adolescent’s and non – orphan adolescent’s.

Categories of adolescent	Mean	S.D	CR Ratio	Level of Significance
Child abuse of Orphan adolescents	63.25	10.61957	3.16	*significant
Child abuse of Non -Orphan adolescents	51.31	10.52241		

*at .01 level of significance

The C.R between Child abuse of orphan adolescent’s and non – orphan adolescent’s came out to be 3.16 which is significant at .05 level. This shows that both the groups differ significantly from each other. Thus hypothesis is rejected at .01 level.

Table 8: Showing the critical ratio on difference between child abuse of orphan adolescent’s boys and non – orphan adolescent’s boys

Categories of adolescents	Mean	S.D	CR Ratio	Level of Significance
Child abuse of Orphan adolescents boys	65.12	10.9	5.69	*significant
Child abuse of Non -Orphan adolescents boys	45.26	9.60		

*at .01 level of significance

The C.R between Child abuse of orphan adolescent's boys and non – orphan adolescent's boys came out to be 5.69, which is significant at .01 level. This shows that both the groups differ significantly from each other. Thus hypothesis is rejected at .01 level.

Table 9: Showing the critical ratio on child abuse of orphan adolescent's girls and non – orphan adolescent's girls

Categories of adolescents	Mean	S.D	CR Ratio	Level of Significance
Child abuse of Orphan adolescents girls	63.34	9.67	5.04.	significant *
Child abuse t of Non -Orphan adolescents girls	50.26	9.27		

*at .01 level of significance

The C.R between Child abuse of orphan adolescent's girls and non – orphan adolescent's girls came out to be 5.04, which is significant at .01 level. This shows that both the groups differ significantly from each other. Thus hypothesis is rejected at .01 level.

Table 10: Showing the critical ratio on child abuse of orphan adolescent's boys and non – orphan adolescent's girls.

Categories of adolescents	Mean	S.D	CR Ratio	Level of Significance
Child abuse of Orphan adolescents boys	65.12	10.9	5.76	significant *
Child abuse of Non-Orphan adolescents girls	50.26	9.27		

*at .01 level of significance

The C.R between Child abuse of orphan adolescent's boys and non – orphan adolescent's girls came out to be 5.76, which is significant at .01 level. This shows that both the groups differ significantly from each other. Thus hypothesis is rejected at .01 level.

Table11: Showing the critical ratio on child abuse of orphan adolescent's boys and orphan adolescent's girls.

Categories of adolescents	Mean	S.D	CR Ratio	Level of Significance
Child abuse of Orphan adolescents boys	65.12	10.9	0.388783	Not significant
Child abuse of Orphan adolescents girls	63.34	9.67		

The C.R between Child abuse of orphan adolescent’s boys and orphan adolescent’s girls came out to be 0.388783, which is Not significant. This shows that both the groups do not differ significantly from each other. Thus hypothesis is accepted. The mean value shows that Child abuse of orphan adolescent boys is better than orphan adolescent girls.

Table 12: Showing the critical ratio on child abuse of non- orphan adolescent’s boys and non – orphan adolescent’s girls.

Categories of adolescents	Mean	S.D	CR Ratio	Level of Significance
Child abuse of non Orphan adolescent boys	45.26	9.60	0.00939	Not significant
Child abuse of Non -Orphan adolescent girls	50.26	9.27		

The C.R between Child abuse of non- orphan adolescent’s boys and non – orphan adolescent’s girls came out to be 0.00939, which is not significant. This shows that both the groups do not differ significantly from each other. Thus hypothesis is accepted. The mean value shows that Child abuse of non- orphan adolescent girls is better than non- orphan adolescent boys

CONCLUSION:-

The study demonstrated that the emotion regulation of orphan and non – orphan adolescents fall in the **poor** spectrum as observed from the manual comparatively. The mean value of emotion regulation of non orphan adolescent boys & girls is slightly better than emotion regulation of orphan boys and girls. Child abuse of orphan adolescents and non- orphan adolescents differ significantly from each other. Orphan boys are more abused than non- orphan boys and non- orphan girls are more abused than orphan girls. Orphan boys are more abused than orphan girls but the non orphan girls are more abused than non- orphan boys.

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Sexual Harassment through Teasing of the Adolescent Girls: A Study on Jhenidah Municipality of Bangladesh

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ABSTRACT: This study was designed to find out the nature and extent of sexual harassment among the adolescent girls in two wards of Jhenidah Municipality, Bangladesh. Following survey research design, data were collected (During 2008-2009) from randomly selected 110 adolescent girls (aged between 13-19 years) exposed to eve-teasing for last 6 months or more. Findings suggest that female adolescents, irrespective of age and education, were sexually harassed frequently, either by classmates or by roadside womanizers through obscene languages, physical harassment, and ugly sexual expression and so on. However, young school going girls were more often the victims of such atrocity. But, in response, most often the victims and their families were reluctant to protest or to report to the law enforcement agencies. Because, the respondents were frequently stigmatized and blamed the conservative patriarchal society as it takes no initiative to stop such inhumane behavior. The study is descriptive in nature, and basically explores the nature and general aspect related to sexual harassment in the study area.

KEYWORDS: Sexual harassment, Violence against women, Gender discrimination, Law enforcement agency, Awareness regarding existing laws.

1 INTRODUCTION

Violence against women¹ has been turned out to be a central concept in the discussion of current development issues, in Bangladesh. Traditionally, Bangladesh is a male dominant society, where the social institutions, at all levels, are controlled by patriarchal creed. The existence of acute gender inequalities, entrenched in the overall structure of Bangladesh, does not allow girls and women to realize their potential. In fact, they are confined within the gender stereotypic expressive roles as daughter, wife and mother, and are kept inside the four walls of home [1], [2].

Hence, women of all economic strata in Bangladesh are vulnerable to maltreatment and abuse by husbands, in-laws and other family members. The rate of reported violence acts against women has risen at an alarming number, especially in rural

¹ Different kinds of female abuse and exploitation activities through oral, physical or mental torture such as, Dowry, sexual harassment, eve-teasing, honor killing, acid throwing, physical torture and so on.

areas of Bangladesh. Among rural married women, as surveyed in 1992 [3] and 1993 [4], 47 percent following 42 percent were reported having experienced physical violence by intimate partners; 43 percent of women in a 1999 study reported having been slapped and beaten [5]. Between 2002 and 2006, analyzing the newspaper and information of media, one study revealed a total of 5128 women and girl children were raped during this period (as published in the paper), one third of which were the victims of dowry related violence and less than one third were the victims of acid violence². Almost two thousands of those rapes were of girl children. In this study, the ratio of rape, dowry and acid violence against women stands for 63 percent, 20 percent and 17 percent, respectively [6], [7]. The daily news reports, now a days, are filled with atrocities including physical and psychological torture, teasing, rape, dowry related violence, trafficking, forced prostitution, coerced suicide and murder.

In recent past, another form of violence, which is fiercer in nature, has evolved widely known as eve-teasing³ (sexual harassment⁴). Eve-teasing, the ruckus and pestering of women, has gradually become brutal form of women suppression and violence often resulting in terrible and sometimes horrifying consequences such as grievous hurt, abduction, acid throwing, rape murder and forced suicide and so forth [8]. It is quite unusual that, 'eve-teasing has nothing to do with any physical harassment' (most of the time) thus law of Bangladesh doesn't 'treat it as violent act' and thus why the legal authority were unable to take the eve-teasing happening so seriously, as a crime [9]. A recent report [10] states that, as many as 12 significant cases found that states teenage girls committed suicide in Bangladesh from 2006 to 2008, and sexual harassment was fueling those incidents, covertly or overtly. They used the data of media coverage, but most of the time frequent cases never get media coverage of eve-teasing cases. Considering the honor of the family or getting scared of the teaser threats, most of the cases never get published or kept hidden.

Evidence of frequent sexual harassment increases girls' dropping out rate from schools, as parents concerned about family honor and dignity more on than daughters' honor or safety [11], [12]. Through the same process, sexual harassment pushes girls into marriage, before they are physically or mentally prepared [13]. And being married at early age, they usually bear their first child while they are still teenagers; therefore, risk the life of both the mother and the children. Because, mothers in aged 15 to 19 years face a 20 to 200 percent greater chance of dying in pregnancy than women aged 20 to 24 years [14], [7]. So it appeared that sexual harassment and its frequent growth caused so many impacts on girls mental, social and political states, and rooted continuous negative effect on their life span. In these circumstances, the study was designed to identify the nature and extent of sexual harassment among the adolescent girls. The research question of the study assessed the basics assumptions/indices like nature, trend, and types of eve-teasing, post action taken after being harassed and so on. The research questions basically seek to explore a general and descriptive outlook of eve-teasing/sexual harassment among the adolescent girls, on that particular municipality (Jhenidah) of Bangladesh.

2 RESEARCH METHODOLOGY

The study was conducted following survey research design in two wards, namely Baparpara and Hamdah, of Jhenidah⁵ Municipality, Bangladesh. Convenience to the researcher to collect information from the field, and as no prior study found in this district about eve-teasing (sexual harassment), the study area was selected purposively, but the two wards are selected randomly. Data were collected from the field, by the researcher himself, during November 2008 to January 2009. Allowing an error tolerance of 7.8 percent and 95 percent confidence level, we chose a sample of 110 adolescent (aged between 13-19 years) girls [15]. Data were collected from these 110 respondents who were randomly selected from 351 census⁶ adolescent

² Throwing acid on person's body or face as a vindictive reaction. Women are the massive victim of this kind of violence activities.

³ In this study, eve-teasing means disturbance or harassment of girls in social atmospheres. Eve-teasing includes bad comments, showing obscene symbol, ugly physical movement of body, obstruction on the way, giving whistle, nasty behavior like pulling lady's gauze scarf, and so on, towards young girls.

⁴ Government of Bangladesh changed the term eve-teasing as sexual harassment category for penal prosecution, thus in this paper the meaning of sexual harassment will be considered as the same with eve-teasing.

⁵ The municipality consists of 9 wards and 33 community area, with the total city boundary of 39.63 sq. km. The total population is 86635, distributed the 52.55 percent of male and 47.45 percent of female [16].

⁶ To identify the sample, a census has been conducted by the researcher among the age group of below 20 years of female, and who are facing eve-teasing experience/s at least for 6 months or more. Small scale census questionnaire (based on teasing experience, address, age and so on) were used to identify those sampling frame (population list), and who willingly wanted to participate for the research. 351 census populations were found in this course and sample of 110 were drawn randomly from the census population.

girls. To find out the objectives of the study, incorporating both open and close ended items in the questionnaire, data about respective concepts were collected through an interview schedule (Printed in Bengali) by face to face interaction between the researcher and the respondents. In addition, secondary data from relevant sources were used to strengthen the rationality of the study and for better comprehensive analysis. Soon after, the data were computerized, analyzed and interpreted using software's like SPSS, MS Word, Excel and so on. Descriptive statistical techniques were used to interpret the variables, and concerned categories of those variables. However, the financial shortage and inadequate time for data collection from the field limited the extensive understanding of the issue. Additionally, the hesitant respondents, unwilling to disclose the awful events of their lives due to social attitude towards female dignity, refused to take part in the primary census. Yet, a handful of them wanted to participate for the census, in order to disclose this dreadful life event, and 110 samples were randomly selected for the face to face interview.

3 RESULTS

3.1 Background Information of the Respondents

In existing social system, younger women are, in general, less powerful since they have fewer resources to mobilize, therefore, they are more at risk of sexual harassment [17], [18]. In fact, the younger women are, evidently, more likely experience sexual harassment, at public or at workplace [19], [20]. The marital status and education of the girls are also found as important factors associated with the incidence of sexual harassment. Studies show that single women, including unmarried, divorced, separated or widowed, have greater chance of experiencing sexual harassment than married women, as married persons tend to have more social capital and protection than singles [21], [19], [22], [23]. Additionally, sexual harassment is evidently found to increase against women with low educational success [22], [24]. In contrast, it also appeared that well-educated women are victimized by the perpetrators, in work-place as well as in educational institutions [25], [26].

Findings (Table 1) reveal that among the respondents, young girls (below 15 years), the unmarried to be specific, were at more risk of sexual harassment than the older and married adolescent girls, as the prior experienced more sexual harassment compare to the later. It is also apparent from the findings that school going girls were more vulnerable to the traumatizing experience of sexual harassment, compared to the girls in colleges and universities.

Table 1. Background Information

Variables	Percentage (%)	Mean/Standard Deviation
Age (in Year)		
14-15	63.6	15.65/1.64
16-17	15.5	
18-19	20.9	
Total	100.0	
Marital Status		
Married	4.0	-
Unmarried	96.0	
Total	100	
Educational Qualification		
Illiterate	0.9	-
Class I – X	65.4	
SSC passed	13.6	
HSC and above	20.0	
Total	100	

3.2 Incidence and Perpetrators of Sexual Harassment

Sexual harassment, a universal social endemic, is generally meant to reinforce men's higher position and domination over women [27], [28] and to reflect the underlying dynamics of gender based power inequality in social system [29], [30]. Hence, women are consistently subjected to sexual harassment, irrespective of age, color, religion, social status and so on, in different social settings, including public and private spheres [31], [32], [33]. They endure different sexual behaviors, including verbal, visual and physical [34], hassled either by classmates, or colleagues [35], [36] and this traumatizing experience continues for a long period of time, ranging from a year or two and even beyond [37], [38], [39], [40].

Findings (Table 2) show that over 90 percent adolescent girls were exposed to sexual harassment for a year or two, and the most common form of such behavior is explicit language, either in face to face situation or over the phone, and few of them were also physically harassed by the perpetrators. It is also apparent from the findings that adolescent girls are not entirely secured in educational institutions as three-fourth of the interviewees reported of eve-teasing in their respective institutions, mostly by their classmates/seniors and to some extent, by the faculties. The perpetrators often attempted to propose the victims, either for marriage or love affair, some even tried to lure them to have pre-marital intercourse.

Table 2. Nature and Incidence of Sexual Harassment

Variables	Percentage (%)
Extent of Sexual Harassment	
Nearly one year	77.0
1-2 years	18.0
More than 2 years	5.0
Total	100
Type of Sexual Harassment	
Whistling	20.9
Obscene language in the street	60.9
Obscene language in cell phone	13.6
Touching	4.5
Total	100
Sexual Harassment in Educational Institutions	
Yes	75.0
No	25.0
Total	100
Perpetrators of Sexual Harassment in Educational Institutions⁷	
Male Classmates/Seniors	97.0
Male Teachers and stuffs	3.0
Total	100
Nature of Proposals by the Perpetrators in Educational Institutions	
Affair	75.0
Marriage	3.0
Friendship	7.0
Pre-marital Intercourse	15.0
Total	100

3.3 Supports for the Victims

Sexual harassment of women is generally considered as a major crime across the globe, yet it remains undisclosed, especially, in developing countries, due to social stigmas upon the victims. In fact, the victims are often blamed for the assaults, and the acts of the offenders, in most cases, are often overlooked, and only a few are exposed [41], [42]. Additionally, the victims are faced with post-assault hostile environments as families and friends often blame or refuse to support based on disbelief, while the legal systems frequently turn down the complaints on no-confirmation ground [43], [44].

Findings (Table 3) show that the victims were more likely being harassed sexually when escorted by another female (84.5%) than male or parents, especially, father. Nevertheless, people, at the spot of sexual assaults, were evidently more or less compassionate for the victims, and such support helped the victims to protest (75.5%) strongly, verbally in particular, against the vindictive activities of the perpetrators. All the family members, the parents in particular (78%), of nearly 95 percent of victims were ready to lend a hand to their assaulted family members. It is, however, observed that less than one fifth of the victims of sexual harassment reported the heinous acts to the police. Despite strong legal provisions against the crime, the victims and their families were reluctant to report to the police since half of the criminals, of reported incidences,

⁷ A total of 82 adolescent girls condemned their classmates and teachers for sexual harassment.

remained unpunished. Moreover, the burden of being stigmatized by the society left no choice for the victims and the families, but to let the bygones or to forget the incidences. Therefore, majority of the victims found the existing social system⁸ primarily guilty for the increasing rate of sexual harassment in Bangladesh.

It is evident in the study that almost all the victims were unaware of the existing legal provisions against sexual harassment, which explains the minimum police report of the incidences. In addition, the victims were found reluctant to raise social awareness against sexual harassment. The fear of being identified might discourage them to participate in social movements against sexual harassment.

Table 3. Supports for the Victims

Variables	Percentage (%)
Aide during Harassment	
Female	84.5
Male	11.8
Parents	3.7
Total	100
Assistance on the Spot	
Yes	50.9
No	49.1
Total	100
Protest against Harassment	
Yes	75.5
No	24.5
Total	100
Nature of Protest⁹	
Oral	70.9
Physical	2.7
Undisclosed	26.4
Total	100
Supports from Family	
Yes	93.6
No	6.4
Total	100
Supportive Members of Family¹⁰	
Father	26.0
Mother	52.0
Brother	12.0
Sister	10.0
Total	100
Reporting Incidents to Police	
Yes	13.6
No	86.4
Total	100

⁸ By social system the respondents indicated the patriarchal social structure of Bangladesh that differentiates between men and women based on stereotypic social roles and expectations and discriminates against women for social status and personal dignity and neglects women's constitutional rights and freedom of movement.

⁹ More than two-third of the adolescents (83) protested against harassment.

¹⁰ A total of 103 interviewees reported having been supported by their families.

Variables	Percentage (%)
Aftermath of Police Report¹¹	
Arrested/Punished	50.0
Threatened	44.0
None	6.0
Total	100
Condemned for Harassment	
Boys	12.7
Girls	1.8
Social system	85.5
Total	100
Awareness regarding Legal Provisions	
Yes	1.8
No	98.2
Total	100
Participation in Awareness Movement	
Yes	5.0
No	95.0
Total	100

4 DISCUSSION

The findings of the study come up with some descriptive explanation of sexual harassment through teasing, and narrate the general character and extent of it. As the study was conducted among teenager who have faced eve-teasing at least for last six months, and among them the younger girls of 14-15 years are the majority. Respondents character showed up that majority of them are unmarried and have the education level of class of I to X. General depiction of the study showed that, the adolescent female considered teasing as whistling towards them, throwing obscene language at street and in cell phone, physical teasing and so on. Among these, the most common harassment (60.90 percent) they have faced is throwing of bad language or comments towards them. Here to mention that, the bad language consist of sexual comments, slang language, irritating words to stimulate sexually, comments about physical structure and dresses, and so on. Some of the finding of the study indicated that the proposal of affair, sexual union, marriage or force friendship also appeared among this harassment acts. In the study area, respondents were facing this kind of harassing experience about months and to some extent more than a year or couple of years.

All these raise question about why this situation continued against girls for longer duration? And why there is no protest or remedies to stop this kind harassing actions against generation? Asking about these questions, the study result showed us some interesting findings. It is found that after being harassed, the respondents get help from the family in maximum numbers, sometimes they protest by themselves or people on the spot assist them after being harassed. But, when it came about filing legal action against those offenders (harasser), to inform the law enforcing agency or to take legal actions, interestingly, it has been found that only 13.6 percent has done it. This can open another door for further research about why after being harassed, or only by protesting on the spot, most of the victims never filed cases under legal law. Because, the evidence of the study showed that, many of the victims had this harassment experience for long duration. What might be the hidden factor/s behind this can be explored by further research.

Culturally, women in Bangladesh were more subject to sexual harassment as the social structure or its relations are determined by the masculine characteristics or male domination [45]. And, it is the culture that determines the societal attitudes towards the female sex and their protection from awful sexual victimization [46]. Experience about the teasing, most of the respondents claimed that they condemn the boys and mostly the patriarchal social structure as responsible. The patriarchy culture based social structure gave more autonomy and freedom to boys, and confined female into some particular boundaries. Supporting this argument, the study showed that, the respondents have experienced sexual

¹¹ Only 12.5 percent of the interviewees (15) reported to the police.

harassment in social atmosphere and even in their education institution as well. Most of the time, they claimed that boys were doing the teasing. Their experience showed that, they have sexual harassment more frequent when they were along with girls (84.5 percent), which sums up their vulnerability about security at social arena. Regarding the support from the family after being harassed, the study revealed that, female person of the family (Mother: 52 Percent; Sister: 10 percent) accompanied the victims mentally or other ways. So, the results showed that respondents are condemning particularly the boys and patriarchy for sexual harassment, and most of the time they only get shelter of mental support under other female (e.g. mother, sister) supporting person. It raise new dimension of research asking about why males from the family or community are not supporting female exclusively, after being harassed. Or, is it only found on this study area or there can be found similarities to other municipality of Bangladesh as well. As we do not have much study on eve-teasing (sexual harassment) in Bangladesh, further research can explain whether sexual harassment is connected to female culturally and structurally or not.

5 CONCLUSION

Sexual harassment, a deviant act against the honor, dignity and self-respect of the women, is burning issue in Bangladesh, now a day. It is evident that adolescent girls, at all ages, are the victims of sexual harassment or teasing, especially young school going girls, who experience this troublesome incident repeatedly, even for a year or two. This unexpected act takes place more frequently in the road side or on the way to educational institutions, where, most of the time the boys of different age were the involved with. The most interesting fact is that, adolescent girls are experiencing public abuse most often when they are with girls. The patriarchal social system of Bangladesh practiced male supremacy over female in every aspect, and the respondents condemn it in many ways. And it seemed that victims or their families were unwilling to take necessary legal actions by the help of law enforcing agency. The frequent harassment experience of the adolescent girls, and withdrawing to have legal actions actually opened different dimensions of further research. It can be take account, to look forward to see, how the patriarchal social system and culture associated to sexual harassment? Why the victims don't want to take legal charge? In this context, comprehensive social research needed to be done, both from the government policy making level, and non government organizational level, to investigate and further assessment regarding sexual harassment of adolescent girls in Bangladesh.

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Croissance Impulsée par les Changements Technologiques

[Growth Impulsed by the Technological Changes]

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ABSTRACT: The economic literature distinguishes between two different approaches to the contribution of human capital to growth. The first approach assumes that human capital plays the same role in production than physical capital. Human capital is an accumulative factor and increases the overall productivity of factors, exogenous technology. This increased efficiency can offset the diminishing returns of capital and thus to support long-term growth. Thus, the accumulation of capital has a positive effect on economic growth. Rather the second approach suggests a technological dimension of human capital, critical to economic growth. This idea identified by endogenous growth, shows that innovation and technological adaptation are the engines of economic growth in the long term. But the relationship between human capital and technology is highly dependent on the composition of human capital. The above said, we will enrich the literature and study the impact of technological change on economic growth. Econometrically, we base our study on the technique of panel data. An estimate by the method of static panel seems more relevant and a positive effect from the Technological Changes to economic growth seems to be confirmed for 39 developing economies.

KEYWORDS: Growth, Technological Changes, Education.

RESUME: La littérature économique distingue deux approches différentes de la contribution du capital humain à la croissance. La première approche suppose que le capital humain joue le même rôle dans la production que le capital physique. Le capital humain est un facteur accumulable et accroît la productivité globale des facteurs, à technologie exogène. Ce surcroît d'efficacité permet de compenser les rendements décroissants du capital et donc de soutenir la croissance à long terme. Ainsi, l'accumulation du capital a un effet positif sur la croissance économique. La deuxième approche suggère plutôt une dimension technologique du capital humain, déterminante pour la croissance économique. Cette idée identifiée par la croissance endogène, montre que l'innovation et l'adaptation technologique sont les moteurs de la croissance économique à long terme. Mais la relation entre le capital humain et la technologie est fortement dépendante de la composition du capital humain. Ceci-dit, nous allons enrichir cette littérature et étudier l'impact des Changements Technologiques sur la croissance économique. Économétriquement, nous nous basons notre étude sur la technique des données de Panel. Une estimation par la méthode du panel statique paraît plus pertinente et un effet positif allant des Changements Technologiques vers la croissance économique semble être confirmé pour 39 économies en développement.

MOTS-CLEFS: Croissance, Changements Technologiques, Education.

1 INTRODUCTION

Nous allons examiner la documentation relative à la variation des compétences et du capital humain et leurs répercussions sur le développement économique et la capacité d'innovation. Notre travail porte sur les grands thèmes suivants : les compétences et le capital humain ; l'innovation et le Changement Technologique et enfin la croissance.

Dans la théorie, puisque le capital humain est lié à la connaissance et aux qualifications et puisque la croissance économique dépend du progrès de la connaissance technologique et scientifique, il est raisonnable de considérer que la croissance est une fonction de capital humain [1]. Aussi le Changement Technologique est essentiel à la théorie de croissance et aux modèles micro-économiques de l'innovation qui émergent à la fin des années 50 et 60.

Depuis le début des années 80 et 90, un cycle important de Changements Technologiques a touché tous les secteurs économiques. Ces changements sont liés particulièrement à l'apparition des Nouvelles Technologies de l'Information et des Communications (NTIC). La transition d'un système d'échelle de production vers les réseaux mondiaux de production, parallèlement à la croissance d'un secteur du savoir comportant ses propres caractéristiques particulières, sont les principales conséquences des NTIC. L'essor de la « nouvelle économie » a eu lieu dans un contexte macroéconomique renouvelé, fortement orienté vers l'intégration et la libéralisation des marchés.

La propagation des NTIC constitue une preuve selon laquelle le savoir et les autres attributs du capital humain prennent une nouvelle pertinence dans tous les secteurs économiques. Depuis longtemps, le savoir est perçu comme le facteur principal du processus d'innovation et comme un déterminant de la croissance économique. L'intensité croissante du savoir dans l'économie a entraîné le délaissement croissant du capital physique au profit du capital humain pour considérer la prospérité économique. Les démarches théoriques récentes de la croissance, telles que la nouvelle théorie de la croissance, ont formalisé ces idées. La nouvelle théorie de la croissance a délaissé l'optique simplificatrice du Changement Technologique exogène pour débiter à analyser le processus endogène de l'investissement dans le capital humain et, par suite, dans le Changement Technologique, où la croissance établit une fonction endogène du comportement des individus et de la politique. Politiquement, cette tendance a entraîné une augmentation de circonspection dirigée vers les compétences et vers l'innovation comme moteurs de la croissance.

2 COMPETENCES ET CAPITAL HUMAIN

Le capital humain est constitué des connaissances et des compétences que les êtres humains transportent dans leur tête et qui leur confèrent une valeur dans l'économie. Cette notion a été préconisée par [2], qui voit le capital humain comme un intrant pour la production et pour l'innovation. Le concept de capital humain a été conceptualisé au cours des années 60 par plusieurs économistes. Le capital humain est un large concept qui englobe les particularités de la scolarisation et de la formation, d'où découle la notion de compétences. C'est ainsi que les définitions des compétences peuvent indiquer une composante particulière de la mesure du capital humain.

Les définitions conceptuelles du capital humain sont nombreuses et parfois divergentes, au sein d'un même organisme. La référence [3] définit le capital humain comme suit : « le savoir que les personnes acquièrent et utilisent au cours de leur vie afin de produire des objets, des services ou des idées dans le contexte du marché ou hors de celui-ci ». Dans une publication suivante, [4] recharacterise le capital humain comme : « les connaissances, habiletés, compétences et autres attributs incarnés dans des personnes et qui ont trait à l'activité économique ». Bien que l'idée dominante a changé, ces deux définitions illustrent la complexité et le vaste porté de ce concept.

Le projet de la Table Ronde Nationale sur l'Environnement et l'Economie (TRNEE) a essayé de caractériser un indicateur du capital humain. La référence [5] définit le capital humain comme : « les capacités, tant innées que dérivées ou accumulées, qu'incarne la population d'âge actif et qui lui permettent de travailler de manière productive avec d'autres formes de capital pour assurer la production économique ». La référence [5] a soumis un cadre qui sert à l'élaboration d'indicateurs du capital humain : la scolarisation. Dans le domaine de la scolarisation, [5] a évoqué six ensembles d'indicateurs (niveau moyen de scolarisation ; taux d'alphabétisation ; pourcentage de la population ayant fait des études universitaires ou l'équivalent ; effectifs des secteurs primaire, secondaire et supérieure ; proportion de la main-d'œuvre qui détient un grade universitaire ; et niveau de scolarisation des 25 à 64 ans), à côté des indicateurs particuliers (participation des adultes à la scolarisation et à la formation ; pourcentage de diplômés ayant des grades en sciences ; et un indicateur du développement de l'enfant à 5 ans). On peut affirmer que la majorité des études empiriques ont employé un indicateur lié à la scolarisation afin de calculer le stock ou le flux de capital humain.

La recherche empirique a mis en application divers indicateurs relatifs à la scolarisation. Par exemple, [6] [7] ont élaboré un ensemble d'indicateurs du niveau de scolarisation afin de mesurer le capital humain d'un grand nombre de pays à l'échelle nationale. Selon ces références : « l'obtention du pourcentage de la population ayant réussi un niveau de scolarisation donné [...] constitue une façon directe de montrer le niveau de compétence et de savoir de la population qui se rapporte à un niveau de scolarisation particulier ». Cependant, ils trouvent que le niveau de scolarisation est un indicateur du capital humain qui comprend de multiples attributs humains. L'emploi de cet indicateur a été répandu au sein des modèles de régression de la croissance. La référence [8] a présenté sept types de variables du niveau de scolarisation (types variés

selon le niveau, la croissance et le sexe) qui ont été utilisées afin d'énumérer les déterminants de la croissance qui ont augmenté la régression transversale à diverses échelles géographiques.

Le statut professionnel constitue un autre indicateur du capital humain qu'on emploie fréquemment, en distinguant les professions libérales et techniques des professions exercées dans les secteurs de production. Les travaux de [9], [10], [11] et [12] constituent des exemples. De plus, certains auteurs ont prêté une attention considérable à la répartition spatiale des universités et des centres de recherche [13]. La composition de groupes professionnels particuliers ne fait toutefois pas l'unanimité. En effet, la mesure des compétences spécialisées (études supérieures, capacité de recherche) se construit la plupart du temps au moyen du nombre d'employés en R&D ou du niveau de dépenses en R&D. Cependant, les grandes catégories telles que les travailleurs du savoir ont été définies de façon différente dans diverses études. Ainsi, la référence [12] met en application une définition exhaustive du secteur du savoir, qui comprend les travailleurs techniques. Par contre, la référence [11] restreint cette définition aux emplois faisant intervenir la production de nouvelles idées, exigeant un degré de créativité supérieur à celui de la plupart des professions techniques.

Relativement au niveau de scolarisation, le concept de compétence est plus étroitement lié à la notion de capacité de faire. La collecte d'indicateurs de compétences précis, tels que les résultats à un test mathématique et de culture scientifique, a été entreprise récemment au moyen d'enquêtes à grande échelle. Ces indicateurs sont utilisés par la recherche économétrique. Les analyses de [14] portent sur l'importance de la qualité de la main-d'œuvre, qu'ils l'obtiennent à l'aide des compétences cognitives en mathématiques et en sciences. De son côté, la référence [15] emploie les résultats des examens acquis par les étudiants, au lieu des taux d'inscription scolaire et des années de scolarité, pour étudier le lien existant entre le capital humain et la croissance. Elle découvre que le résultat d'examen constitue un facteur déterminant de la croissance économique. La référence [16] se base sur les données concernant les résultats des examens pour évaluer les différences entre le milieu rural et urbain au Canada. Cependant, les données restent limitées à un petit échantillon de pays et la disponibilité relative des petites unités territoriales semble être encore plus limitée.

Enfin, d'autres travaux se sont basés sur le revenu et les salaires de la main-d'œuvre pour calculer des mesures du capital humain, tout en supposant que la qualité d'un travailleur dépend du salaire qu'il touche. La référence [17] a mis au point un ensemble d'indicateurs du capital humain pour les États-Unis. Ses résultats prédisent que l'utilisation de la moyenne des années de scolarité comme mesure du capital humain en recherche empirique peut être trompeur. En effet, les calculs de ces auteurs indiquent qu'entre 1940 et 1990, le stock de capital humain aux États-Unis a haussé beaucoup plus vite que la moyenne des années de scolarité. De même, la dispersion de l'indicateur a augmenté au cours des années 80, alors que la dispersion de la moyenne des années de scolarité a baissé.

En conclusion, la pertinence du capital humain quant au processus d'innovation est démontrée par l'emploi d'indicateurs relatifs à la scolarisation comme mesure du potentiel d'innovation. À côté de la relation entre compétences et croissance économiques, plusieurs économistes se sont penchés sur le lien entre compétences et Changements Technologiques. Grant (2002) définit l'innovation comme «le processus par lequel la valeur est extraite des compétences et du savoir, au moyen de la production, de l'élaboration et de la mise en œuvre d'idées visant la fabrication de produits, de processus ou de services nouveaux ou améliorés».

3 CHANGEMENT TECHNOLOGIQUE, INNOVATION, R&D ET CROISSANCE

Selon la théorie micro-économique, la production dépend du travail (L), du capital (K) et de l'état de la technologie ou des connaissances (C) : $Y = f(L, K, C)$. La connaissance est un stock qui augmente et s'accumule au cours du temps. Si à partir de l'idée du feu, Denis Papin produit une machine à vapeur, cette machine sera détruite à la longue, alors que l'idée de la machine à vapeur reste toujours dans la connaissance. Elle s'accumule au stock immatériel de connaissances. On peut admettre que cette accumulation est exogène et prendre le progrès technique comme une donnée que l'on ne cherche pas à expliquer.

Mais la théorie économique peut aussi expliquer cette accumulation. Dans ce cadre, on peut admettre l'hypothèse suivante : les individus créent des connaissances parce qu'ils investissent en R&D, justifiés par les profits qu'ils attendent de l'exploitation de leur invention. Les individus investissent en capital humain, c.-à-d. en éducation et en apprentissage, motivés par les revenus futurs qu'ils recevront de leur formation. Nous avons là une explication endogène du progrès des connaissances.

Au cours des deux dernières décennies, la théorie de la croissance a mis en œuvre le rôle du capital humain dans le processus de développement. L'accumulation du capital humain et la R&D sont deux activités qui se déroulent conjointement au cours du processus de développement [18]. Ces deux variables influencent mutuellement la croissance.

Une plus grande capacité d'innover des firmes est liée à l'investissement en formation [19] et les modèles de croissance ont pendant longtemps considéré que la croissance provient soit du capital humain soit de la R&D.

Dans la littérature économique, nous distinguons deux voies majeures de contribution du capital humain à la croissance. La première approche formalisée par [20] à la suite de [21] et [22] considère que le capital humain joue le même rôle dans la production que le capital physique. Le capital humain est introduit dans la fonction de production comme un facteur qui s'accumule et qui augmente la productivité globale à technologie constante. Ce surcroît d'efficacité permet de compenser les rendements décroissants du capital et donc de soutenir la croissance à long terme. Ainsi, accumuler du capital humain par l'intermédiaire de l'éducation contribue positivement à la croissance. Ce qui compte finalement, c'est le capital humain supérieur dans l'économie. La deuxième approche considère plutôt que c'est la dimension technologique du capital humain qui est déterminante pour la croissance. Le capital humain, notamment le niveau de capital humain qui permet à l'économie de s'adapter au Changement Technologique, qui est le moteur de la croissance à long terme [23]. Les nouvelles théories de la croissance endogène théorisent explicitement le lien entre capital humain, adaptation ou innovation technologique et croissance ([24] [25] et [26]).

L'innovation et l'adaptation technologique sont les moteurs de la croissance de la productivité et donc de la croissance à long terme. Ces innovations dépendent du niveau du capital humain. En effet, le stock de capital humain détermine la capacité d'un pays à innover et à rattraper les pays les plus développés. La nouvelle démarche théorique, appelée nouvelle théorie de la croissance, met en évidence les liens entre l'investissement en capital humain, le Changement Technologique et la croissance économique. Cette démarche a contribué à renouveler la transition d'une économie axée sur les ressources à une économie axée sur le savoir [27].

Selon les théories antérieures sur la croissance, la technologie était un fait ou un produit qui résulte des forces extérieures. Dans le modèle de Solow, qui représente la théorie dominante avant l'apparition de la nouvelle théorie de la croissance, la technologie était identifiée comme le flux de savoir évident. Dans ce modèle, la technologie ne résultait pas des forces économiques ; elle était plutôt déterminée par des forces que le modèle de croissance ne pouvait pas les expliquer. Le modèle de Solow ne fournit pas les causes du Changement Technologique au fil du temps. C'était avec sa publication séminale « A contribution to the theory of economic growth » de 1956 que la technologie était donc un phénomène exogène au modèle. Le modèle de la croissance économique pose que la croissance de l'output par personne est seulement une fonction de croissance des facteurs d'inputs. L'accumulation du capital et de l'amélioration de la main-d'œuvre comme sources de croissance sont basées sur la nature fortuite de la technologie. Lors de l'utilisation de son modèle, Solow a découvert que la plus grande partie de la croissance des États-Unis au cours du siècle dernier ne pouvait s'expliquer par le recours accru au travail et au capital. En effet, il a attribué les facteurs « résiduels » inexpliqués au progrès technologique. Il s'agit aussi d'une mesure de notre ignorance. Selon Solow, la technologie constitue quelque chose qui est accessible à tous et sans frais. Le modèle n'explique ni la provenance ni le coût de ce produit [28]. Cependant, le savoir et la technologie restent les principales sources de croissance économique.

Solow découvre un large « résidu » lorsqu'il estime les déterminants de la croissance. Ce résidu reflète le progrès technologique. Le modèle de Solow postule que le progrès technique est exogène. Le progrès technique selon lui est une manne tombée du ciel car son action est automatique et indépendante des circonstances économiques. La recherche empirique cherche à minimiser ce résidu. Le but était de se concentrer sur une qualité améliorée de la mesure des variables inclus dans les estimations de croissance, pour réduire la taille du résidu. D'autres études cherchent à introduire les inputs autres que le capital et le travail (par exemple la terre). La caractéristique centrale de ces modèles de croissance était le traitement exogène du progrès technique. La technologie reste une boîte noire avec peu d'efforts pour présenter ses déterminants. Les modèles de croissance exogène se basent sur le rendement décroissant [29].

La nouvelle théorie de la croissance dépasse l'hypothèse des rendements décroissants et du Changement Technologique exogène. Selon cette nouvelle théorie, le progrès technologique résulte de l'activité économique. Le savoir et la technologie constituent des produits qui découlent des investissements en capital humain (scolarisation et formation), de l'emploi de main-d'œuvre spécialisée (personnel en R&D) et du matériel. C'est la théorie de la croissance endogène puisqu'elle intériorise le Changement Technologique en un modèle de fonctionnement des marchés. C'est ainsi que la croissance est liée à l'incitation à l'investir en capital physique et humain. Par conséquent, les politiques qui touchent ces incitatifs changeront le taux de croissance à long terme. En outre, la nouvelle théorie de la croissance permet de souligner la limite de l'hypothèse des rendements décroissants du capital. La première version de ces modèles portait sur le mécanisme qui empêche le rendement du capital de baisser sous un seuil déterminé et en particulier les effets des rendements croissants associés à l'accumulation du savoir.

Cette démarche permet de souligner que le savoir et la technologie sont caractérisés par des rendements croissants qui touchent le processus de croissance. Le savoir comporte des propriétés qui diffèrent de celles des autres produits

économiques de nature non concurrentielle et personnelle. Parce qu'il est possible de mettre en commun les idées de les réutiliser et de les accumuler. Elles ne sont pas imposables aux rendements décroissants. En outre, l'accumulation de savoir, par les dépenses en R&D, peut encourager la croissance de production et d'acquisition du nouveau savoir, au moyen d'interactions entre les agents.

Les innovations sont réalisées à travers les efforts de R&D des entrepreneurs et des firmes. Les théories de croissance endogène introduisent implicitement les investissements en développement technologique comme déterminants de la croissance économique endogène. Dans ces modèles, la technologie est essentiellement conceptualisée comme sujet de connaissance aux externalités ou spillovers, résultant dans le rendement croissant de l'investissement [30]. Les tests empiriques de ces théories endogènes fournissent peu de conclusions généralisées, mais augmente la contribution à la croissance d'une gamme d'investissements de technologie tel que l'investissement en R&D et en capital humain.

Les nouvelles théories de croissance économique ([20] et [31]) ont dépassé donc les limites de l'innovation technologique exogène qui était à la base du travail de Solow, en considérant l'accumulation du capital humain comme source déterminante de croissance économique. Ce changement est bien exprimé par [20] : « Le moteur principal de la croissance est l'accumulation du capital humain - de la connaissance - et la source principale des différences dans les niveaux de vie des nations est les différences dans le capital humain. L'accumulation du capital physique joue un rôle essentiel mais subsidiaire. Le capital humain prend place dans les écoles, dans les organisations de recherche et au cours de la production des biens et de l'engagement dans le commerce ».

Actuellement, il est supposé que les Nouvelles Technologies consistent la force conduisant à la croissance de la productivité à long terme : le Changement Technologique et l'innovation comptent parmi les principaux moteurs de la croissance économique. Au niveau micro, malgré les préoccupations suscitées pour le traitement de la R&D comme mesure exhaustive d'innovation, les dépenses en R&D correspondent dans une forte mesure à l'adoption de la technologie et à la croissance économique [32]. A l'intérieur des entreprises, l'importance de la technologie correspond à la croissance de l'entreprise. La référence [28] relève qu'au sein des différentes entreprises, les taux élevés de croissance s'harmonisent avec l'investissement en R&D.

La référence [33] estime que les États-Unis étaient responsables de 56 pour cent de la R&D industrielle dans les pays de l'OCDE en 1973 et de 47,5 pour cent en 1990. Selon ces auteurs, cette réduction de différence de productivité entre les États-Unis et les autres pays représente un signe qui montre que la R&D dans d'autres pays est basée sur l'adoption et l'acquisition des technologies des États-Unis. La référence [34] a étudié la relation entre la R&D et la productivité dans 22 économies industrialisées, de 1971 à 1990, en liant l'augmentation dans la Productivité Totale de Facteur (PTF) aux variations des stocks de la R&D. Leurs résultats ont confirmé un rapport positif entre les stocks de R&D d'un pays et sa propre productivité. En effet, une augmentation de 1 pour cent du stock de la R&D des 7 principaux pays industrialisés augmente la productivité de 0,23 pour cent ; les 15 économies de taille plus petite réalisent des gains plus réduits : une augmentation de 1 pour cent du stock de R&D augmente la productivité de 0,07 pour cent. En outre, ces auteurs ont constaté que les dépenses de chaque pays affectent significativement la productivité des autres pays - environ 1/4 des gains de l'investissement dans la R&D des pays de grande taille par rapport aux autres pays. Les externalités majeures viennent des États-Unis, qui possèdent les plus grands stocks de R&D, chaque augmentation d'un point de pourcentage du stock augmente la productivité des autres pays de 0,04 pour cent. Les petites économies bénéficient plus des stocks externes de R&D que les grandes économies. Dans les petites économies industrialisées, les dépenses en R&D externe faite dans d'autres pays ont un plus grand effet sur la productivité respective que leur propre effort de recherche. Par exemple, une augmentation de 1 pour cent du stock externe de R&D du Portugal en 1990, augmente la PTF portugaise d'environ 0,12 pour cent [1].

A côté, la documentation récente a passé de l'effet quantitatif à l'effet qualitatif de la scolarisation sur la croissance. Cette documentation montre que la qualité de la scolarisation a un effet sur la croissance économique, quelle que soit la quantité de la scolarisation. Les différents niveaux de capital humain n'ont pas la même incidence sur la R&D, source de l'innovation. Les niveaux d'éducation supérieurs sont plus déterminants pour la R&D que les niveaux d'éducation inférieurs qui seront plus utiles pour l'imitation ou l'adoption de technologies développées ailleurs ([35] et [36]).

La référence [37] voit que l'ambiguïté liée aux effets de la scolarisation sur la croissance économique peut s'expliquer par les différences qualitatives des systèmes d'éducation entre les pays et qui ne sont pas prises en considération. L'auteur évalue un modèle de croissance où il prend en considération les diverses caractéristiques du système d'éducation. Plusieurs de ces caractéristiques expliquent les différences qualitatives comme la dotation initiale en capital humain, les infrastructures d'enseignement et l'habileté à distribuer équitablement les services éducatifs. La référence [15] trouve que les résultats d'examen des étudiants définissent le facteur primordial de la croissance économique au lieu des taux d'inscription scolaire et des années de scolarité.

Une telle conclusion confirme la présence de facteurs non économiques pour expliquer la croissance économique comme les méthodes d'enseignement des programmes d'études, les aptitudes des étudiants, comme les milieux sociodémographiques et culturels des différents pays. Les auteurs soutiennent qu'il est possible que la clé de la croissance économique ne se limite pas à une question de fonds. La référence [14], constate que la qualité du capital humain, mesurée au moyen de tests de compétences comparés, constitue une forte relation avec la croissance économique. Ils montrent que la qualité de la main-d'œuvre a un effet beaucoup plus important que la moyenne des années de scolarité.

Nous pouvons dire qu'une des principales répercussions de la nouvelle théorie de la croissance est que les investissements en capital humain touchent le Changement Technologique qui, à son tour, possède une influence sur le taux de croissance de l'économie [38]. De ce point de vue, le taux de croissance de l'économie est fonction des décisions prises par les agents économiques, comme l'accumulation de capital physique, les investissements en capital humain ou les dépenses en R&D.

Les références [6] et [39] montrent que la croissance économique d'une nation a un lien significatif avec son stock de capital humain antérieur, mesuré par le niveau de scolarisation de ses citoyens. Dans une étude sur 98 pays au cours de la période entre 1960 à 1985, la référence [39] a conclu que le taux de croissance de la production est fortement lié avec la quantité initiale du capital humain. Cette observation concorde avec l'hypothèse selon laquelle un niveau plus élevé de capital humain engendre une croissance plus rapide du PIB par habitant. La référence [40] montre l'importance des écarts technologiques dans l'explication des différences de croissance économique entre pays. Elle observe un profil systématique où les pays en retard peuvent converger vers les pays à revenu élevé, mais seulement lorsqu'ils ont une capacité sociale requise, c.-à-d. un nombre de personnes capables de gérer les ressources nécessaires, y compris l'investissement, l'éducation et la R&D. Elle affirme que l'investissement en éducation est un complément important de la croissance économique.

La référence [41] a confirmé les résultats de [39] concernant l'effet du capital humain sur le taux de croissance réel de l'output par habitant, en employant le taux initial d'éducation supérieure comme indicateur du capital humain. Basé sur l'analyse empirique pour la Corée du Sud et le Taiwan dans le cadre de l'équilibre dynamique, la référence [41] a prouvé que la croissance économique est facilitée par l'amélioration de l'offre globale, ceci étant traduit en progrès technologique et en formation du capital humain.

Dans une approche plus complexe, la référence [42] a modélisé le progrès technologique mesuré par la croissance de la PTF en fonction du niveau de l'éducation. Elle a confirmé l'hypothèse selon laquelle le capital humain affecte la croissance en influençant sur le taux d'innovation technologique d'un pays et en influant l'allure de l'adoption des technologies venant de l'extérieur. Elle se fonde sur l'hypothèse de [24], selon laquelle le capital humain affecte la capacité à adopter les Nouvelles Technologies et à rattraper les pays les plus avancés, estime l'effet du capital humain associé au canal technologique sur la croissance. Ses estimations qui portent sur un Panel de pays pour la période 1965-1985, montrent que ce terme affecte positivement et significativement la croissance. La référence [43] confirme les résultats de [42] et trouve que le capital humain affecte la capacité de rattrapage technologique d'un pays. Les résultats obtenus par Benhabib et Spiegel avec un échantillon cross-country de 78 pays au cours de la période 1960-1985, suggèrent que le rôle du capital humain, comme condition nécessaire pour l'adoption et la création de la technologie adaptée aux besoins internes, soit plus important qu'être un facteur de production.

La référence [34] estime une équation en reliant la PTF au capital R&D national et étranger. Leurs paramètres estimés suggèrent une influence importante des deux variables. De même la référence [44], elle relie dans un travail empirique la PTF à la R&D dans une économie fermée. Elle trouve le même résultat mais l'influence de la diffusion technologique internationale est plus forte que celle de la R&D domestique. A côté, la référence [45] précise que la productivité marginale du capital augmente avec le ratio du capital humain au capital physique et, en présence d'externalités, elle augmente également avec le niveau de capital humain. Il semblerait que les nations possédant un niveau élevé de capital humain puissent générer un nombre d'effets externes positifs relativement à l'accumulation individuelle du capital humain.

La référence [46] affirme que l'introduction du capital humain ou de la connaissance permettent de contourner les problèmes des analyses néo-classiques traditionnelles car leur accumulation ne dépend plus du produit où se situent les rendements physiques marginaux décroissants. Le progrès technique est alors autorisé par l'accumulation des connaissances. Dans ce contexte, la référence [26] trouve qu'une grande partie des connaissances accumulées et des externalités d'information comme la diffusion de la connaissance proviennent de l'effort de R&D des firmes. En effet, une augmentation du capital humain employé (un accroissement du niveau de connaissance global) tend à augmenter la productivité des chercheurs. A long terme, la croissance économique dépend de la capacité des activités de R&D à mobiliser leurs stocks respectifs de capital humain et de connaissances pour progresser le progrès technique.

Les facteurs du capital humain constituent les principaux déterminants de l'innovation et du Changement Technologique. Le lien entre le capital humain et l'innovation semble revêtir une double signification : le capital humain est pertinent pour la création de nouveaux produits et pour le processus de diffusion et d'adoption de l'innovation actuelle. L'amélioration des compétences et des innovations sous-entend un processus de production, d'acquisition et de mise en commun du savoir. La référence [32] signale que « Les dépenses consacrées à l'éducation et à la formation pourraient [...] avoir des effets plus durables sur la croissance si l'innovation était confortée par un niveau élevé de qualification et par la formation, accélérant ainsi le progrès technologique, ou si l'existence d'une main-d'œuvre très qualifiée facilitait l'adoption des Nouvelles Technologies. En effet, le progrès technologique est souvent étroitement lié à l'éducation, surtout dans le cas de l'enseignement supérieur. Il est donc probable que l'éducation contribue à la croissance non seulement en améliorant la qualité de la main-d'œuvre, mais également à travers l'innovation ».

De la même manière, la référence [47] examine les deux facettes de la R&D : l'innovation et la capacité d'apprentissage. Elle incite sur le fait que la R&D comporte à la fois un effet direct sur l'innovation et un effet indirect sur la capacité des entreprises à cerner et à assimiler le savoir extérieur. La diffusion de la technologie ne résulte pas de la présence du stock de savoir des autres. Elle exige aussi que le destinataire soit capable d'assimiler et d'adopter la technologie. Les activités de R&D peuvent contribuer à faciliter l'intégration des technologies par une hausse de la capacité d'assimilation des entreprises. Par conséquent, la R&D affecte la croissance de la productivité des entreprises par deux manières. D'une part, elle augmente directement le niveau technologique par l'ajout des informations nouvelles (ou d'innovation). D'autre part, la R&D augmente la capacité d'assimilation de l'entreprise et entraîne plus de retombées technologiques. La référence [47] incite sur le fait que l'effet d'apprentissage de la R&D est plus important que l'effet d'innovation pour expliquer la croissance de la productivité des entreprises.

Sur le plan international, la référence [48] montre ainsi que l'effet du capital humain sur la croissance dépend de la distance par rapport à la frontière technologique. Les pays éloignés du leader technologique se basent sur la capacité d'imitation. Le capital humain non-qualifié constitue donc un déterminant de la croissance. En effet, plus un pays est proche du leader technologique, plus le capital humain qualifié représente un moteur de la croissance, car il joue le rôle d'innovateur. Basés sur un Panel de pays de l'OCDE de 1960 à 2000, cette référence montre que ce terme d'interaction entre l'éducation supérieure et la technologie affecte positivement la croissance pour les pays suffisamment proches des États-Unis.

La référence [49] s'intéresse aux effets du capital humain sur la croissance de la PTF. Elle montre que le capital humain supérieur corrigé de la productivité possède un effet positif et significatif sur la croissance des pays de l'OCDE. Elle montre aussi que le capital humain supérieur influence positivement la croissance de la productivité. Ainsi, le capital humain ou l'éducation peut expliquer la croissance dans les pays développés à travers son impact sur le niveau technologique. Mais il est probable que les différents niveaux de capital humain n'ont pas le même impact sur la croissance et le progrès technologique. Le capital humain supérieur qui est employé dans la R&D, est celui qui possède plus d'influence sur le niveau technologique et par suite sur la croissance.

Le cadre théorique de [50] est un modèle à générations imbriquées dans le cadre de la croissance endogène. Cependant, les agents peuvent accumuler du capital humain en se basant sur l'investissement dans l'éducation. Plus le niveau technologique est élevé, plus il devient difficile d'innover. La probabilité de réussir à innover dépend principalement du niveau de capital humain de l'agent.

Les résultats de [50] sont les suivants : le taux de croissance de l'économie dépend positivement du nombre d'individus dans le secteur d'innovation et du capital humain supérieur. Si le nombre d'individus innovateurs augmente, le taux de croissance de l'économie augmente aussi. Plus le secteur d'imitation est important, plus le taux de croissance de l'économie sera faible. Ce qui veut dire que les niveaux de qualification faibles n'ont pas un effet positif sur la croissance. Les niveaux de qualification élevés touchent l'innovation qui à son tour affecte la croissance.

La référence [50] montre que le capital humain supérieur est un déterminant de la croissance dans les pays proches de la frontière technologique. Son modèle montre que les institutions, comme le degré d'ouverture internationale, le niveau de protectionnisme et les barrières à l'entrée, adaptées à une économie en phase de rattrapage constituent un obstacle pour une économie technologiquement avancée. La référence [51] montre que le niveau du capital humain d'un pays par rapport à la frontière technologique détermine la capacité d'un pays à appartenir au groupe des pays qui croissent au même taux que le pays leader. Ces analyses soulignent que le capital humain et surtout le capital humain supérieur joue un rôle déterminant dans la croissance des pays proches des États-Unis sur le plan technologique.

La référence [48] met en évidence la relation positive entre le capital humain et la croissance des pays technologiquement avancés. Elle se concentre sur 19 pays de l'OCDE. Ses estimations affirment que l'éducation supérieure

ou le capital humain supérieur n'a pas d'impact positif sur la croissance des pays développés. Cependant, lorsque ces variables sont rapportées au niveau de la productivité moyenne déjà atteint, elles exercent un effet positif sur la croissance de ces pays. Ce qui la permet de dire que le ratio capital humain sur le niveau technologique a un impact positif sur la croissance des pays de l'OCDE. C'est la référence [23] qui a identifié cet effet de capacité d'absorption identifié. Chaque acte de transfert de technologie exige une innovation dans le pays destinataire. Plus l'économie s'adapte aux Nouvelles Technologies importées plus son niveau moyen de capital humain est élevé. La référence [49] trouve que le niveau du capital humain supérieur n'influence pas directement la croissance, mais à travers la technologie.

La référence [48] étudie l'impact du capital humain élevé sur la croissance à travers son rôle spécifique sur l'innovation technologique. Elle montre que la distribution du capital humain par rapport au niveau moyen de la productivité détermine la trajectoire de la croissance à long terme de l'économie. La distribution du capital humain détermine l'allocation des individus entre le secteur de R&D porteur de croissance et le secteur d'adaptation de la technologie existante. Elle montre que la croissance dépend du nombre d'agents qui investissent dans la R&D et dans l'éducation. Pour elle, ce choix d'investissement dans la R&D est endogène et dépend du niveau du capital humain des individus par rapport au niveau technologique déjà atteint.

Pour ce faire, la référence [48] construit un modèle où les individus prennent deux décisions : d'abord ils décident au cours de leur jeunesse le temps qu'ils consacrent à l'éducation pour augmenter leur niveau de capital humain, ensuite à l'âge adulte, ils choisissent la technologie de production. Un individu peut choisir soit de produire par l'adoption directe de la technologie existante soit d'investir dans la R&D pour créer une innovation technologique qui est un incrément par rapport à la technologie existante.

La référence [48] montre que les agents qui reçoivent un niveau de capital humain faible possèdent un avantage comparatif à produire par l'adoption de la technologie existante alors que ceux qui ont un capital humain élevé peuvent réussir une innovation plus importante par l'investissement dans la R&D. Par ailleurs, les agents qui choisissent de s'orienter dans la R&D, investissent plus dans l'éducation que ceux qui adoptent la technologie d'adaptation. Cette incitation à investir plus dans l'éducation provient de la relation croissante entre le niveau de capital humain et la réussite des activités de R&D.

La référence [50] établit donc une relation entre la composition du capital humain et la distance à la frontière technologique. Elle montre que le capital humain qualifié ou supérieur influence la croissance lorsque l'économie est proche de la frontière technologique. La référence [50] voit que les gains de productivité liés à l'innovation et à l'imitation de technologies dépendent aussi de la distance par rapport à la frontière technologique. Pour un pays éloigné de la frontière technologique, les gains de productivité passent plus précisément par l'imitation des technologies existantes alors que pour un pays proche de la frontière technologique, l'innovation représente le principal moteur de la croissance. La référence [49] diffère de ces deux travaux par le fait qu'elle ne s'intéresse pas à la distance par rapport à la frontière technologique pour démontrer l'effet du capital humain supérieur sur la croissance. Ainsi, dans le modèle l'influence du capital humain supérieur est spécifique à chaque pays et dépend du niveau technologique déjà atteint.

Toutes les innovations qui sous-tendent la croissance de nos économies ne tombent évidemment pas du ciel. Elles résultent d'efforts soutenus en R&D. Les innovations résultent plus généralement de l'activité créatrice de ceux que Schumpeter nomme les entrepreneurs, c.-à-d. tous ces individus qui produisent de l'innovation, non seulement par la recherche, mais aussi en essayant de résoudre des problèmes posés par les processus de production existants ou par l'adaptation aux circonstances, ou en apprenant par l'expérience (le concept de learning by doing).

Le développement n'est pas seulement une question de production de technologies nouvelles, mais aussi une question d'acquisition des technologies existantes. C'est ainsi que plusieurs auteurs soutiennent les politiques d'ouverture au commerce en insistant sur les gains issus des transferts technologiques. Mais pour bénéficier de ces technologies, il est nécessaire de détenir le capital humain capable de l'utiliser.

Plus généralement, les analyses posent indirectement la question du type de capital humain qui entre en jeu dans le processus de convergence. En effet, si les analyses macro-économiques considèrent un stock agrégé, alors il semble crucial d'intégrer une distinction entre le capital humain utile pour développer des technologies nouvelles et le capital humain utile pour absorber ces technologies. Le stock de capital humain peut naturellement faciliter le rattrapage, dans la mesure où il favorise l'acquisition de technologies existantes. Néanmoins, cela peut s'avérer insuffisant pour un rattrapage complet, les nations en développement n'acquérant que des technologies relativement anciennes pour les pays innovateurs.

Le problème crucial des pays en développement est que leur spécialisation dans des activités peu intensives en capital humain incite les jeunes à ne pas investir dans l'éducation et incite les travailleurs qualifiés à migrer vers les pays développés. Cette spécialisation hypothèque davantage les possibilités de développement puisqu'elle réduit l'incitation à investir dans la formation. La fuite des cerveaux incite sur la différenciation entre les travailleurs qualifiés, qui peuvent migrer vers les

pays développés et les travailleurs non-qualifiés restent. Dans la mesure où les travailleurs qualifiés sont créateurs d'externalités positives, la fuite des cerveaux est un facteur aggravant le sous-développement.

Le Changement Technologique dans les pays les moins avancés se produit principalement en apprenant les technologies qui existent déjà dans des économies plus avancées et non pas en repoussant plus loin les frontières du savoir. Les théories de croissance néoclassique et endogène considèrent ceci comme un transfert de technologie dans lequel l'accès à la technologie étrangère est la conséquence automatique de l'ouverture au commerce et aux investissements étrangers et équivaut à une utilisation efficace. Cependant, les études empiriques démontrent que, dans la pratique, l'acquisition, la diffusion et l'amélioration des technologies étrangères demandent un effort considérable de la part des sociétés. Une grande partie du savoir est tacite et les sociétés travaillent dans un climat d'incertitude, avec des informations incomplètes. Il faut donc du temps, des efforts et des investissements coûteux pour apprendre à utiliser efficacement la technologie. L'apprentissage technologique est ainsi essentiel au Changement Technologique. Quel est donc l'impact des Changements Technologiques sur la croissance économique des pays en développement ?

4 LE MODELE ET LES DONNEES

Notre travail estime le Croissance (c'est la variable expliquée) en fonction du Changement Technologique, du Revenu, du Capital Humain et des Distorsions du Marché (ce sont les variables explicatives).

Le modèle central de notre travail est le suivant :

$$\text{Croissance}_{i,t} = \alpha_i + \beta_1 \text{ Changement Technologique}_{i,t} + \beta_2 \text{ Revenu}_{i,t} + \beta_3 \text{ Education Primaire}_{i,t} + \beta_4 \text{ Education Secondaire}_{i,t} + \beta_5 \text{ Education Supérieure}_{i,t} + \beta_6 \text{ PI}_{i,t} + \mu_{it}$$

Où « i » représente chaque pays et « t » représente chaque période de temps (avec $t = 1, 2, \dots, T$). Croissance_{it} est le taux de croissance du PIB réel par tête pour le pays i à l'instant t. Changement Technologique_{it} est la valeur des technologies importés à l'instant t. On a choisit cette mesure des Changements Technologiques parcequ'on s'intéresse aux pays en développement qui sont des consommateurs de technologies. Inégalité_{it}; Revenu_{it}; Education Primaire_{it}; Education Secondaire_{it}; Education Supérieure_{it} et PI_{it} sont respectivement, le Revenu, l'Education Primaire, l'Education Secondaire, l'Education Supérieure et les Distorsions du Marché pour le pays i à l'instant t et μ_{it} est le terme d'erreur.

Les données utilisées pour estimer le modèle proviennent de plusieurs sources. Les taux de Croissance annuels sont pris aussi à partir de [52]. Le Changement Technologique est tirée de [53]. Le Revenu est retiré aussi à partir de [52], sachant qu'il est mesuré par le log du PIB réel par tête. Les statistiques du capital humain sont représentées par la moyenne des années d'Education Primaire, Secondaire et Supérieure proviennent de la base de données International Data on Educational Attainment: Updates and Implications [7]. Les Distorsions du Marché sont retirées aussi à partir de Penn World Tables et elles représentent le niveau du prix de l'investissement. Notre modèle se concentre sur la croissance pour la période allant de 1980 à 2010. Et nous avons procédé avec un échantillon de 39 pays homogènes en développement : Algeria, Argentina, Bolivia, Bulgaria, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Ecuador, Egypt, Guatemala, Honduras, Hungary, India, Indonesia, Iran, Malaysia, Malta, Mauritius, Mongolia, Morocco, Pakistan, Panama, Paraguay, Peru, Philippines, Romania, Singapore, Sri Lanka, Tajikistan, Thailand, Trinidad & Tobago, Tunisia, Uganda, Ukraine, Uruguay, Zambia.

5 L'ESTIMATION

Il y a une diversité de techniques qui peuvent être utilisées pour estimer l'équation. Les méthodes standards pour l'estimation de Panel sont les effets fixes ou les effets aléatoires. Les coefficients estimés sont sensiblement différents dans les deux cas.

Le test de la spécification de Hausman (1978) peut être un moyen d'évaluation. Pour notre échantillon considéré, la réalisation de la statistique du test de Hausman est de 5,51. Etant donné que le modèle comporte six variables explicatives ($K = 6$), cette statistique suit un Khi deux à six degrés de liberté. Le seuil est de 12,592. Nous acceptons donc l'hypothèse nulle d'absence de corrélation entre les effets individuels et les variables explicatives. Ainsi, nous devons privilégier l'adoption d'un modèle à effets aléatoires et retenir l'estimateur des MCG (estimateur BLUE). Il n'existe alors pas un caractère commun entre les pays et le terme d'erreur se décompose.

Nous allons examiner l'influence des variables fondamentales sur la Croissance Economique : Le Changement Technologique, le niveau du revenu, l'investissement humain et le prix de l'investissement. Non seulement la plupart des

coefficients estimés doivent concorder avec ceux traditionnellement rapportés dans la littérature, mais aussi la plupart d'entre eux doivent être significatifs. Notre principale question de recherche, dans ce modèle, se demande si les Changements Technologiques touchent la croissance économique.

Le coefficient du Revenu est positif et fortement significatif : une augmentation du Revenu entraîne une augmentation de la croissance. Nous avons trouvé un effet négatif et fortement significatif de l'Education Primaire, un effet positif et fortement significatif pour l'Education Secondaire. Pour l'Education Supérieure, elle pratique aussi une influence positive et fortement significative sur la croissance. Ce résultat montre que l'éducation est très corrélée avec la croissance. Ainsi, l'Education Supérieure ou secondaire sont ceux qui influencent positivement la croissance. Ce qui montre qu'une augmentation de l'éducation secondaire et supérieure favorise la croissance parce que la main-d'œuvre qualifiée est celle qui s'adapte aux technologies importées.

Le coefficient sur les Distorsions du Marché est négatif et significatif. Une augmentation du prix de l'investissement baisse la croissance économique. On peut dire donc, qu'une hausse du prix de l'investissement freine la croissance. Et enfin, le coefficient sur le Changement Technologique est positif et très significatif. Le Changement Technologique joue donc un rôle crucial dans la détermination de la croissance économique. Une relation positive entre la croissance et les Changements Technologiques peut être confirmée pour un échantillon de pays en développement. Les Changements Technologiques approuvent donc la croissance économique dans les pays en développement. Le résultat de notre estimation est rapporté dans le tableau 1.

Tableau 1. Résultats de l'estimation

Estimation	Effet Individuel fixe	Effet individuel aléatoire
Constante	0,123 (0,000)	1,751 (0,000)
Changements Technologiques	1,4562 (0,000)	1,9875 (0,000)
Revenu	0,697 (0,000)	0,1597 (0,000)
Education Primaire	-0,0089 (0,016)	-0,0098 (0,027)
Education Secondaire	0,3241 (0,001)	0,1258 (0,012)
Education Supérieure	0,3684 (0,204)	0,6587 (0,028)
PI	-0,1078 (0,587)	-0,0036 (0,032)
Pays	39 pays	39 pays

Note: Les valeurs entre parenthèses représentent les probabilités.

6 CONCLUSION

Nous nous sommes intéressés aux aspects théoriques et empiriques de la relation allant des Changements Technologiques vers la croissance économique. L'objet de ce travail est l'analyse des déterminants des Changements Technologiques. Il s'agit d'une question centrale pour les pays en développement, car l'innovation est un moteur de la

croissance économique et constitue un élément important du processus de développement industriel et d'intégration dans l'économie mondiale. La croissance résulte du progrès technique qui résulte à son tour de la concurrence entre les recherches qui génèrent les innovations effectuées par les différentes firmes. De très nombreux facteurs internes et externes sont susceptibles d'influencer la décision de s'engager dans une activité d'innovation ou de s'adapter et d'importer les technologies déjà existantes, ainsi que leurs probabilité de succès pour stimuler la croissance économiques.

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STIFFNESS OF A COMPOSITE MATERIAL MANUFACTURED WITH TANNIN'S BINDER OF AUTRANELLA CONGOLENSIS

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ABSTRACT: In last decades, the need for implementation of biodegradable materials is a showy concern for the planet earth because they contribute to the fight against environmental pollution and the valorization of plant resources. For this purpose, a composite developed with the tannin's binder and reinforcement of autranelle congolensis has been established. Throughout this work, two types of materials were manufactured under the same experimental. The implementation of biodegradable materials made with tannin's binder of autranelle congolensis (type1 materials) and synthetic materials based on Urea Formaldehyde (type2 materials). At the end of testing, it appears that type 1 materials are stiffer than type 2 materials: Indeed, the three-point bending tests performed on sample of type 1 materials when sizing rate varies between 25 and 78%, gave a Young's modulus varies between 43.832 and 466.652 MPa against 24.200 to 266.001 MPa for type 2 materials. A volume effect on the stiffness has established on the two types of materials: stiffness is increasing with the length between supports. For both materials, Young's modulus increases with the length between supports. The stiffness increases with temperature and the sizing rate. Materials having a high sizing rate are less resistant to moisture. The type 2 materials are resistant to moisture than type 1 materials. The binder developed with the tannin of autranelle congolensis has a gel time between 50 and 152 seconds.

KEYWORDS: biodegradable; urea formaldehyde; sizing rate; volume effect; absorption rate.

1 INTRODUCTION AND OBJECTIVES

Since the beginning, nature has always been generous to humans. It made available to them, fossil resources, oil resources, plant and animal very helpful. These elements constitute for them a wealth because they are used in the timber industries, aeronautics, bituminizing, decoration, tanning...[5]. At the time when humanity suffers from environmental threats, minds are mobilizing to deal with this scourge, the biodegradable materials manufactured using natural resources are an alternative.

From eighteenth century to the twentieth century, a long period during which petroleum was king, materials were manufactured by using a synthetic matrix as UF, PF, MF... [1]. to fully exploit these natural wealth, it is important for us to manufacture materials based with the tannin's binder from tropical plants and more particularly based of wood used in Cameroon: Autranelle congolensis, species most used in plating. It is in this perspective that we want to: Develop the tannin's binder; manufacture the materials based tannin's binder; manufacture materials based Urea Formaldehyde; dry the materials by varying the temperature; make bending tests "three points"; calculate stiffness; compare the two materials.

The main objective of this work is to consider the replacement of urea formaldehyde resins by natural binder developed with tannin while comparing the two types of materials (materials made with tannin's binder and those based on urea formaldehyde); consider the manufacture of biodegradable particle board based tannin's binder of autranelle congolensis and finally contribute to the reduction of environmental pollution.

To achieve this, we are going to review materials and methods used, give results and interpreted them.

2 MATERIALS AND METHODS

The bark of autranelle congolensis (plant known in Cameroon on the name mukulungu) used for the development of binder and reinforcements of materials come from the company ECAM- PLATING, a company located at Mbalmayo - Cameroon. Tests have taken place in the Natural Substance Laboratory N°3 of the University of Yaoundé I and in Laboratory of Mechanics, Materials and Structures of the National Advanced School of Engineering, University of Yaoundé I, and Cameroon.

2.1 MATERIALS

2.1.1 BINDER'S DEVELOPMENT

Materials that have allowed us to develop the binder after extraction of tannin [2] are:

- Tannin: bark's extract of autranelle congolensis;
- Cassava flour: load in the development of the adhesive;
- KOH: an additive making the middle basic while changing the PH;
- Hexamine: additive acting as hardener;
- A boiler water bath;
- A kite balloon, containing glue;
- The beakers containing tannin;
- A spatula to stir the glue;
- Test tube and beaker for determination of gel time;
- An electronic balance for measuring the constituents used in the development...

2.1.2 MANUFACTURING OF MATERIALS

The materials used for the manufacture of composite materials and bending tests three points are:

- A mold $150 \times 15 \times 15 \text{ mm}$ to produce samples of materials;
- Binder's tannin used in the manufacture of type 1 materials;
- Urea formaldehyde: resin use to produce type 2 materials;
- An oven for drying the material depending temperature ;
- Lead compactness materials;
- Three-point bending tests machines to calculate the Young's modulus of different samples produced:
- The weights;
- A dial gauge for reading travel.

2.2 METHODS

The extraction of tannin [3] leads us to the development of binder's tannin, manufacturing type 1 and 2 materials, and "three-point" bending tests. After that test, Young's modulus and other values such as mechanical tensile strength, slenderness's effect, heat resistance were determined and these mechanical characteristics of type 1 and type 2 materials were compared. The specimens are reinforced by particles of autranelle congolensis (wood).

2.2.1 TANNIN'S BINDER' DEVELOPMENT

Prepare tannin in water solution N°1 at 50% concentration and cassava flour in water solution N°2 at 30% on the tannin solids base then mix solution N°1 and solution N°2. The pH was adjusted to 10 with a potassium hydroxide (30%). Finally add 5% of hexamine solution (30%) on the tannin solids based [2].

2.2.2 MANUFACTURING OF COMPOSITE MATERIALS

Two types of materials were manufactured: the biodegradable materials manufactured with tannin's binder (type 1 materials) and materials manufactured with Urea Formaldehyde's resin (type 2 materials). The manufacturing of materials is summarized [4] as below:

- Crushing: This is an operation which consists to reduce wood in bark particles;
- sifting: Removal large and dust particles because they would give defectives composites.
- sizing: quantity of binder used is between 25 and 78 % of the total composite weight. These resins are shuffled directly with the wood particles before molding;
- mixing : mixing wood particles and the binder to form "cake" or "dough";
- casting : dough was poured into a mold of $150 \times 15 \times 15$ mm;
- pressing: it takes place under significant pressure cold (20 KN/mm^2);
- Heating : it is made by variation of the temperature (60 to 120°C);
- Removal from the mould: it is carried out after evaporation of certain water in the materials.

2.2.3 DRYING MATERIALS

The heating of the materials at a T temperature (80 to 90°C) allows the evaporation of water contained in the materials.

2.2.4 BENDING TESTS

The principle of the "3-point" bending test [5] is to determine the maximum tensile strength of a material on two supports with an application of the force at the midway between the supports at a constant speed over a test tube. By using the device below, put a weight on a pan suspended at the specimen and wait until the comparator stabilizes to read the deflection on its dial. The operation is repeated until reaching a value m to the rupture or the appearance of cracks on the specimen.



Fig.1: testing machine "3 point" bending

2.2.5 RIGIDITY

Young's modulus were determined and other values such as the mechanical tensile strength, the absorption rate and the resistance to humidity.

2.2.5.1. YOUNG'S MODULUS

There are links between the two variables (y and F), the geometry of specimen (L, h and b) and the characteristics of the material (σ, ε and E).

The specimen of rectangular shape is placed on two supports and loaded single in the middle by a load until failure.

The Young's modulus E_i are determined by:

$$E_i = \frac{1}{4b} \left(\frac{L}{h}\right)^3 \frac{\Delta F}{\Delta f} \quad (1)$$

And the stiffness K is deduced by:

$$K = \frac{EA}{L} \quad (2)$$

L: Distance between two supports;

B: width of the sample (15 mm)

H: sample thickness (15 mm).

The average Young's modulus \bar{E}_m of each sample is given by:

$$\bar{E}_m = \frac{\sum_i^n E_i}{n} \quad (3)$$

$i = 1$ to n ; $n = 35$ samples per test

The plot of a histogram makes it possible to study a distributive modulus based the sizing the rate and temperature.

2.2.5.2. SQUARE ERROR

The values of square error are derived by the formula:

$$\sigma_m = \sqrt{\frac{\sum_{i=1}^n (E_i - \bar{E}_m)^2}{n}} \quad (4)$$

2.2.5.3. Tensile strength

The bending stress is expressed by the following classical equation [2]:

$$\sigma = \frac{3 FL}{2 BH^2} \quad (5)$$

L: distance between supports; F: applied load;

B: width of the specimen; H: thickness of the specimen.

At the break:
$$\sigma_{\max} = \frac{3 F_{\max} L}{2 BH^2} \quad (6)$$

2.2.5.4. EFFECT OF SLENDERNESS

To know the effect of volume on the tensile strength, the three points bending tests were performed with different lengths between the supports (120,90,60 and 30 mm).

2.2.5.5. MOISTURE RESISTANCE

It is determined by the NF B 51 262 [6].It describes " V100 " method which consists of immersing the specimens of 50x50 mm in boiling water for at least one hour. The samples are left to cool in cold water for 1 to 2 hours, removed from the water, free of excess water by sponging wet and then tested.

2.2.5.6. WATER ABSORPTION

The rate water absorption (TA) in each specimen ($50 \times 50 \text{ mm}$) is determined by **NFEN 317 [7]** :

$$TA = \frac{m_f - m_i}{m_i} \times 100 \quad (7)$$

m_f : Final mass material after immersion in water;

m_i : Initial mass of the material

A relationship between water absorption and the razing rate in materials was determined.

2.2.5.7. AVERAGE'S COMPARISONS

Population means (E_1, E_2, E_3, E_4, E_5) were compared by applying the "test of Z " or "reduced gap" is to compare the parameters by testing their difference [8] (in this case compares the average of Young's moduli of the samples). These comparisons have allowed us to retain the different populations (E_1, E_2, E_3, E_4, E_5).

To do so it:

- Take two samples from two different populations i and j ;
- Consider the averages of two populations i and j , and calculate their variance: S^2_i et S^2_j

- calculate $Z = \frac{|E_i - E_j|}{\sqrt{\frac{S^2_i}{n_i} + \frac{S^2_j}{n_j}}} \quad (8);$

- If $Z < 1.96$, the difference between the parameters is not significant and it is concluded that the average population denoted E_i is not significantly different from the average population denoted E_j ;

- If $Z > 1.96$, the difference between the parameters is significant, E_i is different from E_j .

3 RESULTS AND DISCUSSION

3.1 RESULTS

3.1.1 TANNIN'S BINDER DEVELOPMENT

The adhesive obtained is black, viscous and gel time is less than 200 seconds; it binds all wood materials and plastics; for good adhesion, apply high pressure for a few seconds [5].

3.1.2 MANUFACTURING OF COMPOSITE MATERIALS

330 Specimens of size $150 \times 150 \times 15 \text{ mm}$ were manufactured: 165 of type 1 materials and 165 of type 2 materials. The sizing rate in each case allows us to combine these samples: 5 peoples at 35 specimens per people [$2 \times (5 \times 35) = 330$].

Sizing rate is defined as (table 1):

Table 1: proportion of composite material's constituents

Sizing rate	Reinforcement rate	Populations
25	75	E1
33	67	E2
50	50	E3
65	35	E4
78	22	E5

3.1.3 STIFFNESS

Young's modulus, Tensile strength, volume effect

Table 2: Summary of mechanical properties

Binder	Caractéristiques	E5	E4	E3	E2	E1
Tannin's binder of autrenelle congolensis	σ_{max} (MPa)	0,777	0,977	1,222	1,355	1,533
	F_{max} (N)	350	440	550	610	690
	\bar{E}_m (Mpa)	466,652	266,63	162,922	82,901	43,832
	L_{min} (mm)	30	30	30	30	30
	A (mm ²)	450				
	K (N/mm)	6999	3999	2443	1243	657
Formaldehyde urea	σ_{max} (MPa)	0,666	0,777	0,977	1,222	1,355
	F_{max} (N)	300	350	440	550	610
	\bar{E}_m (MPa)	266,001	194,604	77,100	45,134	24,200
	L_{min} (mm)	30	30	30	30	30
	A	450				
	K	3990	2919	1156	667	363

The study of stiffness depending the sizing rate gives:

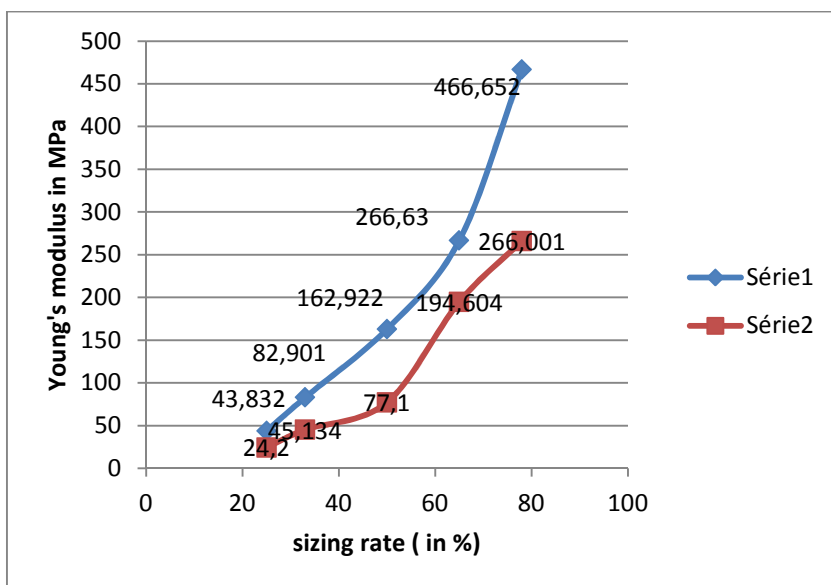


Fig. 2: Young's modulus depending of the sizing rate

On the figure above, the Serie 1 give the evolution of the rigidity of autranelle congolensis depending on the sizing rate and series 2 give that of type 2 materials.

The Young's modulus increases with the sizing rate. The different populations are manufactured at different temperatures and different sizing rate.

By varying the length L between the supports at a given temperature, we have:

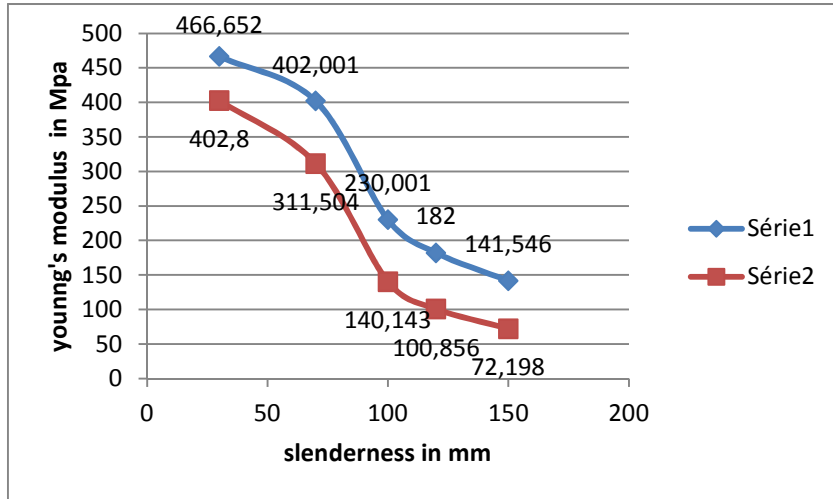


Fig. 3: Young's modulus depending the effect of slenderness

The graph above shows the evolution of the Young's modulus depending the effect of slenderness. Series 1 shows the plot of Young's modulus of type 1 materials depending the slenderness and the series 2 that type 2 materials. In each case, the Young's modulus decreases progressively as

the length between the supports is high. For a minimal length ($L = 30\text{ mm}$), the rigidity is the highest.

The histogram below shows the evolution of the modulus depending the temperature in each case of studied materials, for length $L = 30\text{ mm}$:

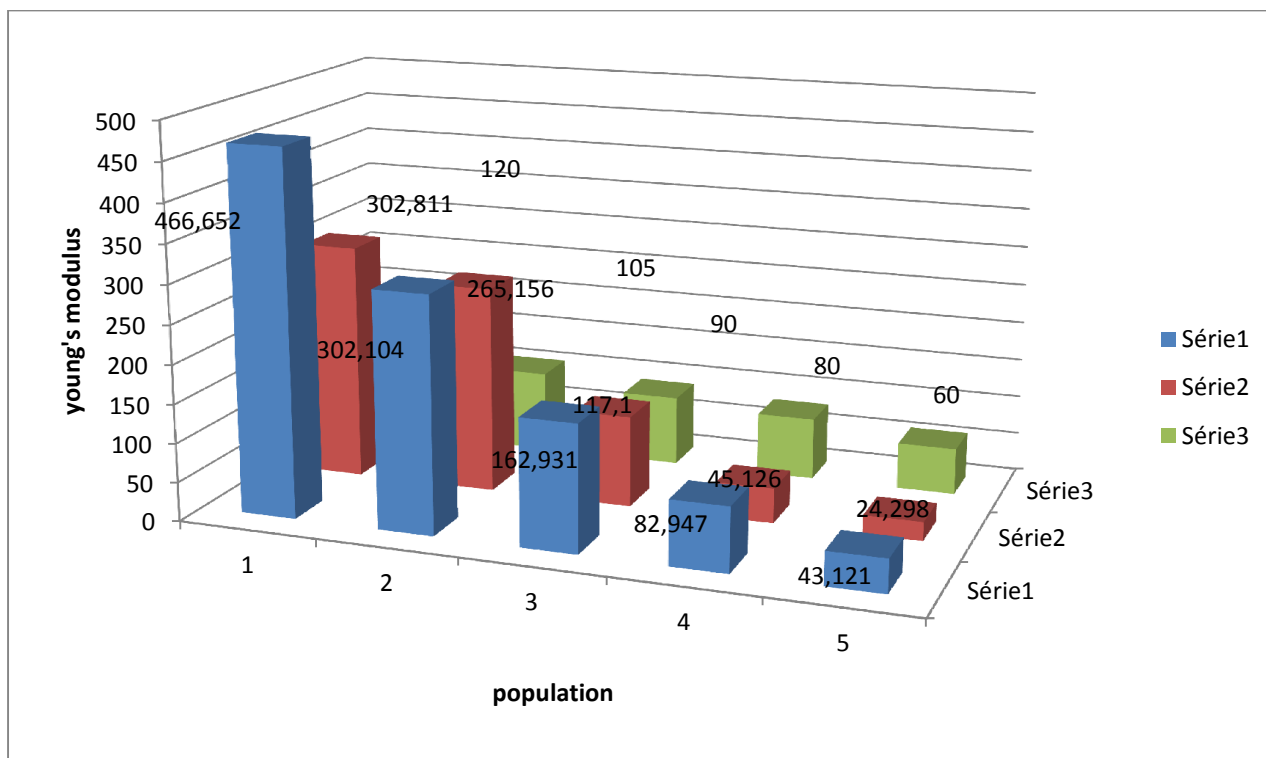


Fig.4: Young's modulus depending the sizing rate and temperature

Series 1 show the variation of Young's modulus of material manufactured with Tannin's binder depending temperature, the series 2 those type 2 materials and Series 3 the variation of temperature depending population.

On the abscissa axis are the five different populations of each type of materials. The Young's modulus increase simultaneously with the temperature and the sizing rate.

Square error

Square errors were calculated with a risk of 5% by varying the temperature and sizing rate.

3.1.4 MOISTURE RESISTANCE

Study of moisture resistance has led us to conclude that type 2 materials with high temperature sintering are more resistant than the type 1; both caught in the same experimental conditions.

3.1.5 WATER ABSORPTION RATE

The calculation of the absorption rate in each sample depending temperature allows us to obtain:

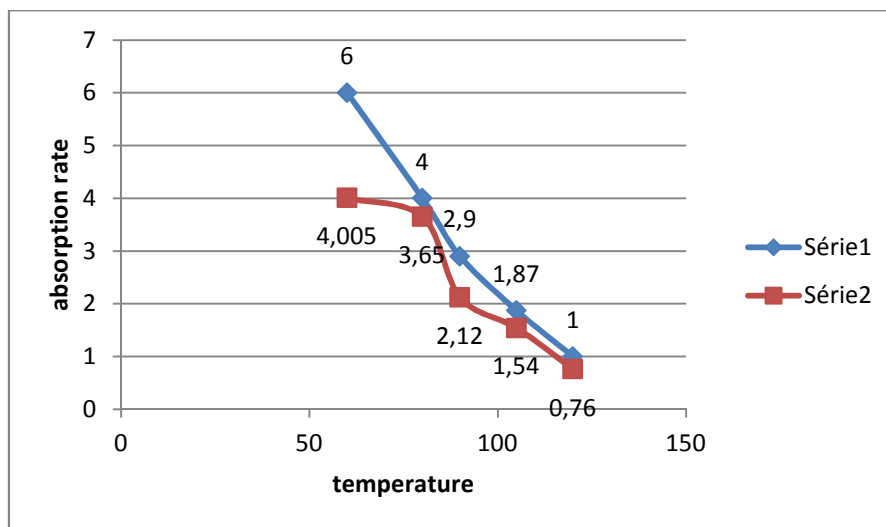


Fig. 5: Absorption rate depending the temperature

The absorption rate increased simultaneously with the drying temperature and the sizing rate.

3.1.6 COMPARISON

Given the different results above, type 1 materials are stiffer than type 2 materials.

3.2 DISCUSSION

Mechanicals properties are increased with the sizing rate and drying temperature, it means that, when the quantity of water contained in the material is evaporated with the temperature and time, materials become stiffer. The high sizing rate is one of adverse effects in a composite material because materials are not resistant to moisture. The ratio: $(\text{young's modulus of type 1 materials}) / (\text{Young's modulus of type 2 material}) \geq 1.15$ means that Mechanical characteristics of type 1 materials are at least 1.15 times those of type 2 materials. In fact, tannins' binder are more important than Urea Formaldehyde's resin and mechanical properties of materials manufactured with tannin's binder of autranelle congolensis are greater than those manufactured with Urea Formaldehyde's resin. Materials manufactured with tannin's binder can be resistant to moisture contrary to materials manufactured with urea formaldehyde resin. Materials manufactured with tannin's binder of autranelle congolensis with 65% rate would give the same results as materials containing 78% of Urea Formaldehyde's rate (Young's modulus of type 1 materials is 402.001 at 65 % rate against 402.8 for type 2 materials at 78 %), these values may be justified by good mechanical performance of tannin's binder of autranelle congolensis. The Sizing rate content in the biodegradable material must be as low as possible to increase the resistance to moisture and not only for economic reasons, as it is the case in the synthetic materials [7].

4 CONCLUSION

Materials made from tannin's binder of autranelle congolensis have better characteristics than those based on Urea Formaldehyde: so we can replace urea formaldehyde resin by tannin's binder of autranelle congolensis to manufacture biodegradable materials (chipboard) and contribute to the fight against environmental pollution. It is question of encouraging the development of green adhesives (especially in Africa) based on data derived from plants (tannins, lignin, and cellulose) to produce biodegradable material and suggests methods of conservation of these adhesives.

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Food Quality of Rural Poor in India: A Case Study of Orissa and Bihar

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ABSTRACT: India is home to 22 per cent of the world's poor, but the majority is in rural area. Such a high incidence of poverty is a matter of concern in view of the fact that food security and its quality has been one of the major concerns for rural poor. Agricultural wage earners, small and marginal farmers and casual workers engaged in non-agricultural activities, constitute the bulk of the rural poor. Small land holdings and their low productivity are the cause of poverty among households dependent on land-based activities for their livelihood. Even after six decades of independence and two decades of economic liberalization, it remains the bitter truth. This study assumes greater significance, because, majority of the rural poor still depend on low quality of food grain leading to poor health and malnutrition. An effective public distribution system with quality of food grain would help in reducing the government spending on public health problems. This study could be useful not only to India, but to many other economies that are on the threshold of transition; where majority of the population, still lives in the rural areas, and are predominantly dependent on agriculture for their livelihood. This study was undertaken with the objective of analyzing the socio-economic conditions of rural poor of India with respect to their quality of food grain consumption. The study conducts a questionnaire based survey on demographic, economic, and perceptible parameters on quality of food; using ordinal logit model to identify variables useful for the study. The respondents with larger income have more chances of consuming good quality of food. Interestingly, it is also found that most of the poorest of the poor respondents spend high share of their income on food consumption.

KEYWORDS: Ordinal Regression Model; Food Quality; Rural Poor, Below Poverty Line; Bihar; Orissa; India.

1 INTRODUCTION

The word 'food' refers to the chemical substances taken into the body in order to keep the body in a healthy and active condition. The body requires food for growth, repair and replacement of its worn-out tissues. Hence, food has to provide the required raw material, energy and other regulating substances, like vitamins and minerals, for the smooth functioning of the body, besides meeting the calorific requirements like carbohydrates, proteins, fats, etc [1]. Therefore, food is a basic human need and the major source of nutrients needed for human existence. The problem of adequate nutrition is regarded as a major strategic issue that attracts intensive attention at all levels. Its importance stems from important political and socio-economic dimensions [2].

Food insecurity includes problems with the quantity and quality of available food, uncertainty of food supply and food insecurity experiences, which include running out of food and purchasing power to buy food, skipping meals and hunger due to financial constraints. Food availability and access is restricted due to high food prices and limited resources, which result in inadequate quantity and poor quality of diet in households [3]. The rise in food prices not only has an adverse impact on the quantity and quality of food consumption, but it also forces the poor to reduce their expenditure on basic needs and investments in human assets, such as education and health and to sell productive assets with negative effects on their current and future livelihoods [4]. Poor dietary quality or diversity is a significant contributing factor of under nutrition, specifically micronutrient deficiencies.

In the past few decades, the food grain situation in India has undergone substantial change. From a position of growing shortages in the mid 1960s, India became able in the 1980's to produce enough to meet its current demand and at the same time generate a small surplus. At present India is the world's second largest producer of food next to China [5]. However, the concern is about several underlying features of production and consumption that may make the present position difficult to sustain over the years, but India does have the capacity to double the food grains produce in the next ten years. One of the major features of production and consumption is the growth in population and decrease in agricultural land. Another concern is the distribution of food grains among the rich and poor population especially among rural area [6].

India is the second most populous country in the world, with over 1.01 billion people out of which more than seventy percent live in rural areas [7]. The number of poor people in India, according to the country's Eleventh National Development Plan, amounts to more than 300 million. The country has been successful in reducing the proportion of poor people from about 55 per cent in 1973 to about 27 per cent in 2004 [8]. But almost one third of the country's population of more than 1.1 billion continues to live below the poverty line, and a large proportion of poor people live in rural areas. Poverty remains a chronic condition for almost 30 per cent of India's rural population [9]. The incidence of rural poverty has declined somewhat over the past three decades as a result of rural to urban migration and poverty alleviation program by the government [10].

In India, poverty is defined on the basis of a minimum per capita daily nutritional requirement of 2,100 calories in urban areas and 2,400 calories in rural areas [11]. These figures are based on the recommendations submitted in 1979 by the Government of India Task Force on Minimum Needs and Effective Consumption Demand. According to the report of the Task Force, the poverty line was defined as per capita monthly expenditure of Rs 49.09 in rural areas and Rs 56.64 in urban areas at 1973/74 prices, corresponding to per capita daily calorie requirements in rural and urban areas. The definition covers expenditures on food and non-food items (such as fuel, clothing, housing, health, education and social services) and ensures adequacy of calorie consumption. On the map of poverty in India, the poorest areas are in parts of Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Jharkhand, Orissa, Chhattisgarh and West Bengal [12].

Therefore the objective of this paper is to discuss the factors guiding rural poor household choices of food quality [13]. This is crucial for policies to combat under nutrition, specifically micronutrient deficiencies among rural poor. As there is economic progression in a country, there is likely to be shift towards better quality of food. Understanding this "transition in food quality", as it has come to be called, is therefore of prime importance for designing policy interventions. It is also important for food security planners who must anticipate future demand for better quality of food, as well as for those concerned with the longer-term health consequences of food intake. Here we undertake the first analysis of a nationally representative survey of rural poor households in India particularly Orissa and Bihar to describe patterns of rural food consumption, in the context of the conceptual framework of the quality of food transition. In the next section we describe the dataset. Following that, we present a descriptive analysis, focusing on types of rural poor and their quality of food intake; by income and expenditure, as well as a multi ordinal analysis of the determinants of food intake. Finally, we provide a discussion and summarize conclusions.

2 METHODOLOGY FOR SAMPLE SELECTION AND DATA COLLECTION

The data used in this paper was collected from primary sources based on fieldwork conducted during 2001-2002. The study covered two states of India. In the first stage of the multi-stage sampling used, two districts of each state were chosen. The districts were selected through purposive sampling to ensure that these districts were adequately representative of the state with respect to geographical distribution and special conditions of the state, if any. A total of four districts were chosen at the end of the first stage. Four blocks were identified in district in the second stage through circular systematic sampling using Directory of Blocks as the frame of reference. From each of the selected block ten gram panchayats was chosen using convenience sampling. A gram panchayat is the lowest administrative unit in India. In some cases a gram panchayat may consist of only one village, while in other, it may have a number of villages, hamlets or padas. The selection of villages/gram panchayats was done carefully so that these would properly represent the blocks. Individual respondents were the final sampling units. From each of the selected village or gram panchayat, eighteen respondents were selected randomly. Special care was taken to ensure that out of eighteen fifteen respondents were covered under officially declared Below Poverty Line (BPL) category. Rest three non official BPL respondents constituted the control group. Finally, the schedule for respondents filled up for each of them. A total of 2640 were covered in the entire study.

3 FOOD INTAKE BY RURAL POOR OF ORISSA AND BIHAR IN INDIA

Poverty in India is widespread, with the nation estimated to have a one third of the world's poor. Out of 1.01 billion populations, 300 million are still below the poverty line, according to the country's Eleventh National Development Plan, a

large proportion of India's poor live in rural areas. Within rural areas, poverty is concentrated in five out of the 17 major (undivided) states, which account for nearly two thirds of poor people in the country. These states are: Bihar, Orissa, Uttar Pradesh, Madhya Pradesh, and Maharashtra. Among the poor states, Bihar and Orissa are at the bottom level amounts to 20.47 million and 8.4 million poor people respectively [14].

In India, cereals formed the largest component of the diet [15]. Consumption of pulses was very low; this may be due to increasing prices of pulses. Consumption of milk, fruits and vegetables and animal food continue to be quite low. Consumption of all foodstuffs increases with increasing income [16]. This is especially true for sugar, oil, and animal products. With the availability of wheat and rice through public distribution system the poorer segment of the population have changed over to rice and wheat as staple cereals [17], [18]. Coarse cereals such as bajra, ragi, maize and jawar, which are rich in micronutrients and minerals, are no longer being consumed in substantial quantity by the rural poor in rural Orissa and Bihar with higher poverty rates and low per capita income, as cereals formed the major food item. Since cereal consumption and intake of energy is high but under nutrition rates are also high. This is perhaps due to high-energy expenditure among poor in these states among manual labour [19].

Total number of households residing in rural India was 138.3 million, out of which, the share of Orissa was five percent i.e. 6.8 million and that of Bihar nine percent i.e. 12.7 million [7]. A total number of 2880 respondents, with 1440 respondents each from states of Orissa and Bihar, spread across 160 Gram Panchayat of four districts were studied. Out of 2880 respondents, 2400 respondents have Below Poverty Line (BPL) card and the rest 480 did not have the BPL card due to various reasons such as lack of own house, awareness level, etc. An analysis of table 1 reveals that the quality of food intake of rural poor in Orissa and Bihar. The quality of food is categorised into three parts i.e. poor, medium and good according to the nutrients in the food taken by the rural poor. The households consumed only cereals come under the first category. However, along with cereals, pulses consumption belongs to second category. Instead of cereals and pulses, the consumption of milk, fruits and vegetables or animal food continue to be considered as good quality of food.

Twenty five percent of the BPL listed respondents consumed good quality of food in each state. However, the respondents do not have BPL card consumed good quality of food is found to be 5 and 10 percent in Bihar and Orissa respectively. The medium quality of food is taken by majority of BPL listed respondents and the poor quality is claimed by 30 percent only in Orissa. But in case of Bihar, majority of BPL listed respondents consumed poor quality of food followed by medium quality. On the other hand, the poor quality of food is taken by the respondents do not have BPL card is 74 percent in Bihar and 48 percent in Orissa. From the above discussions it is observed that the BPL respondent households have taken better quality of food than the respondent households do not BPL cards. This may be due to the assistance provided by the government to BPL households in India. Finally, the quality of food taken by the respondents as a whole is found to be better in Orissa than Bihar.

TABLE 1. Quality of Food Intake by Rural Respondent Households

Quality of Food	Orissa ^a		Bihar ^b	
	BPL Listed	BPL not Listed	BPL Listed	BPL not Listed
Good	306	27	292	10
Medium	543	98	445	53
Poor	350	115	462	177

Source: Field survey conducted in ^a2001 and ^b2002

The importance of income and expenditure as a factor affecting quality of food taken is however, apparent even in the case where the switch to good quality of food is not complete [20]. Table 2 reveals that the average income and expenditure per annum among the BPL household respondents in Orissa and Bihar is a little over Rs, 20,000; with Bihar scoring marginally over Orissa. The difference in income levels could also be due to higher average earning member of family in Bihar or due to the time lag. The income and expenditure of the respondents do not have BPL card is just 60 percent of that of the respondents having BPL card in both the states. The higher income and expenditure of respondents having BPL card, could be the main reason of assistance provided by the government through various developmental scheme. On the other hand, the per capita income and expenditure of the respondents in Orissa is found to be higher than Bihar.

TABLE 2. Socioeconomic Characteristics of Orissa and Bihar

Socioeconomic Parameters	Orissa ^a		Bihar ^b	
	BPL Listed	BPL not Listed	BPL Listed	BPL not Listed
Average Annual Income (Rupees)	22324	11857	23181	12396
No. of Respondents Annual Income ≤ Rs. 20000	765	219	570	216
No. of Respondents Annual Income > Rs. 20000	434	21	630	25
Average Annual Expenditure (Rupees)	22953	13009	23720	13370
Average Annual Expenditure on Food (Rs.)	19958	11657	19706	11899
Average Household Size (No)	6	5	7	5
Average Earning Household Members (No)	1.7	1.2	1.6	1.1

Source: Field survey conducted in ^a2001 and ^b2002

4 DEVELOPMENT OF MODEL

The formulation of ordinal regression models are the special cases of the general linear model [21]. The binary logistic regression model estimates a set of regression coefficients that predict the probability of the outcome of interest. The logistic model can be written as a function of the probabilities, which results in a linear combination of parameters that is

$$\ln\left(\frac{\text{prob}(\text{event})}{1 - \text{prob}(\text{event})}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_i X_i$$

It is the log of an odd that an event occurs. By incorporating the ordinal nature of a dependent variable in the binary model, the ordinal logistic regression model has been developed. Instead of considering the probability of an individual event, consideration of the probability of that specific event and all events that are ordered before it has been taken. In ordinal logistic regression, the event of interest is observing the particular quality of food or less.

All of the odds are of the form: $\theta_j = \text{prob}(\text{score} \leq j) / \text{prob}(\text{score} > j)$

The function can be written as $\theta_j = \text{prob}(\text{score} \leq j) / (1 - \text{prob}(\text{score} \leq j))$,

Since the probability of a score greater than j is 1 – probability of score less than or equal to j.

The quality of food taken by rural people are poor, medium and good assigned by a particular score i.e. 1, 2 and 3 respectively. Therefore modelling the following odds are

$$\theta_1 = \text{prob}(\text{poor}) / \text{prob}(\text{greater than poor})$$

$$\theta_2 = \text{prob}(\text{poor or medium}) / \text{prob}(\text{greater than medium})$$

The last category i.e. good does not have an odds associated with it since the probability of scoring upto and including the last score is 1.

Therefore the ordinal logistic model for a single independent variables is then

$$\ln(\theta_j) = \alpha_j - \beta X, \text{ where } j \text{ goes from } 1 \text{ to the number of categories minus } 1.$$

Each logit has its own α_j term but the same β s coefficient. That means that the effect of the independent variable is the same for different logit functions. The effect of a unit change in X on the log odds ratio of the event occurring is given by the corresponding β coefficient. Taking the log odds ratio into consideration is very useful since the interpretation of the coefficient is immediate. The independent variable in the model is income. Using this variable, this paper tries to find the probability of quality of food intake by rural poor, at a given significance level. The switch to good quality of food has been made, in part, a function of income; because of the fact that we are dealing with spending on good food which increases the household cost; and that the capacity to spend has direct relationship with income [22]. Further, it is hypothesized that persons with larger income will spend more, ceteris paribus. As logit model is not linear in parameters, they are estimated by using maximum likelihood techniques. The maximum likelihood estimator is consistent and normally distributed in large samples, so that t-statistics and confidence intervals for the coefficients can be constructed in the usual way.

5 ANALYSIS OF MODEL OUTPUT

Table 3 presents the parameter estimates of the logit regression of the ordinal dependent variable (Food Quality) for a selection of a independent variable (Income) is coded as 1, if the respondent’s income is less than or equal to Rs. 20, 000, otherwise 2. The estimation, using the SPSS software package, was performed on the dataset consisting of 2879 observations (respondents). From case processing summary, it is found that, 38, 40 and 22 percent of respondents are consuming poor, medium and good quality of food respectively. On the other hand 61.5 percent of the respondents having yearly income below Rs. 20, 000 but only 38.5 percent of the respondents have income more than Rs. 20, 000. Since there is no missing data, almost all observations were considered for the purpose of analysis.

The coefficient for respondent having income less than or equal to Rs. 20,000 is found to be -3.821, however the respondent having income more than Rs. 20,000 is the reference category and have coefficient of 0. The coefficient for those whose household having less than Rs. 20,000 yearly income is negative, this implies it is associated with poorer food quality. The ratio of the odds for lower to higher food quality for those having less than Rs. 20,000 yearly income and those more than Rs. 20,000 yearly income is found to be 45.65 stays the same for over all quality of food. Based on the small observed significance level, the null hypothesis that it is zero is rejected, hence there appears to be a relationship between household income and quality of food consumed by the respondent. The quality of food is increased with increasing the income level.

TABLE 3. Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.
Threshold	[Food = 1]	-3.382	0.12	769.1	1	0
	[Food = 2]	-0.114	0.06	3.638	1	0.05
Location	[Income=1]	-3.821	0.13	894.9	1	0
	[Income=2]	0 ^a	.	.	0	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

The chance of consuming good quality of food is highest i.e. 0.53 by the respondent having yearly income more than Rs.20, 000, followed by medium quality (0.44) then poor quality (0.03). On the other hand, the chance of consuming poor quality of food is highest i.e. 0.61 by the respondent having yearly income less than or equal to Rs.20, 000, followed by medium quality (0.37) then good quality (0.02).

TABLE 4. Test of Parallel Lines^a

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	38.936			
General	26.033	12.903	1	0

Null hypothesis states that location parameters (slope coefficients) are the same across response categories.

a. Link function: Logit

The relationships between the income and the logits are the same for all the logits. The result of the test of parallelism in Table 4 which indicates that the null hypothesis is rejected i.e. the link function selected is correct for the data or that the relationships between the income and logits are the same for all logits. From the analysis of all the logits given above, it can be observed that rise in income level has positive impact in determining the likelihood of switching over to good quality of food. However, non-availability of good quality food grain seems to be the major detrimental factor, in the switchover decision in few cases. Hence, the families having relatively higher income have a very high probability of consuming medium and good quality of food grain.

6 CONCLUSION

Hike in the food prices has impacted the pockets of rich and poor equally. The cost of food grain of the middle income group is pinching the pockets; and the increase in household budget is threatening even the mere existence of the poor person [23]. According to some of the existing studies, the food security is the major concern in the world today. In the prevailing circumstances, it becomes essential to look for quality of food consumed by the poor rural household.

This study is undertaken with the objective of analyzing the socio-economic conditions of rural poor in India with respect to their quality of food consumption. The study conducts a questionnaire based survey on demographic, economic, and perceptible parameters on quality of food; using ordinal logit model to identify variables useful for the study. This study assumes greater significance, because, majority of the rural poor are still dependent on poor quality of food. To make this happen, the government should have an efficient distribution system for food grain. This study could be useful not only to India, but to many other economies that are on the threshold of transition; where majority of its population is still living in the rural areas, and are predominantly dependent on agriculture for their livelihood.

Data collected through the field study and subsequent data analysis, revealed that nearly 40 percent of rural poor in India are consuming poor and medium quality of food, but only 20 percent are taking good quality of food. About sixty one percent of the poor household respondents that took the survey have annual income less than Rs. 20,000; rest thirty nine percent having annual income more than Rs. 20, 000. This implies some of the respondents whose annual income is less than Rs. 20,000 is also consuming medium quality food. The factors emerging out of the analysis is that the income of the respondent has great influence in the switchover to good quality of food.

Providing the good quality of food could also act as a great boost to an emerging economy such as India because, at every world forum, food security concerns form part of core discussions. Immense pressure is mounted on India and other emerging economies to have control over malnutrition. Making good quality of food easily available will be beneficial, not only for the development, but will also help in malnutrition. Government of India should actively consider providing incentives, duty cuts, etc., and encourage supplying improved quality of food grain to the rural poor. By providing good quality of food, government will be in a position to reduce the rural health hazards, which would ultimately help in reducing the government spending on public health; as also improving the living conditions of the rural poor. This would result in a win-win situation, both at the micro as well as macro levels.

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Pipeline Vibration Reduction in Reciprocating Compressors

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ABSTRACT: Pipeline vibration due to reciprocating compressors is a major problem faced by Oil and Gas industries worldwide. We present a method to reduce the pipeline vibration of 2HD/1 opposed-balanced reciprocating compressor. Vibrational readings are recorded for two of the reciprocating compressors in the plant (ONGC-Uran); Compressor A with major vibration in discharge pipeline and compressor B with vibration within acceptable limits so as to find the source of vibration in compressor A. As per the layout, pipeline design of reciprocating compressor A is done in SolidWorks software. Vibrational analysis of the pipeline by varying the external support locations is carried out using Ansys software. From the study, it is understood that the pressure pulsation in pulsation dampener is the primary reason for pipeline vibration. A suggestion for the vibration reduction is made by adding supports to alter the frequency of the pipeline. We conclude that for overall system performance and vibration reduction, anti-vibration measures as suggested should be implemented.

KEYWORDS: Vibration, Ansys, Harmonics, Pulsations, Frequency, SolidWorks

1 INTRODUCTION

Reciprocating compressor (RC) is the most widely used type of compressor found in industrial applications and is a crucial machine in gas transmission pipelines, petrochemical plants, refineries, etc. due to a high pressure ratio achievement [1]. A reciprocating compressor is a positive displacement compressor that uses pistons driven by a crankshaft to deliver gases at high pressure. The intake gas enters the suction manifold, then flows into the compression cylinder where it gets compressed by a piston driven in a reciprocating motion via a crankshaft, and is then discharged. They can be either stationary or portable, can be single or multi-staged, and can be driven by electric motors or internal combustion engines [2-4]. Reciprocating compressors are capable of giving large pressure ratios but the mass handling capacity is limited or small. Reciprocating compressors may also be single acting compressor or double acting compressor. Single acting compressor has one delivery stroke per revolution while in double acting there are two delivery strokes per revolution of crank shaft [5].

2 BACKGROUND THEORY

When gases are compressed by any of the usual methods now employed commercially it is frequently found that several undesirable effects of pressure variation appear in the system associated with the compressor or in the compressor itself. All of these undesirable effects are connected in some manner with pulsation phenomena which appear as a result of the reciprocating action of the compressor. In certain systems where rotary or other types of compressors are employed, as contrasted with the reciprocating type, similar pulsation phenomena are evident. However, the present discussion will be confined to the phenomena which appear in systems utilizing reciprocating compressors, and in particular those which are

employed in the compression of lean gas for transmission in pipelines, or for other purposes such as recycling or re-pressuring operations [6]. Reciprocating compressors emit pulsations by virtue of their design. Pulsations travelling away from and to the compressor cylinders will set up standing wave patterns that result in unbalanced pressure forces in the piping system. These unbalanced forces can result in extreme levels of vibration on the compressor and associated piping [7].

2.1 SOURCE OF PULSATIONS

Reciprocating compressors generate flow modulations that in turn generate pressure pulsations. The flow modulations come about as a result of intermittent flow through the suction and discharge valves, as well as geometry effects due to the (finite) length of the connecting rod.

Figure 1 shows a schematic of a compressor cylinder. The suction flow (Q_s) enters the cylinder, and the discharge flow (Q_d) exits the cylinder. The velocity of the piston, shown in Figure 1, is approximately sinusoidal in shape. The deviation of the actual piston motion from the sinusoidal shape is due to the finite length of the connecting rod. As the ratio of the connecting rod length to the crank radius (L/R) is increased, the shape becomes more closely sinusoidal. The pressure pulsation generated by the compressor is proportional to the flow (Q_s or Q_d) modulation [8, 9].

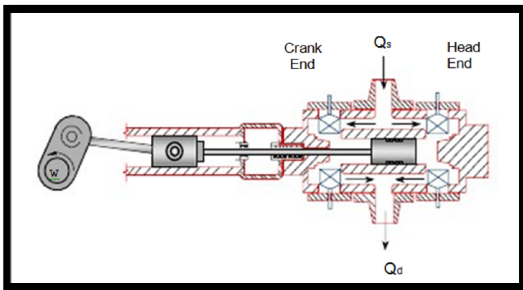


Fig 1: Double acting reciprocating compressor cylinder [9]

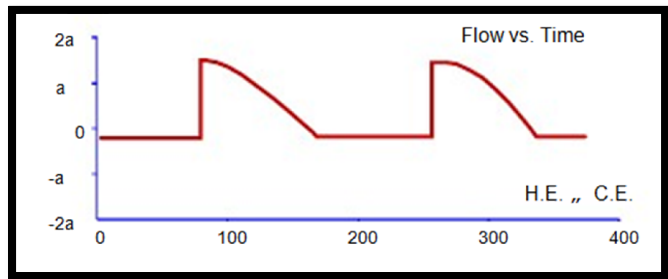
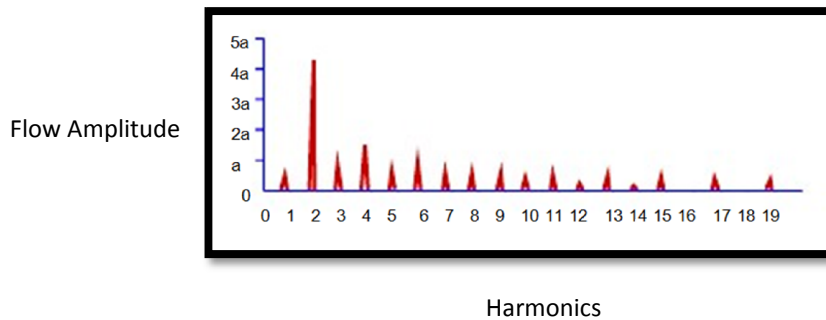


Fig 2: Unsymmetrical double acting compressor cylinder [9]

For a “perfect” double acting cylinder (symmetrical head end and crank end flows), the flow versus time contains two identical flow “slugs” 180 degrees apart in time. Therefore, the odd harmonics (in this idealized case) cancel, so that the nonzero cylinder flow excitation occurs at even harmonics of running speed (2, 4,...). Actual cylinders have piston rods, differences in head end/crank end clearance volumes and finite length connecting rods, so that the two “flow slugs” generated each revolution are not identical (Figure 2). Therefore, even in double acting operation, the cylinder will, in general, produce flow excitation at all harmonics of running speed as shown in Figure 3. These flow harmonics act as excitations to the piping acoustics, and the acoustic resonances of the piping will amplify pulsation at particular frequencies [9, 10].



**Fig 3: Flow frequency spectrum for double acting cylinder [9]
Where “a” is a positive integer different for different compressors**

3 DESIGN OF PULSATION DAMPENER AND PIPELINE SYSTEMS

The LPG Unit of ONGC Uran Plant consists of four reciprocating compressors two in each unit that is LPG Unit-1 and LPG Unit-2. In LPG Unit-2, reciprocating compressor (B) is working completely fine without any vibration in its pipeline system contrary to the reciprocating compressor (A) which shows visible and dangerous level of vibration when its switched on. The compressor (A) is therefore is not used and the load is completely is taken by compressor (B) without any stand by. The input parameters and conditions are same for both the reciprocating compressors with almost similar external support locations in pipeline systems.

Vibrational readings were taken at different locations of both the compressors to find out the source of maximum vibrations. The measurements were taken using Emerson’s CSI 2130 Health Analyzer kit. The readings were compared and it was observed that the major vibrations were observed in the pipeline systems. Figure 4 and 5 shows the location of major vibrations (marked in red).



Fig 4: Points of heavy vibration (on-site location)

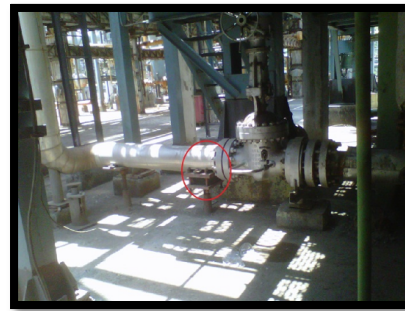


Fig 5: Points of heavy vibration (on-site location)

As the problem was seen in the pipeline systems, the study was conducted from the pulsation dampener. The design of the pipe layout was made according to the dimensions measured on-site. Both the designs are made in SolidWorks software.

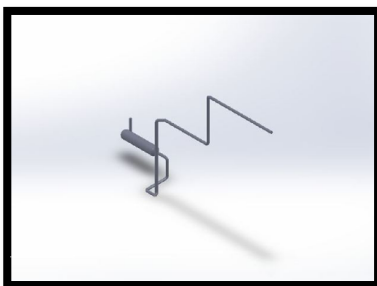


Fig 6: pulsation dampener and pipeline

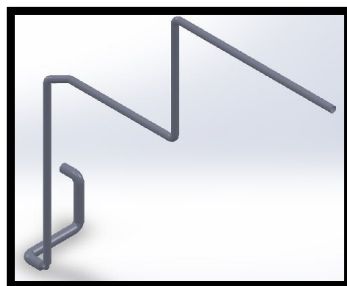


Fig 7: Pipeline layout

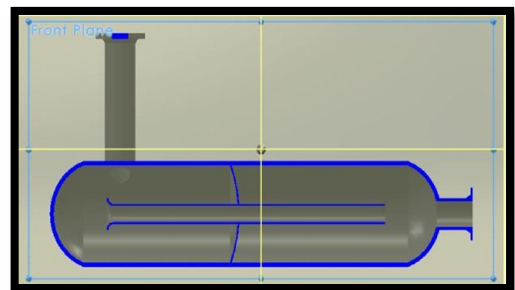


Fig 8: Sectional view- Pulsation dampener

Figure 6 shows the pulsation dampener and the complete piping layout designed in SolidWorks software. The pipeline layout consists of 8” diameter pipe as well as 6” diameter pipes which are connected with the help of a reducer as shown in Figure 7. The sectional view of the pulsation dampener can be clearly visible from figure 8. It consists of the baffle plate which divides the dampener into two chambers. The choke pipe is fixed symmetrically to allow the flow of gases between the chambers. Inlet of gas flow is little offset to provide enough time for the pulsation to die down.

4 MODEL ANALYSIS

The problem of vibration in pipeline is solved by providing the external supports to the discharge pipelines of the compressor. The principle of shifting the mechanical natural frequency of pipe line away from the harmonics of forcing frequencies is being used to solve the problem.

Formulae

Pulsating frequency (f_p) = $M \cdot (N/60)$ Hz [

- N = RPM of Motor = 327
- M = 1 for single acting
= 2 for double acting [9].

The pulsating frequency is calculated to be 10.9 Hz and has been used for the analysis to find the accurate support locations.

Input parameters

- Element Type = Solid 185
- Young's Modulus of Elasticity = 111GPa
- Poisson's ratio = 0.26
- Density = 7.2 g/cm³
- Mesh type = Hexahedral

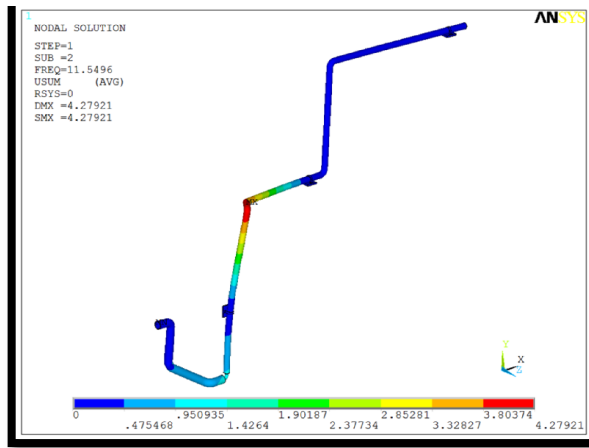


Fig 9: Current support location model analysis

The natural frequency of the current pipeline system was found to be 11.54 Hz which is very close to the forcing frequency 10.9 Hz (Figure 9). The analysis shows large amplitude of vibration (the red colour) which is exactly the location of visible vibration in the on-site reciprocating compressor pipeline structure. Hence the support locations have to be modified to alter the natural frequency of the pipeline to completely avoid the occurrence of vibration due to acoustic resonance.

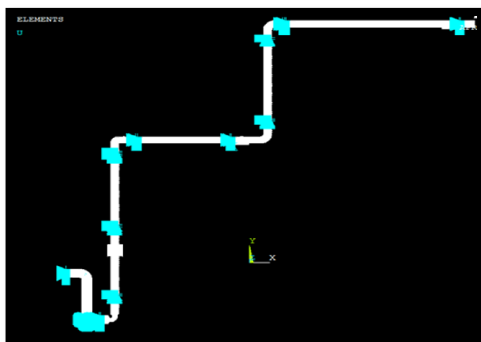


Fig 10: Modified support locations

***** INDEX OF DATA SETS ON RESULTS FILE *****

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	53.773	1	1	1
2	53.957	1	2	2
3	112.58	1	3	3
4	126.73	1	4	4
5	128.97	1	5	5
6	132.16	1	6	6
7	133.38	1	7	7
8	135.51	1	8	8
9	146.43	1	9	9
10	147.06	1	10	10

Fig 11: Model shapes and frequencies

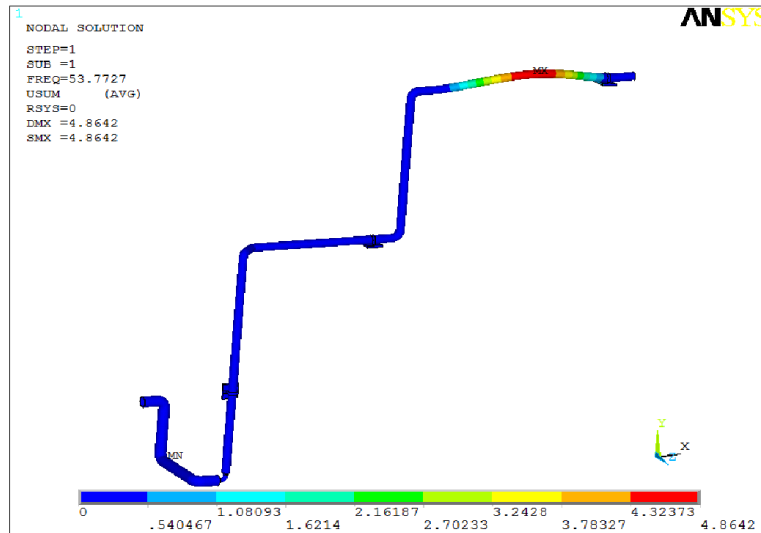


Fig 12: Modified support locations analysis (a)

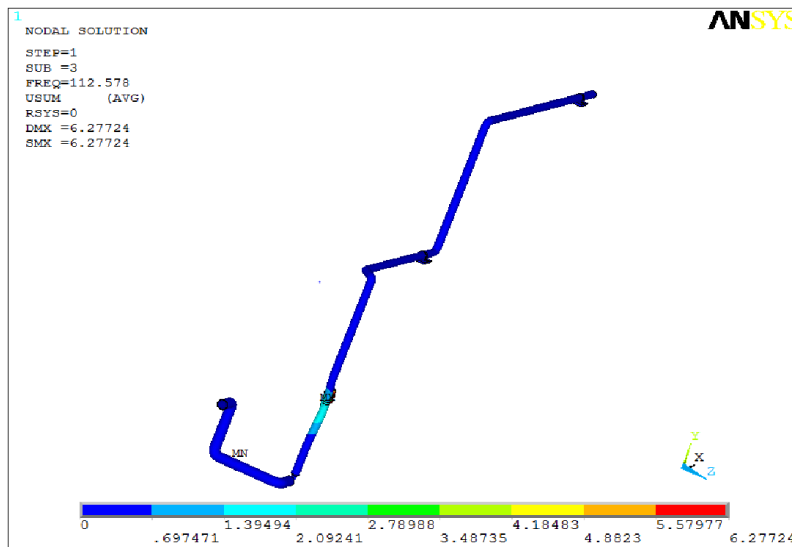


Fig 13: Modified support locations analysis (b)

The modified support locations are shown in figure 10. It can be seen that the natural frequency of the pipeline has changed from 11.54 Hz to 53.77Hz (figure 11) which is nearly 90% away from the forcing frequency (fourth harmonic) of the pipeline structure. Figure 12 and 13 shows the deformation in the pipeline and we can conclude that the vibration is reduced to considerable extent in the system.

5 REMARKS AND CONCLUSION

The following conclusions has been derived from the model analysis

- Natural frequency of pipeline set-up after support modifications = 53.77 Hz
- Pulsation forcing frequency = 10.9 Hz
- A safety factor of 90% from the nearest (fourth) harmonic is obtained in the modified support structure to ensure resonance does not occur.
- After analyzing all the possible natural frequencies in between the each set of harmonics to prevent the acoustical resonance, the natural frequency of 53.77 Hz obtained from optimization of support locations avoids complete vibration in the piping.

And hence the support locations as specified should be implemented to bring the vibration within acceptable limits. For reaching more accurate and optimum results, the forcing frequency obtained at the outlet of the pulsation dampener

calculated using flow analysis should be used for modal analysis. However the flow analysis requires very fine meshing. The pressure time transient output can be converted into amplitude frequency by doing a FFT transformation. The frequency thus obtained can be further used to do the model analysis for more accurate results.

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Implementation of the EGSnrc / BEAMnrc Monte Carlo code - Application to medical accelerator SATURNE43

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ABSTRACT: The Monte Carlo method is the most accurate method for the simulation of radiotherapy equipment. Linear accelerator (Linac) is currently the most widely used in radiotherapy center's machines. In this work we run the Monte Carlo code EGSnrc under the platform BEAMnrc to calculation of important photon beam parameters by modeling the head of the linear accelerator SATURNE43. The aim of this study was to calculate the dosimetric functions, namely: the dose profile and Percentage depth dose (PDD) for a 12 MV photon beam generated by Linac SATURNE43 and delivered in a water phantom. Photons are generated by the bremsstrahlung effect of electrons during interaction with the tungsten target. All calculations are done by considering a square field dimension 10x10cm² at a depth z = 100 cm from the target. Analysis of the data stored in the phase space is performed and photons spectrum is extracted. The PDD and the 10cm depth dose profile distributions are compared to experimental data by the Monte Carlo code EGSnrc under the platform BEAMnrc. A good agreement is obtained for both distributions and a reasonable computing time is obtained by use of the following fundamental parameters of the simulation: ECUT = 0.4MeV, PCUT = 0.12MeV, FWHM = 0.17cm and ESAVE = 1MeV.

KEYWORDS: SATURNE43, Monte Carlo, EGSnrc, dose distribution, TPS.

1 INTRODUCTION

The aim of using external radiotherapy in cancer treatment using high radiation doses from photon or electron beams. Healthy tissues and organs at risk surrounding the tumor should be preserved during treatment by the optimization of the irradiation parameters using a convenient Treatment Planning System (TPS).

However, a quality control program should be implemented to compare the results provided by the TPS with experimental data. The experimental data are obtained by measurement of dosimetric parameters such as dose profile and percentage depth dose (PDD) [8].

There are innumerable dosimetry techniques already available that compare experimental results with Monte Carlo simulations. Also the precise prediction of the absorbed dose distributions in patients irradiated by clinical beams plays an important role in radiotherapy treatment. A Monte Carlo method is the most accurate way to calculate it [4]. In this work we use the EGSnrc / BEAM code for modeling the head of a linear accelerator SATURNE43 and calculate the dose distribution across the phantom.

BEAMnrc is a Monte Carlo code system for simulating radiation therapy sources. It was developed as part of the OMEGA project a collaboration between the National Research Council of Canada and a research group at the University of

Wisconsin–Madison. It is based on the EGS code system for the coupled transport of electrons and photons BEAMnrc is a package of codes for building accelerator geometries and for evaluating the results of simulations through those geometries. The geometry of the accelerator to be simulated is built up from a series of predefined “component modules”(CMs), BEAMnrc can model all types of medical linear accelerators, using the code component module system [1, 9].

The OMEGA project can be divided into three stages: an accelerator simulation, characterization and representation of the beam and the dose calculation. The modeling of the head of a medical linear accelerator is the most important part of the program (BEAMnrc) [1, 7].

The code BEAMnrc can produce a so called phase space file of the beam at specified scoring planes on the model, these planes are to be placed at the back of an already defined CM and the planes have to be perpendicular to the central-axis. A phase space file contains full information (charge, energy, position and direction) about the particles crossing the scoring plane. BEAMnrc also offers a variety of radiation sources (point source, a source that emits radiation isotropic ally over a specified volume, phase space file as source, etc...) and some so called variance reduction techniques to speed up the calculations.

BEAMnrc is considered as a reference in radiation therapy where they are compared to the results of other codes with this code.

2 MATERIALS AND METHODS

2.1 MEASUREMENT DATA

Measurement data of depth dose or off-axis lateral dose was obtained from EURADOS group [5].

2.2 MONTE CARLO SIMULATION PARAMETERS

The Simulate linear accelerator Saturn 43 by method of Monte Carlo was done in two steps:

2.2.1 SIMULATION THE HEAD OF THE LINEAR ACCELERATOR SATURNE 43

We constructed the model of the LINAC Saturne 43 geometry using Monte Carlo code BEAM/EGSnrc.

The different components of the irradiation head were modeled using the modules (CM) Code. The model of the accelerator is comprised of a succession of planes perpendicular to the z axis in a module which is horizontal planes. Each CM is independent of the others and is distinguished by its numbering. The same CM can be used several times without interacting with the previous ones. It is the user who connects to each other. A module can be considered as a block having an input surface and an output surface. CMs are composed of elements that are numbered in the double direction of increasing z. BEAMnrc uses a local numbering according to the CM and a second global numbering based on the entire accelerator. This allows the code to follow the path and interactions experienced by the particles in the accelerator head. The components were applied to model the target, primary collimator, flattening filter, monitor chamber and jaws. Thereafter, a compilation is necessary to allow verification of the geometric model of overlap between components, it allows the generation of the necessary files to the code execution, as mortjob.mortan file that contains the definition of the different parameter simulation [1, 6, 7].

At the end of this step, the components of a linear accelerator for a 12MV photon beam are shown in Figure (1)

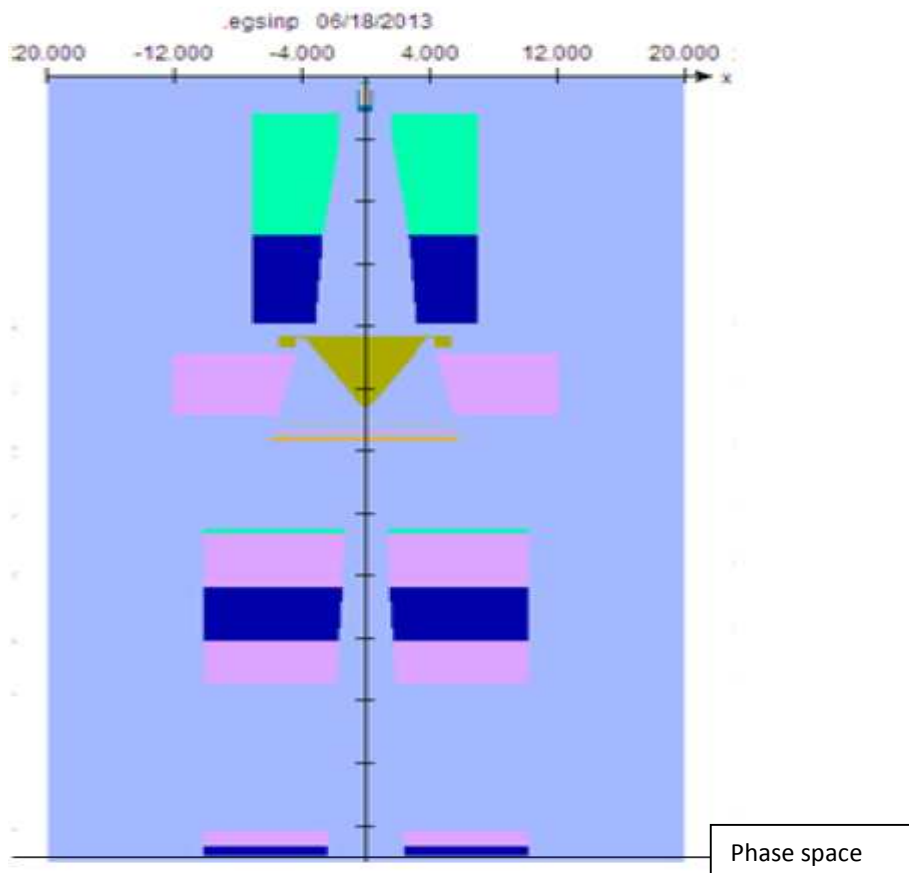


Fig. 1. Saturne 43 Linac head modeling by BEAMnrc code in 2D geometry

During this study the variance reduction techniques used are:

- The energy Cutoffs for photons and electrons respectively were set to 120 keV,400keV
- Bremsstrahlung splitting is DIRECTIONAL
- ESAVE =1MeV (Energy in MeV below which electron will be discard in range rejection)

The parameters of the source of electrons:

- Source number. 19 define a source with Gaussian distribution in the X and Y plane incident from the front. for mono energetic beam Equal 11.4MeV
- Gaussian distribution (x-y plane) with origin on beam axis for FWHM =1.7mm and BEAM SIGMA= 0.0722 cm

In our study the phase space obtained for these parameters is calculated at -50 cm from the tungsten target by simulating 60×10^6 mono-directional incident electrons. A phase space file of roughly 4GB is created and it contains about 32.10^6 photon tracks and 2×10^5 electron tracks.

Other files can be saved for the dose and the statistical uncertainty in the various components of the treatment head these files have an extension egslst.

2.2.2 SIMULATION OF DOSE DISTRIBUTION IN THE WATER PHANTOM

In this step we calculate the dose distribution in water Phantom by Code dosxyz. DOSXYZnrc is an EGSnrc-based Monte Carlo simulation code for calculating dose distributions in a rectilinear voxel phantom and is based directly on the DOSXYZ code developed for the EGS4 code system. DOSXYZnrc is part of the OMEGA BEAM system of codes developed at NRC. Density and material in every voxel may vary. A variety of beams may be incident on the

phantom, including full phase-space files from BEAMnrc, In order to calculate the dose distribution must be defined Phantom of water, the source of the particles, the parameters of code Dosxyz and The EGSnrc Parameters [2].

In this step the phase space file is used as a source and is put at 40cm from the water phantom, a water phantom with dimensions of 40 cm × 40 cm × 40 cm was simulated under the gantry with a source-surface distance (SSD) of 90 cm. The phantom was divided into voxels, with each voxel's dimensions being 5 mm × 5 mm × 5 mm, in which we collected the energy deposited to calculate the relative dose absorbed in the phantom. The percentage depth dose (PDD) and beam profiles were calculated in a water phantom a square field dimension 10x10cm² at a depth z = 100 cm from the target. We simulated 5.108 particles with the module DOSXYZnrc. We then compared them with measurements for validation of our Monte Carlo model.

3 RESULTS

The curves of PDD are normalized at 10cm depth and are obtained for a field size of 10x10cm² and a SSD= 90cm, and lateral dose profile normalized at 10cm in water.

In Fig. 2, 3 we show experimentally measured data and EGSnrc/BEAMnrc Monte Carlo simulation results. (2) Shows the depth-dose curves, (3) shows lateral dose profile at 10 cm depth, for the 10 × 10 cm² field, And (3) we show laterals dose profiles at 0, 5, 10, 15, 20 cm depth, with the 12MV beam (SSD = 90 cm)

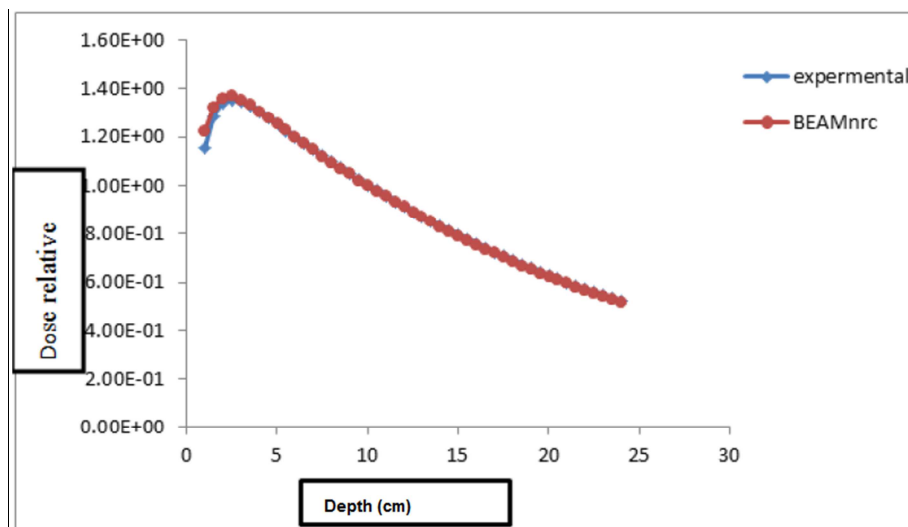


Fig. 2. PDD comparison between measurement and MC simulation for 12MV, filed size 10 × 10 cm2

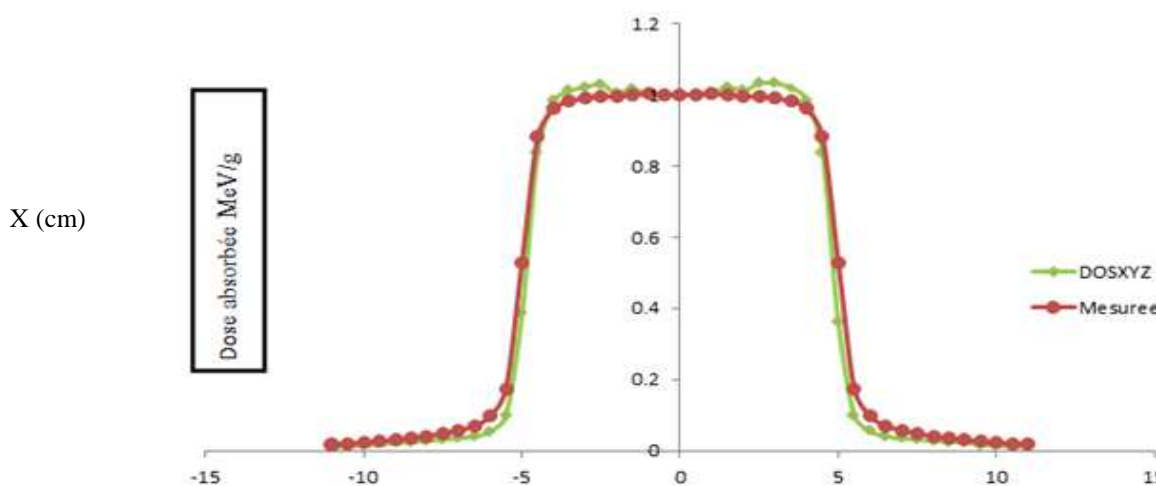


Fig. 3. lateral profile comparison between measurement and MC simulation

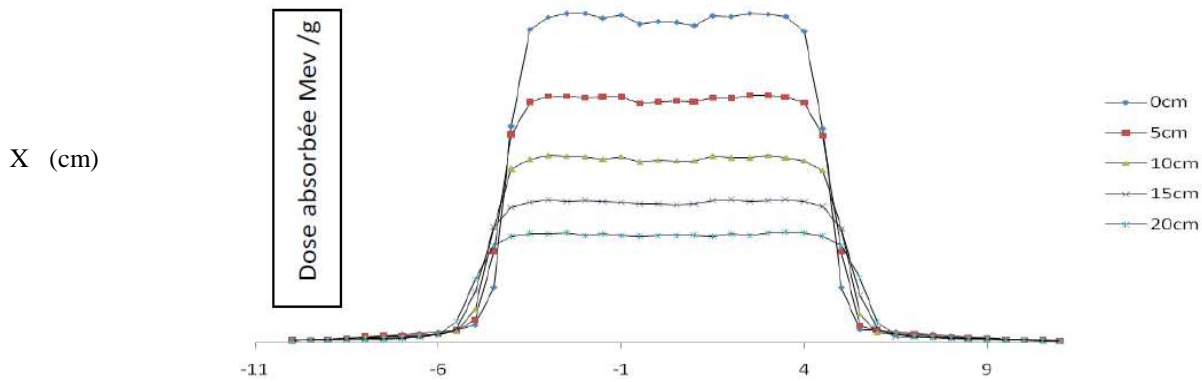


Fig. 4. Lateral dose profiles at 0, 5, 10 and 20 cm depth for $10 \times 10 \text{ cm}^2$ field with a 12MV beam.

In Figure (2, 3) We note there is good agreement between calculated and measured results, In (2) depth dose matched perfectly with a few of the disagreement around the dose build-up point, In (3) lateral dose profile the values so close with a very slight statistical difference in central plateau may fade with time simulation or increase the number of particles simulated

In Figure (4) Lateral dose profiles are very sensitive to the depth in a phantom. The results show that increasing the depth tends to reduce the dose in two areas: central plateau and darkness. As against, lateral dose profiles outside the field is less sensitive than the depth.

To analyses of the data stored in the phase space and photons spectrum Performs by BEAMDP Code, BEAMDP (BEAM Data Processor) is a program developed for the OMEGA (Ottawa Madison Electron Gamma Algorithm) project[3], the phase space file was generated by BEAMnrc at $z = 50\text{cm}$, for 12MV. These file was analyzed, and the characteristics of the particles they contained were plotted. The graphs that were taken from BEAMDP were Mean Energy, Energy Fluence vs. position, Energy Fluence distribution and distribution the Particle in x-y plane, As shown in Figures 5,6,7 and 8

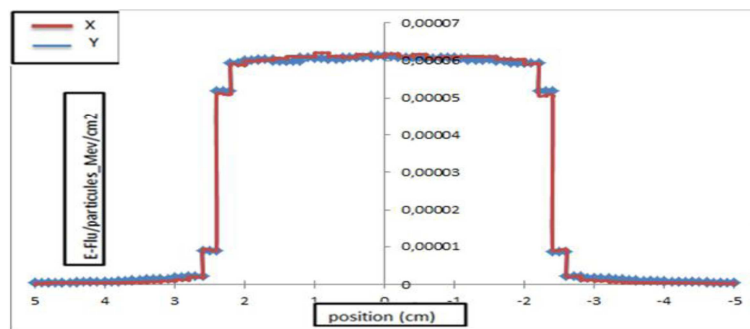


Fig. 5. Energy Fluence vs. Position for 12MV on X and Y axis

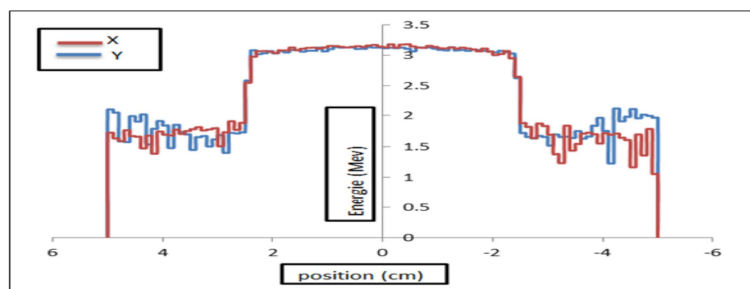


Fig. 6. Mean Energy

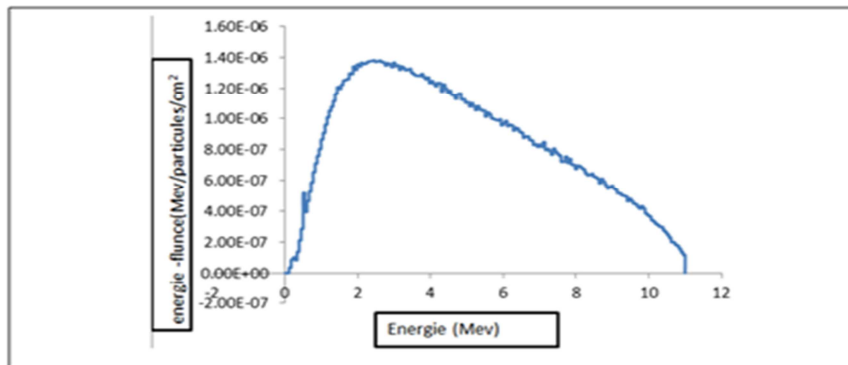


Fig. 7. Energy Fluence Distribution

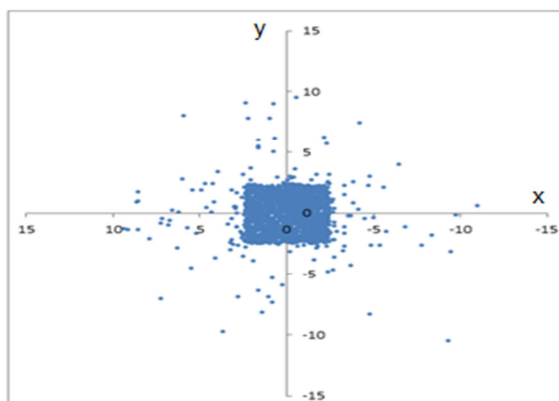


Fig. 8. distribution the Particles in x-y plane

In Figures 5, 6, 7 and 8, we note that BEAMDP is very effective for spectral beam analysis and validation of the field that we use in the simulation and it is necessary to analyze the errors that may be associated with simulation. So it is very important in the planning of radiotherapy.

4 CONCLUSION

in this work, we have modeled the medical linear accelerator Saturn 43 by EGSnrc/BEAMnrc Code, the results which obtained by EGSnrc simulation are acceptable and shows Excellent agreement and a slight statistical difference with the experimental results, so we mastered the installation and operation of this system for the simulation of linear accelerator used in radiotherapy. Accuracy of this method in the calculation of the dose distribution and analysis of the data stored in the phase space file so we can use this code in the treatment planning system of radiation therapy, to improve the statistical simulations, we see, firstly study the effect of certain components of the head SATURN 43 of dose distributions and the energy spectrum of photons as the flattening filter and jaws Secondly the different variance reduction techniques for Optimizing simulation in terms of time.

ACKNOWLEDGMENTS

I want to thank my supervisor pr. Tarek EL Bardouni for guiding me and I thank him very much for welcoming me in his laboratory, its availability and for his invaluable assistance in the completion of this work and especially for the supervision of this work, also extend my sincere thanks to Prof E. Chakir, H. Boukhal and M. Azahra for their collaboration and technical support to this work.

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Cartographie des zones à l'origine de l'ensablement des canaux du bassin versant du Gourou (Abidjan – Côte d'Ivoire)

[Mapping of areas causing silting channels (Abidjan – Côte d'Ivoire)]

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ABSTRACT: The present study is led on the Gourou watershed, in the autonomous district of Abidjan. Many quantities of sands and macroelements stream to this watershed's exutory in rainy season, blocking drainage canals and invading decantation basin. The objective of this work is to determine the origins of the sands in order to make map. To do it, we update the watershed's limits according to water separation lines. Then, we make a map of erosion zones susceptible to give up sands. The processing of all these data reveals a plurality of this sand blocking origins; the most producing zones being the ones situated near the road arteries. Sands come mainly from numerous bare zones of the watershed, from disorderly installed human activities and from the canals of the drainage network poor maintenance; some canals are being broken by place.

KEYWORDS: Gourou watershed, sand blocking, eutrophication, plastic arts, rainwater, pollution.

RESUME: La présente étude est menée sur le bassin versant du Gourou, situé dans le district autonome d'Abidjan. De grandes quantités de sables affluent à l'exutoire de ce bassin en saison pluvieuse, bouchant les canaux de drainage et envahissant les ouvrages de retenue.

L'objectif de nos travaux de terrain et du traitement des données recueillies est la détermination des zones à l'origine de cet ensablement et leur cartographie. Pour y parvenir, nous procédons à une actualisation des limites du bassin versant suivant les lignes de partage des eaux. Ensuite, nous élaborons une cartographie des zones de forte érosion ainsi que des lieux d'activités anthropiques situés aux abords des canaux à ciel ouvert et susceptibles de céder du sable. Le traitement de toutes ces données révèle une pluralité des origines de cet ensablement ; les zones les plus productrices étant celles situées non loin des artères routières. Les sables proviennent principalement des nombreuses zones dénudées du bassin, des activités humaines anarchiquement installées et du mauvais entretien du réseau de drainage dont les canaux se trouvent rompus par endroit.

MOTS-CLEFS: Bassin du Gourou, ensablement, eutrophisation, objet plastique, eau pluviale, pollution.

1 INTRODUCTION

Un bassin versant est l'aire de réception des précipitations et d'alimentation des cours d'eau (réseau hydrographique). Sa surface correspond à l'aire délimitée par l'ensemble des points les plus hauts qui constituent la ligne de partage des eaux ou ligne de crête. Le bassin versant se compose de un ou plusieurs sous-bassins et connaît, au cours de son évolution, d'importantes modifications du fait des activités anthropiques et des conditions climatiques. Le Bassin versant du Gourou est

un vaste territoire dont les eaux se concentrent au niveau du carrefour de l'Indénié pour se déverser dans la lagune Ebrié. Aussi, paraît-il important de signifier que ce bassin est caractérisé par des sols fortement érodés, des bas-fonds et des collines à forte pente. Plusieurs travaux de réaménagement ont été réalisés sur le lit principal et certains de ses affluents à travers différents projets gouvernementaux. Cependant, la satisfaction apportée par ces aménagements s'estompe au fil du temps à cause des quantités progressives de sables et de déchets solides qui se déposent dans les canaux du réseau de drainage et les bassins de retenue pour obstruer le passage de l'eau. Ces immondices multiplient les inondations au carrefour de l'Indénié tout en accélérant le dépôt de sable sur les berges de la lagune Ebrié. Vu l'ampleur et la récurrence du phénomène, l'on se demande d'où pourraient provenir tous ces sables et ces innombrables immondices essentiellement composés d'ordures et d'objets plastiques ? Notre étude se propose donc d'analyser le problème en amont. De manière spécifique, il s'agit de repérer les origines des sables ainsi que les sites de provenance des déchets solides que l'on trouve en aval du bassin du Gourou, après avoir actualisé les limites de ce dernier.

2 PRESENTATION DE LA ZONE D'ETUDE

Le Bassin versant du Gourou est un vaste territoire situé au centre-nord de la ville d'Abidjan avec une population de près de 500 000 habitants. Il s'étend du Nord au Sud, d'Abobo à l'échangeur de l'Indénié. D'une largeur variable, il est limité à l'Est par le prolongement du boulevard Latrille vers le quartier des Il Plateaux et à l'Ouest par la ligne du chemin de fer reliant Adjamé à Abobo (Projet de gestion intégrée du bassin versant du Gourou - Phase d'urgence, 2010).

Toutes les eaux de ce bassin se concentrent au niveau du carrefour de l'indénié pour se déverser dans la lagune.

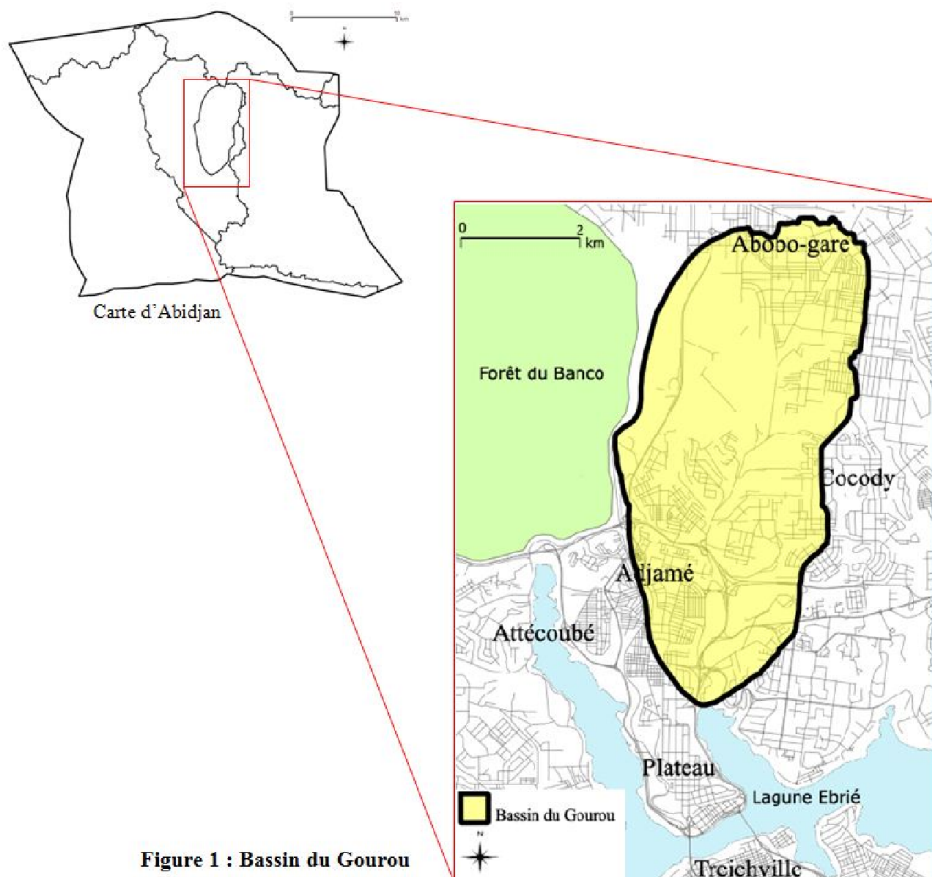


Figure 1 : Bassin du Gourou

3 MATERIEL ET METHODES

3.1 MATERIELS D'ETUDE

- **Données numériques et géographiques**

Images SRTM (Shuttle Radar Topography Mission)

Les données SRTM sont des données altimétriques de la surface du terrain selon un maillage régulier. Parmi les images SRTM disponibles, nous avons utilisé SRTM-3 version 2 (Source: United States Geological Survey (USGS) 2004). Leur résolution est de 90 mètres soit 3 arcs secondes, couvrant toute la zone d'étude. (Coulibaly, 2009).

Les références des images SRTM utilisés sont : SRTM N05W005.hgt et N05W004.hgt.

Données GPS

Les données GPS utilisées pour cette étude ont été recueillies sur le terrain au cours de nos prospections. Ce sont exclusivement des données UTM.

De façon stratégique, nous avons repéré des points à différents endroits du bassin versant avec des observations différentes (**Annexe I**).

- **Matériel technique et informatique**

Sur le plan technique, nous nous sommes munis de :

- 1 Appareil photo numérique de résolution 12 Méga Pixel pour les prises de vue et les différentes captures ;
- 1 GPS Garmin Etrex pour la prise des coordonnées des points et parcelles étudiés ;
- 1 bloc-notes pour noter les coordonnées géographiques et tous les autres détails pouvant faciliter la localisation des sites étudiés ;
- 1 stylo à bille pour la notation et l'estimation de la taille de certains éléments ;
- 1 ordinateur pour l'installation des environnements de travail et le stockage de la base des données numériques ;
- 1 tableur Excel pour la saisie et la concentration des données UTM ;
- 2 logiciels d'information géographique (LIG) :
 - GRASS GIS version 6.4.2 pour l'extraction des bassins versants et du réseau hydrographique ;
 - Quantum GIS version 1.8.0 pour matérialiser les contours du grand bassin et du sous-bassin concernés par notre étude, actualiser les paramètres caractéristiques (longueur, superficie, largeur moyenne etc.) et établir la carte des sites prospectés.

Les deux versions de logiciel ci-dessus cités sont compressées dans un fichier unique d'installation gratuit sur http://qgis.org/downloads/QGIS-OSGeo4W-2.0.1-3-Setup-x86_64.exe

3.2 METHODES UTILISEES

- **Prétraitement des images SRTM**

Pour notre étude nous avons utilisé l'algorithme de connexité D8 dont les huit (08) directions matérialisent les quatre (04) points cardinaux principaux (Nord, Sud, Est et Ouest) et les quatre (04) points cardinaux secondaires (Nord-Est, Nord-Ouest, Sud-Est et Sud-Ouest).

L'intérêt réside dans la rapidité d'obtention de l'information et dans son systématisme qui permet d'obtenir des informations pertinentes pour les plans d'eau candidats à l'aménagement sur toute une région. Le prétraitement des images s'est fait en deux (02) principales étapes :

Etape 1 : La mosaïque et le formatage de l'image de base

Cette première étape a consisté d'abord à constituer une image unique mosaïquée de notre zone d'étude. Ensuite, le fichier d'extension .hgt obtenu a été converti en format grid (format raster) avant d'être introduit dans l'environnement de travail.

Le format grid est le format de fichier utilisé dans par l'algorithme D8.

Etape 2 : Prétraitement du fichier grid

L'objectif ici était d'atténuer les effets de points bas dû aux imperfections du fichier grid pour ne pas fausser le réseau hydrographique en empêchant l'écoulement de l'eau (Payraudeau, 2002).

Le raster ainsi obtenu a servi à constituer la carte d'accumulation et à extraire le réseau hydrographique ainsi que les bassins versants.

- **Extraction des bassins versants**

Cette opération a été effectuée automatiquement en utilisant le module **r.watershed** du logiciel Grass GIS (**Raster > modélisation hydrologique > analyse de bassin versant**) pour identifier tous les bassins avec une superficie minimale de 1 km carré.

- **Extraction du réseau hydrographique**

C'est à partir de la carte d'accumulation obtenue que nous avons extrait le réseau hydrographique. Pour cette opération, nous avons utilisé le **calculateur Raster** de Grass GIS (**Raster-->calculateur de carte**), c'est-à-dire le module **r.mapcalc**. Nous avons commencé par calculer le logarithme de la valeur absolue de l'accumulation nommé (**log_accumulation**), un paramètre utile pour les calculs hydrologiques dont la formule est : **log_accumulation=log(abs(accumulation)+1)** avec pour commande Grass: **r.mapcalclog_accumulation=log(abs(accumulation)+1)**.

Nous avons utilisé à nouveau **r.mapcalc** pour extraire de cette couche un réseau hydrographique avec une valeur seuil de 6.

- **Repérage du bassin versant du Gourou**

Pour repérer le bassin versant concerné, nous avons ajouté, au projet Quantum, un fichier csv créé sur Excel à partir des coordonnées géographiques du **Tableau II**.

Après traitement par l'interface du logiciel, les points géoréférencés du csv sont apparus à l'intérieur de l'un des bassins préalablement extraits. Nous en avons donc extrait les caractéristiques suivantes : périmètre, surface, longueur et largeur moyenne.

- **Résumé graphique (Cartographie)**

Les zones sableuses arables, les versants abrupts, les grandes parcelles non couvertes à pente forte ou moyenne et les parois des canaux rompus du bassin ont été repérées et géolocalisées avec un GPS Garmin. Leurs coordonnées géographiques ont permis de créer un fichier csv de points étiquetés que le processus "**Ajouter une couche de texte délimité**" a positionné sur la surface du bassin versant du Gourou.

Processus dans Quantum : -Ajouter une couche de texte délimité

Paramétrage : [Délimiteur sélectionné] =Point-virgule

[Champ X]=Longitude ; [Champ Y]=Latitude ; [Paramétrage d'étiquette]=Observation.

4 RESULTATS ET DISCUSSION

4.1 RESULTATS

- **Les bassins versants et le réseau hydrographique d'Abidjan**

Les bassins versants de superficie égale ou supérieure à un (01) km², contenus dans les limites d'Abidjan, sont nombreux et de formes très diversifiées.

Le réseau hydrographique est dense du fait de la régularité des pluies et de l'immensité de la lagune.

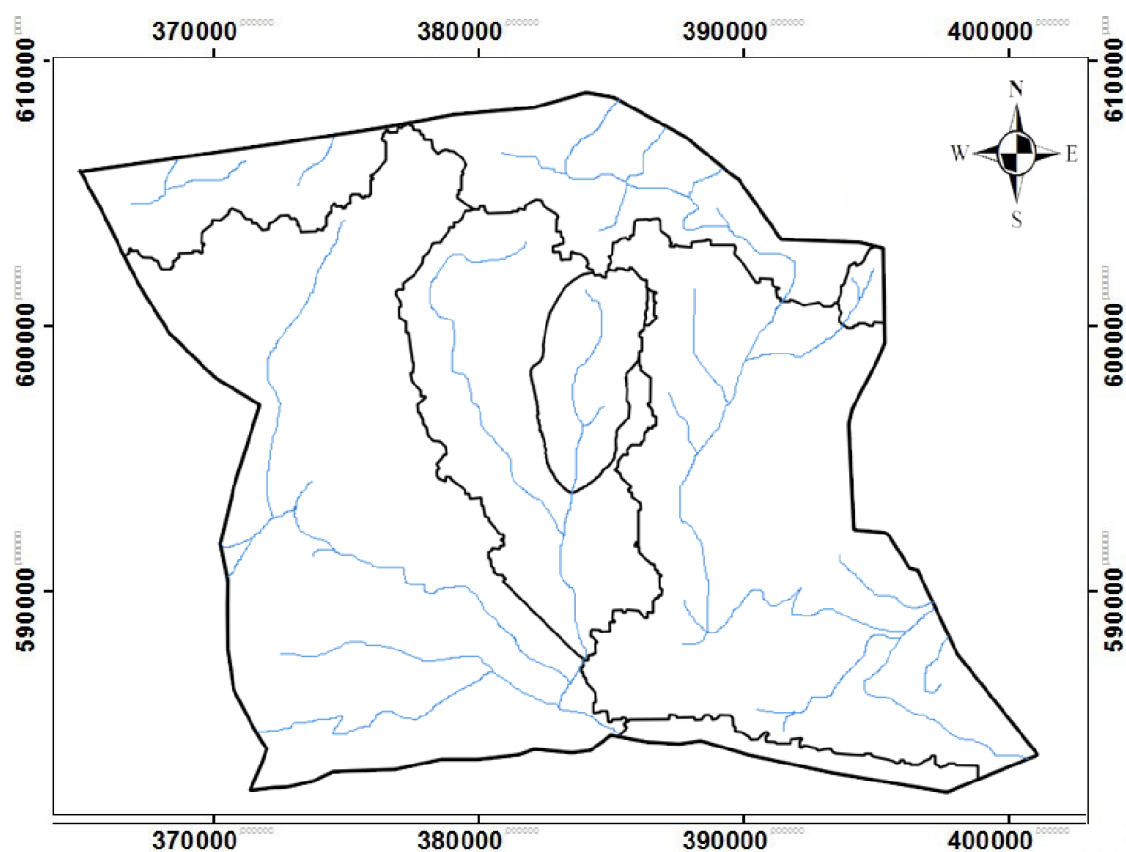


Figure 2 : Bassins versants et réseau hydrographique d'Abidjan

- **Caractéristiques du bassin versant du Gourou**

Limites du bassin

Les lignes de partage des eaux bordant le bassin versant du Gourou sont constituées par :

- La ligne du chemin de fer reliant Adjamé à Abobo à l'Ouest
- La ligne de partage des eaux tortueuse partant d'Abobo gare à Angré
- Le prolongement du boulevard Latrille des 2 Plateaux jusqu'au carrefour Saint Jean à l'Est
- La ligne courbe reliant le carrefour Saint Jean à la Lagune Ebrié et remontant jusqu'au boulevard Nangui Abrogoua à partir du "Café de Rome" au Plateau (**Fig.4**).

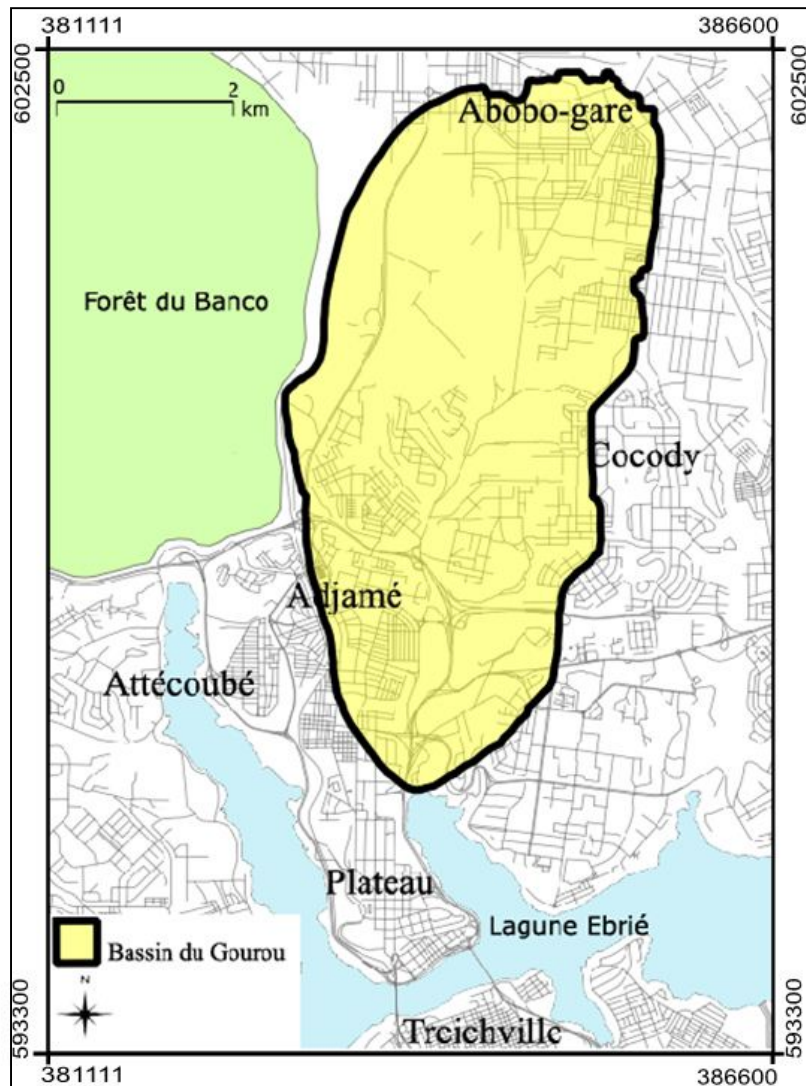


Figure 4 : Limites du bassin versant du Gourou

Paramètres actualisés du BV du Gourou

Paramètre	Valeur
Largeur moyenne	3 km
Longueur maximale	9.0 km
Superficie	27.4 km ²
Périmètre	22.9 km

Tableau II : Quelques paramètres caractéristiques du BV du Gourou

4.1.1 ZONES D'ORIGINE DES SABLES

Les zones à l'origine de l'ensablement sont visibles à plusieurs endroits du bassin.

En amont du bassin, on en dénombre beaucoup moins que dans les zones avales. L'accent a donc été mis sur les zones à forte production de sables que nous avons répertoriés dans un résumé graphique (Fig. 5).

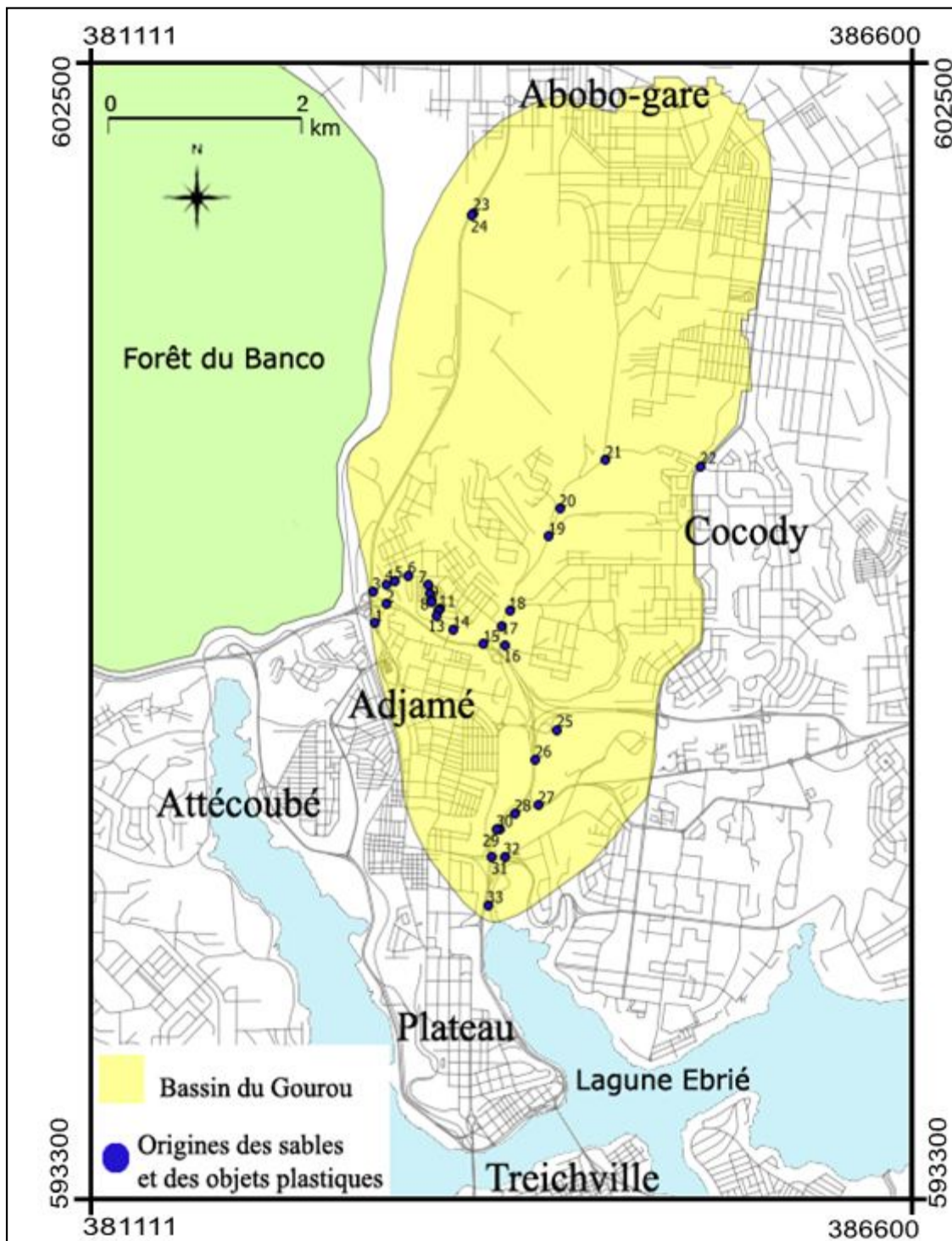


Figure 5 : Zones à l'origine de l'ensablement des canaux du bassin du Gourou

La prospection de tous ces sites, d'amont en aval, donne lieu à plusieurs observations que nous avons consignées dans le tableau ci-après.

N°	Localité	Observation	Longitude	Latitude
1	Adjamé Casse: Garage-en-haut	Dépotoir de sachets plastiques	385997	592885
2	Adjamé Casse: Echangeur	Sachets plastiques dans canalisation	386120	593082
3	Adjamé Marché de bétail	Erosion prononcée des flancs du bitume	385972	593210
4	Adjamé: zone aval du marché de bétail	Canal fortement ensablé et transformé en dépotoir	386108	593294
5	Williamsville	Pont à mousson et canal d'eau usée à 40 cm au-dessus du sol	386210	593329
6	Williamsville: Entrée CRS	Bordure du bitume escarpée	386353	593377
7	Williamsville: Complexe Sportif de la Cité U.	Erosion visible - Pas de revêtement gazonné	386554	593280
8	Williamsville: Terrain de foot de la cité U.	Affleurement d'une conduite souterraine métallique	386575	593198
9	Williamsville: Terrain de basket bitumé	Entièrement recouvert de sable	386593	593129
10	Williamsville: au Nord du complexe sportif	Passerelle creusée par l'érosion (80 cm de profondeur)	386595	593112
11	Williamsville: Hôtel Clément	Rue délabré et caillouteux du fait du lessivage	386685	593034
12	Williamsville: Ecole méthodiste	Canal d'eau pluviale hors sol (1m de sol lessivé)	386670	593009
13	Williamsville: non loin de l'Ecole méthodiste	Dépotoir: présence d'objets plastiques	386658	592972
14	Williamsville: Ancien pont piéton	Canal bouché par des ordures et objets plastiques	386832	592818
15	Agban gendarmerie: Echangeur	Ensablement bordure de route	387155	592672
16	Agban gendarmerie: Entrée du camp	Travaux d'assainissement	387378	592663
17	Williamsville: Carrefour Djeni Kobinan	Canal rompu et flancs érodé	387350	592850
18	Williamsville: Carrefour Djeni Kobinan	Canal transformé en dépotoir	387432	593011
19	Adjamé Paillet: Station PETROCI	Glissement de terrain	387856	593781
20	2Plateaux Bidonville	Habitations sur terrain à très forte pente	387968	594066
21	2Plateaux Colombie	Versant abrupt	388463	594570
22	2Plateau Duncan: Bld Latrille	Limite Est du bassin	389475	594506
23	Abobo Plaque ANADOR	Ravin aux versants accidentés	387048	597118
24	Abobo Plaque ANADOR: Entrée garage	Environ 1.5m de terre érodé	387026	597090
25	Adjamé: nouvelle gare de Bingerville	Gros sillons d'érosion + grande quantité de sable lessivée	387940	591793
26	Adjamé 220 Lgt: place des martyrs	Débouché d'un canal plein de sable, sachets et ordures	387711	591483
27	Adjamé 220 Lgt: Bassin du lycée technique	1er Bassin de retenue (Dégrillage - Dessablage)	387742	591009
28	Adjamé Frat-Mat	Grand canal ensablé coiffé par un pont (route lycée technique)	387491	590926
29	Adjamé Frat-Mat	2e Bassin de retenue (Dessablage): Sable, objets plastiques...	387329	590763
30	Adjamé Frat-Mat	Pont devant Fraternité Matin: Enormes quantités de sable	387298	590766
31	Adjamé Indénié: haut du pont	Vue aérienne du carrefour de l'indénié	387243	590479
32	Carrefour de l'indénié	3e bassin de retenue complètement enherbé et obstrué	387374	590481
33	Exutoire du bassin versant du Gourou	Recul des eaux lagunaires: Eutrophisation	387195	589982

Tableau II : Observations spécifiques des zones d'ensablement

4.2 DISCUSSION

Sables provenant des zones escarpées

La plupart des zones à forte ou moyenne pente du bassin ne sont pas recouvertes ou sont mal entretenues. L'érosion occasionne une dégradation continue de la surface du sol de ces surfaces. Sous l'effet de la gravité, l'eau de pluie se crée des sillons et des rigoles de largeur et de profondeur croissantes au fil du temps. Ces zones cèdent donc des quantités considérables de sables qui sont acheminés vers les canalisations en temps pluvieux. Dans certains quartiers du bassin, notamment dans les zones pentues de Williamsville, le lessivage dû à la pente est très avancé et l'on peut voir par endroit des affleurements des canaux souterrains et même un débordement des bouches d'égout se retrouvant à plus de 40cm au dessus du niveau du sol.

Sables provenant des aires de jeux

Les aires de jeux tels que les terrains de football non gazonnés sont le théâtre de mouvements répétés d'aller et venue quotidiens qui fragilisent la surface du sol ; c'est le cas du terrain de football du "Gbak" derrière la cité universitaire de Williamsville. On y trouve une couche de sable engendrée par les fréquents matchs qui s'y déroulent au quotidien. Et, en temps pluvieux, tout ce sable est emporté vers les canalisations en transitant par le terrain de basket situé en aval. La couverture sableuse du terrain bitumé de basket (épaisseur 1cm) dénote de l'ampleur du phénomène.

Sables provenant des espaces non bitumés

Les espaces aménagés pour servir de gares couvrent généralement de grandes surfaces pour permettre une grande mobilité aux véhicules. Lorsque ces espaces ne sont pas bitumés, ils sont exposés aux frottements des pneus et au lessivage pluvial.

La nouvelle gare de Bingerville située à Adjamé 220 logements est une surface non bitumée de plus d'un hectare. Sur la surface de cette gare, il est facile de remarquer des larges sillons dessinés par la pluie ; ce qui donne à l'ensemble un relief crevasé. Des sables sont donc cédés par le sol et collectées par le canal principal au niveau de l'échangeur sous-jacent, et acheminées allègrement vers l'exutoire en passant par les bassins de retenue.

Sables provenant des flancs des canaux rompus

Sur tout l'ensemble du bassin, les canaux d'assainissement drainent à la fois les eaux usées et les eaux pluviales. Les plus répandus sont ceux à ciel ouvert, normalement destinés à évacuer les eaux pluviales. Mais, à certain endroits, le vieillissement et l'envahissement de ces ouvrages par les racines des végétaux a fini par les fragiliser. Au carrefour *Djeni Kobinan*, non loin de la gendarmerie d'Agban, nous pouvons constater la rupture d'un canal non entretenu, envahi par la broussaille, dont les parois sont fortement érodées.

Sables provenant de l'occupation incontrôlée du sol

L'occupation des sols du BV du Gourou ne fait l'objet d'aucune autorisation administrative dans la plupart des cas. Certaines populations s'installent le long des collines après avoir fait des aménagements caduques et parfois suicidaires. Nous pouvons donc constater la naissance de petits quartiers jonchant les collines qui, autrefois, étaient des espaces enherbés contribuant à la stabilisation des sols. Le rognage et le déblai de ces zones escarpées donne lieu à la mobilisation d'énormes quantités de sables argileux qui sont lessivés pendant les saisons pluvieuses et acheminés vers les conduites.

5 CONCLUSION ET PERSPECTIVES

Au terme de cette étude, il apparaît clairement que l'ensablement des canaux et de l'exutoire du bassin versant du Gourou est le résultat de l'érosion des sols dénudés couplé avec les activités anthropiques. Toutes ces actions contribuent à mobiliser des masses considérables de sables dont l'accumulation cause d'énormes dégâts de plusieurs natures et à plusieurs niveaux. Nous listons entre autres les problèmes hydrauliques au niveau des canalisations, les inondations au niveau de la voirie et des habitations, la prolifération de nombreuses maladies, l'eutrophisation du plan d'eau lagunaire etc.

Il s'avère alors opportun voire primordial de prendre des résolutions.

Aux autorités administratives, il revient de prévoir dans la marge budgétaire un fonds pour l'entretien des réseaux d'assainissement, depuis l'amont jusqu'à l'aval. Aussi une restitution du couvert végétal des parcelles dénudées et un bitumage des gares routières s'imposent.

Aux scientifiques sollicités pour les études et l'élaboration des projets de gestion ou de curage, recommandation est faite de concevoir des modèles de solutions couvrant toute l'étendue du bassin et prenant en compte les différentes sources de production de sables dans leurs diversités.

Par ailleurs, des points de déversement d'ordures ménagères doivent être aménagés et l'on doit aussi sensibiliser les populations sur la nécessité de maintenir les canaux à ciel ouvert propres et dégagés.

En outre, il est important que chacun, selon son niveau de responsabilité, comprenne la nécessité de ne pas installer les activités humaines trop près des ouvrages d'assainissement à ciel ouvert par précaution de ne pas déranger la libre circulation de l'eau dans ces ouvrages.

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ANNEXES

Illustration photographique des zones à l'origine de l'ensablement des canaux du bassin versant du Gourou

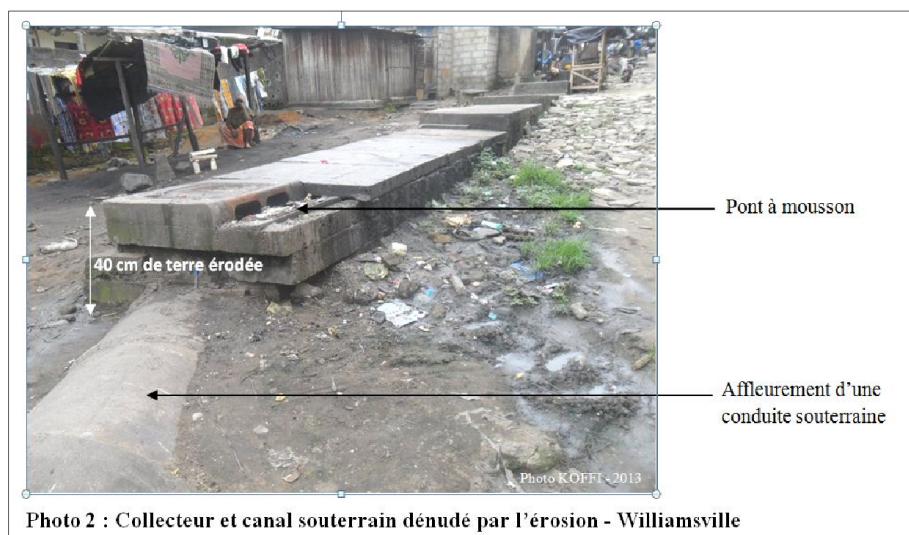
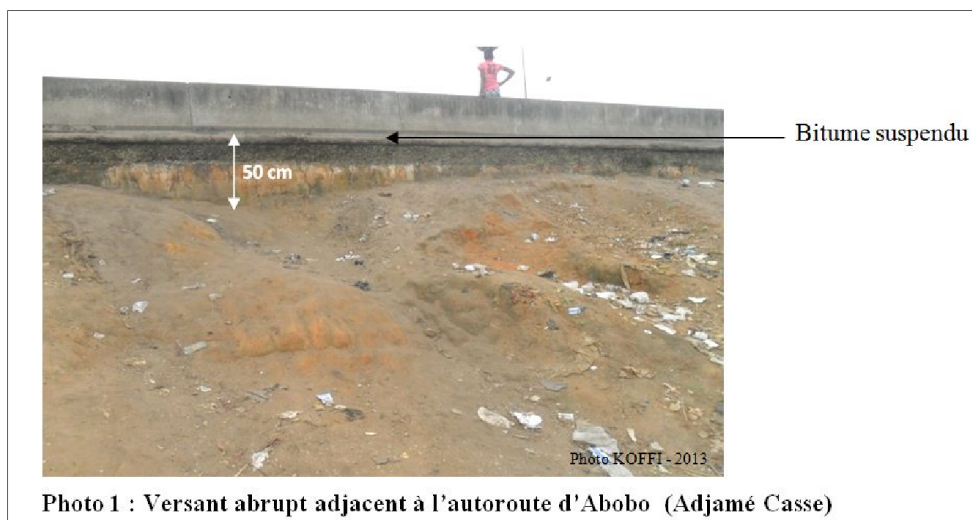




Photo 3 : Terrain de football lessivé – cité universitaire de Williamsville



Photo 4 : Canal rompu aux flancs érodés – Carrefour Djeni Kobinan de Williamsville

Approche instrumentée support de l'auto-évaluation des connaissances au service des formations de Master : perceptions, pratiques et pistes de propositions

[A Technology-Enhanced approach to automate assessments for Master's trainings: perceptions, practices and track proposals]

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ABSTRACT: Any assessment is an objective driven process. In our case, the objective is to support training sessions by utilizing Technology-Enhanced approach, particularly ontologies and web semantic paradigms. Hence, we emphasize the idea that to provide a training which could fulfill individually the needs of all learners, we should establish an assessment of their prerequisites knowledge first. We call such method "Assessment Module". Such assessment is still a complex task and intellectually demanding for teachers. To suit our scenario of use and to meet the teacher's needs, we propose the modeling and the implementation of a new methodology for the learner's assessment in order to set-up an automated assessment for a better individualized training, particularly in Masters' training. Our approach is based on a conceptualization of knowledge and on a modeling of MCQ assessment added to a fuzzy-modeling method to refine the assessment's results. In this article, we present in detail our approach as well as two study cases we did as proof of concept, and the experimental results we got later on. The experimentations has validated our assumptions and has demonstrated that the framework we proposed and the way how it was designed provide a distinguished assessment of learners almost similar to when it is done manually by a human evaluator. Fulfilling this requirement is the prior step toward any Technology-Enhanced Individualization of training in higher education.

KEYWORDS: Assessment, Modeling, Ontology, Decision processes, Teaching/Learning, Experiments.

RESUME: Nous proposons dans cet article l'élaboration et la mise en place d'une méthodologie d'instrumentalisation de l'auto-évaluation des connaissances de l'apprenant pour les systèmes éducatifs, particulièrement dans le cas des formations de Master. Notre approche consiste en la conceptualisation et la modélisation de connaissances et de QCM d'évaluation produits à base d'ontologies couplée avec un raisonnement flou. Nous présentons ensuite les résultats expérimentaux qui vont permettre de valider nos hypothèses de travail. L'originalité de cette contribution est qu'elle entretient l'expertise pédagogique de l'évaluation des acquis de l'apprenant le long de sa conception. Dans cette perspective, l'obtention d'information profitable sur les acquis de l'apprenant permet de mieux orienter l'apprentissage ainsi que les pratiques pédagogiques dans l'enseignement supérieur.

MOTS-CLEFS: Evaluation, Modélisation, Ontologie, Processus de Décision, Enseignement/Apprentissage, Expériences.

1 INTRODUCTION

1.1 CONTEXTE

A l'heure actuelle, les formations supérieures au Maroc de niveau Master s'affirment en tant qu'un vrai hub universitaire faisant converger des étudiants issus de formations de Licences d'origines différentes. Cette tendance se confirme notamment dans les formations de Masters professionnels qui accueillent des effectifs croissants d'étudiants ayant des besoins éducatifs accrus et variés du point de vue adaptation de parcours de formation. Par exemple, le Master de Télécommunications et Réseaux à l'université d'El-Jadida (notre étude de cas) intègre éventuellement des candidats issus de 4 Licences majeures, à savoir : Licence Electronique, Licence Informatique, Licence STIC et Licence Réseaux et Télécommunications. Une autre contrainte, qui rend plus ardu l'enseignement de ce type de formations, est l'effectif réduit des enseignants-chercheurs spécialistes intervenants dans ces formations. En plus de leurs activités de recherche, ces derniers sont dans l'obligation d'assurer conjointement plusieurs tâches à savoir : l'enseignement, l'encadrement et l'évaluation. Parmi ces trois principales tâches, l'évaluation constitue le repère qui permettra entre autres aux enseignants de situer les acquis de leurs étudiants au début de la formation (évaluation diagnostique), de mesurer leur évolution au cours des enseignements pour y ajuster au besoin les choix pédagogiques appliqués (évaluation formative) et enfin de vérifier que leurs étudiants ont acquis les connaissances suffisantes tout en certifiant le(s) niveau(x) requis (évaluation sommative). Par conséquent, la prise en compte des acquis des apprenants nécessite de disposer d'informations sur ces derniers. Toutefois, et selon plusieurs critiques [1] ; [2] ; [3], l'évaluation telle qu'elle est pratiquée dans l'enseignement supérieur restent très critiquable dans le sens où elle n'est pas conduite d'une façon qui bénéficie comme elle le devrait aux apprenants et à leurs apprentissages. « ...on enseigne ce qui peut se mesurer ; on ne mesure pas ce qui devrait s'apprendre pour parvenir à mieux l'enseigner » [4]. Ce constat est confirmé particulièrement dans le cas des universités marocaines où les dispositions de l'évaluation restent parfois rares, trop subjectives ou en retard par rapport au progrès technologique réalisé et aux améliorations récentes dans le système d'enseignement [5] ; [6] ; [7].

A la lumière de ces constatations, il apparait combien est très problématique le fait de concevoir un système d'enseignement supérieur de qualité, capable de s'adapter à des étudiants issus de formations hétérogènes intégrant de plus en plus des formations de Master sans avoir nécessairement le nombre suffisant d'enseignants spécialisés pour les former, les encadrer et les évaluer convenablement (évaluations diagnostique, formative et sommative). D'où l'intérêt et la nécessité de faire appel à des méthodologies préconisant de l'aide instrumentée pour assister ces formations. Néanmoins, fournir un tel soutien est un processus complexe qui soulève plusieurs défis [8].

Pour notre part et depuis plus de dix ans, nous avons proposé pour résoudre cette problématique de recherche plusieurs dispositifs de Formation Ouverte et A Distance (FOAD) comme appui à des formations supérieures présentielle spécialisées en Télécommunications et Réseaux [9]. En résumé, il s'agit d'une plateforme FOAD collaborative orientée métaphore spatiale (appelée M@roc Téléformation) et couplé avec un système d'observation d'usage récoltant les traces des étudiants au cours leurs formations [10], d'un environnement informatique appelé SMART-Project, dédié à la pédagogie par projet, médiatisé par un système multi-agents [11] et un environnement informatique support de la modélisation sémantique et de la production collaborative des contenus en contexte d'apprentissage en ligne (appelé Moulinette) [12]. Ces contributions visent à aider les enseignants dans le cadre des formations hybride (Face-to-Face et enligne) essentiellement en matière de formation collaborative, d'encadrement et de production de supports pédagogiques. Par ailleurs, en ce qui concerne l'évaluation et puisque nous nous sommes intéressés dans un premier temps à l'évaluation dans le cadre de l'apprentissage en autoformation comme complément à la formation présentielle, nous avons identifié la nécessité d'avoir une approche d'évaluation diagnostique (baptisé Positionnement) au préalable d'une autoformation pour qu'elle soit fortement individualisée (pour un Systèmes Tuteurs Intelligents (STI) par exemple) [13].

1.2 CADRE DE RECHERCHE ET OBJECTIFS

Dans cette étude, nous considérons que la méthodologie que nous avons adoptée pour le positionnement de l'apprenant n'est pas uniquement valable au début d'une formation ou restreinte à l'autoformation mais peut s'opérer à tout moment et pour tout type de formation. Partant de ce postulat particulier et des constats précités concernant nos formations masters, ce travail a pour objectifs (1) de fournir aux enseignants une approche générique d'aide à l'évaluation automatisée facilitant les pratiques évaluatives et (2) de renforcer par la même occasion l'apport de l'évaluation pour le développement des enseignements. Ainsi nous associons à nos objectifs spécifiques (1) et (2) nos hypothèses de travail (H1) et (H2) respectivement :

- **H1** : dans le contexte actuel, il doit y avoir une approche d'émulation capable d'automatiser le processus de l'évaluation de manière à se rapprocher étroitement de l'expertise humaine;
- **H2** : si cette approche existe, elle pourra être instrumentée pour qu'elle soit suffisamment générique (indépendance vis-à-vis du domaine d'enseignement, du moment de l'évaluation et du public cible) et permettra ainsi d'inciter les enseignants à tenter fréquemment des évaluations pour mieux appréhender l'hétérogénéité de leurs étudiants et mesurer la pertinence de leurs choix pédagogiques durant toute la formation.

A la croisée de ces deux prémisses, le travail de recherche que nous présentons ici concerne la mise en place d'un support instrumenté d'aide à l'évaluation des connaissances afin d'apporter des éléments de réponses à notre problématique liée aux formations spécialisées ayant un public cible hétérogène et ce dans le cadre d'une démarche expérimentale. Nous visons la proposition d'un méta-modèle d'évaluation instrumenté par des ontologies, d'un modèle de QCM (Questionnaire à Choix Multiples) et d'un processus de jugement (Décision) basé sur la logique floue. Pour ce faire, nous positionnons dans un premier temps notre travail vis-à-vis de l'état de l'art, en particulier la prise en compte de l'hétérogénéité des connaissances des étudiants au lancement de formations au supérieur (et d'autoformation éventuellement) et le rôle de tel diagnostic dans l'amélioration des enseignements dans le contexte de notre travail. Dans un second temps, nous exposons notre approche en présentant les postulats sur lesquels il est fondé ainsi que les méthodologies mises en œuvre, que ce soit lors de sa modélisation ou de son implémentation. Nous détaillons surtout notre démarche pour la construction des différents éléments constitutifs de notre méta-modèle et leurs relations concourantes inspirées de l'expertise pédagogique, étape suivie par la description et l'implémentation du processus de jugement de l'enseignant-expert pour une estimation pertinente du niveau de connaissances des apprenants.

Afin d'évaluer notre approche, nous exposons les expérimentations que nous avons réalisées au sein du laboratoire STIC pour différentes formations supérieures (spécialité Télécommunications et Réseaux) depuis l'année 2007 à 2014 : [3] ; [14] ; [7]. Nous allons aborder l'analyse de nos résultats de manière rétroactive pour pouvoir examiner judicieusement le processus de notre approche. En effet, d'après l'auteur Baron, "un axe prometteur est celui des recherches visant à analyser des dynamiques d'appropriation d'outils technologiques dans des systèmes d'activité" [15]. Par souci de simplicité et de clarté, nous exposons un retour d'expérience sélectif selon les aspects que nous désirons souligner à travers telle ou telle expérience. Nous nous référons d'abord, à notre première expérimentation que nous avons menée dans le domaine des réseaux informatiques au sens d'illustrer notre travail à l'aide d'une étude de cas et valider notre première hypothèse (H1). Puis, nous vérifierons que l'hypothèse H2 est valide à travers l'analyse des résultats de notre deuxième expérimentation (Domaine des Communications Numériques) tout en reconsidérons ceux de la première expérimentation (Domaine des réseaux informatiques). Il s'ensuivra enfin une conclusion récapitulant nos contributions et leurs impacts sur la qualité des enseignements/apprentissages dans le contexte de notre travail tout en dressant les perspectives de la recherche présentée.

2 ASPECTS FONDAMENTAUX DE L'ÉVALUATION ET CHOIX CONCEPTUEL

2.1 POURQUOI UNE ÉVALUATION DIAGNOSTIQUE EST-ELLE NÉCESSAIRE DANS LE CADRE D'UNE FORMATION HÉTÉROGÈNE ?

La qualité d'un système d'enseignement professionnel dépend essentiellement de la prise en compte de l'hétérogénéité du public cible du point de vue connaissances requises par rapport au domaine d'apprentissage, ce qui offre à ce système la possibilité de s'adapter à chaque apprenant [16]. Pour cela, nous avons besoin d'être informé à travers une évaluation sur les connaissances pré-acquises de l'apprenant concernant la matière en question pour pouvoir situer le niveau actuel de ses acquis juste avant le début de sa formation par rapport à une échelle présumée des niveaux de connaissances et des objectifs pédagogiques à atteindre. Par exemple, nous considérons deux apprenants A et B en début d'une formation de Master Télécommunications et Réseaux (T&R). L'apprenant A est de spécialité Réseaux et B est de spécialité Electronique. Sans une évaluation diagnostique des connaissances de ces deux apprenants, la formation pourrait commencer d'une manière uniforme indépendamment du niveau de chacun. On se trouvera alors confronté à l'une de ces deux situations : l'apprenant A sera dans l'obligation embarrassante et ennuyeuse de réétudier les concepts qu'il a déjà acquis ou c'est l'apprenant B qui aura des difficultés à combler ses lacunes par rapport à tous les nouveaux concepts à étudier. Dans les deux cas et si on ne prend pas les mesures adéquates, la motivation et la qualité de l'apprentissage des étudiants seront remises en question. Ce constat est valable même au sein d'un groupe d'apprenants de spécialité identique étant donnée l'hétérogénéité des programmes interuniversitaires ou celle des niveaux des apprenants de la même promotion. En pratiquant une évaluation diagnostique, l'enseignant aura plus de visibilité sur l'ensemble de ses apprenants et pourra donc entreprendre des enseignements différenciés (rappels, projets, autoformation, travail de groupe, ...) [7] pour uniformiser progressivement les

niveaux de connaissances des apprenants à travers une adaptation dynamique au cours de la formation (observation de l'activité de l'apprenant, évaluation/régulation) [17]. Certes, de telles opérations sont fastidieuses pour un enseignant mais elles peuvent éventuellement être réalisées d'une manière propice si elles sont partiellement ou complètement automatisées.

2.2 ÉVALUATION COGNITIVE

L'évaluation dans l'enseignement est un terme unique mais s'exerçant sous forme de processus multiples à des moments distincts et pour des objectifs différentes par rapport à une même formation. Nous reprenons ici la définition de ce terme donnée par les auteurs Daniau et Bélanger : « l'évaluation consiste à établir un jugement de valeur sur un objet à partir d'informations méthodiquement recueillies. Elle vise ensuite à prendre des mesures qui découlent de ce jugement afin d'améliorer ce qui a été évalué » [18]. Selon De Ketele et al, ce jugement de valeur est traduit en termes de prise de décision [19] où l'acte d'évaluation est « un processus qui commence quand on se fixe un objectif à atteindre, et qui se termine quand on a pris une décision en rapport à cet objectif. Cela ne signifie pas que le processus global se termine avec la décision. Au contraire, celle-ci marque le début du processus de rétroaction qui est tout aussi important que l'évaluation ». En plaçant ces définitions dans un cadre conceptuel, nous repérons des opérations corrélées dont émergent les démarches du modèle général de l'approche que nous cherchons à élaborer. En effet, la généricité de cette approche suppose des choix qui devraient inclure une réflexion sur le diagnostic manuel tel qu'il est réalisé habituellement par les enseignants et une modélisation des apprenants qui soit pragmatique. Le modèle de l'apprenant selon [20], représente l'état courant des connaissances de l'apprenant. Les auteurs en distinguent divers sous-modèles qui peuvent être répertoriés en trois composantes principales :

- modèle statique (données générales sur la personne : nom, identificateur, âge, objectifs,...);
- modèle cognitif (connaissances possédées);
- modèle affectif (préférences, style d'apprentissage, profil psychologique, état émotionnel ou motivationnel)

Dans le processus éducatif de notre approche, les objectifs sont principalement axés sur l'aide à l'apprentissage cognitif [21]. Nous nous focalisons donc sur l'adaptation par rapport au niveau de connaissances de l'apprenant (modèle cognitif) pour pouvoir éventuellement individualiser son apprentissage afin de lui permettre de progresser. Nous cherchons donc à expliciter et à formaliser l'expertise de l'enseignant dans son travail de diagnostic des connaissances des apprenants. Ceci est concrétisé à travers des éléments et étapes intervenants dans la construction de notre modèle instrumenté d'autoévaluation des connaissances. Or, d'une manière générale la question de la modélisation des connaissances de l'apprenant est un problème plutôt difficile [22]. Ainsi, pour rendre à l'évaluation des connaissances de l'apprenant dans un système éducatif instrumenté, sa dimension pédagogique issue de l'assistance humaine, une vision sur ces considérations fondamentales a favorisé notre réflexion dans ce sens.

3 MÉTHODOLOGIE DE CONCEPTION

La méthodologie de conception et de construction que nous proposons se base sur la modélisation de l'expertise humaine (enseignant-expert) au niveau pédagogique concernant l'évaluation des connaissances des apprenants. Cette implémentation doit préserver au maximum la fidélité pédagogique de l'évaluation humaine et affirmer la viabilité d'évaluer les connaissances d'un apprenant par un modèle cognitif ontologique et par des test QCM.

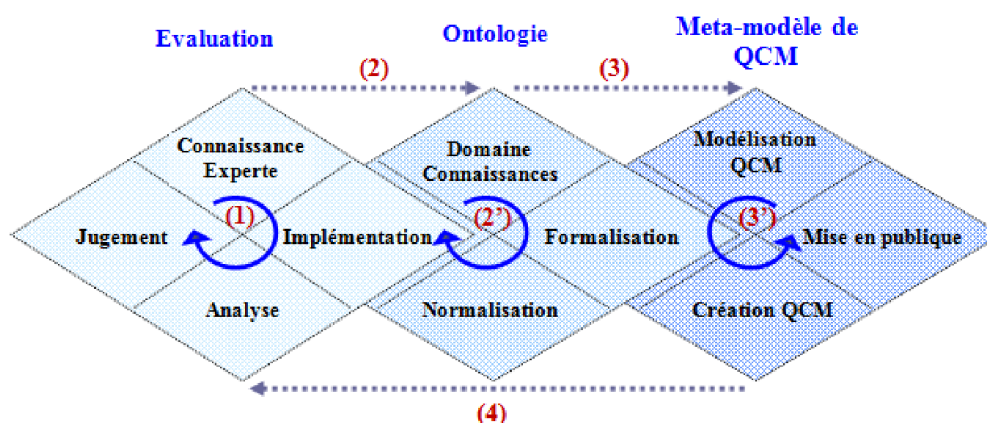


Fig. 1. *Éléments et étapes intervenants dans la construction du Module Evaluation*

Pour atteindre ces objectifs, notre proposition s'exprime à travers les éléments et les liens (illustrés sur la Figure 1), que nous allons étudier explicitement et mettre en pratique dans cette recherche axée sur une instrumentation appropriée de l'évaluation des connaissances de l'apprenant dans un système de formation à partir de l'expertise humaine : liens entre l'évaluation et l'expertise de l'enseignant (1) ; liens entre l'évaluation et le domaine de connaissances (2)&(2') ; enfin liens entre l'évaluation et son exploitation pédagogique, en l'occurrence l'estimation du niveau de connaissance de l'apprenant (4) à l'issue d'une évaluation à base de QCM (3)&(3').

Pour ce faire, nous avons adopté la méthodologie détaillée sur la Figure 2. Dans la présente étude, le développement de notre approche permettant de vérifier les acquis des apprenants lors d'une formation se base sur la définition d'objectifs pertinents devant contribuer ensuite à déterminer les connaissances manquantes. Nous joignons dans ce sens la définition du processus évaluatif de [23] : Evaluer consiste à recueillir un ensemble d'informations reconnues comme suffisamment pertinentes, valides et fiables, et à examiner le degré d'adéquation entre cet ensemble d'informations et un ensemble de critères jugés suffisamment adéquats aux objectifs fixés au départ ou ajustés en cours de route, en vue de fonder une prise de décision. En effet, l'approche basée sur les objectifs est particulièrement applicable dans l'évaluation de matières d'apprentissage s'appuyant clairement sur des objectifs : *The objectives-based approach is especially applicable in assessing tightly focused projects that have clear supportable objectives* [24]. L'approche permet de mesurer les progrès de l'apprenant de façon précise et d'atteindre ainsi une évaluation dite "objective", reposant sur des éléments concrets et connus dès le départ. A la fin de ce processus, l'enseignant sera informé sur le niveau de connaissance de l'apprenant par rapport au domaine d'apprentissage [25].

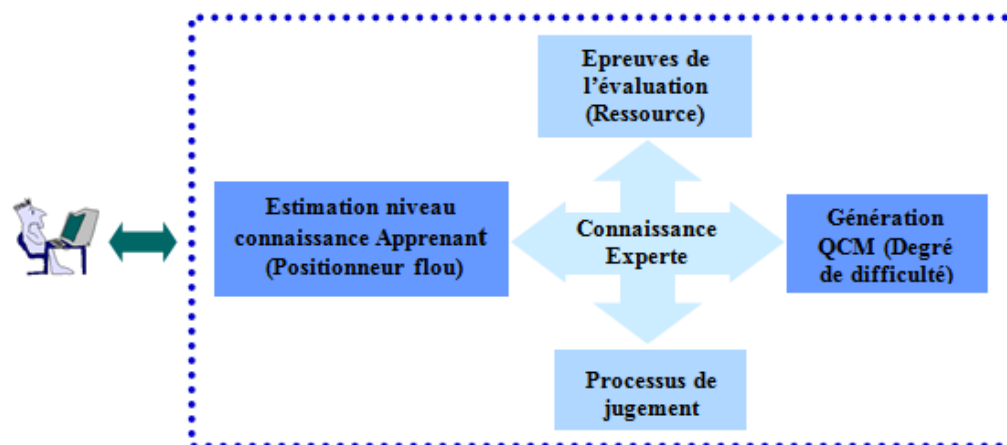


Fig. 2. Schéma montrant la méthode suivie pour la construction du Module Evaluation des connaissances basée sur l'expertise humaine

La partie suivante représente la description linguistique de la connaissance experte intervenant dans le processus d'élaboration du Module Positionnement. Parmi les aspects de la connaissance de l'enseignant-expert qui devraient être modélisés pour approprier l'évaluation du niveau de connaissance de l'apprenant nous avons notés : la nature de la matière à enseigner, le niveau de difficulté des questions et le processus de jugement de l'expert. Ainsi, la définition de l'importance relative des critères utilisés, fournit au Module Evaluation la connaissance venant de l'expertise de l'enseignant.

Pour ce faire, nous avons besoin de deux types de la connaissance experte : une description relative au domaine à enseigner que nous avons modélisé à base d'ontologie pour un établissement pertinent des épreuves de l'évaluation et une description relative au processus de jugement de l'expert.

3.1 CONCEPTUALISATION DU DOMAINE DES CONNAISSANCES À BASE D'ONTOLOGIES

L'efficacité de notre approche présuppose néanmoins l'existence d'un modèle du domaine de connaissance susceptible d'être développé, ou d'être mis en œuvre, au sein de l'application cible. Notre approche est interdisciplinaire et comparative, on cherchera d'abord à élaborer une modélisation du domaine de connaissance et un méta-modèle pour les QCM d'évaluation associés dans le but d'aboutir à une meilleure évaluation des connaissances de l'apprenant. Dans cette section

nous justifions le choix des ontologies en tant qu'outil de conceptualisation capable de formaliser les modèles sur lesquelles nous travaillons pour implémenter le Module Evaluation.

Ainsi, nous avons choisi d'utiliser les ontologies parce qu'elles constituent un support intuitif et compréhensible de la formalisation capable de structurer d'une manière très fine les connaissances. En plus la modification et la réutilisation de la représentation des connaissances d'un domaine d'apprentissage à base d'ontologie est souple. Une raison de plus est la capacité des ontologies à représenter n'importe quel domaine d'enseignement, sans altérer la séparation recommandée entre les niveaux de modélisation du domaine, de l'apprenant et des QCM. En fin, l'instrumentalisation des ontologies, rendue accessible à l'aide des langages et des paradigmes du web sémantique, est susceptible de favoriser l'individualisation de l'apprentissage dans tout dispositif informatique intégrant notre Module Evaluation.

La définition que nous avons retenue pour l'ontologie est celle de [26] ; [27] qui définissent une ontologie comme étant une conceptualisation des objets du domaine selon un certain point de vue, imposé par l'application. Elle est conçue comme un ensemble de concepts, organisés à l'aide de relations structurantes. Nous détaillons ensuite les étapes de construction de notre ontologie à travers le cycle suivant (Figure 3) :

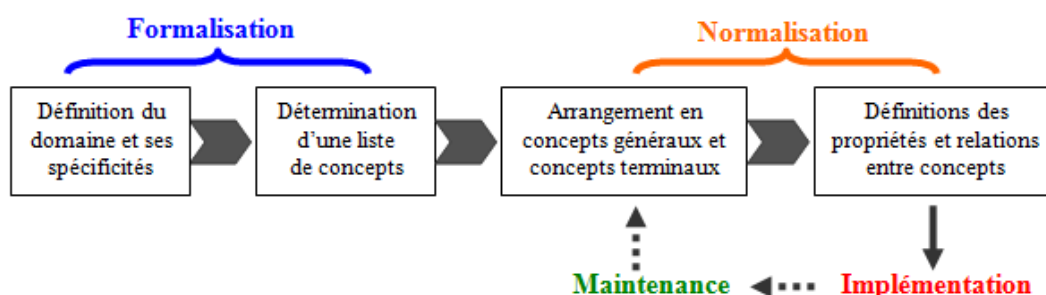


Fig. 3. Différentes phases de raffinement de la structure de l'ontologie

3.1.1 DÉFINITION DU DOMAINE DES CONNAISSANCES ET SES SPÉCIFICITÉS

Dans notre cas d'étude, il est primordial pour modéliser la connaissance d'un domaine, de communiquer de façon simple avec les spécialistes de ce domaine qui ne sont pas forcément informaticiens. Ainsi, le formalisme des réseaux sémantiques est le plus adapté à nos besoins. En effet, les réseaux sémantiques sont dotés d'une assez grande facilité de lecture car proches du langage naturel, et sont, de plus, facile à étendre et à mettre à jour.

Nous commençons le développement de notre ontologie en définissant la portée du domaine de connaissance c'est-à-dire les questions auxquelles la base de connaissances fondée sur cette ontologie devrait pouvoir répondre :

- dans quel but utiliserons-nous l'ontologie ?
- à quels types de questions l'ontologie devra-t-elle fournir des réponses ?

A ce niveau, la composition de l'ontologie va pouvoir répondre à deux objectifs. Le premier est de construire un modèle du domaine de connaissance fondamental pour un système de formation. Cette première partie donnera naissance à une base de connaissance des concepts à enseigner.

Le deuxième objectif est la mise en place d'un Module Evaluation, évaluant les acquis de l'apprenant, nécessitant l'élaboration d'une base de tests sous forme d'un méta-modèle de QCM.

3.1.2 DÉTERMINATION D'UNE LISTE DE CONCEPTS

La réalisation de telles bases de connaissance pourraient donc répondre à plusieurs besoins :

- permettre de gérer l'ensemble des concepts consultables avec différents niveaux de détail ;
- servir à organiser et à mettre à disposition des éléments didactiques divers dont des situations d'apprentissages et leur analyse ;
- gérer une évaluation maintenant à jour l'état des connaissances et fournir des épreuves de référence ou d'évaluation calibrées.

3.1.3 ARRANGEMENT DES CONCEPTS ET DÉFINITIONS DES RELATIONS

La conception du Module Evaluation est basée sur des critères objectifs, à travers laquelle on compare les capacités de l'apprenant par rapport au contenu du domaine prédéfini. Il s'agit de mesurer les acquis des apprenants pour définir leurs difficultés de compréhension, de maîtrise des concepts par rapport aux capacités et objectifs visés par l'apprentissage en question.

Par conséquent, après avoir énuméré les termes importants dans l'ontologie (normalisation), il faut ensuite les arranger. Nous avons opté de les organiser en concepts généraux et concepts terminaux à l'aide de relations structurantes (formalisation). En effet, notre approche consiste à s'appuyer sur l'idée d'objectifs à atteindre et celle des ontologies. Nous utilisons la terminologie de "concept général" correspondant à un élément de connaissance global qui comprend plus d'une unité de connaissance significative. Celui-ci se décompose en "concepts terminaux" qui désignent chacun une unité de connaissance significative. Nous définissons une unité de connaissance significative comme étant le plus petit élément de connaissance ayant un sens et participant à la complétude de la définition du domaine de connaissances en question. Dans cette optique, un concept terminal est un élément essentiel qui va nous permettre de mesurer les acquisitions et par suite définir les items du test d'évaluation.

3.2 CONCEPTUALISATION DU MÉTA-MODÈLE DES QCM

En prenant en considération toutes les données issues de la modélisation de la connaissance experte, l'objectif de cette phase est d'élaborer concrètement le Module Evaluation. Donc, nous avons modélisé explicitement ce module sous forme d'une structure sémantique abstraite appelé méta-modèle des QCM. Le méta-modèle des QCM sert en fait à représenter une description abstraite, explicite et formelle des épreuves du QCM que l'on veut produire afin de permettre à l'enseignant de représenter à ses collaborateurs d'une façon succincte et concise les différents QCM à produire. Ce méta-modèle regroupe une liste d'items du QCM. Chaque item du QCM évalue un concept du domaine des connaissances.

3.2.1 CONCEPTION DES ÉPREUVES DE L'ÉVALUATION

Afin de mesurer la connaissance de l'apprenant par rapport au domaine de connaissances considéré, un test d'évaluation s'impose. Pour construire ce dernier, nous nous sommes inspirés de l'approche *Component Display Theory* concernant les niveaux de performance [28] et de "la Taxonomie de Bloom" [29]. La nature des capacités visées va être explicitée en fonction des objectifs. Par ailleurs, il existe plusieurs manières de mesurer l'apprentissage, notamment les deux suivantes : soit en mesurant le contenu d'apprentissage, soit en procédant par projet. Le projet consiste à mettre l'apprenant en situation d'activité afin d'utiliser les contenus d'apprentissage, de le mettre en situation d'effectuer un transfert de connaissances.

Quant à mesurer le contenu d'apprentissage par des questions, selon [30] trois types de questions sont souvent utilisées :

- questions fermées de type QCM "Questions à Choix Multiples" ;
- question semi-ouverte ou question à réponse construite souvent de type texte, il s'agit de créer une réponse type et d'accepter les variations autour de cet espace-là ;
- questions ouvertes de type projet, simulation, production de rapport, etc.

En raison de contraintes techniques fortes de la situation d'évaluation, toutes les questions sont au format QCM. Cette forme de questionnement a pour avantages d'éviter un travail de correction et d'automatiser la saisie des réponses des apprenants. On considère que les questions à choix multiples sont les plus polyvalentes. Elles permettent en effet d'évaluer aussi bien la mémorisation que la compréhension et l'application. Il y a quatre types de questions à choix multiples où l'apprenant doit découvrir soit :

- la bonne réponse ;
- la meilleure réponse ;
- la réponse incorrecte ;
- la réponse qui complète une association.

Vu que la rédaction de ce genre de questions est très laborieuse, notre choix s'est porté sur le premier type pour pouvoir indiquer d'une manière simple et précise l'action attendue de la part de l'apprenant.

3.2.2 MODÉLISATION DU DEGRÉ DE DIFFICULTÉ DES QCM

L'épreuve de l'évaluation est composée de plusieurs questions pour lesquelles nous avons cherché à définir une hiérarchie des différents niveaux de maîtrise. Pour ce faire, nous avons attaché des propriétés qualitatives à chaque élément du QCM pour indiquer son degré de difficulté {Facile, Moyen, Difficile}.

Nous avons essayé de modéliser cette connaissance experte en se basant sur deux paramètres clefs que nous avons définis comme suit :

- **Aspect Concept** : à travers ce paramètre nous faisons apparaître la difficulté reliée au concept lui-même, la mise en relief de cette difficulté se fait en allant de l'aspect sommaire à l'aspect spécifique des concepts en question ;
- **Formulation Item** : la difficulté par rapport à ce paramètre touche la manière de formuler l'énoncé de l'item en combinant des affirmations générales et des affirmations nuancées.

La Figure 4 ci-dessous présente les différentes combinaisons qui nous ont permis la modélisation du degré de difficulté des questions.

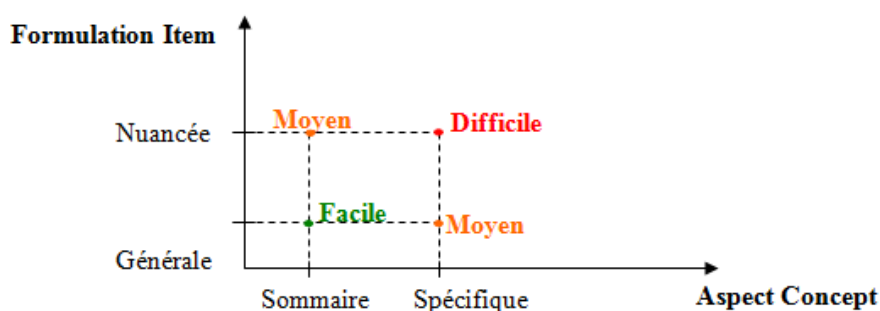


Fig. 4. Modélisation du degré de difficulté des éléments du QCM

3.3 IMPLÉMENTATION DU MODULE EVALUATION

3.3.1 DESCRIPTION DU PROCESSUS DE JUGEMENT

Le test sujet de l'évaluation, se compose de questions à choix multiples qui sont présentées à l'apprenant suivant une variation aléatoire du degré de difficulté {Facile, Moyen, Difficile}. L'analyse des résultats est exécutée en vérifiant les réponses aux questions posées. Ce processus recouvre à la fois le recueil et la modélisation des connaissances experte (côté enseignant-expert). Le recueil se rapporte à la collecte des données. La modélisation correspond à l'identification et à la caractérisation des connaissances et de leurs propriétés. Plusieurs techniques existent pour le recueil de données, nous avons essentiellement utilisé l'entretien et le questionnaire. Ces derniers couvrent un ensemble de techniques qui ont pour fin la favorisation et l'assistance pour la description de la façon dont un travail a été accompli.

A travers cette étape, nous nous intéressons donc en premier lieu à la verbalisation de l'action, telle qu'elle est réellement mise en œuvre dans l'accomplissement de la tâche de l'évaluation. Ici, le terme d'action englobe les actions matérielles et mentales du processus de l'évaluation. En conséquence, il est nécessaire de faire appel à un travail d'explicitation vu que, dans une situation donnée, une partie des compétences pratiques utilisées appartient aux représentations mentales, et donc peu verbalisables. L'analyse effectuée nous a amenés à définir une grille suggérant les principaux aspects à considérer lors de la description et la compilation du processus de jugement de l'expert. Durant la phase de recueil, cette grille rappelle les thèmes généraux des informations à rechercher et les points qui pourraient être affinés :

- pourcentage des réponses correctes ;
- degré de difficulté des QCM {Facile, Moyen, Difficile} ;
- état de la connaissance "mesurée" {Connaissance Insuffisante, Connaissance Moyenne, Connaissance Suffisante};
- niveau de connaissances estimé de l'apprenant {TI : Très Insuffisant, I : Insuffisant, S : Suffisant, TS : Très Suffisant}.

Pour que l'évaluation soit aussi proche que possible de la manière qu'un enseignant-expert évalue un apprenant, nous avons choisi un modèle qualitatif en se basant sur les résultats des entretiens établis avec l'enseignant-expert, qui classe l'état de la connaissance "mesurée" à travers la réponse de l'apprenant sur trois niveaux de valeur {Connaissance Insuffisante, Connaissance Moyenne, Connaissance Suffisante} et ce en fonction du pourcentage global des réponses correctes par rapport aux trois catégories des QCM {Facile, Moyen, Difficile}. Cette modélisation est illustrée comme suit (Tableau 1) :

Table 1. Modélisation qualitative de l'état des connaissances "mesurées" chez l'apprenant par catégorie de QCM

Recueil de la connaissance experte		Estimation de la qualité de la connaissance de l'apprenant
Pourcentage des réponses correctes aux QCM de degré Facile	0% - 60%	Connaissance Insuffisante
	50% - 90%	Connaissance Moyenne
	80% - 100%	Connaissance Suffisante
Pourcentage des réponses correctes aux QCM de degré Moyen	0% - 50%	Connaissance Insuffisante
	40% - 80%	Connaissance Moyenne
	70% - 100%	Connaissance Suffisante
Pourcentage des réponses correctes aux QCM de degré Difficile	0% - 40%	Connaissance Insuffisante
	30% - 70%	Connaissance Moyenne
	60% - 100%	Connaissance Suffisante

Ainsi le jugement de l'expert consiste à évaluer le niveau de connaissances d'un apprenant par rapport aux concepts d'un domaine de connaissance donné selon l'échelle {TI : Très Insuffisant, I : Insuffisant, S : Suffisant, TS : Très Suffisant} numérotés respectivement {1, 2, 3, 4}. Cette évaluation est déduite à partir d'un raisonnement de décision sur la base des pourcentages des réponses correctes aux QCM de degré facile, de degré moyen et de degré difficile. Le Tableau 2 ci-dessous illustre un exemple d'évaluation de 4 cas d'apprenants, établi en fonction du pourcentage de leurs réponses correctes et le jugement résultant (chemins en pointillés sur la Figure 5).

Table 2. Exemple d'évaluation de 4 apprenants

Apprenants	Pourcentage des réponses correctes aux QCM de degré facile	Pourcentage des réponses correctes aux QCM de degré moyen	Pourcentage des réponses correctes aux QCM de degré difficile	Jugement
A	25% (connaissance insuffisante)	58% (connaissance moyenne)	25% (connaissance insuffisante)	Très Insuffisant (niveau 1)
B	74% (connaissance moyenne)	23% (connaissance insuffisante)	74% (connaissance moyenne)	Insuffisant (niveau 2)
C	85% (imprécision entre : connaissance moyenne et connaissance suffisante)	85% (connaissance suffisante)	85% (connaissance suffisante)	Suffisant (niveau 4)
D	93% (connaissance suffisante)	93% (connaissance suffisante)	10% (connaissance insuffisante)	Très Suffisant (niveau 3)

Naturellement, le processus du jugement est un acte d'évaluation singulier dépendant de la conception et de l'expertise de chaque évaluateur et reste par conséquent modulable en fonction des modalités dictées par chaque enseignant-expert au moment de la conception pédagogique. La Figure 5 représente schématiquement la description d'un processus de jugement de l'enseignant-expert (avec les exemples du Tableau 2) à partir d'une grille basée sur le pourcentage des réponses correctes, sur le niveau de performance d'un apprenant par rapport aux concepts d'un domaine d'apprentissage donné. L'avantage de la capture et l'instanciation de telle grille de manière explicite est de faciliter l'automatisation ultérieure du processus de jugement à l'aide des outils informatiques rendant possible l'évaluation des apprenants en absence de l'enseignant-expert. Les défis à relever dans ce sens sont comment garder le processus de jugement, une fois implémenté techniquement, très proche de celui de l'enseignant-expert et suffisamment générique pour tout modèle d'apprenant et pour toute situation d'apprentissage y compris une autoformation, loin de l'enseignant concepteur lui-même.

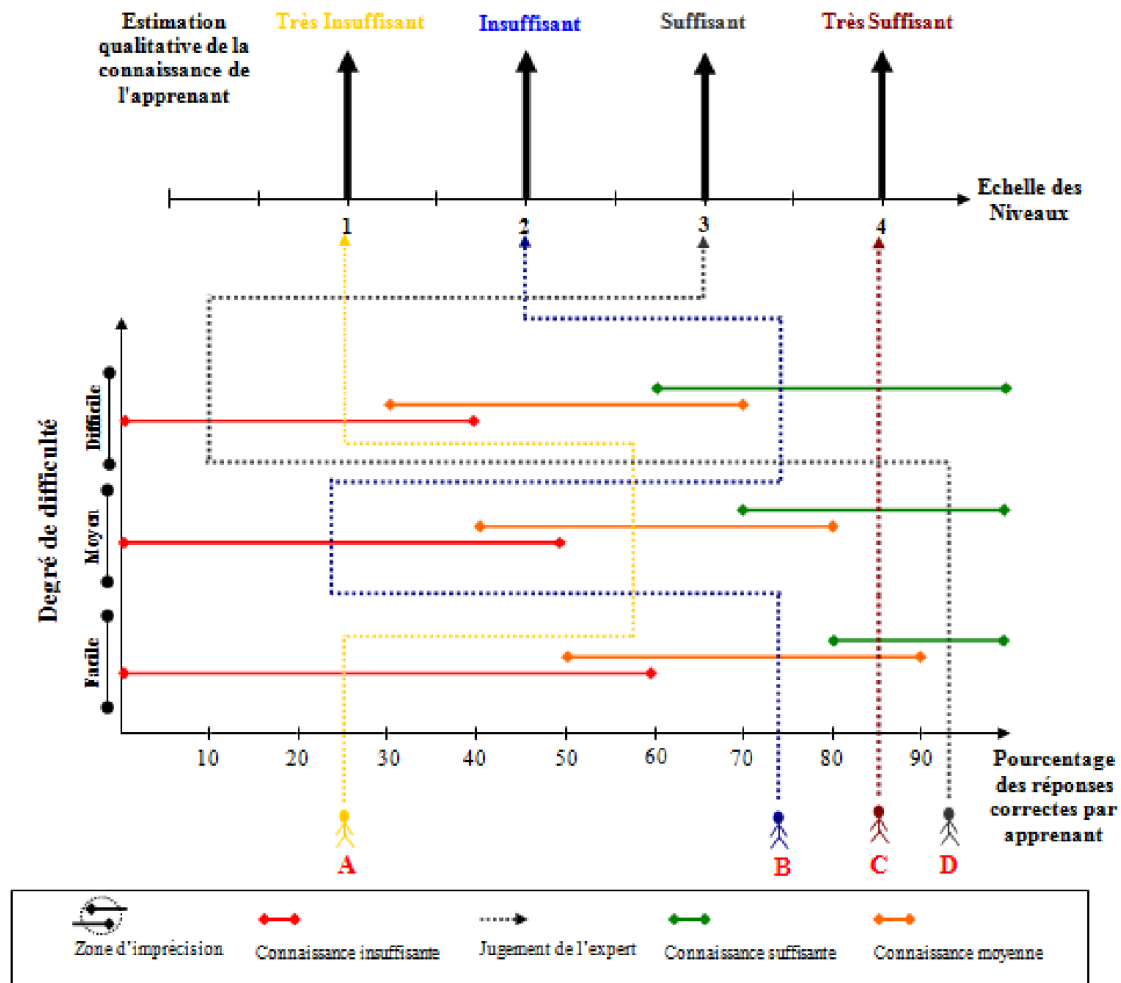


Fig. 5. Description relative à la modélisation du processus de jugement de l'enseignant-expert

Nous essayons de modéliser ce processus d'évaluation par l'utilisation des ensembles flous visant à combiner les mesures quantitatives pourcentage des réponses correctes par niveau de difficulté {Facile, Moyen, Difficile} afin d'obtenir des caractérisations qualitatives de la connaissance de l'apprenant selon l'échelle {1, 2, 3, 4} indiquant respectivement les niveaux {Très Insuffisant, Insuffisant, Suffisant, Très Suffisant}.

3.3.2 ESTIMATION DU NIVEAU DES CONNAISSANCES DE L'APPRENANT (POSITIONNEUR FLOU)

Le Positionneur flou représente la connaissance de l'enseignant-expert en forme linguistique et inclut les caractéristiques de l'apprenant sous forme d'un ensemble de systèmes flous, réalisant de cette façon le processus d'évaluation comme un expert. C'est à dire qu'une décision n'est prise qu'en combinant des faits flous, contribuant chacun à un certain degré à une

relation floue et à la décision finale [3]. La logique floue est employée pour manipuler l'imprécision et pour exprimer la connaissance qualitative de l'expert d'une manière clairement interprétable [31].

La présence de l'incertitude est un facteur important qui mène souvent aux erreurs dans l'évaluation des connaissances de l'apprenant (Exemple : cas de l'apprenant C là où le pourcentage des réponses correctes aux QCM de degré facile nous a engendré une imprécision entre la connaissance moyenne et la connaissance suffisante (Figure 5)). Ces zones d'incertitude modélisent les erreurs et approximations impliquées lors du recueil de l'information à partir des mesures, partiellement en raison de la nature abstraite de la connaissance humaine et de la perte d'information résultant de sa quantification. Vu les attributs de ce problème, il est évident que l'élaboration d'une méthode fiable pour l'évaluation de l'apprenant doit être basée sur une manipulation réussie de l'incertitude (Figure 6).

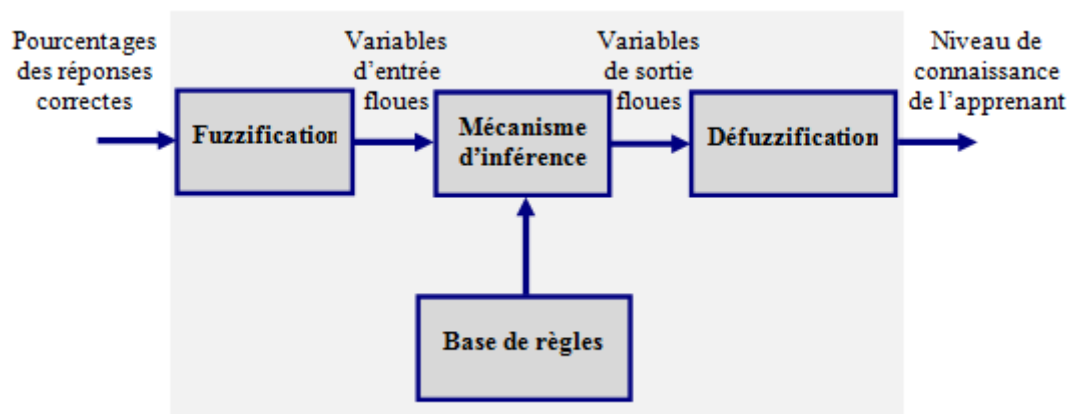


Fig. 6. Schéma bloc de la structure du Positionneur Flou

Dans notre cas, l'univers de discours E des variables d'entrée correspond au pourcentage des réponses correctes, discrétisé en 11 éléments {0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100}. Pour un élément x de E, la valeur $f(x)$ représente le degré d'appartenance de x à un sous ensemble flou. Comme mentionné au paragraphe 2.4.1, nous avons choisi un modèle qualitatif, qui classe la connaissance par degré de difficulté sur trois niveaux de valeur {Insuffisant, Moyen, Suffisant}. Ceci se traduit par la répartition de l'univers de discours de chaque variable d'entrée en trois sous-ensembles flous : connaissance insuffisante, connaissance moyenne et connaissance suffisante notés {Insuffisant, Moyen, Suffisant}.

Pour la variable de sortie, l'univers de discours est discrétisé en 4 éléments. En effet, dans notre approche nous avons considéré quatre niveaux précis variant de 1 à 4, échelle d'estimation du niveau de connaissance d'un apprenant, que nous avons qualifiées respectivement par {Très Insuffisant, Insuffisant, Suffisant, Très Suffisant}. Or, les opérateurs utilisés dans le positionneur flou agissent uniquement sur des variables floues. Par conséquent, il est nécessaire de transformer ces variables non floues en des sous-ensembles flous. Pour ce faire, les sous-ensembles flous associés aux niveaux {1, 2, 3, 4} sont respectivement « Niveau Très Insuffisant », « Niveau Insuffisant », « Niveau Suffisant » et « Niveau Très Suffisant ». Par souci de simplification, nous avons notés ces quatre sous-ensembles flous par {Très Insuffisant, Insuffisant, Suffisant, Très Suffisant}. Le mécanisme d'inférence consiste en l'utilisation de règles floues pour évaluer de nouvelles variables floues en sortie. En effet, la conception d'une base de règles floues est un processus interactif. La plus grosse part de travail se trouve au niveau du recueil des connaissances expertes. Ainsi, en utilisant les données correspondant aux différentes entrées et sorties, l'enseignant-expert fournit une série de combinaisons qui se rapproche de son raisonnement. Un des intérêts de la logique floue est la possibilité de valider la base des règles auprès de ceux qui ont fourni l'expertise, avant de la tester sur un système réel.

A la fin de l'inférence, l'ensemble flou de sortie est déterminé, mais il n'est pas directement utilisable pour donner une information précise. Cette étape (défuzzification) consiste à faire la transformation des variables quantitatives obtenues en variables qualitatives. A partir de la base de règles (fournie par l'expert) et des sous-ensembles flous correspondant à la fuzzification, le mécanisme d'inférence calcule le sous-ensemble flou relatif à la sortie du système. La génération de la variable de sortie se fait en utilisant la méthode du centre de gravité, selon laquelle le système calcule le nombre (s) qu'on arrondit au nombre entier le plus proche. A la fin de la défuzzification, nous obtenons l'évaluation finale du niveau de connaissance de l'apprenant. Ainsi, si $(s) = 1$, nous caractérisons le niveau de connaissance de l'apprenant sur la matière

comme 'Très Insuffisant', si (s) = 2 comme 'Insuffisant', si (s) = 3 comme 'Suffisant' et si (s) = 4 comme 'Très Suffisant' (Figure 5).

Finalement, notre Module Evaluation fournira une estimation qualitative de la connaissance des apprenants, permettant ainsi à l'enseignant d'agir sur l'opération "enseignement/apprentissage" en conséquence.

4 ETUDE DE CAS

Notre approche a été concrétisée et évaluée lors d'une expérimentation réalisée avec un groupe d'apprenants issus d'une licence et qui voulaient intégrer un Master en Télécommunication et Réseaux. A travers cette expérimentation, nous tentons, d'une part, de comprendre les difficultés induites par ce changement et les enjeux de cette nouvelle situation de formation. D'autre part, nous cherchions à vérifier la validité des performances de notre Module Evaluation avant qu'il soit implémenté techniquement comme une partie intégrante d'un dispositif de formation.

Soixante apprenants issus d'une licence et qui étaient sur le point d'intégrer le Master Spécialisé Télécommunications et Réseaux ont participé à cette expérience. Ils ont été invités à passer un test d'évaluation diagnostique correspondant à la discipline "Réseaux Informatiques". Nous disposons d'un ensemble hétérogène d'apprenants du point de vue prérequis (Licences en Informatique, en Electronique, en STIC et en Réseaux) par rapport au domaine en question.

4.1 CHOIX DE L'OUTIL POUR L'IMPLÉMENTATION INFORMATIQUE DES ONTOLOGIES ET DU MÉTA- MODÈLE DES QCM

Le choix concernant l'ontologie en tant que paradigme de conceptualisation et de structuration des connaissances est déjà fait, nous passons à ce stade au niveau qui concerne l'implémentation informatique de ces ontologies construites à l'issue de notre modélisation et ce dans le cadre de cette expérimentation. Pour implémenter des modèles à base d'ontologies, il existe différents environnements et éditeurs d'ontologies tels que : Protégé, OntoÉdit, etc. Dans le cadre de notre étude, l'outil Moulinette [12] a été retenu.

Moulinette est un environnement informatique support de la modélisation sémantique et de la production collaborative des contenus en contexte d'apprentissage en ligne et qui permet aux enseignants, au travers d'une interface web, d'élaborer très aisément des modules d'apprentissage en ligne depuis la phase de la modélisation des connaissances jusqu'à la production finale des ressources pédagogiques. Cet environnement informatique vise particulièrement à abstraire la complexité de la production des contenus pédagogiques pour les enseignants afin de favoriser la réutilisation ainsi que l'échanges des ressources pédagogiques pour des acteurs relativement débutants en matière de production.

Il a été choisi pour plusieurs raisons. En fait, la méthodologie de conception et de production proposée par l'environnement Moulinette est fortement adaptée aux modalités de mise en place de notre approche de modélisation de l'évaluation. En effet, la nature pluridisciplinaire de ce travail de recherche fait appel à différentes compétences et expertises pédagogiques selon différents niveaux d'abstraction (création de l'ontologie du domaine, création du Modèle Evaluation, édition et création des ressources de QCM). A ce niveau et grâce à des technologies Web accessibles côté serveur et côté client, Moulinette supporte et intègre les fonctionnalités de la modélisation cognitive des apprenants, de la création formelle des ontologies du domaine de connaissance et de la production des modules d'apprentissage dans un contexte coopérative par la gestion de projet, notamment dans le cas d'une équipe hétérogène. Deuxièmement, il s'agit d'un environnement où l'information peut être à la fois traitée et lisible de manière très pratique et simple par les utilisateurs grâce aux descripteurs textuels et graphiques qu'offre cet outil. La réutilisation des ontologies et méta-modèles créés est facilitée grâce à l'option export en XML et en RDF disponible sur l'environnement.

4.2 APPLICATION DE LA CONCEPTUALISATION DU DOMAINE DES CONNAISSANCES ET DES QCM A LA MATIERE 'RESEAUX INFORMATIQUES'

Le fait qu'une étude empirique ne peut être réalisée hors contexte, oblige à choisir un domaine particulier dans lequel se placer. Le domaine des réseaux informatiques constitue un domaine important qui s'ouvre à nous en matière de qualification de ressources et faisant partie du cursus du Master en Télécommunications et Réseaux auquel les apprenants de notre expérimentation s'apprêtent à accéder.

La conception d'une telle ontologie est une démarche délicate, en particulier si l'on souhaite qu'elle fasse l'objet d'approbation dans une communauté assez large. Cependant, il est toujours utile de prendre en considération ce que d'autres personnes ont fait dans le domaine : corpus textuels, taxonomies, normes ou fragments d'ontologie préexistants, d'examiner ces ressources et de les exploiter comme base pour définir graduellement l'ontologie du domaine.

Pour ce faire nous avons tout d'abord fait appel à des bibliothèques d'ontologies réutilisables existantes sur le Web et dans la littérature. Nous avons consulté la bibliothèque des ontologies Ontolingua, la bibliothèque des ontologies DAML, certaines ontologies commerciales disponibles pour le grand public comme UNSPSC, RosettaNet et DMOZ. Après cette recherche, il n'existe pas à notre connaissance d'ontologie répondant aux besoins de notre domaine particulier. Toutefois pour les besoins de cette étape, nous commençons le travail de développement de l'ontologie à partir de l'ébauche que nous allons rédiger. En se basant sur de la documentation disponible sur Internet et sur la connaissance des experts du domaine, nous avons établi une liste des concepts du domaine d'apprentissage en question : "réseaux informatiques".

4.3 ARRANGEMENT EN CONCEPTS GÉNÉRAUX ET CONCEPTS TERMINAUX ET DÉFINITIONS DES RELATIONS

Les réseaux informatiques constituent un domaine qui utilise un ensemble et sous-ensembles de concepts reliés entre eux par des relations spécifiques. Le schéma de la Figure 7 ci-dessus explicite la succession des étapes que nous avons adoptées pour le déroulement du développement de l'ontologie.

La structure du modèle du domaine fait apparaître des relations de type :

- utilise (*uses*) : cette relation est utilisée pour définir la décomposition structurelle du modèle du domaine ;
- possède (*has*) : cette relation montre que le domaine de connaissances se compose d'un ensemble et sous-ensembles de concepts ;
- est un (*is a*) : cette relation exprime la notion de définition qui existe entre deux éléments du modèle.

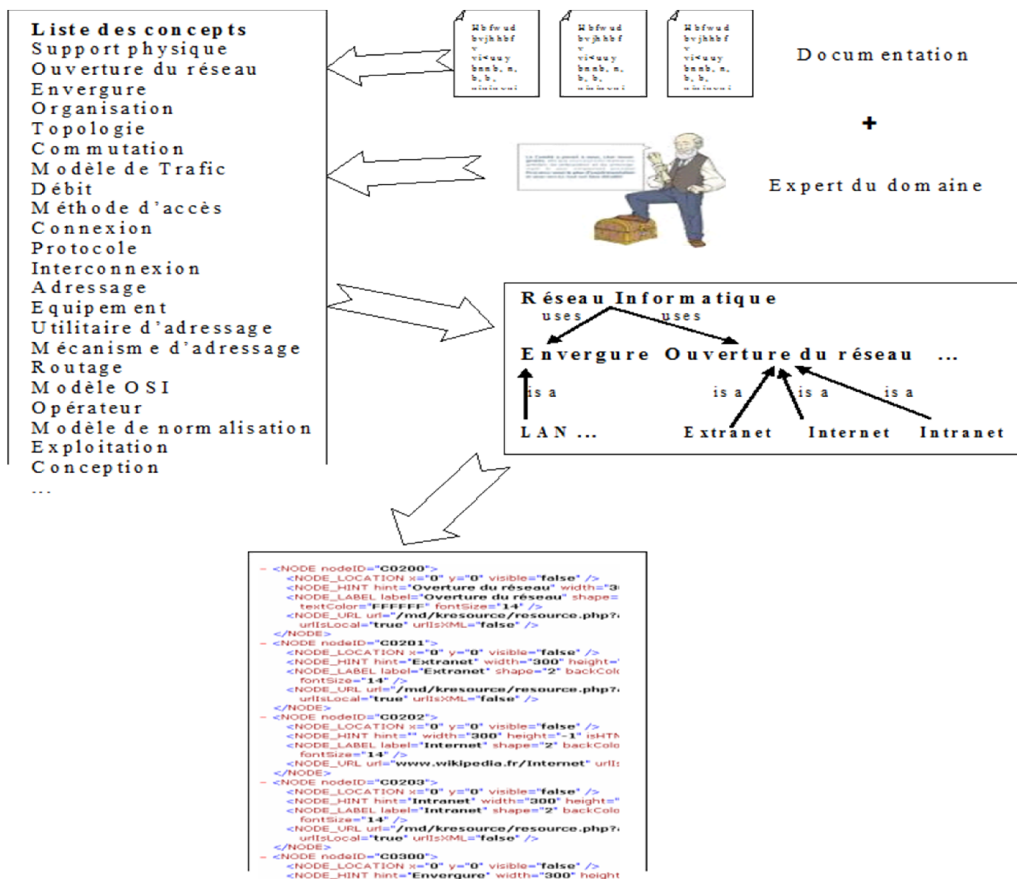


Fig. 7. Schéma détaillé résumant les étapes de la construction de notre ontologie

4.4 RÉSULTATS DE L'IMPLÉMENTATION DE L'ONTOLOGIE DES RÉSEAUX INFORMATIQUES

A l'aide de Moulinette, nous avons développé l'ontologie des réseaux informatiques qui peut être décrite comme un assemblage de concepts que nous avons nommés concepts généraux englobant des ensembles de concepts intermédiaires (Figure 8). Ensuite l'expert du domaine a décrit les différents concepts et les intra-relations qui existent entre eux dans le domaine de connaissance. Chaque concept intermédiaire se décompose à son tour en un ensemble de "sous-concepts" que nous avons nommés concepts terminaux et qui sont reliés entre eux par des relations spécifiques.

A travers cette représentation, nous avons essayé de réaliser un degré élevé de la structuration des connaissances dans le but de pouvoir assurer par la suite éventuellement un apprentissage individuel efficace. Nous rappelons qu'il n'existe pas un point de vue unique pour la représentation des connaissances utilisant les ontologies. Nous pouvons être amenés à étendre et faire évoluer le schéma de notre ontologie et son contenu. L'environnement Moulinette nous permet à la fois d'explorer cette ontologie et aussi de s'assurer de sa cohérence au cours de la phase de maintenance et de mise à jour.

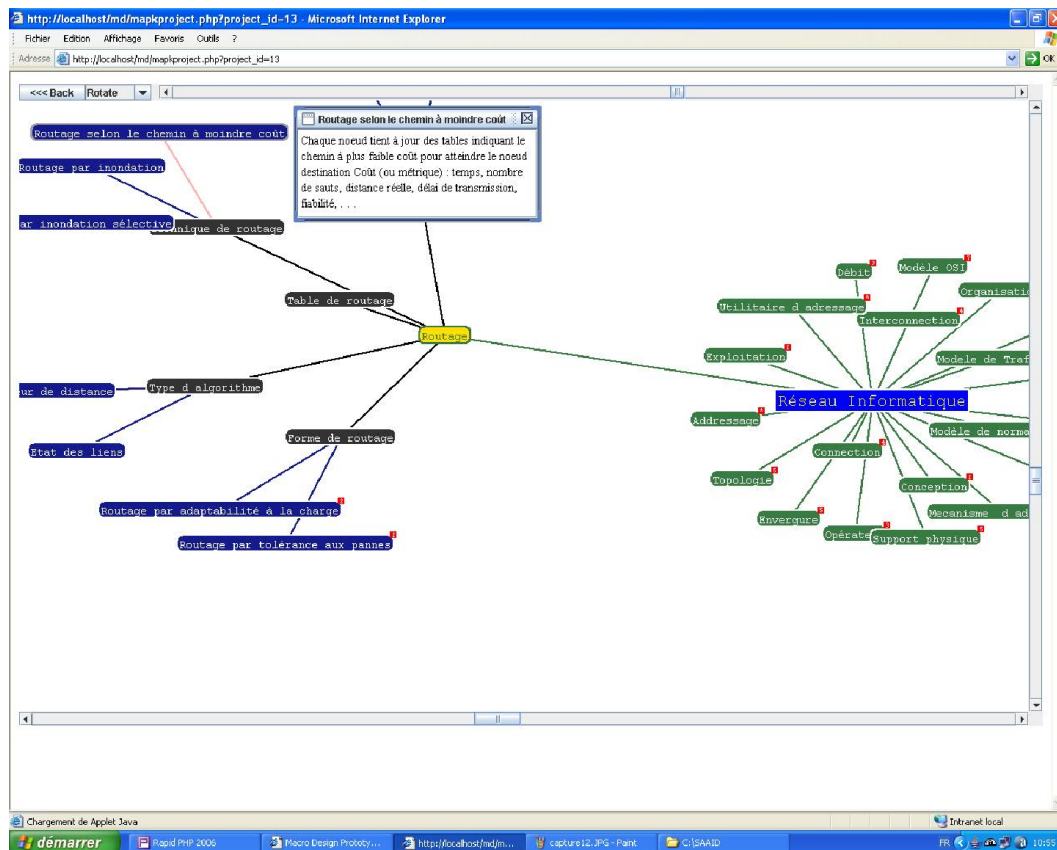


Fig. 8. L'ontologie des réseaux informatiques fait apparaître les sous-concepts (concepts intermédiaires en noir) reliés à chaque concept général (en vert)

4.5 IMPLÉMENTATION DU MÉTA-MODÈLE DES QCM

Grâce au modèle de représentation des connaissances basé sur les ontologies, nous avons pu formuler les énoncés des différents éléments des QCM d'une manière explicite et sémantique. Pour chaque item d'un QCM, l'expert du domaine nous a décrit : l'idée principale, les intentions pédagogiques, le contexte d'utilisation, les relations avec les autres nœuds et avec le domaine de connaissance, en plus de la mise à jour du statut de la finalisation le long du processus de la production. En conséquence, au niveau implémentation, il a été facile d'instancier méticuleusement le méta-modèle des QCM sous forme de médias web grâce à des descripteurs textuels et graphiques proposés par l'environnement Moulinette (Aqqal et al., 2009). Le Module Evaluation a été par la suite exporté et publié pour les apprenants participant à notre expérimentation. Par ailleurs, les données descriptives de chaque niveau d'abstraction, à savoir l'ontologie de connaissance et méta-modèle de

QCM, ont été également fournies séparément en format XML pour une réutilisation éventuelle. La Figure 9 illustre bien ceci, elle fait apparaître les concepts mis en jeu pour construire l'énoncé du QCM1.

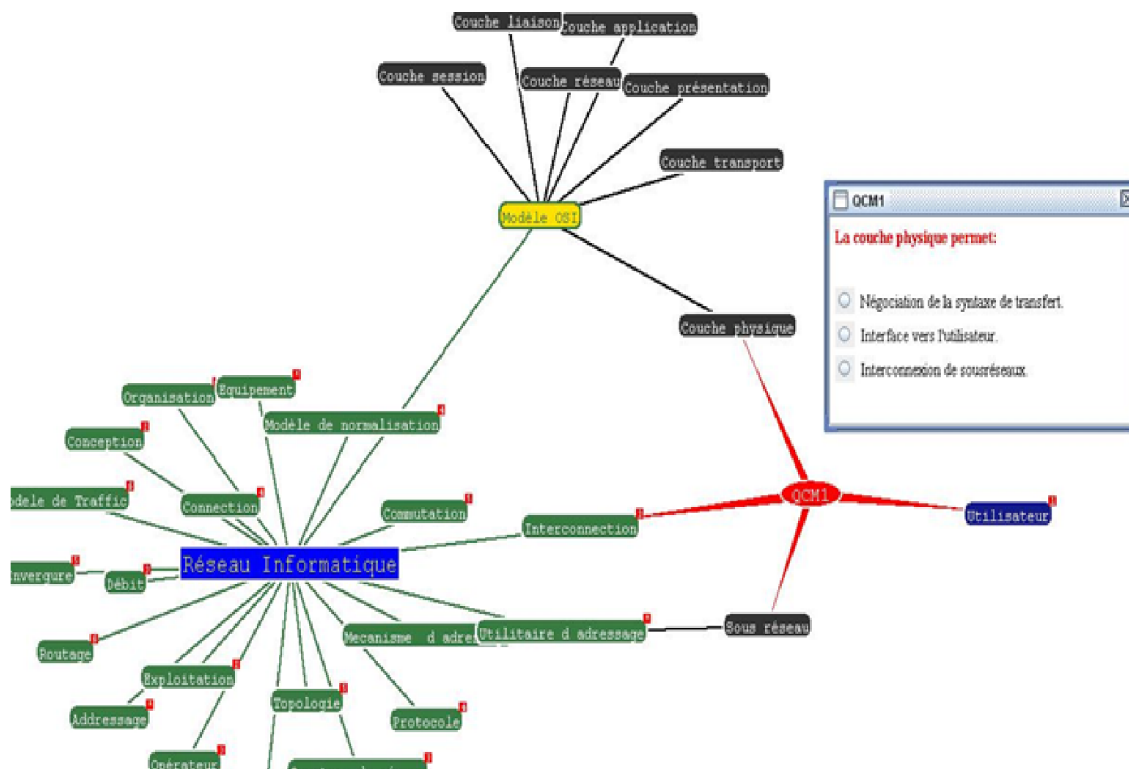


Fig. 9. Concepts mis en jeu pour construire l'énoncé du QCM1

5 RÉSULTATS ET BILAN

5.1 PREMIERE EXPERIENCE

Nous présentons dans cette partie les données provenant de l'expérience que nous avons effectuée visant à évaluer la méthode proposée. Plus précisément, les réponses que les apprenants ont données lors d'une "évaluation test", ont été utilisées afin de vérifier la validité des performances de notre Module Evaluation en termes de pertinence, de cohérence et d'efficacité. A cette fin, la sortie 'Niveau Connaissance' de l'apprenant, issue du Module Evaluation, a été comparée avec l'évaluation séparée d'un enseignant-expert et avec le simple processus d'évaluation basé sur le calcul manuel du pourcentage des réponses correctes considérant toutes les questions au même degré de difficulté (que nous avons nommé évaluation traditionnelle). Le test d'évaluation d'une durée de deux heures comportait 144 QCM réparties sur les trois degrés de difficulté {Facile, Moyen, Difficile} et couvrant des concepts de la discipline "Réseaux Informatiques".

Dans cette "évaluation test", le professeur du cours a eu le rôle de l'enseignant-expert. Une fois l'expérience terminée, il a examiné les réponses des apprenants à ce test et a évalué leurs niveaux de connaissances sur le sujet, en tenant compte du nombre, du type et de la difficulté des questions auxquelles ils ont répondu correctement. En se basant sur l'approche proposée, le Module Evaluation estima le niveau de connaissance de chaque apprenant sur le sujet. D'autre part, nous avons estimé par calcul manuel, le niveau de connaissances des apprenants en se basant sur le principe du pourcentage des réponses correctes (évaluation traditionnelle).

D'après les résultats obtenus, les estimations faites par le Module Evaluation et celles du professeur coïncident dans 92 (en pour cent) cas d'apprenants ; ce qui valide notre hypothèse H1. Par contre, seulement dans 60 (en pour cent) cas d'apprenants, les estimations de l'enseignant sont les mêmes que celles basées sur le pourcentage traditionnel des réponses correctes (Figure 10). En conséquence, les résultats de cette expérimentation nous ont permis d'apprécier l'efficacité (degré d'atteinte des objectifs) de la méthode proposée par rapport à la méthode de l'évaluation traditionnelle (Manuelle). Le Module Evaluation peut en effet effectuer l'évaluation "comme procède" un enseignant-expert. Par ailleurs,

ces résultats nous ont permis aussi d'apprécier les moyens mis en œuvre par la méthode proposée pour modéliser et approcher l'expertise humaine dans le domaine de l'évaluation des connaissances ainsi que leur adéquation aux objectifs de départ (pertinence et cohérence).



Fig. 10. Performance de l'évaluation par l'approche proposée (Module Evaluation) par rapport à celle de l'enseignant-expert en comparaison avec l'évaluation traditionnelle

5.1.1 QUE NOUS APPRENNENT CES RÉSULTATS ?

Ce test est ainsi très révélateur des acquisitions des différents apprenants et permet de fournir un indicateur précieux pour apprécier la situation des apprenants en fonction de leur formation d'origine (Licences en Informatique, Electronique, STIC et Réseaux) au regard des performances générales attendues en fin de formation concernant le domaine d'apprentissage "Réseaux Informatiques".

5.1.2 UNE MAÎTRISE DIFFÉRENCIÉE DES PERFORMANCES PAR NIVEAU

Les apprenants dont les performances les positionnent dans le niveau Très Insuffisant (groupe 1) réussissent rarement les items relevant des concepts les plus difficiles. Ceux des niveaux Insuffisant (groupe 2) et Suffisant (groupe 3) peuvent réussir des items relevant de degrés de difficulté variés. Les apprenants du niveau Très Suffisant (groupe 4) ont des performances élevées (Figure 11). Les apprenants du groupe 1 ne sont capables que de répondre très ponctuellement à une sollicitation. Leur meilleur taux de réussite est atteint aux items de difficulté relative au " Degré Facile" (en moyenne 34%). Pour les autres degrés de difficulté, les taux de réussite aux items sont très faibles (autour de 22% pour "Degré Moyen" et 11% pour "Degré Difficile"). On peut faire l'hypothèse que ces taux de réussite sont révélateurs de graves lacunes quant aux capacités les plus fondamentales de la discipline en question.

Les apprenants du groupe 2 ne montrent pas de difficultés aussi importantes que ceux du groupe 1. Bien que leurs taux de réussite, pour les items de difficulté relative au " Degré Facile" et au " Degré Moyen", soient respectivement autour de 60% et 54 %, on ne peut considérer qu'ils atteignent un niveau de maîtrise suffisant des performances sollicitées. Avec 39% de réussite moyenne aux items de difficulté relative au " Degré Difficile", on peut les considérer comme des apprenants fragiles du point de vue de ce niveau pour lequel ils restent bien en dessous de la moyenne de réussite postulée. Cette fragilité est probablement à la source de leurs difficultés à faire preuve des concepts plus exigeants.

Les apprenants du groupe 3 représentent presque 3 % de la population. Leurs difficultés sont loin d'être aussi aiguës que celles rencontrées par les apprenants des deux premiers groupes. Leur taux de réussite (en moyenne 77%) pour les items de difficulté relative au " Degré Facile" est supérieur à celui souhaité. Ces apprenants maîtrisent les items de difficulté relative au "Degré Moyen" (72%) pour laquelle la marge de progression reste cependant importante. C'est la performance aux items de difficulté relative au " Degré Difficile" qui leur pose problème. Toutefois, même s'ils sont encore peu assurés sur ce point, ils en réussissent en moyenne 56%.

Les apprenants du groupe 4 rencontrent très peu de difficultés relatives au "Degré Facile" dont ils réussissent les items à un niveau élevé (90%). Ils maîtrisent assez bien les items de difficulté relative au " Degré Moyen" (8%). Les différences de performances relatives aux items de difficulté relative au "Degré Difficile" s'amoinissent davantage pour ce groupe (66%).

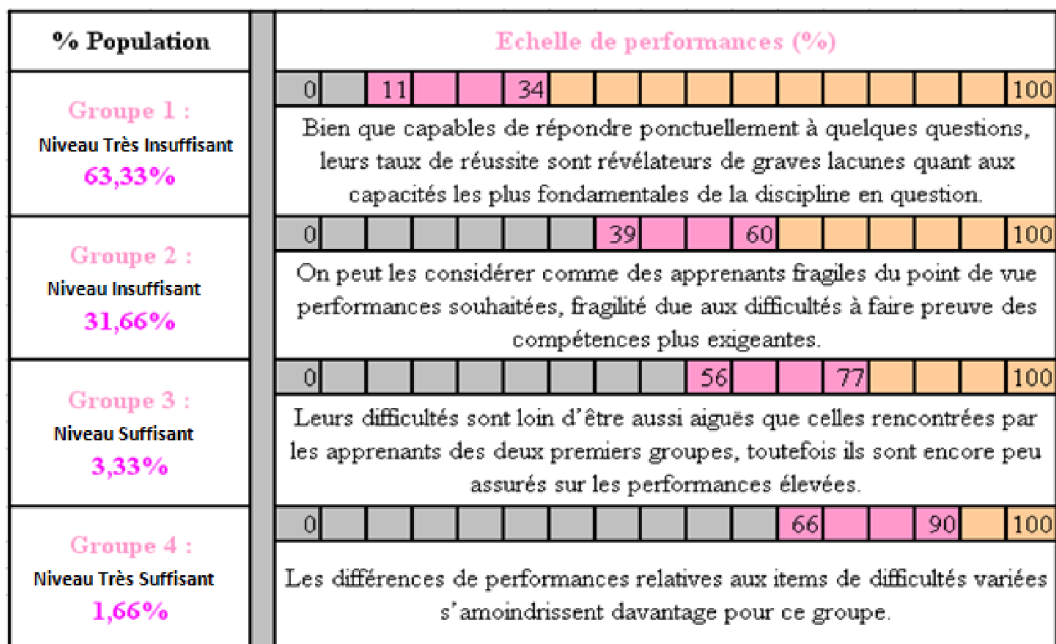


Fig. 11. Performances différenciées par rapport aux différents niveaux de connaissances

5.1.3 DES PERFORMANCES QUI VARIENT EN FONCTION DU CURSUS UNIVERSITAIRE

Rappelons que l'ensemble de cette évaluation-test correspond à un premier état des niveaux de connaissances des apprenants en début du Master Spécialisé Télécommunications & Réseaux pour la matière "Réseaux Informatiques". Un de ses objectifs est de permettre un suivi de l'évolution de ces niveaux de connaissances au cours du temps.

D'après la Figure 12, les résultats obtenus des performances des apprenants sont très différenciés selon leur formation d'origine (Licences en Informatique, en Electronique, en STIC et en Réseaux).

Les apprenants issus d'une Licence Réseaux (33,33 % de la population) ont des performances qui peuvent permettre de considérer qu'ils maîtrisent de façon satisfaisante l'ensemble des concepts généraux attendus.

Les apprenants issus d'une Licence STIC (41,67 % de la population) et Informatique (11,67 % de la population) sont des apprenants qui, même s'ils atteignent partiellement les objectifs attendus concernant le premier et le deuxième degré d'exigence, butent sur ceux du degré d'exigence plus élevé retenus par le Module Evaluation.

Les apprenants issus d'une Licence en Electronique méritent une attention particulière. Leur proportion évaluée à 13,33 % de la population, se situe complètement au bas niveau de l'échelle (Figure 13). Au regard de leurs performances, ces apprenants se trouvent en grande difficulté.

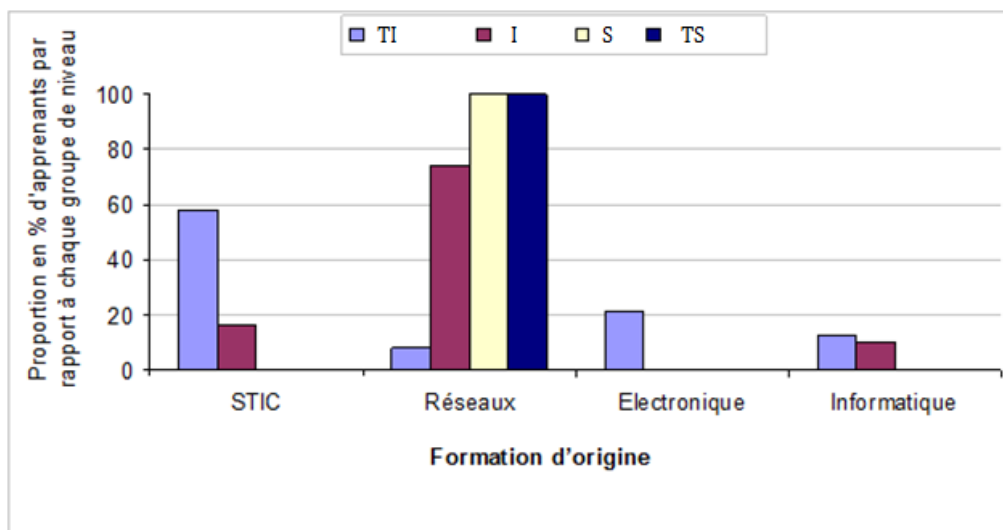


Fig. 12. Performances différenciées en fonction du cursus universitaire par rapport à chaque groupe de niveau de performance constitué pour l'ensemble de la population {TI: Très Insuffisant, I: Insuffisant, S: Suffisant, TS: Très Suffisant}.

Lecture du graphe : La proportion d'apprenants de niveau de connaissance Insuffisant, issus d'une licence STIC, constitue 58% de l'effectif total qualifié par ce même niveau.

Ces premiers constats permettent d'illustrer l'hétérogénéité des apprenants dans la maîtrise des concepts généraux attendus en début du Master Spécialisé Télécommunications & Réseaux. C'est pourquoi, il faut sans doute s'interroger sur deux autres questions qui sont liées : les objectifs du programme à atteindre et les concepts qui doivent être considérés comme acquis en fin de formation à la fois pour poursuivre immédiatement une mise à niveau et pour s'insérer harmonieusement dans la vie professionnelle et sociale.

Par ailleurs, cette "évaluation-test" vient confirmer ce qui était déjà perceptible lors des entretiens de sélection au même Master Télécommunications & Réseaux, à savoir que nos apprenants semblent plus à l'aise pour des questions de base considérée comme de bas niveau alors qu'ils éprouvent des difficultés pour des questions compliquées considérées comme de haut niveau.

Ce constat, comme celui de la grande hétérogénéité des connaissances de nos apprenants, implique :

- en amont, une réflexion sur la prise en compte des difficultés de ces apprenants dès l'entrée en Master, puisque l'on sait qu'elles sont déjà constituées à ce moment et ne feront que se confirmer dans la mesure où la construction et l'acquisition des concepts de plus haut niveau s'étaye sur ceux du niveau le plus bas ;
- en aval, une réflexion sur la prise en compte des difficultés de ces apprenants à l'entrée de la vie professionnelle.

En fin, il reste à souligner que cette "évaluation-test" a pu confirmer globalement par les résultats dégagés l'appartenance des étudiants selon leurs cursus universitaires en nous affirmant par la même occasion que nos résultats émulsés ne vont pas en contradiction avec les évaluations humaines (conformément à H1). Cela est particulièrement vérifié dans le cas des étudiants de spécialité Réseaux (donc certifiés Réseaux suite à des évaluations humaines dans le cadre de leur Licence) qui se sont distingués par leurs résultats dans le domaine des Réseaux Informatiques (domaine de notre évaluation-test 1). (Figure 12)

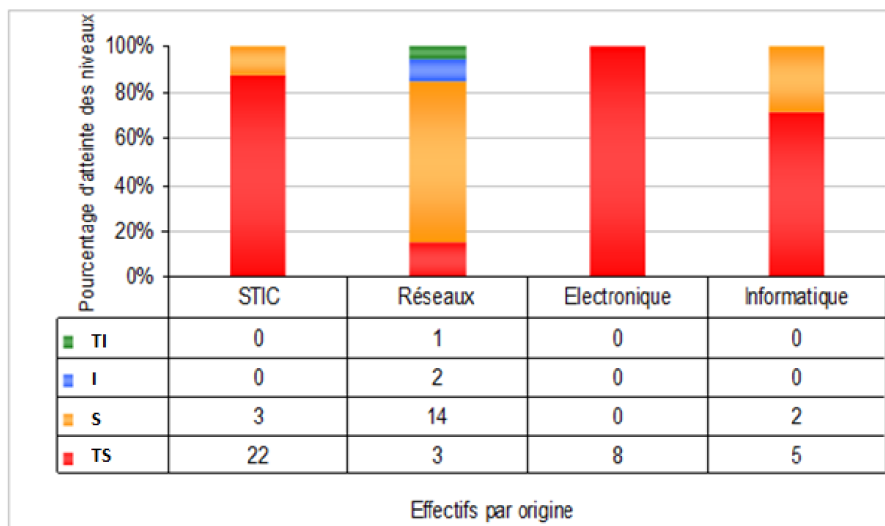


Fig. 13. Performances différenciées par rapport aux différents niveaux de performance relativement à un même cursus universitaire {TI: Très Insuffisant, I: Insuffisant, S: Suffisant, TS: Très Suffisant}.

5.2 DEUXIEME EXPERIENCE

Dans le même contexte nous comptons, à travers une deuxième expérimentation menée au sein de notre département de physique, concrétiser et évaluer notre approche instrumentée support de l'auto-évaluation des connaissances. L'expérience a fait appel à trente-trois étudiants, issus d'une licence et qui ont intégré le tronc commun du Master Spécialisé Télécommunications & Réseaux et Electronique & Informatique Industriel, ont participé à cette expérience. Ils ont été invités à passer un test d'évaluation des connaissances correspondant à la discipline *Communications Numériques*. Nous disposons d'un ensemble hétérogène d'étudiants du point de vue prérequis (Licence en Electronique : 16 étudiants, Licence en STIC + Réseaux & Télécoms : 17 étudiants) par rapport au domaine en question.

Suite à l'examen des réponses des étudiants à cette évaluation diagnostique, nous avons estimé leurs niveaux de connaissances sur le sujet en tenant compte du nombre, du type et de la difficulté des questions auxquelles ils ont répondu correctement. Le résultat a été qualifié selon l'échelle {Très Insuffisant, Insuffisant, Suffisant, Très Suffisant}. La Figure 14 montre que les étudiants ayant suivi une formation préalable en Télécommunications ont relativement de meilleures connaissances que ceux issus d'une licence Electronique. Par conséquent, ce résultat vient encore confirmer la validité de l'approche proposée à travers la concrétisation de l'hypothèse H1.

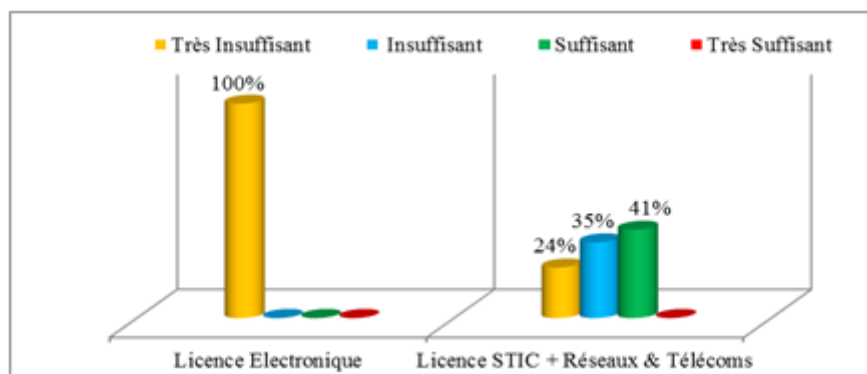


Fig. 14. Evaluation diagnostique en % du niveau de connaissance des étudiants pour le domaine des connaissances 'communications numériques' - promotion 2012.

Etant donné que notre objectif est de conduire le maximum d'étudiants aux niveaux de performance attendus à la fin de cet enseignement, nous avons adopté une pratique pédagogique au sens du développement des enseignements basée entre

autres sur le travail collaboratif privilégiant le changement des individus par le moyen des groupes. Ceci permettra de motiver et rétablir l'intérêt à l'apprentissage chez les apprenants dans le but d'améliorer la qualité des apprentissages. Dans notre cas, le travail de groupe a été intégré aux séances du cours de cet enseignement faisant appel à des petits groupes hétérogènes d'étudiants (licences d'origines différentes). Pour mesurer la validité de notre approche, nous avons considéré les résultats de l'évaluation sommative menée en fin de session pour les étudiants inscrits au tronc commun de ce master (Licences en Electronique : 17 étudiants, STIC + Réseaux & Télécoms : 18 étudiants). Les résultats ont été interprétés selon les mêmes qualificatifs de l'évaluation diagnostique précédente à savoir {Très Insuffisant, Insuffisant, Suffisant, Très Suffisant}. La figure 15 ci-dessus montre bien que l'évolution des niveaux de connaissances des étudiants est très significative. L'écart entre les résultats des deux catégories de licences devient faible. On tend ainsi vers une homogénéité satisfaisante des acquis d'apprentissage des étudiants. Sans prétendre que nos résultats sont absolument généralisables, nous avons pu concrétiser partiellement l'hypothèse H2 et vérifier à partir d'un premier bilan la validité de l'approche proposée concernant l'indépendance vis-à-vis :

- **du domaine d'enseignement** : nos expérimentations ont été réalisées avec des domaines différents (Réseaux informatiques et Communications numériques en l'occurrence) ;
- **du moment de l'évaluation** : nos évaluations ont été réalisées avec succès en début de formation (cas des expérimentations 1 et 2) et en fin de formation (cas de l'expérimentation 2) ;
- **et du public cible** : nos expérimentations ont été réalisées avec des promotions différentes d'étudiants issus de cursus universitaires différents.

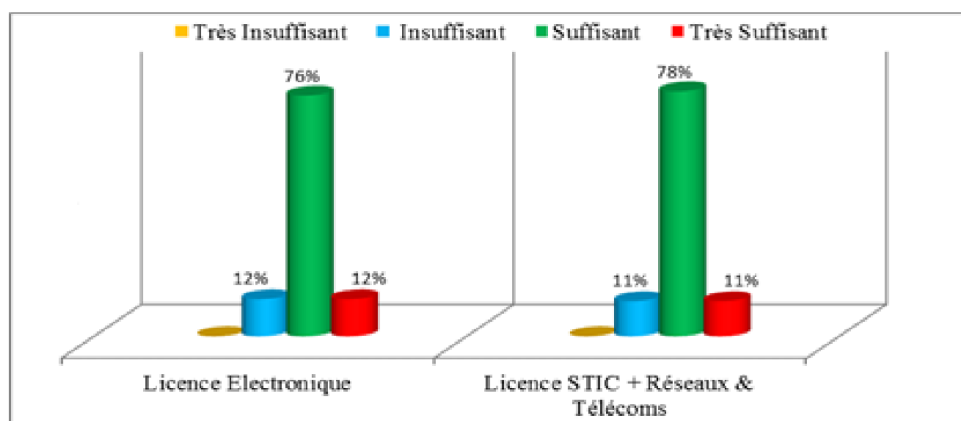


Fig. 15. Evaluation sommative en % du niveau de connaissance des étudiants pour le domaine des connaissances 'communications numériques' - promotion 2012.

Par ailleurs et pour valider la contribution de la méthode pédagogique utilisant le travail de groupe, nous avons fait appel à un groupe témoin (promotion 2011). Il s'agit d'évaluer l'efficacité de l'enseignement dispensé en fonction des résultats des étudiants. La Figure 16 montre la comparaison des résultats de l'évaluation sommative de la promotion 2012 (avec amélioration partielle des pratiques enseignantes) par rapport à ceux de la promotion précédente (sans amélioration des pratiques enseignantes). On remarque une apparition de la colonne concernant les résultats qualifiés de «Très suffisant» qui dépasse les 10% et une disparition totale de celle concernant les résultats qualifiés de «Très insuffisant» pour la promotion 2012, ce qui vient confirmer ce qui était déjà perceptible à savoir l'impact favorable des pratiques pédagogiques mise en place au tour du travail de groupe sur l'apprentissage des étudiants.

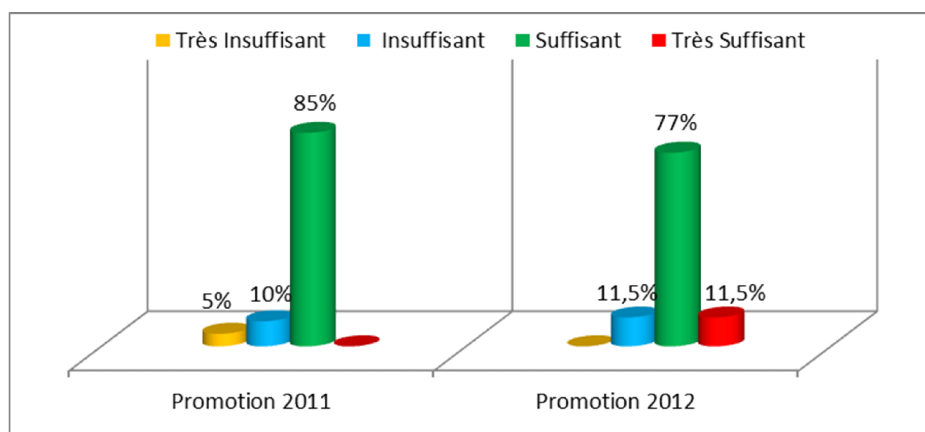


Fig. 16. Comparaison des résultats de l'évaluation sommative pour la promotion 2011 (sans amélioration des pratiques enseignantes) et la promotion 2012 (avec amélioration des pratiques enseignantes).

6 CONCLUSIONS ET PERSPECTIVES

Dans un objectif de mise en réussite de l'apprenant le long de son parcours d'apprentissage, nous avons cherché à comprendre comment et à quel moment de la formation, un enseignement peut être adapté à un apprenant donné. Cela nous a conduits à nous intéresser dans cet article à l'estimation du niveau de connaissance de l'apprenant, par l'observation de son niveau cognitif, ce qui a fait appel aux recherches dans les domaines de l'évaluation des acquis, de modélisation de l'apprenant, de l'ontologie des connaissances et la théorie des ensembles flous.

Pour une construction générique de notre Module Evaluation, nous avons travaillé à partir d'une expertise pédagogique validée dans les systèmes éducatifs. La réutilisation d'expertise nous a permis de proposer une représentation multidimensionnelle du processus évaluatif que nous avons étudié, conçu et implémenté explicitement. Pour approprier l'évaluation du niveau de connaissance de l'apprenant, nous avons retenu les aspects : nature de la matière à enseigner, niveau de difficulté des questions et processus de jugement dans la description linguistique de la connaissance experte intervenant dans le Module Evaluation. L'ontologie des QCM générant les épreuves de l'évaluation diagnostique a bien intégrée les différentes dimensions de la connaissance experte. Le diagnostic mis en œuvre dans ce modèle est complètement automatisé à travers une application développée dans ce sens : collecte des résultats et traitement initial des données et analyse des QCM. Nous avons employé la logique floue pour manipuler l'imprécision et pour exprimer la connaissance qualitative de l'expert d'une manière clairement interprétable. L'approche basée sur l'exploitation des apports de la théorie des ensembles flous et l'ontologie des connaissances est très intéressante, aussi bien du point de vue de la valorisation de l'intégration des technologies de l'information et de la communication à l'enseignement/apprentissage, que du point de vue de la généricité qu'on peut apporter au diagnostic et à l'évaluation en général.

Afin de vérifier la validité des performances de notre Module Evaluation, nous avons effectué deux expérimentations, réalisées avec des groupes de trente-cinq à soixante apprenants issus d'une licence et qui ont intégré le Master Spécialisé Télécommunications et Réseaux (laboratoire STIC). Nous disposions d'un ensemble hétérogène d'apprenants du point de vue prérequis (Licences en Informatique, Electronique, STIC et Réseaux) par rapport au domaine en question. Cette expérimentation a démontré l'intérêt d'un tel modèle fondé sur la dimension pédagogique issue de l'expertise humaine et basé sur les ontologies et la logique floue. En effet, notre Module Evaluation de l'apprenant a permis d'approcher au mieux l'estimation du niveau de connaissance de l'apprenant par rapport à celle de l'enseignant-expert. Il a permis également de rendre compte dans une approche systémique de l'efficacité des pratiques pédagogiques mises en œuvre.

Notre choix pour la modélisation de la connaissance s'est porté sur les ontologies qui ne représentent pas en elles-mêmes une fin pour notre étude mais une nécessité d'usage. Au-delà de leur qualité pour la modélisation de la connaissance, les propriétés des ontologies favorisent le paradigme du raisonnement. Deux ontologies particulières ont été conçues et présentées dans le cadre de cet article :

L'ontologie du domaine des connaissances par laquelle le système peut accéder à une connaissance du domaine afin de rechercher les concepts adéquats, les organiser et vérifier la cohérence de la situation d'apprentissage à proposer.

L'ontologie des QCM générant les épreuves de l'évaluation qui contient les énoncés, les items, leurs degrés de difficulté et les relations les liant aux concepts utilisés dans le domaine des connaissances, pour appliquer des stratégies différentes lors de la composition des tests.

Les résultats expérimentaux ont été encourageants, même effectués sur des groupes d'essai limités et montrent que le l'évaluation de l'apprenant par la méthode proposée approche de manière cohérente, efficace et pertinente l'expertise humaine dans le domaine de l'évaluation des connaissances. Le Module Evaluation, comme support l'évaluation instrumentée, permettra une meilleure détection des difficultés rencontrées par les apprenants et donc une meilleure prise en compte de ceux-ci en mettant en place des situations pédagogiques adaptées à chacun et à l'ensemble des apprenants.

A la fin de ce travail, nous soulignons certaines portées qui ouvrent des perspectives nouvelles :

Le processus d'évaluation proposée à travers notre approche permet de prendre en compte différents aspects et formes du paradigme de l'évaluation provenant de l'expertise pédagogique humaine. Nous pouvons adapter notre Module Evaluation pour qu'il puisse intégrer d'autres informations fournies par divers experts pédagogiques.

Par ailleurs, si ces expérimentations nous ont démontré l'intérêt pédagogique et la faisabilité technique de notre méthodologie, notre Module Evaluation qui cependant n'est pas exhaustif, aura comme perspective l'implémentation de l'ensemble des fonctions techniques nécessaires pour pouvoir étudier de près comment l'automatisation de l'évaluation peut servir d'un bon point de départ capable de personnaliser les apprentissage et faire aboutir le développement des enseignements. Une autre piste de recherche qui concrétisera intégralement notre deuxième hypothèse consiste à mesurer la corrélation entre l'adoption d'une telle stratégie d'évaluation et l'implication voir même l'engagement des enseignants afin d'instaurer et encourager ces pratiques évaluatives dans l'université Marocaine.

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Entrepreneuriat et croissance économique : effet du capital social

[Entrepreneurship and economic growth: effect of social capital]

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ABSTRACT: This article analyzes the relationship between entrepreneurship and economic growth for a panel of developed and developing countries during the period 1990-2004, as well as the importance of the social capital in the relationship between entrepreneurship and economic growth. Our study will be conducted using the method of static data panel. The main results of this study are, first, the level of social capital and entrepreneurship are significantly and positively correlated, on the other hand, a high level of social capital as an indirect effect on economic growth through its effect on the entrepreneurial activity. Thus, this article aims to develop elements of theoretical and empirical answers to the effect of a sound institutional environment and adequate capital on enhancing entrepreneurial activity that would have positive effects on investment and economic growth.

KEYWORDS: Entrepreneurship, social capital, economic growth, panel data, GMM.

RESUME: Cet article analyse la relation entre l'entrepreneuriat et la croissance économique pour un panel de pays développés et en développement au cours de la période 1990-2004, ainsi que l'importance du capital social dans la relation entre l'entrepreneuriat et la croissance économique. Notre étude sera effectuée en utilisant la méthode des données de panel statique. Les principaux résultats de cette étude sont, d'abord, le niveau du capital social et l'entrepreneuriat sont significativement et positivement corrélés, d'autre part, un niveau élevé de capital social a aussi un effet indirect sur la croissance économique par son effet sur l'activité entrepreneuriale. Ainsi, cet article se propose d'élaborer des éléments de réponses théoriques et empiriques à l'effet d'un environnement institutionnel sain et d'un capital social adéquat sur le renforcement de l'activité entrepreneuriale qui aurait des effets positifs sur l'investissement et la croissance économique.

MOTS-CLEFS: Entrepreneuriat, capital social, croissance économique, données de panel, MMG.

1 INTRODUCTION

Dans l'histoire de l'analyse économique, différentes variables ont été envisagées pour expliquer le progrès des nations. Traditionnellement, les variables quantitatives ont été principalement prises en compte. Au cours du vingtième siècle, avec l'introduction des modèles de croissance endogène et l'amélioration des méthodes statistiques et des informations sur les données, les variables qualitatives ont été quantifiées. Quelques exemples peuvent être donnés : la démocratie, la corruption, la règle du droit, le capital social et l'entrepreneuriat. Ces variables ont maintenant leurs mesures quantitatives qui sont utilisées dans l'analyse de nombreuses questions économiques.

L'entrepreneuriat peut ainsi se définir comme une activité impliquant la découverte, l'évaluation et l'exploitation d'opportunités. Un des facteurs importants dans la réussite ou non d'un processus de création d'une nouvelle entreprise et qui aide l'entrepreneur à contrer ces difficultés est sa capacité à développer et à mobiliser son capital social. Le capital social

désigne les réseaux de relations d'un acteur individuel ou collectif et les ressources qu'il peut mobiliser grâce à ces réseaux, il permet à l'entrepreneur d'obtenir des ressources qui, autrement, ne lui seraient pas accessibles, mais d'une façon plus onéreuse en termes de temps, de coûts ou d'efforts pour les acquérir. En ce sens, deux avantages directs sont obtenus à partir du capital social pour les entrepreneurs: les ressources et les informations.

L'existence d'un groupe de personnes qui doivent être intéressés à prendre des risques sur leurs fonds afin de générer de nouvelles entreprises engendre un effet positif de l'activité entrepreneuriale sur la croissance économique.

Cette discussion sur le capital social et l'entrepreneuriat laisse entendre à certains entrepreneurs des défis, ils doivent tenir compte: de l'accès au capital, de la nécessité d'innover, et des exigences et des attentes des communautés locales des propriétaires d'entreprises.

Par conséquent, l'entrepreneuriat a des effets positifs sur la croissance économique. Pour cette raison, il est intéressant de déterminer les facteurs favorisant l'entrepreneuriat. Plusieurs ont été pris en considération, en particulier ceux liés aux politiques publiques et au comportement économique. Toutefois, le capital social pourrait avoir un rôle important dans le processus entrepreneurial, parce que l'existence d'organisations établies peut activement encourager le développement de nouvelles activités. Le capital social joue un rôle important dans cet encouragement, ce qui facilite le recours aux ressources nécessaires pour créer une nouvelle entreprise.

2 DÉFINITION ET IMPORTANCE DE L'ENTREPRENEURIAT

L'entrepreneuriat peut se définir comme une activité impliquant la découverte, l'évaluation et l'exploitation d'opportunités. En effet, l'entrepreneuriat a pour but d'introduire de nouveaux biens et services ; de nouvelles structures d'organisation ; de nouveaux marchés, processus, et matériaux par des moyens qui n'existaient pas auparavant. Pour [1], les idées entrepreneuriales sont des opportunités de profit qui étaient auparavant passées inaperçues. Les entrepreneurs agissent sur ces idées et l'économie devient plus productive. L'entrepreneuriat est considéré donc comme un instrument clé permettant d'améliorer la compétitivité entre les nations, de favoriser la croissance économique et d'accroître les possibilités d'emploi. Chercheurs et preneurs de décisions s'accordent pour dire qu'une économie entrepreneuriale est une économie dynamique et innovatrice, c'est-à-dire qui expérimente de nouvelles idées et de nouveaux produits ou processus ce qui lui permet de se renouveler.

Les trois grands courants de pensée de la théorie de l'entrepreneuriat sont ceux de [2] qui définit l'entrepreneuriat comme la capacité à introduire des innovations, de [3] qui considère que l'entrepreneuriat productif est favorisé par les incitations pour les entrepreneurs de se consacrer à l'innovation productive et de [1] qui admet que la découverte d'une opportunité correspond à l'élément central de l'entrepreneuriat.

Mais, comme il faut trouver une définition plus inclusive, nous partirons ici avec celle présentée par l'OCDE en 2007 stipulant que l'entrepreneuriat est le résultat de « *toute action humaine pour entreprendre en vue de générer de la valeur via la création ou le développement d'une activité économique identifiant et exploitant de nouveaux produits, de nouveaux procédés ou de nouveaux marchés* ». Toutes les variables qui favorisent ces actions humaines en vue d'un résultat économique contribuent à expliquer l'entrepreneuriat. L'entrepreneuriat entraîne donc la création de valeurs nouvelles sur les marchés territoriaux ou extérieurs, telles que de nouvelles structures de production et la création de nouveaux biens.

«L'entrepreneuriat, c'est l'action humaine, soutenue par le milieu environnant, générant de la valeur sur le marché par la création ou le développement d'une activité économique, évoluant avec cette valeur pour finalement affecter l'économie, et ce, dans le but de mieux répondre aux besoins individuels et collectifs d'un territoire»¹.

Ainsi, les chercheurs ont proposé un nombre important de perspectives ou de définitions de l'entrepreneuriat, ainsi que plusieurs mesures d'entrepreneuriat qui reflètent différents types d'activités. L'entrepreneuriat est donc relativement difficile à mesurer et plusieurs études se sont appuyées sur les données de l'auto-emploi, les enquêtes, les interviews spécialisées pour examiner l'entrepreneuriat à partir d'un point de vue empirique. L'OCDE (1998) reconnaît que la mesure de l'entrepreneuriat est une tâche très difficile, car il n'y a pas de consensus sur un ensemble fiable et pratique d'indicateurs.

¹ P.-A. Julien et L. Cadieux, *La mesure de l'entrepreneuriat, Rapport d'étude, Institut de la Statistique du Québec, 2010*

L'auto-emploi est souvent utilisé comme mesure de l'entrepreneuriat ([4]). Cependant, il peut ne pas refléter adéquatement les nuances d'entrepreneuriat dans les pays en développement. L'auto-emploi peut être mesuré à partir des données officielles d'emploi auto-déclarées et probablement abandonner les répondants non déclarés (informels).

Le projet Global Entrepreneurship Monitor (GEM) est un effort pour produire des données qui peuvent être comparables entre les pays, il est principalement basé sur des enquêtes et des interviews spécialisées. Le GEM passe en revue un échantillon aléatoire de personnes pour produire l'indice « Total Entrepreneurial Activity » pour chaque pays. L'indice TEA est la somme des entreprises naissantes (les gens en train de monter une affaire) et des nouvelles entreprises. Cet index mesure par enquête l'intérêt que la population active porte à la création d'entreprise.

Les Enquêtes de la Banque mondiale auprès des entreprises (WBGES) sont également conçues pour comparer les pays, et mesurer l'entrepreneuriat du secteur formel ainsi que le nombre de nouvelles sociétés à responsabilité limitée (SARL) enregistrées officiellement. Par définition, WBGES ne comprend pas le secteur informel, comptant seulement : « *les unités économiques du secteur formel constituée en personne morale et enregistrés dans un registre public, qui est capable, d'encourir des responsabilités et de s'engager dans des activités économiques et des transactions avec d'autres entités* ».

D'autres approches de la mesure d'entrepreneuriat se concentrent sur l'évaluation de sa dynamique. L'approche de l'OCDE consiste à identifier des indicateurs clés, elle est sensiblement plus large que l'auto-emploi, l'approche GEM et l'approche WBGES. Pour soutenir cet objectif, une liste d'indicateurs de base reflète les différents types d'entrepreneurs, tels que mesurés par les variables individuelles pour le nombre de propriétaires d'entreprises (y compris l'auto-emploi), la formation de l'entreprise en général et pour certains types d'entreprises (par exemple, les entreprises à forte croissance).

La mesure de l'entrepreneuriat peut donc varier selon la taille, le secteur et le dynamisme des entreprises, de même que selon l'apport de leur milieu produisant du capital social porté par des réseaux informationnels plus ou moins riches.

3 ENTREPRENEURIAT ET CROISSANCE ÉCONOMIQUE

Depuis les premiers travaux de Solow, la théorie de la croissance économique s'explique par une augmentation des ressources primaires du capital et du travail employés dans la production et la croissance de la productivité totale des facteurs. La théorie de la croissance économique inclut les facteurs internes institutionnels du marché et de l'entreprise, qui expliquent les différences de bien-être entre les pays à n'importe quel instant donné. Solow s'interroge également sur la dynamique de la croissance du bien-être menant à la convergence ou la divergence des niveaux de revenu par habitant ([5], [6], [7], [8]).

L'hypothèse de départ de la théorie économique de l'entrepreneuriat, c'est que l'économie est dotée de certains facteurs, ainsi l'entrepreneuriat contribue à la production grâce à une combinaison de facteurs de production (capital et travail), et donc une allocation des ressources plus entrepreneuriale implique un plus grand niveau de production et de bien-être. Cette fonctionnalité est considérée comme exogène dans les modèles de croissance, et des travaux plus récents cherchent maintenant à identifier les aspects particuliers du facteur de contribution de l'entrepreneuriat dans la croissance économique. Quelques tentatives ont été faites pour incorporer l'entrepreneuriat dans les modèles de croissance. Les axiomes de la théorie de la croissance endogène ont créé de nouvelles possibilités pour adapter l'entrepreneuriat et/ou l'innovation dans les modèles de croissance. Un premier exemple est une version de [6] dans laquelle le moteur de la croissance est le secteur de la recherche, qui produit des modèles pour de nouvelles variétés de biens d'équipements qui sont à leur tour produites et utilisées dans le secteur de la production de biens. [9] indiquent que les politiques de R&D doivent être discutées dans le contexte plus large de questions régionales, telles que l'entrepreneuriat, la recherche universitaire, le capital humain, le capital social et les structures de l'industrie. Ce sont des questions interdépendantes qui doivent être examinées dans un cadre politique plus globale.

Il existe plusieurs études qui établissent un lien direct entre l'entrepreneuriat et la croissance économique. D'autres études empiriques portent sur une relation indirecte, en particulier, en établissant une interaction entre l'entrepreneuriat et la croissance de l'emploi. De plus en plus, il y a des études qui tentent d'analyser le rapport entre le niveau de l'entrepreneuriat et la croissance économique des pays ou dans les régions d'un pays. Ces études essaient d'expliquer comment l'entrepreneuriat est un facteur important pour expliquer des niveaux plus élevés de croissance économique.

Au niveau des pays, il existe de nombreuses études qui prennent en compte la relation entre l'entrepreneuriat et la croissance économique. [10] proposent trois variables explicatives de la croissance économique d'un pays: le taux de l'entrepreneuriat, l'indice de la compétitivité mondiale et le rendement par habitant, et ils incluent également la variable dépendante dans une période antérieure afin de minimiser les éventualités. Après avoir utilisé la base de données du GEM à différentes périodes, ils concluent que l'effet du taux de l'activité entrepreneuriale sur la croissance économique affecte le

niveau de développement économique positivement. [11] ont utilisé le niveau de l'entrepreneuriat des pays comme une variable indépendante, exprimé par le taux d'entrepreneurs embryonnaires, défini dans la base de données GEM 2002 sur 36 pays. La principale conclusion est que le flux de nouveaux entrepreneurs tend à diminuer avec le niveau de développement à un certain point, pour croître à nouveau à partir de ce point (fonction U). En utilisant la base de données GEM 2002 concernant 37 pays, [12] partent d'une fonction de production Cobb-Douglas pour expliquer l'entrepreneuriat et l'innovation technologique comme des facteurs déterminants de la croissance, et ont conclu qu'une croissance rapide de nouvelles entreprises génère la création d'emplois dans les petites et moyennes entreprises dans les pays développés.

D'autre part, [11] ont fourni une analyse alternative de la relation «revenu-entrepreneuriat» dans un groupe de pays développés. Ils ont employé des données de l'OCDE et un taux d'entrepreneuriat basé sur la proportion totale entre les propriétaires des entreprises et la population active entre les années 1972 et 2004. Dans ce cas, le graphique est en forme de L, à long terme, de sorte que la proportion de l'activité entrepreneuriale n'augmenterait pas en fonction de niveaux de revenu, elle tendrait plutôt à rester stable.

Utilisant la base de données GEM 2002 concernant 37 pays, [12], commencent à partir d'une fonction de production Cobb-Douglas pour expliquer l'entrepreneuriat et l'innovation technologique comme des facteurs déterminants de la croissance et ont conclu qu'une croissance rapide de nouvelles entreprises génère la création d'emploi dans les petites et moyennes entreprises dans les pays développés. [13], ont examiné la relation entre l'entrepreneuriat, la répartition des revenus et la croissance économique en développant les idées de [2] et en les testant empiriquement par la base de données GEM. Les principales conclusions de l'étude sont: la politique budgétaire a un effet positif sur l'investissement de différentes manières: l'investissement public accru et réduit les imperfections sur le marché de crédit ou finissent avec des restrictions qui nuisent à l'investissement dans le capital physique et humain, et qu'il ya un effet négatif du taux d'intérêt et des effets positifs des services publics et du taux de l'entrepreneuriat.

[14] ont utilisé des données de panel de 23 pays de l'OCDE entre 1974-1998 pour analyser la relation entre l'entrepreneuriat et le chômage. Théoriquement, il est évident que l'entrepreneuriat réduit le chômage, mais aussi que le chômage augmente le niveau de l'entrepreneuriat.

[15] ont également utilisé des échantillons des pays de l'OCDE pour tester empiriquement l'effet de l'entrepreneuriat sur la croissance économique, en ajoutant un proxy des connaissances techniques générées dans ces pays comme une variable explicative de la croissance économique. L'hypothèse testée est que l'entrepreneuriat est le canal qui facilite les externalités de connaissances techniques. Il est à noter que dans les modèles endogènes des connaissances techniques générées et des retombées sont un stimulant endogène à la croissance. Ils ont testé un modèle dans 20 pays de l'OCDE, ils ont trouvé que la variable R & D et le niveau de l'entrepreneuriat ont un effet positif sur la croissance économique. La variable R & D seule peut ne pas avoir l'effet escompté sur la croissance économique et la même chose pour le niveau de l'entrepreneuriat. Cependant, la combinaison de deux variables a un effet considérable sur la croissance économique. Dans une deuxième étude, [15] ont formulé un modèle alternatif, qu'ils ont développé en deux phases : dans une première équation, ils ont estimé le niveau de l'entrepreneuriat en fonction d'un vecteur de variables de contrôle, et dans une deuxième équation, ils ont utilisé la première équation comme variable explicative de la croissance économique. Il s'agit d'une tentative de neutraliser l'effet de la causalité simultanée entre l'entrepreneuriat et la croissance économique. Les deux études ont été testées sur un échantillon de 18 pays de l'OCDE, ils ont conclu que l'entrepreneuriat génère de la croissance économique, alors que l'effet de la R & D reste incertain. Une variable pour le niveau d'éducation de la population (les connaissances technique comme proxy) a également montré un effet positif sur la croissance économique. [16] ont présenté une nouvelle variable basée sur les données de brevets comme proxy de l'entrepreneuriat productif au lieu d'un proxy basé sur les données de l'auto-emploi. Ils ont examiné 22 pays de l'OCDE et ils ont trouvé une relation positive entre la mesure proposée à l'entrepreneuriat productif, le degré d'innovation dans différents pays et la croissance économique, alors que la mesure alternative basée sur l'auto-emploi semble négativement corrélée avec la croissance économique.

Dans leurs études sur la théorie des régimes régionaux de croissance, [17] ont proposé quatre régimes différents de croissance au niveau régional: l'entrepreneur, la routine, les niveaux de rotation et le retrait. Le concept du régime de croissance a été opérationnalisé en fonction du degré de l'entrepreneuriat, telle que mesuré par la création de nouvelles entreprises et la croissance de l'emploi dans chaque région spécifique.

En termes de densité de population, on peut conclure que les régions à forte densité de population ont plus de difficultés à créer des emplois, et les changements de régime se produisent dans les régions moins denses en termes de population, ce qui indique un effet de déséconomies d'échelle qui l'emportent sur les effets positifs de l'agglomération. Ainsi, les petites entreprises et les start-ups peuvent ne pas être nécessaires pour la croissance régionale à court terme, mais elles sont importantes dans le développement économique à long terme.

[18] reproduit l'étude par [17] pour les districts de l'ancienne République fédérale d'Allemagne. Ils ont mené leur étude en deux phases : ils ont analysé l'effet de l'entrepreneuriat à court terme sur la création d'entreprises et ils ont cherché à saisir l'effet de la création d'entreprise à long terme. Les résultats étaient similaires aux travaux pionniers.

En 2004, Fritsch a mené une étude qui a comparé la création d'entreprises et leur performance. Pour expliquer la création d'entreprises, il a utilisé huit variables indépendantes: le nombre d'employés dans leur secteur, les chômeurs, le pourcentage des employés ayant un diplôme universitaire, le pourcentage d'emplois dans le secteur des PME, l'intensité du capital, le coût unitaire du travail, le coût du capital et la croissance du PIB. L'auteur conclut que les caractéristiques d'un régime de croissance peuvent changer au fil du temps, mais que ce développement dépend de son contexte historique. En tant que tels, les régimes de croissance ne résultent pas de rien, mais évoluent dans une période de temps qui peut être longue.

[10] ont analysé la relation entre la création d'entreprise à travers un proxy de l'entrepreneuriat et la croissance de l'emploi, ils ont utilisé comme échantillon la Royaume-Uni entre 1980 et 1998. Cette étude lie l'effet de la création de nouvelles entreprises et la croissance de l'emploi de politiques publiques spécifiques qui ont soutenues l'entrepreneuriat au Royaume-Uni. La différence entre les régions entrepreneuriales et non entrepreneuriales dépend du stock et de la qualité de leur capital humain.

[19] ont testé le concept de capital-risque et l'effet de ce phénomène sur la croissance régionale. Le concept de l'activité entrepreneuriale à capital risque proposé correspond à un facteur de production comme le capital et le travail. Ainsi, la disponibilité du capital-risque dans une région peut être plus importante pour promouvoir la croissance économique. Les auteurs ont trouvé un effet positif du capital-risque sur la croissance économique régionale. [20] ont estimé une fonction de production pour des régions allemandes dans les années 90, ils ont conclu qu'il existe une relation positive entre l'entrepreneuriat, le capital-risque et la croissance économique régionale.

Pour les Etats Unis, [21] ont conclu que l'entrepreneuriat mesurée par le taux d'entrée et de sortie des entreprises influe positivement sur la croissance mesurée en termes de productivité. Aussi pour les Etats Unis, [9] ont proposé un modèle de croissance économique dans lequel le taux de croissance économique régionale est une fonction du taux de croissance de la connaissance économique locale, combinée avec les taux de croissance du capital et du travail. La croissance de la connaissance économique locale est une fonction de la R & D, de l'entrepreneuriat, de la recherche universitaire, du capital humain, du capital social et de la structure de l'industrie. Leurs résultats indiquent que l'entrepreneuriat joue un rôle significatif dans la croissance régionale.

4 ENTREPRENEURIAT ET CAPITAL SOCIAL

Les origines du concept de capital social remontent aux années 1970, et ce afin d'essayer de trouver des facteurs autres qu'économiques pour expliquer la réussite de certains processus économiques. Cette problématique a été évoquée dans les études de [22], [23] et [24]. Ces auteurs font appel à des concepts tels que la confiance, la participation de la société civile et les réseaux sociaux, le tout formant le « capital social » d'une collectivité donnée.

[22] est reconnu comme un pionnier des études sur le capital Social. Il distingue entre le capital social et le capital humain, qui est défini comme l'ensemble des habilités et des compétences possédées par un acteur individuel, tandis que le capital social se trouve dans les relations entre les personnes ou les acteurs. Pour [22], le capital social réside uniquement dans les interactions sociales des agents, c'est-à-dire qu'il est essentiellement relationnel, il n'appartient pas à une personne isolément, mais réside à l'intérieur d'un groupe. Il constitue donc un bien public qui est partagé par un groupe d'individus et n'a donc pas un caractère privé. Pour [22] le capital social est inhérent à la structure sociale, Il ne résulte pas d'une intention de l'acteur, il doit donc être considéré comme une ressource naturelle et non comme le résultat d'un investissement délibéré comme c'est le cas chez Bourdieu.

De son côté, [23] définit le capital social ainsi : « *Les caractéristiques de l'organisation sociale, telles que, les réseaux, les normes et la confiance sociale, qui facilitent la coordination et la coopération pour un bénéfice mutuel* »². Le capital social est une notion relative aux caractéristiques de l'organisation sociales telles que les réseaux, les normes et la confiance. D'une façon générale, les relations sociales et les contacts personnels que les individus développent tout au long de leur vie sont d'une grande utilité, car ils permettent d'accéder à des avantages et des bénéfices variés. Ainsi, dans la vie de beaucoup de

² Putnam [1995], p 67. Traduction

gens, les liens avec des personnes influentes, avec des amis ou avec des membres de la famille, ainsi que les réseaux de relations découlant de ces contacts servent à trouver ou à changer d'emploi ([25]).

Au cours des dernières décennies, c'est sous le nom de Putnam que s'est diffusée une certaine idée du capital social, dans la communauté des économistes. Dès 1996, la Banque mondiale a mis en œuvre un programme de recherche très ambitieux sur l'importance du capital social pour le développement. Les conclusions qui en ont été tirées reconnaissent leur filiation avec les travaux de Putnam, dans le sens où la définition du capital social qui est retenue par la Banque mondiale est très proche de la conception originale de l'auteur : « *Le capital social fait référence aux normes et aux réseaux qui rendent possible l'action collective* »³.

Des études ont montré que le capital social conduit au succès professionnel des cadres d'entreprises, notamment, à travers le renforcement de leur pouvoir et de leur statut ([26]). La littérature sur le capital social connaît depuis quelques années un développement rapide. La proposition centrale de la théorie du capital social repose sur l'argument selon lequel les réseaux de relations sociales constituent une ressource précieuse pour la conduite des affaires car ils facilitent l'action économique ([27], [26]) et permettent aux entrepreneurs d'élargir leur champ d'action, d'économiser leurs moyens et d'accéder à des ressources et opportunités exclusives.

Ainsi, le capital social est le produit d'un consensus entre des visions différentes d'une même notion, ce qui l'amène à revêtir un aspect à la fois multidimensionnel et multiforme. Mais son caractère souple et englobant empêche de donner une définition conceptuelle et opérationnelle du capital social, de sorte qu'il apparaît comme un concept fourre-tout. Une alternative à la dérive actuelle des études sur le capital social réside dans l'adoption d'une définition précise de cette notion. Or, une telle définition existe et a été initiée par [28] dans un cadre analytique macro-social. Malheureusement, l'introduction par [22] du capital social dans la sphère micro-économique s'est faite en dénaturant la vision initiale du concept. Il est donc possible de se baser sur la définition du capital social par Bourdieu à condition de revisiter le travail de [22]. Dans ce cadre, le capital social d'un agent correspond à l'ensemble des ressources qui peuvent lui être fournies par un réseau de connaissances durables.

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L'intérêt pour l'étude de l'entrepreneuriat réapparut avec plus d'intensité dans les années 70, avec un accent sur les théories économiques par le biais des constatations empiriques et réflexions théoriques. Il a été constaté que plusieurs pays développés, principalement en Europe, ont lancé de nouvelles initiatives, après des années de ralentissement économique et de déclin de la création d'entreprise. D'autres parts, des réflexions théoriques qui ont marqué l'économie mondiale, se reflètent dans les économies nationales. Ces changements indiquent que la croissance économique a été soutenue non seulement dans les économies d'échelle ou de gamme, mais que les entreprises ont un rôle important dans la croissance économique.

Les études sur le capital social menées jusqu'ici dans le champ de l'entrepreneuriat ont bien montré son importance pour les projets de création d'entreprises. En général, la littérature a considéré que l'importance du capital social dans le domaine de l'entrepreneuriat a été attribuée au fait qu'ils fournissent des ressources, l'accès à des ressources ou du soutien affectif. En ce sens, la pertinence est due au fait que l'entrepreneuriat est liée à l'innovation et à l'avantage concurrentiel. Par conséquent, une relation positive entre le capital social et l'entrepreneuriat est prévue et d'une manière indirecte, il permettrait également de renforcer la croissance économique.

³ Banque mondiale [2004], www.worldbank.org/poverty/scapital.

5 ANALYSE EMPIRIQUE

Dans cette étude, nous essayons de s'engager dans une analyse empirique de la relation entre le capital social, l'entrepreneuriat et la croissance économique pour un échantillon de 45 pays développés et en développement en utilisant des données sur la période 1990-2004. Pour cela, nous utilisons l'économétrie des données de panel.

Par conséquent, notre objectif dans cette partie est d'étudier empiriquement les effets de l'entrepreneuriat et du capital social sur le taux de croissance du PIB par tête.

Dans ce contexte on présente tout d'abord, un modèle de croissance complet. En suite nous présentons les variables de ce modèle et nos sources de données. Enfin, on présente les méthodes d'estimations utilisées dans ce travail pour tester empiriquement le modèle de croissance de Solow augmenté par le capital humain, traitant de la relation entre le capital social, l'entrepreneuriat et la croissance économique.

5.1 SPÉCIFICATION DU MODÈLE ÉCONOMÉTRIQUE

Notre objectif dans cette partie, est d'étudier l'importance du capital social dans la relation entre l'entrepreneuriat et la croissance économique pour un échantillon de pays développés et en développement.

Nous allons donc tester empiriquement à l'aide d'un modèle de croissance de Solow augmenté par le capital humain la relation entre le capital social, l'entrepreneuriat et la croissance économique.

En effet, à la suite des travaux de [29], et [30], l'objectif de notre étude empirique, est d'ajouter d'autres déterminants de la croissance économique dans l'équation du modèle de croissance de Solow augmenté du capital humain, traitant de la relation entre capital social, l'entrepreneuriat et la croissance économique.

$$IE_{it} = \alpha_i + \beta_0 IKS_{it} + \epsilon_{it} \quad [1]$$

$$Y_{it} = \alpha_i + \beta_1 \lgdp_f_{it} + \beta_2 IKH_{it} + \beta_3 IINV_{it} + \beta_4 IDF_{it} + \beta_5 QI_{it} + \beta_6 IE_{it} + \epsilon_{it} \quad [2]$$

Dans cette section, nous essayons de s'engager dans une analyse empirique de la relation entre le capital social et l'entrepreneuriat. Par conséquent, deux équations sont estimées:

Où i et t dénotent respectivement le pays et le temps.

Pour $i = 1, \dots, 45$ / $t = 1990, \dots, 2004$.

Avec α_i l'effet spécifique individuel, $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ et β_6 sont les paramètres à estimer dans ce modèle et ϵ_{it} est le terme d'erreur.

5.2 PRÉSENTATION DES VARIABLES ET DE LEURS SOURCES

Les variables qui seront présentées sont recueillies pour un panel de 45 pays développés et en développement au cours de la période 1990-2004. La variable dépendante est le taux de croissance du PIB par tête (Y) et les variables indépendantes sont le logarithme du PIB initial \lgdp_f qui sert à contrôler la convergence, le capital humain (KH), le taux d'investissement par rapport au PIB (INV), le développement financier (DF), la qualité de l'environnement institutionnel (QI), le capital social (KS) et l'entrepreneuriat (E).

5.2.1 LA VARIABLE DÉPENDANTE

Nous utilisons, dans notre analyse empirique, le taux de croissance du PIB par habitant comme variable dépendante. Les données, pour les 45 pays de notre échantillon représentatif, relatives à cette variable sont retirées à partir des données de Penn World Tables (2009).

5.2.2 LE CAPITAL HUMAIN

Le capital humain est mesuré par le nombre moyen d'années d'éducation secondaires de la population de 15 ans et plus, à partir de la base de données de Barro et Lee (2001).

5.2.3 LE CAPITAL PHYSIQUE

Le capital physique est mesuré par l'investissement brut, les données sont tirées de la base de données de la Banque Mondiale.

5.2.4 LE DÉVELOPPEMENT FINANCIER

Le développement financier est mesuré par le passif quasi-liquide en pourcentage du PIB qui est la somme des devises et dépôts de la banque centrale (M0), plus les dépôts à terme fixe et d'épargne, les dépôts transférables en devises étrangères, les certificats de dépôt, et les mises en pension de titres, plus les chèques de voyage, les dépôts à terme fixe en devises étrangères, les effets de commerce, et les parts de fonds communs de placement ou de fonds fournis aux conditions du marché détenus par des résidents. Cela équivaut à la masse monétaire M3 moins les dépôts transférables et les devises électroniques (M1). Les données sont tirées de la base de données de la Banque Mondiale.

5.2.5 LA QUALITÉ DES INSTITUTIONS

La qualité des institutions est mesurée par un indice général qui s'appuie sur deux catégories distinctes : les libertés civiles et les libertés politiques publiées par l'ONG, Freedom House. Les premières renvoient à la liberté, d'expression et de croyance, au droit d'association et d'organisation, à l'autonomie individuelle, au droit à la vie privée. Les libertés politiques recouvrent quant à elles la capacité des individus à participer librement au processus politique : le droit de vote, le droit d'appartenir à un parti politique, le pluralisme des élections, le pouvoir effectif des représentants élus.

Les pays se voient attribuer deux notes et une lettre. La première note est relative aux droits politiques, la deuxième concerne les droits civils. Chacune des deux notes est comprise entre 1 et 7, 1 étant la meilleure situation et 7 la pire. Cette notation provient des études annuelles Freedom in the World, établie par la Freedom House.

5.2.6 L'ENTREPRENEURIAT

L'entrepreneuriat est mesuré par l'auto-emploi, les données sont tirées de la base de données de la Banque Mondiale.

L'auto-emploi est l'indicateur le plus fréquemment utilisé pour l'entrepreneuriat dans la littérature qui traite d'un certain nombre de questions, telles que le niveau de l'entrepreneuriat dans les pays, le lien entre l'entrepreneuriat et la croissance et la relation entre la fiscalité et l'entrepreneuriat. La principale raison d'utiliser l'auto-emploi comme un indicateur de l'entrepreneuriat est une fonction de commodité: tous les pays développés communiquent des données sur l'auto-emploi, en facilitant les analyses entre les pays et à travers le temps.

[15] sont souvent cités comme les premiers auteurs qui ont utilisé le taux d'auto-emploi comme un indicateur de l'entrepreneuriat, pourtant plusieurs autres proxys peuvent être appliqués selon la question qui se pose. Si, d'autre part, l'aspect novateur de l'entrepreneuriat est souligné, un proxy préférable impliquerait les entreprises innovantes plutôt que l'auto-emploi ou les entreprises de taille particulière.

Comparer et analyser les données d'auto-emploi est difficile. Tout d'abord, il n'existe pas de définition consensuelle de l'auto-emploi. Deuxièmement, il peut y avoir des différences dans la couverture des données, ce qui conduit certaines industries à être sous-représentées et les autres peuvent être totalement exclues. Troisièmement, les données peuvent être collectées de différentes manières, à partir d'enquêtes ou de registres. Quatrièmement, la façon de classer les gens peuvent différer. Dans les enquêtes, le classement dans le groupe approprié peut être effectué soit par l'intervieweur ou par le répondant.

Les travailleurs autonomes peuvent être largement définis comme les personnes occupées qui ne sont pas employés. Une définition plus distincte peut être fondée sur le risque économique et le type d'autorité concernée.

Une définition sociologique de travailleurs indépendants peut inclure la propriété des moyens de production et d'autonomie dans le processus de travail. Deux types d'études empiriques quantitatives peuvent être distingués. Un type d'études utilisent les modèles explicatifs basés sur un ensemble d'hypothèses dérivées des considérations théoriques au sujet des facteurs qui influencent les décisions d'auto-emploi. D'autres études développent les modèles structurels expliquant l'auto-emploi. Les modèles structurels reposent sur l'utilisation rationnelle que l'auto-emploi se produise si les rendements attendus de l'auto-emploi dépassent ceux du travail rémunéré.

Bien que la valeur du capital social n'ait pas été largement reconnue dans les études économiques d'auto-emploi, les sociologues ont depuis longtemps reconnu son importance ([22]). Le capital social peut réduire les effets de l'incertitude et augmenter les rendements attendus de l'auto-emploi.

Après avoir présenté les modèles et les variables ainsi que leurs sources, on focalise notre recherche sur la présentation des méthodes d'estimation. Dans le cadre de notre partie empirique la méthode d'estimation suivie est la méthode des données de panel statique.

5.3 MÉTHODES D'ESTIMATION ET INTERPRÉTATIONS DES RÉSULTATS

Nous présentons dans cette partie les résultats d'estimations du modèle représentés dans les équations [1] et [2]. La structure du modèle telle qu'elle a été présentée ci-dessus, nous conduit à réaliser des estimations sur un modèle de panel hétérogène. Ainsi nos estimations portent sur la méthode des données de panel statique.

5.3.1 LA MÉTHODE DES DONNÉES DE PANEL STATIQUE

Nous utilisons une méthode qui permet de prendre en compte l'hétérogénéité inobservée des pays de l'échantillon. Ces caractéristiques individuelles peuvent être de nature déterministe ou aléatoire. Le test de spécification de Hausman permet de choisir l'une ou l'autre de ces spécifications. Le modèle à effets fixes (MEF) sera retenu si la probabilité attachée à la statistique de test de Hausman est inférieure à 10%.

TEST DE HAUSMAN

Rappelons que le test de spécification de *Hausman* (1978) est un test de spécification des effets individuels. Il sert à discriminer les effets fixes et aléatoires. L'hypothèse testée concerne la corrélation entre les effets individuels et les variables explicatives.

Ainsi, sous H_0 , le modèle peut être spécifié avec des effets individuels aléatoires et l'on doit alors retenir l'estimateur des MCG (estimateur BLUE). Sous l'hypothèse alternative H_1 , le modèle doit être spécifié avec des effets individuels fixes et l'on doit alors retenir l'estimateur *Within* (estimateur non biaisé).

Sous H_0 , la statistique H suit asymptotiquement un Chi-deux (χ^2) à K degrés de liberté.

RESULTATS D'ESTIMATION

Le modèle qui sera estimé est présenté par l'équation [2] :

$$Y_{it} = \alpha_i + \beta_1 \text{lgdp_f}_{it} + \beta_2 \text{IKH}_{it} + \beta_3 \text{IINV}_{it} + \beta_4 \text{IDF}_{it} + \beta_5 \text{QI}_{it} + \beta_6 \text{I}\hat{\text{E}}_{it} + \varepsilon_{it} \quad [2]$$

Dans ce premier modèle, on cherche à tester les effets de l'entrepreneuriat (mesuré par l'auto-emploi) sur le taux de croissance du PIB par tête.

En utilisant la méthode des données de panel statique pour notre échantillon, au cours de la période 1990-2004, on obtient les résultats présentés dans le tableau (1).

Tableau 1. Effet de l'entrepreneuriat sur la croissance économique

Variable dépendante : Croissance du PIB réel par tête (Yit)	MEF
	(1)
lgdp_f	-0.2785 (0.0414)***
IKH	0.0003 (0.0164)
IINV	0.0550 (0.0244)**
IDF	-0.0060 (0.0166)
QI	-0.0066 (0.0089)
E	-0.0020 (0.0011)*
Constante	2.4291 (0.3597)***
Observations	225
Nombre de pays	45
R2	0.4937
Test de Hausman	(0.0323)

***significativité à 1%, ** significativité à 5%, * significativité à 10%. La période d'étude 1990-2004 est subdivisée en Cinq sous-périodes de trois années chacune. Toutes les variables sont exprimées en logarithme népérien, sauf la variable QI. La variable dépendante est la croissance du PIB réel par tête. Le test de Hausman correspond à la statistique du test de Hausman, avec la p-value entre parenthèses.

D'après les résultats d'estimation, et plus précisément, les statistiques des tests de Hausman, on constate que les estimations retenues, seront celles des modèles à effets individuelles fixes et l'estimateur MCO sera l'estimateur non biaisé.

Le PIB initial présente également un coefficient négatif et significatif qui confirme l'hypothèse de convergence conditionnelle, comme dans [29], où les pays en développement ont tendance à croître plus rapidement que les pays développés.

La régression (1) dans le tableau (1) montre qu'il existe un effet positif et significatif avec l'indice de la qualité des institutions. Le coefficient estimé pour l'auto-emploi est statistiquement significatif mais négatif. En d'autres termes, une diminution de l'activité entrepreneuriale, semble avoir un impact positif sur la croissance économique.

De même [16] constate que l'auto-emploi est négativement corrélé avec le PIB réel par habitant dans 22 pays de l'OCDE au cours de la période 1980-1995, alors que la variable basées sur les données de brevets est positivement corrélée avec la croissance économique.

5.3.2 ETUDE DE LA RELATION ENTRE LE CAPITAL SOCIAL ET L'ENTREPRENEURIAT

Comme cela a été souligné, l'entrepreneuriat a des effets sur la croissance économique. Toutefois, le capital social pourrait avoir un rôle important dans le processus entrepreneurial, parce que l'existence d'organisations établies peut activement encourager le développement de nouvelles activités. Le capital social joue un rôle important dans cet encouragement, ce qui facilite le recours aux ressources nécessaires pour créer une nouvelle entreprise.

Il en résulte donc que l'entrepreneuriat a un effet sur la croissance économique à travers le capital social. Pour distinguer l'effet indirect du capital social sur la relation entre l'entrepreneuriat et la croissance, nous estimons dans l'équation 2 la relation entre le capital social et l'entrepreneuriat. Les résultats des estimations sont présentés dans le tableau ci-dessous :

Tableau 2. Etude de la relation entre le capital social et l'entrepreneuriat

Variable dépendante : Auto-emploi (IE)	MCO
	(2)
IKS	0.0051 (0.0248)*
Constante	-0.1850 (0.2169)
Observations	225
Nombre de pays	45
R2	0.2928
Test de Hausman	(0.1806)

***significativité à 1%, ** significativité à 5%, * significativité à 10%. La période d'étude 1990-2004 est subdivisée en Cinq sous-périodes de trois années chacune. La variable dépendante est l'entrepreneuriat. Le test de Hausman correspond à la statistique du test de Hausman, avec la p-value entre parenthèses.

Le tableau (2) montre clairement que le capital social exerce son coefficient positif attendu. Par conséquent, les améliorations dans le capital social aura des effets positifs sur l'entrepreneuriat.

L'équation (2) montre la relation entre le capital social (KS) et l'entrepreneuriat (E). Comme nous l'avons expliqué dans la section précédente.

5.3.3 EFFET DE L'ENTREPRENEURIAT ET DU CAPITAL SOCIAL SUR LA CROISSANCE ÉCONOMIQUE

Après avoir pris en compte l'effet du capital social dans l'estimation de l'entrepreneuriat, nous allons estimer de nouveaux notre équation. Les résultats des estimations sont présentés dans le tableau ci-dessous :

Tableau 3. Effet de l'entrepreneuriat et du capital social sur la croissance économique

Variable dépendante : Croissance du PIB réel par tête (Yit)	MCO
	(3)
lgdp_f	-0.2920 (0.0406)***
IKH	0.0076 (0.0166)
IINV	0.0401 (0.0251)*
IDF	-0.0023 (0.0164)
QI	-0.0073 (0.0088)
Ê	0.0576 (0.0245)**
Constante	2.5907 (0.3548)***
Observations	225
Nombre de pays	45
R2	0.5009
Test de Hausman	(0.0019)

***significativité à 1%, ** significativité à 5%, * significativité à 10%. La période d'étude 1990-2004 est subdivisée en Cinq sous-périodes de trois années chacune. Toutes les variables sont exprimées en logarithme népérien, sauf la variable QI. La variable dépendante est la croissance du PIB réel par tête (Growth). Le test de Hausman correspond à la statistique du test de Hausman, avec la p-value entre parenthèses.

Nous mesurons la performance économique par le taux de croissance du produit intérieur brut (GDP) par habitant entre 1990 et 2004. Les données suggèrent la convergence dans la performance économique au cours des années 90 parce que la corrélation entre le taux de croissance par habitant du PIB et le PIB initial est -0.2920, qui suggèrent que les régions traînantes en 1990 rattrapent dans la dernière décennie

Le tableau (3) montre également que les coefficients estimés suivent toutes nos attentes théoriques. Ainsi, après avoir pris en compte l'effet du capital social dans l'estimation d'entrepreneuriat. Cette dernière variable est devenue positivement et significativement corrélée avec la croissance économique.

De toute évidence, l'entrepreneuriat a un impact positif et significatif sur la croissance économique. Les résultats de ce dernier tableau nous amènent à conclure que le capital social renforce la croissance économique par le biais de ses effets sur l'entrepreneuriat.

En effet, nos résultats affirment qu'un capital social adéquat et un environnement institutionnel sain sont également nécessaires pour renforcer l'activité entrepreneuriale qui aurait des effets positifs sur la croissance économique.

6 CONCLUSION

L'objet de ce travail était de mettre en valeur le rôle que peut jouer le capital social dans la relation entre l'entrepreneuriat et la croissance économique. Dans ce contexte, nous avons présenté une synthèse des principaux travaux traitant la relation entre l'entrepreneuriat, le capital social et la croissance économique.

Le capital social facilite aux entrepreneurs l'accès à l'information et aux ressources qui sont moins chers que ceux offerts par les institutions financières. Ces ressources sont nécessaires afin qu'ils puissent développer et soutenir leurs activités. En ce sens, l'entrepreneuriat est lié à l'innovation et à l'avantage concurrentiel. L'importance de l'entrepreneuriat se manifeste

non seulement dans les initiatives des politiques publiques qui favorisent le développement de nouvelles entreprises, mais aussi au sein des organisations établies qui encouragent activement le développement et la recherche de nouvelles opportunités.

Par conséquent, une relation positive est attendue entre les deux facteurs. En outre, comme l'entrepreneuriat est considéré comme étant un facteur important favorisant la croissance économique, le capital social montrerait également un effet positif sur la croissance économique d'une manière indirecte. Pour tester ces hypothèses, nous avons procédé à une étude empirique (45 pays développés et en développement au cours de la période 1990-2004).

Cette analyse économétrique nous permettra de tester l'effet direct du capital social sur l'entrepreneuriat. De plus, elle mettra en évidence l'effet indirect de l'entrepreneuriat, accompagné du capital social, sur la croissance économique.

Le résultat obtenu confirme les deux hypothèses principales : le capital social favorise l'entrepreneuriat. À son tour, l'entrepreneuriat stimule la croissance économique.

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A SIMPLE MODEL FOR PREDICTING SKIN DOSE FOR PATIENTS UNDERGOING ROUTINE CHEST X-RAY EXAMINATIONS

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ABSTRACT: In this work, the predicted skin doses of patients undergoing routine medical examinations were carried out at Federal Medical Centre, Makurdi. Measurements were also made using phantoms and Thermo-Luminescence Dosimeter (TLD) in place of patients in order to compare the results obtained. The predicted mean chest doses for 100 patients undergoing routine medical examinations at Federal Medical Centre Makurdi were $724.964\mu\text{Gy}$ using Edmonds' formula. The predicted average dose using our modified formula was $723.138\mu\text{Gy}$. We repeated the above measurements but this time with TLD badges using phantoms in place of patients. Twelve measurements were carried out. The results were found as follows: The average skin dose from TLD badges was $1137.70\mu\text{G}$. While the results of our modified formula are in close agreement with the Edmonds' formula, there is disagreement between the measured and predicted data. These discrepancies in the results could be as a result of excess workload and the age of the machine.

KEYWORDS: Dosimetry, Radiation Protection, Phantoms.

PACS NO.: 87.57.uq, 87.53.Bn.

1 INTRODUCTION

The use of X-rays for diagnostic and therapeutic purposes has become very common recently. It is common to find X-ray machines in almost all hospitals and some clinics all over the world. It is not surprising that 90% of the man-made irradiations are from this source. There is therefore concern as to the effects of X-rays exposure dose rates such as those encountered in diagnostic and therapeutic radiology. Genetic mutations due to gonadal dose, congenital defects caused by foetal irradiation and somatic effects of X-ray such as cancer induction and premature aging may arise as a result of X-ray exposure [1]. Indeed, there has been growing concern that the quantities of X-radiation delivered during diagnostic and therapeutic procedures may produce significant amount of cancer and other disorders [2]. Emphasis now is on producing the maximum benefit from radiology with the minimum amount of radiation consistent with good quality control in medical X-ray [3].

For effective radiation monitoring and protection from medical X-rays, accurate determination of patient skin dose prior to and during radiographic and radio-therapeutics procedures is often essential in the administration of patient dose within recommended guidance levels in hospitals. Since the results of skin dose measurement depends vastly upon the kind of measurement technique employed, several approaches encompassing analytical sequencing of computation models and in-situ monitoring of administered dose using state of the art equipment has been reported based on stipulated dose specification parameters [4]. The relevant dose specification parameters required on any occasion depends critically on the kind of non-invasive procedure considered [5]. These specifications typically allows for the adoption of the best practicable combination required in achieving a dose level capable of yielding acceptable results without compromising the quality of the application.

Recently, a great deal of research has been devoted to the improvement of the existing measurement techniques in order to achieve higher levels of accuracy at lower doses. Remarkably, these studies have been very successful and well documented, and almost all systematic information obtained point to the fact that any protective measure to be adopted has to align with the measurement technique. In this regard, several theoretical models have been proposed to account for the whole body dose during any radiological examination. Patient dosimetry is now widely accepted as a vital point of quality assurance process in diagnostic radiology, and the use of thermoluminescent dosimeters (TLDs) is a recommended method of entrance dose measurement [4]. Whilst it is one of the most convenient methods for dosimetry as its use in the clinical environment is simple, it is a somewhat time consuming technique with several draw backs [4]. It primarily measures the dose to itself and not that of the whole patient geometric size. The use of software suites and analytical methods to carryout entrance dose and effective dose evaluation is a modern resource in dosimetry and is being widely accepted in Hospitals.

In this study, we present a simple model for estimating entrance skin dose from the knowledge of X-ray output parameters. We used X-ray machines based on single-phase generator output.

2 MATERIALS AND METHOD

2.1 MATERIALS

The X-ray machines used for this work were from the Federal Medical Centre, Makurdi, Benue State.

The single-phase mobile diagnostic X-ray machine has the following specifications as shown in the Table 1 below.

Table 1. Technical specifications of the X-ray machine used at Federal Medical Centre, Makurdi

Total filtration	2.1 mmAl
Manufacturer	GEC medical; equipment limited Wembly, Middle Sex, England.
Year of manufacture	1980
Model	Meditronics Diagnox 4006
Type	R105
Anode type	Rotating anode with 1.0mm focus.
Exposure time	From 3ms to 5s (selected by the processor according to mAs selected).
kV range	40-120kV (steps of 1kV)
%load	The selection of the tube load depends on the quality of the main supply. If the main supply regulation is very good this should always be selected to 100%.
Phase type	Single-phase.

A graduated measuring tape was used in measuring chest thicknesses of patients, lead aprons were used as shield for workers [6]. Phantoms of different sizes were also employed.

TLD Badges and Their Specification

Table 2. TLD Badges used at Federal Medical Centre, Makurdi on the single-phase X-ray machine and their numbers.

Phantom size (cm)	SSD(cm)	TLD Number
16	139	a0000 321t
16	147	a0000 172t
16	144	a0000 433t
18	114	a0000 148t
18	135	a0000 309t
18	142	a0000 050t
20	157	a0000 276t
20	157	a0000 348t
20	120	a0000 163t
24	129.6	a0000 377t
24	136	a0000 476t
24	123	a0000 484t

2.2 METHOD

I) Patient-Machine Arrangement

100 patients were exposed at the Federal Medical Centre, Makurdi in a Posterior - Anterior position for chest X-ray examinations, using a single-phase X-ray machine. The chest exposures, during routine radiological examinations were computed using Edmonds' formula [7]. We then made several approximations to the Edmonds' method with the preset values of radiographic exposure factors of peak kilo voltage (kVp), product of tube current (mA) and exposure time(s) as (mAs) and the percentage load (%load), on a single-phase X-ray generator. The patient is asked to stand erect with the chest placed on the film enclosed in a cassette at a given distance away from the X-ray tube (source). The chest thickness of the patient is measured with the aid of a graduated tape and the source to skin distance (SSD) obtained by subtracting the chest thickness (CT) from film to focal distance (FFD) as shown in Fig. 1 below. The various appropriate values of (kVp) and mAs were subsequently read on the X-ray machine control panel, during the chest X-ray examination.

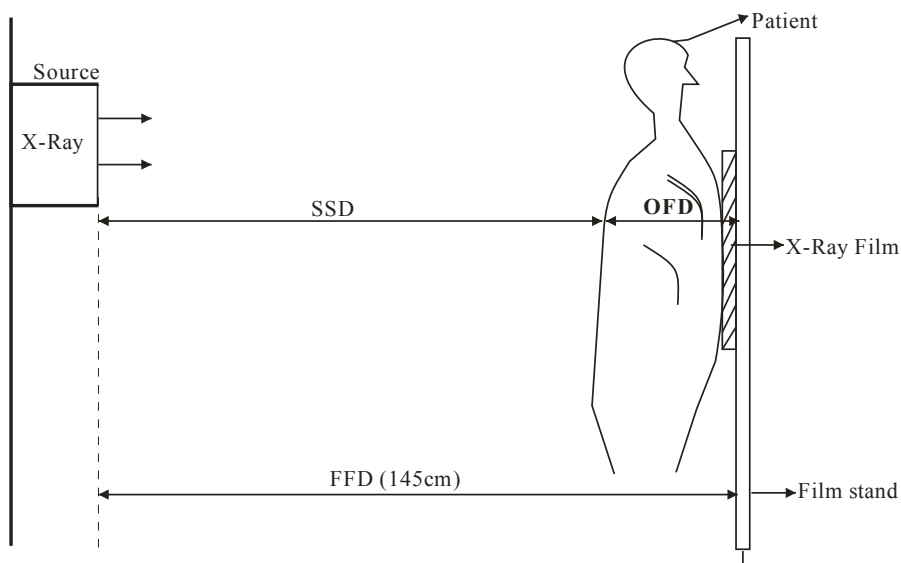


Fig. 1 Illustration of a typical diagram of patient under investigation.

II) Phantom-Machine Arrangement.

Twelve (12) TLD (thermoluminescence dosimeters) were used to measure the amount of radiation doses. The TLD badges were placed in the middle on the front view of the phantoms filled with water facing the X-ray source and their corresponding SSD, kVp, mAs and the average thicknesses of the phantom measured. The phantom – machine arrangement is shown in Fig. 3.

The phantom should be of a material that absorbs and scatters photons in the same way as tissue. A phantom material should have the same density as tissue and should contain the same number of electrons per gram. Water and wet tissues absorb photons in almost the same way, and for this reason water has been used in this work. The materials used for the construction of phantom were; polyvinyl glass, RTV Silicone sealant, hawk saw, tape and a transparent cello- tape. The phantoms were made of different sizes; 16cm, 18cm 20cm and 24cm thicknesses as shown below:



Figure 2a. 24cm phantom



Fig 2b. 20cm phantom



Fig 2c. 18cm phantom



Fig. 2d: 16cm phantom

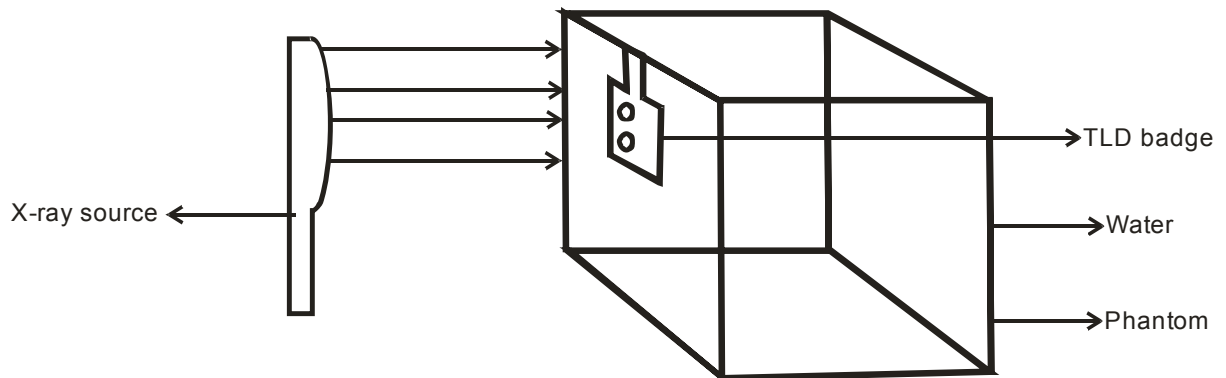


Fig 3 Showing a TLD badge being exposed

Annealing and Calibration of TLDs

The TLDs were annealed, using Hashaw 4500 TLD Reader with Win-REMS (Window based Radiation Evaluation and Measurement System). This was done as follows:

The TLD badges were removed from the plastic holder and the chips scanned with a scanner or computed by using keyboard to type the number of the chips. After which the chips were slotted into the TLD reader, then, the input key will be pressed on the keyboard, and the data will be displaced on the monitor with the peak of radiation displayed as the dose in nano-Coulomb (nC), the current in Pico-Amperes (pA) and voltage in Volts (V). This was done in 24hrs at 80°C.

After annealing the chips, the TLD badges were irradiated for the reader calibration. The aim of annealing and calibrating TLD badges is for the recycling of the cards for future field dosimetry, using phantoms or patients. The annealed irradiated cards are stored at least for 24hours.

Finally, the annealed and calibrated TLD badges (which are tissue equivalent) were exposed with phantoms and water at Federal Medical Centre, Makurdi using single - phase X-ray generator with phantom stand of an average height of 165cm to enable us predict the skin doses of patients undergoing radiological examinations. And the final results were read at National Institute of Radiation Protection and Research, Physics Department, University of Ibadan as shown in Table 1.

3 THEORY

The skin dose prediction based on an expression derived by Edmonds (1984) [7] for a single - phase generator is as follows:

$$\text{Skin dose}(\mu\text{Gy}) = \frac{418.0(KV_p)^{1.74}(mAs)^{1.0}(1/T+0.114)}{(SSD)^2} \tag{1}$$

We suggest a simplified model for skin dose in the form:

$$\text{Skin dose}(\mu\text{Gy}) = Ae^{-kx}(kV_p)^\beta(mAs)^\gamma T^\delta \tag{2}$$

Equation (2) has an exponential term which indicates how X-rays attenuate exponentially as an alternative to the inverse square law suggested in the Edmonds’ formula.

Here A, k, β, γ, δ are parameters to be fitted to the observed skin dose data. We also noticed that for a particular X-ray machine, T has a constant value. So the dependence on T in equation (1) above is a constant for a particular X-ray machine hence we include it in the skin dose formula, as;

$$\text{Skin dose}(m\text{Gy}) = Ae^{-kx}(kV_p)^\beta(mAs)^\gamma \tag{3}$$

Here we have used β = 1.74 and γ = 1.0 as was found by Edmonds during his fit to the ICRP data, hence equation (4) becomes;

$$\text{Skin dose}(\mu\text{Gy}) = Ae^{-kx}(kV_p)^{1.74}(mAs)^{1.0} \tag{4}$$

Equation (4) is now fitted to the data obtained by the Edmonds’ formula of equation (1) through a least square method to obtain the values of A and k.

Finally, the above procedure using patients was repeated with phantoms and TLD badges. The analysis is based on the experimental values read from TLD 4500 Hashaw Reader from National Institute of Radiation Protection and Research, Physics Department, University of Ibadan.

4 RESULTS AND ANALYSIS

We now present the results of data collected at the Federal Medical Centre, Makurd, using the radiographic parameters, kVp, mAs, and chest thickness (CT) obtained for each patient from the single-phase X-ray machine described above to determine the doses for patient undergoing chest radiography. In our analysis, we used Edmonds’ formula given by equation (1) to obtain dose A as depicted in Table 1. We also used a least square fit to get dose B based on our modified equation (4). The least square fit gave us the following equation:

$$\text{Dose B} (\mu\text{Gy}) = 0.117056e^{-0.015959x}(kV_p)^{1.74}(mAs)^{1.0} \tag{14}$$

Table 3 shows the predicted and experimental doses calculated, dose A gives the result based on Edmonds' formula. Dose B gives the results based on our present formula while dose C give the results using phantoms.

Table 3. Predicted and experimental doses calculated from Federal Medical Centre, Makurdi.

kVp	mAs	Chest	SSD	dose A	dose B	dose C
73	20	16	139	446.016	444.85	1614
75	25	16	147	522.493	512.98	1327.2
70	20	16	144	386.317	381.81	659.8
70	20	16	134	446.128	447.87	685.6
70	20	18	142	397.276	394.19	1039.5
70	20	18	140	408.708	406.97	1718.3
69	20	18	142	387.453	384.44	1051.4
70	20	18	114	616.395	616.27	792.3
72	25	18	135	577.031	578.66	1023.6
75	25	19.5	157	458.053	437.31	1006.8
75	25	20	157	458.053	437.31	1005.9
77	25	20	120	820.805	826.26	1416
74	25	20	120	765.965	771.06	
75	25	20	140	576.048	573.61	
75	25	20	130	668.080	672.86	
73	25	23	134	599.902	602.25	
75	25	23	127	700.015	705.85	
75	20	23.4	129.6	537.768	541.73	
92	63	24	136	2194.937	2198.48	
75	25	24	123	746.285	752.38	
75	25	24	117	824.790	827.99	
75	25	17	123	746.285	752.38	
73	20	16	139	446.016	444.85	
75	25	16	147	522.493	512.98	
70	20	16	144	386.317	381.81	
70	20	16	134	446.128	447.87	
68	20	17	143	372.471	368.87	
75	25	17	123	746.285	752.38	
75	25	17	143	552.132	546.79	
70	25	17	144	482.897	477.26	
70	25	17	133	566.077	568.84	
70	25	17	137	533.504	533.67	
70	20	17	128	488.933	492.88	
72	20	17	132	482.847	485.63	
75	25	17	134	628.790	631.25	
75	25	18	150	501.802	489.00	
74	25	18	132	633.029	636.67	
75	25	18	135	619.509	621.25	
72	25	18	131	612.808	616.80	
70	20	18	135	439.543	440.78	
70	20	18	132	459.749	462.40	
70	20	18	130	474.004	477.39	
70	20	18	130	474.004	477.39	
68	20	18	129	457.704	461.21	
75	25	18	138	592.867	592.21	
85	50	18	132	1611.312	1620.59	
68	20	18	133	430.587	432.69	
75	25	18	129	678.478	683.68	

kVp	mAs	Chest	SSD	dose A	dose B	dose C
75	25	18	129	678.478	683.68	
70	20	18	139	414.610	413.52	
70	20	18	140	408.708	406.97	
70	20	19	134	446.128	447.87	
73	23	19	144	477.918	472.34	
73	25	19	144	519.476	513.41	
71	25	19	136	554.907	555.80	
74	25	19	131	642.731	646.92	
90	63	19	131	2276.923	2291.75	
70	25	19	134	557.660	559.84	
73	25	19	134	599.902	602.25	
75	25	19	134	628.790	631.25	
75	25	19	127	700.015	705.85	
75	25	19	139	584.367	582.83	
70	20	19	139	414.610	413.52	
70	20	19	131	466.795	469.84	
70	20	19	131	466.795	469.84	
75	20	19.2	133	510.625	513.12	
85	50	19.5	132.8	1591.957	1600.03	
74	20	19.5	128.5	534.386	538.60	
75	25	19.5	136.5	605.968	606.56	
75	20	20	133	510.625	513.12	
75	25	20	157	458.053	437.31	
74	25	20	130	652.657	657.32	
73	25	20	130	637.388	641.94	
72	25	20	133	594.516	597.42	
72	25	20	133	594.516	597.42	
70	25	20	134	557.660	559.84	
75	25	20	130	668.080	672.86	
74	20	20	130	522.126	525.86	
74	20	20	126	555.803	560.52	
88	50	20	137	1588.902	1589.39	
75	25	20	126	711.171	717.21	
70	20	20	135	439.543	440.78	
75	25	20	125	722.595	728.75	
90	63	21	129	2348.073	2366.08	
74	25	21	129	662.815	667.90	
70	25	21	139	518.262	516.90	
70	25	21	135	549.429	550.98	
77	50	21	126	1488.988	1501.63	
70	40	21	126	1009.155	1017.72	
70	20	21	128	488.933	492.88	
70	20	21	128	488.933	492.88	
75	25	21	126	711.171	717.21	
88	50	22	128.5	1806.060	1820.30	
77	20	22	130	559.507	563.51	
79	20	22	129	594.142	598.70	
85	40	22	128	1370.874	1381.93	
85	40	22	85	3108.705	2744.83	
75	25	22	133	638.281	641.40	
68	20	22	122	511.734	515.73	
70	20	22	122	538.207	542.41	

kVp	mAs	Chest	SSD	dose A	dose B	dose C
75	25	22	123	746.285	752.38	
75	25	23	102	1085.212	1051.93	
75	25	23	130	668.080	672.86	
75	25	23	121	771.160	776.78	
85	63	24	128	2159.126	2176.54	
68	20	17	143	372.471	368.87	
			Total	72496.4	72313.8	13340.4
			Average	724.964	723.138	1111.7
			Std dev.	481.350	467.123	471.987

5 DISCUSSION

The main aim of this article is to design a model for predicting skin dose received by patients undergoing X-ray examinations at Federal Medical Centre, Makurdi, and to compare the results with measurements carried out with TLD badges using phantoms.

It was found that the predicted mean chest doses for 100 patients undergoing routine medical examinations at Federal Medical Centre Makurdi were 724.964 μ Gy using Edmonds' formula. The predicted average dose using our modified formula was 723.138 μ Gy.

We repeated the above measurements but this time with TLD badges using Phantoms in place of patients. Twelve measurements were carried out. The average dose using TLD badges was 1137.70 μ Gy.

As can be seen from our results, the predicted mean dose using Edmonds' formula [7] agrees very well to within 1% with that using our modified formula. However, both results differ significantly with the results using TLD badges and phantoms. This difference may be attributed to several factors, some of which include:

- i. The age of the machine. It is known that the focal spot angle of the X-ray tube increases with the age and use of the machine, and with the increases in the mA station selected. This effect called focal spot blooming can have a significant effect on the dose received by patients. We did not carry out any performance test of this effect on the X-ray machine used in this study.
- ii. There may be variations on the stated kVp and the measured kVp which could significantly affect the amount of dose received by patients. We also did not carry out any performance test regarding this effect.
- iii. Exposure time also directly affects the amount of radiation emitted from an X-ray tube. We did not carry out any performance test on timer accuracy as well.

6 CONCLUSION

In this paper we have successfully fitted a modified model for predicting skin dose from the Edmonds' formula [7]. In our modified model, we have used an exponential factor which shows how X-rays attenuate with distance from the source. Our fitted results agree with the Edmonds' formula to within 1%.

Finally, we have compared the results of our modified model and those of the Edmonds' formula [7] to those obtained using TLD badges and phantoms in place of patients. We have found a significant disagreement between the measured results and the predicted methods. We have advanced several arguments why these results could differ from each other.

It would be interesting to carry out performance tests on the machine to see how the effects mentioned above could affect the amount of dose received by patients.

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La relation entre cœur des compétences vertes, innovations vertes et image verte des entreprises dans le contexte tunisien

[The relationship between green core competencies, green innovations and green image of companies in the Tunisian context]

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ABSTRACT: In front of the evolution of the ecological pressure of the NGO (Non-Governmental Organization) and labor unions (syndicates), and in front of increasing awareness of the consumers, the employees, and the shareholders, companies are obliged to transform these pressures into run-up which urges them to improve and to create their core competencies and their green images and to introduce ecological innovations to guarantee their surviving.

KEYWORDS: Core competencies, ecological innovations, green images of SMC, Green marketing.

RESUME: La prise en compte de la responsabilité environnementale dans la gestion des entreprises s'est largement développée, ces quatre dernières décennies. Face à l'évolution des pressions écologiques des ONG et syndicats, et face à une sensibilisation croissante des consommateurs, des salariés, et des actionnaires, les entreprises se trouvent obliger de transformer ces pressions en élan qui les pousse à améliorer et créer leurs compétences fondamentales et leurs images vertes et d'introduire des innovations écologiques pour parvenir à survivre.

MOTS-CLEFS: Compétences fondamentales, innovations écologiques, images vertes des PME, marketing vert.

1 INTRODUCTION

Les crises financières récurrentes ainsi que les contraintes imposées par l'environnement naturel (la pollution, la raréfaction et l'épuisement inévitable des ressources primaires, le déclin de la biodiversité,...), l'environnement social et sociétal (droits humains fondamentaux, santé et sécurité au travail, ...), et l'environnement économique, couplées parfois de certaines valeurs éthiques du management, incitent certaines organisations à se tourner vers le développement durable.

Ce changement de cap semble, d'après certaines études, se traduire par des champs d'opportunités: améliorations au niveau de la productivité, valorisation de l'image de l'organisation, le développement des compétences. Plus encore, elle s'avère être un vecteur solide d'innovations, en particulier par l'adoption d'une approche par les avantages [51].

L'introduction de ce concept dans l'entreprise importe une grande modification de ses objectifs, sa stratégie ou encore son mode de communication. L'intégration de facteurs clés de succès environnementaux et sociaux aux facteurs clés de succès économiques, déclinés à partir de la stratégie de développement durable, vient modifier la représentation de la compétitivité.

Or, le développement durable selon sa définition comporte trois dimensions à savoir : la dimension économique, écologique et sociale, dans ce présent travail nous nous intéressons uniquement à sa dimension écologique.

L'implication des entreprises dans des programmes concrets en faveur de la protection de l'environnement n'est plus seulement l'expression de leurs responsabilités sociales, elle est devenue, dans beaucoup de cas, un impératif économique et social vital. Par conséquent, la nature n'est pas seulement une ressource matérielle: Elle véhicule également des ressources affectives, sociales et culturelles auprès de l'ensemble du personnel des organisations.

L'accent mis sur l'innovation et le développement des compétences donne la priorité à l'axe de la pérennité et risque, par-là même, de mettre en péril la compétitivité et la création de valeur.

Nombreux chercheurs ont déjà tenté d'identifier et de catégoriser les comportements environnementaux des entreprises ainsi que de mettre en évidence les motivations et les obstacles à la mise en place de stratégies dites « vertes ».

Quelques recherches ont également examiné comment assurer le pilotage environnemental de l'entreprise mais ces études sont restées jusqu'à présent assez limitées dans leurs analyses.

Dans ce cadre, notre recherche se propose de répondre à la question centrale suivante :

Quelle est la relation entre cœur des compétences vertes, innovation verte (de produit et de procédé) et image verte des entreprises industrielles tunisiennes?

Henri Ford (1920), affirmait que : « L'entreprise doit faire des profits, sinon elle mourra. Mais si l'on tente de faire fonctionner une entreprise uniquement sur le profit, elle mourra aussi, car elle n'aura plus de raison d'être ».

Beaucoup d'entreprises pensent que l'adoption d'une gestion environnementale est un investissement inutile, ou même ont été induits en erreur que ce serait entraver leur développement et leur croissance.

Au contraire, plusieurs études antérieures pensent que la pollution était la preuve concrète de l'utilisation inefficace des ressources, et les entreprises qui sont pionnières dans l'innovation verte pourront profiter du "leadership," ce qui leur permet de demander un prix plus élevé pour les produits verts et, en même temps, améliorer leurs images corporatives, développer de nouveaux marchés et acquérir des avantages compétitifs ([48], [32], [15]).

Les entreprises engagées activement dans la gestion de l'environnement et de l'innovation verte peuvent non seulement réduire les déchets de production et augmenter la productivité, mais aussi améliorer la productivité globale, augmenter leur réputation et améliorer leur compétitivité ([48], [55], [9], [15]).

Bien que **Prahalad et Hamel (1990)** ont proposé le concept de cœur des compétences, les chercheurs précédents avaient accordé une grande attention à explorer les questions pertinentes du cœur des compétences, mais rares sont les études qui ont entamé la question de l'impact de la contrainte écologique sur le cœur des compétences d'entreprise et sa relation avec l'innovation environnementale et l'image verte.

Par conséquent cette recherche, en examinant comment s'opère la gestion environnementale dans les organisations, et plus particulièrement dans les entreprises industrielles, qui sont à l'avant-plan des problèmes liés à la pollution, a pour but d'élargir le cadre de gestion pour prendre en compte la dimension écologique.

En fait, les raisons précitées sont réunies pour donner naissance à notre problématique de recherche s'agissant de comprendre la relation qui existe entre le cœur des compétences vertes, l'innovation verte de produit et de procédé et l'image verte des entreprises industrielles tunisiennes.

L'objectif de cet article consiste à vérifier la présence d'une relation entre cœur des compétences vertes, innovation verte de produit et de procédé et image verte des entreprises ; développer un modèle conceptuel qui illustre les relations existantes entre ces variables; tester ce modèle dans le contexte des entreprises tunisiennes ; enrichir la littérature existante sur le thème du management environnementale et aider les entreprises à améliorer leurs connaissances de base sur l'innovation verte et la gestion de l'environnement pour accroître leur implication dans la contrainte écologique.

2 DEFINITION DU CŒUR DES COMPÉTENCES VERTES

La notion de compétence est abordée très tôt sous le thème de compétences distinctives (lieux où une entreprise excelle) [54]. Aujourd'hui, si la parenté avec les compétences distinctives demeure explicite chez certains auteurs ([34], [46]), la plupart aborde les compétences sous l'angle des ressources. Les compétences sont alors une combinaison opportune de ressources. Il existe une hiérarchie entre les ressources et les compétences. On considère généralement que plusieurs ressources peuvent se combiner pour constituer une compétence. Ce processus de "combinaison de ressources" est alors

souvent décrit comme une forme d'apprentissage organisationnel. Ainsi, pour **R.M. Grant (1991)**, les ressources, prises de façon isolées, constituent rarement des forces productives génératrices de valeur. En fait, créer une compétence nécessite un assemblage de ressources, mais implique également un apprentissage, qui va se faire au travers de la répétition, de l'expérience.

Selon **Hamel et Prahalad (1990)** : « **le cœur des compétences est l'apprentissage collectif d'une organisation et particulièrement comment coordonner les diverses compétences techniques et intégrer les multiples courants technologiques** ».

Reed et de Fillippi (1990) ont proposé la définition la plus englobant en précisant que : « **Les compétences sont issues de la façon dont une entreprise utilise ses aptitudes et ressources internes par rapport à la concurrence** ». Se situant par rapport à la concurrence, les compétences sont, dès lors, les sources d'avantages concurrentiels. [59]

Le concept de Cœur de compétence, compétence centrale ou compétence fondamentale ou encore distinctive fut introduit dans le domaine du management par **Prahalad et Hamel** en **1990**. Ils avancèrent que : « **le cœur de compétence est un domaine d'expertise qui résulte de l'harmonisation de technologies et d'activités professionnelles complexes** ».

Comme exemple, ils citaient l'expertise dans le domaine des moteurs de Honda. Honda pouvait exploiter son cœur de compétence pour développer de nombreux produits depuis les tondeuses à gazon jusqu'aux voitures et aux camions. Pour prendre un autre exemple de l'industrie automobile il a été avancé la compétence fondamentale de Volvo est la sécurité.

Galunic et Rodan (1998) considèrent que « **un cœur de compétence ne permet pas seulement de différencier une entreprise d'une autre, mais également à l'intérieur d'une même entreprise de distinguer une compétence d'une autre. En d'autres termes, un cœur de compétence guide une entreprise à réorganiser ses compétences selon la demande de son environnement** ».

Coyne, Hall, et Clifford (1997) ont avancé une autre définition: « **un cœur de compétence est une combinaison de compétences et de savoirs complémentaires présents dans un groupe ou dans une équipe et qui se traduisent par la capacité de réaliser une ou plusieurs tâches essentielles à un standard de niveau mondial** ».

L'intégration de facteurs clés de succès environnementaux et sociaux aux facteurs clés de succès économiques, déclinés à partir de la stratégie de développement durable, vient modifier la représentation de la compétitivité. L'accent mis sur le développement des compétences donne la priorité à l'axe de la pérennité et risque, par-là même, de mettre en péril la compétitivité et la création de valeur.

Les compétences vertes, écologiques, ou encore dites environnementales selon (Chen et al, 2006) sont considérées comme « l'apprentissage collectif et les capacités d'innovation écologique et la gestion de l'environnement dans une organisation ».

Selon **Helper, Orsoni et Kalika (1996)** elles sont composées de quatre facteurs :

- Les savoirs
- Les systèmes techniques
- Les systèmes de management
- Les valeurs et les normes

L'organisation autour des compétences fondamentales exige un changement radical dans l'organisation des entreprises: la première étape passe par l'identification des compétences fondamentales; l'étape suivante consiste à repenser l'architecture de l'entreprise et donner une impulsion à l'apprentissage des alliances et un pôle de développement interne [49]. En outre, le cœur des compétences répond à trois exigences:

- Ils fournissent un accès potentiel à une grande variété de marchés,
- Elles contribuent de façon significative à la valeur des produits offerts sur le marché
- Il est difficile pour les concurrents d'imiter.

La création des compétences fondamentales est importante pour les performances de l'entreprise et le succès des entreprises ([21], [29]).

Si ces définitions ont le mérite de clarifier un domaine encore très flou, elles en demeurent fort peu opérationnelles et ne permettent en rien de mesurer et donc d'identifier les compétences d'une entreprise. C'est pourquoi, il convient à présent de repérer les dimensions et les indicateurs permettant de qualifier ces compétences de stratégiques.

3 L'INNOVATION VERTE

L'importance de l'innovation comme un moteur de compétitivité, de rentabilité et de productivité est bien documentée dans la littérature [47]. De ce fait, l'innovation est considérée comme l'un des principaux moyens par lesquels l'organisation peut atteindre une croissance durable.

La notion d'innovation est un élément incontournable de l'appropriation du concept de développement durable. On s'aperçoit qu'elle ouvre la voie à une véritable transformation des règles de l'entreprise. Associer l'idée de développement durable à celle d'entreprise a pour conséquence la nécessité de repenser ses relations, ses interactions avec ses parties prenantes car il existe des contradictions à gérer, et des différents à arbitrer [40]. Ainsi, positionner l'entreprise dans une démarche de développement durable conduit à réviser les modes de pensée et à mettre en œuvre de nouvelles méthodes de travail : concilier court terme et long terme, global et local.

Le terme d'innovation désigne le processus réalisant la nouveauté. Ainsi, une innovation est, selon **Barreyre (1980)** : « **Un processus, c'est-à-dire un ensemble de phénomènes, conçu comme actif et organisé dans le temps, dont l'aboutissement est une réalisation originale qui comporte des attributs créateurs de valeur, la mise en application originale et porteuse de progrès d'une découverte, d'une invention ou simplement d'un concept** ».

Ce processus comprend trois étapes:

- L'élaboration de l'innovation - convergence entre une fonction à remplir, un concept et des ingrédients,
- Le développement et l'introduction,
- La diffusion.

Ainsi, l'innovation selon **Rogers (1995)** n'est pas « **une idée, une pratique, ou un objet perçu comme nouveau par un individu ou toute autre unité d'adoption** » mais le processus produisant cette idée, pratique ou objet nouveau.

Une étude de **l'OCDE (1991)** va dans ce sens, pour cet organisme, l'innovation est un processus itératif initié par la perception d'une opportunité d'un nouveau marché et/ou d'un nouveau service pour une technologie basée sur une invention dont le développement, la production et le marketing tentent de conduire au succès commercial. Ce processus, selon **Garcia et Calantone (2002)**, ne comprend pas seulement l'activité de recherche, mais aussi le développement du produit, sa fabrication, le marketing, sa distribution, le service et son adaptation au cours de sa vie.

Selon Le **manuel d'Oslo (2005)**, l'innovation c'est : « **La mise en œuvre d'un produit (bien ou service) ou d'un procédé nouveau ou sensiblement amélioré, d'une nouvelle méthode de commercialisation ou d'une nouvelle méthode organisationnelle dans les pratiques de l'entreprise, l'organisation du lieu de travail ou les relations extérieures** ».

L'innovation verte est utilisée pour améliorer la performance de la gestion environnementale afin de satisfaire les exigences de protection de l'environnement [15].

L'éco-innovation est toute forme d'innovation (technologique ou non, nouveaux produits et services ou encore nouvelles pratiques commerciales) qui crée des perspectives commerciales tout en protégeant l'environnement, dans la mesure où elle présente un impact écologique nul ou limité, ou optimise l'exploitation des ressources (y compris la consommation d'énergie).

Elle se définit aussi comme « l'introduction d'un produit (bien ou service), d'un procédé, d'une méthode d'organisation ou de marketing nouveau ou amélioré significativement, qui génère un bénéfice environnemental comparé aux alternatives existantes. Les bénéfices environnementaux peuvent être l'objectif principal de l'innovation ou le résultat d'une innovation visant d'autres objectifs. Les bénéfices environnementaux peuvent être dégagés au cours du processus de production du bien ou du service ou lors de son utilisation »¹.

Il existe plusieurs classifications pour l'innovation, parmi ces classifications nous avons choisi celle identifiée par **Hamel (2008)** qui distingue quatre types d'innovations qu'il présente sous forme d'une pyramide :

¹ http://insee.fr/fr/themes/document.asp?reg_id=3&ref_id=16815



FIGURE 1: LA PYRAMIDE DE L'INNOVATION

Source : Moingeon & Lehmann-Ortega (2006), p. 53. Fig1

Si chaque innovation apporte une contribution à la réussite de l'entreprise, certaines formes d'innovations révèlent, selon Hamel, une aptitude supérieure dans l'obtention d'un avantage concurrentiel durable. A la base de la pyramide, on trouve :

- **L'innovation de procédés** : correspond à l'excellence opérationnelle (performance des systèmes d'information, sous-traitance, délocalisations), dont l'intérêt est incontestable, mais qui se diffuse rapidement d'une entreprise à l'autre et ne se révèle donc pas décisive sur le plan concurrentiel.
- **L'innovation de produits/services** : correspond à l'apparition d'un produit nouveau ou encore à un produit déjà existant mais incorporant une nouveauté. Si elle peut être à l'origine d'un développement considérable de l'organisation, est souvent rapidement copiée, voire dépassée, si son succès ne repose pas sur des caractéristiques uniques de l'entreprise.
- **L'innovation stratégique** : consiste en l'offre d'un nouveau modèle économique. Elle correspond à une rupture et peut perturber la concurrence, mais, selon **Hamel (2008)**, l'identification des clés du succès de l'entreprise reste relativement aisée, empêchant l'innovation de s'avérer décisive.
- **L'innovation managériale** : permet de provoquer une rupture durable. Elle se distingue des autres formes d'innovation parce qu'elle repose sur une combinaison complexe de ressources et de savoir-faire particulièrement difficile à identifier et à dupliquer pour un concurrent.

Or l'innovation stratégique et l'innovation managériale sont des innovations organisationnelles. Les innovations environnementales vertes entourent toutes les innovations qui ont un effet bénéfique sur l'environnement écologique, ils incluent le processus, le produit, et les innovations d'organisation.

Dans ce travail, nous nous focaliserons principalement sur des explications de l'innovation de produit et de l'innovation de processus ou de procédé. Les innovations organisationnelles ne réduisent pas des incidences sur l'environnement directement, mais facilitent l'exécution (processus et produit) des innovations environnementales techniques aux compagnies [42].

La performance en termes d'innovation permet de mesurer la capacité de l'entreprise à renouveler son portefeuille de produits ou d'activités. Un niveau d'innovation élevé représente par conséquent un avantage déterminant vis-à-vis des concurrents.

Chen et al. (2006) définissent la performance d'innovation verte comme la performance des matériels et des logiciels impliqués dans l'innovation de produits écologiques ou des processus, y compris l'innovation technologiques qui sont impliqués dans l'économie d'énergie, prévention de la pollution, le recyclage des déchets, la conception des produits verts...

4 L'IMAGE VERTE DE L'ENTREPRISE

L'image qui se dégage de l'industrie est en effet celle de l'infrastructure très polluante où aucune préoccupation environnementale n'est mise. Ainsi les entreprises doivent prendre en considération que leurs clients commencent à avoir des exigences en matière du respect de l'environnement. Avoir une image verte est devenue un argument de vente incontestable. Il suffit pour s'en convaincre de regarder les compagnies publicitaires actuelles pour les véhicules par exemple ; Tous les constructeurs utilisent l'argument écologique (qu'il soit fondé ou non). L'opinion publique est désormais sensible à la problématique de l'énergie : Agir concrètement pour réduire consommations énergétiques et communiquer régulièrement

sur les résultats obtenus donnera une image positive à l'entreprise. Cet atout supplémentaire ne sera sans doute pas superflu pour conserver la clientèle et en convaincre une nouvelle. [38]

L'image de l'entreprise est l'ensemble des représentations matérielles et immatérielles que se font les personnes appartenant à un public déterminé. C'est l'ensemble des connaissances et évocations associées à une entreprise par un individu ou un public défini. [14]

Selon ([37], [39]), elle résulte d'une stratégie et d'un processus de communication qui s'efforce d'équilibrer en permanence : L'image voulue, l'image possible : l'analyse de l'environnement est essentielle pour redéfinir l'image voulue en image possible, l'image projetée et l'image perçue.

L'état de l'image se mesure à l'aide de baromètres image, en posant des questions sur des points jugés importants pour la stratégie d'image. Les PME procèdent souvent à des enquêtes (ponctuelles, de positionnement...) pour apprécier l'évolution de l'image de l'entreprise.

Pour **Hu et Wall (2005)**, pour être de qualité, l'image de l'entreprise doit être :

- **Juste**
- **Originale**
- **Durable**
- **Positive**

Pour gagner et conserver un avantage concurrentiel, l'entreprise doit avoir une bonne réputation aux yeux de tous ses partenaires : les salariés, les clients, les investisseurs, les collectivités locales. La rentabilité et la survie de l'entreprise dépendent de sa capacité à convaincre les salariés de l'intérêt de travailler pour elle, les clients d'acheter ses produits, les investisseurs d'apporter crédit et financement, les collectivités de l'accueillir dans leur périmètre local. La communication externe comme interne sert à construire l'image de l'entreprise.

5 LA CONSTRUCTION DES HYPOTHESES DE LA RECHERCHE

La théorie des ressources est une théorie générique ; elle présente un large éventail d'approches dont on cite l'approche basée sur la connaissance, et plus récemment l'approche basée sur les compétences. Cette dernière avance l'hypothèse que les compétences de l'entreprise font sa force compétitive et lui procurent l'avantage concurrentiel durable. Dans la littérature managériale, on distingue entre deux acceptions de la notion de compétence, selon qu'on se met dans le domaine du management stratégique ou de la Gestion des Ressources Humaines (GRH). Cependant, ces deux acceptions sont à placer sur un même continuum, dont elles forment les deux extrémités : la compétence en GRH renvoie aux capacités et talents humains qui représentent le niveau individuel de celle-ci, et la compétence en management stratégique fait référence à la compétence organisationnelle c'est-à-dire la capacité de l'entreprise à réaliser une activité ou une tâche en s'appuyant sur ses ressources.

la compétence : « un ensemble de dimensions de performance observables, incluant la connaissance individuelle, habiletés, attitudes, et comportements, ainsi que, équipe collective, processus, et capacités organisationnelles, qui sont reliés à une performance élevée, et qui procurent à l'entreprise un avantage compétitif soutenable » [3].

Ainsi l'innovation se trouve au cœur de la notion des compétences dans le sens où de la diversité des compétences techniques et de la multitude des courants technologiques résultent les innovations et nécessitent en amont des compétences managériales et humaines d'innovation (autonomisation et responsabilisation, communication, créativité, exploration...).

Talke et al. (2006) ont développé un modèle pour expliquer les compétences et l'apparition d'initiatives pour l'innovation, et ont soutenu que le développement des compétences peut stimuler l'innovation.

D'autre part, **Ritter et Gemü Grisons (2003)** pensaient que les entreprises ont besoin de développer leurs compétences, afin d'augmenter leur succès. L'innovation et les compétences des entreprises ont eu un impact positif significatif sur le succès des entreprises.

Ainsi, des études antérieures affirment que le cœur des compétences des entreprises peuvent conduire leur innovation, et renforcer davantage leurs performances d'innovation ([23], [25] ; [52], [53], [58]).

Selon **Chen et al. (2008)**, en se basant sur la théorie de ressource de base, le cœur des compétences vertes a un impact positif sur l'innovation verte.

Dans le même cadre, en s'appuyant sur les études de **Chen et al (2008)**, nous nous permettons de tester l'hypothèse suivante dans le contexte Tunisien :

Hypothèse 1 : le cœur des Compétences vertes d'entreprise est positivement associé à l'innovation verte.

L'examen de la littérature antérieure nous a montré que l'innovation est mesurée par plusieurs dimensions dont on va appuyer sur deux types d'innovation verte : l'innovation de produit et l'innovation de procédé. Ainsi, cette hypothèse se divise en deux sous hypothèses à savoirs :

Hypothèse 1a : le cœur des compétences vertes d'entreprise est positivement associé à l'innovation verte de produit.

Hypothèse 1b : le cœur des compétences vertes d'entreprise est positivement associé à l'innovation verte de procédé.

Chan (2000) a démontré que l'image verte du pays d'origine a eu un effet positif significatif sur l'efficacité de la publicité et du marketing.

En outre, **Corrigan (1996)** a souligné que les industries d'exportation irlandaise a connu une croissance importante, depuis la promotion de l'Irlande comme un centre vert européen de produits et services de qualité, telle qu'elle avait l'avantage de l'image verte.

Par ailleurs, **Hu et Wall (2005)** affirment que la compétitivité des attractions touristiques pourrait être renforcée par de saines pratiques de gestion de l'environnement. Ainsi, la gestion environnementale du pays a eu une influence positive sur leurs images vertes ([17], [35]).

De même, les images vertes sont également importantes pour les entreprises en particulier dans les tendances de la conscience écologique des consommateurs et les sévères règlements internationaux de protection de l'environnement.

Les entreprises qui sont les pionniers de l'innovation écologique peuvent avoir l'avantage du leadership, donc ils peuvent demander des prix relativement élevés pour leurs produits verts, et obtenir à nouveau des avantages concurrentiels.

En se basant sur l'approche relationnelle, **Chen (2008)** a proposé l'hypothèse suivante que nous allons la vérifier dans les entreprises tunisiennes:

Hypothèse 2 : Le cœur des compétences vertes d'entreprise est positivement associé à leur image verte.

L'innovation verte est utilisée pour améliorer les performances de gestion de l'environnement, afin de satisfaire à l'exigence de protection de l'environnement, et les entreprises peuvent accroître la productivité des ressources grâce à l'innovation verte à faire avec les coûts environnementaux [14].

En outre, les entreprises qui sont pionnier dans certains nouveaux produits verts pourrez profiter des avantages qui leurs permettent de demander des prix plus élevés pour les produits verts, à concrétiser la notion de produits écologiques dans la conception et le paquet de leurs produits pour augmenter leurs avantages de différenciation de leurs produits, et d'améliorer encore leurs images ([15], [32], [44], [48], [55], [56]).

Proposée par **Chen et al. (2008)** dans le cadre de l'approche relationnelle, cette hypothèse sera testée au cours de cette étude afin de vérifier son degré d'acceptation dans le contexte tunisien :

Hypothèse 3 : L'innovation verte d'entreprise est associée positivement à leur image verte.

Selon **Chen et al. (2008)**, l'innovation verte se divise en innovation verte de produit et innovation verte de procédé. Ainsi, cette hypothèse est subdivisée en deux sous hypothèses comme suit :

Hypothèse 3a : L'innovation verte de produit d'entreprise est associée positivement à leur image verte.

Hypothèse 3b : L'innovation verte de procédé d'entreprise est associée positivement à leur image verte.

Donc à partir de ces variables explicatives, de ces variables à expliquer et des liens qui les unissent, notre modèle conceptuel à tester sera présenté comme suit :

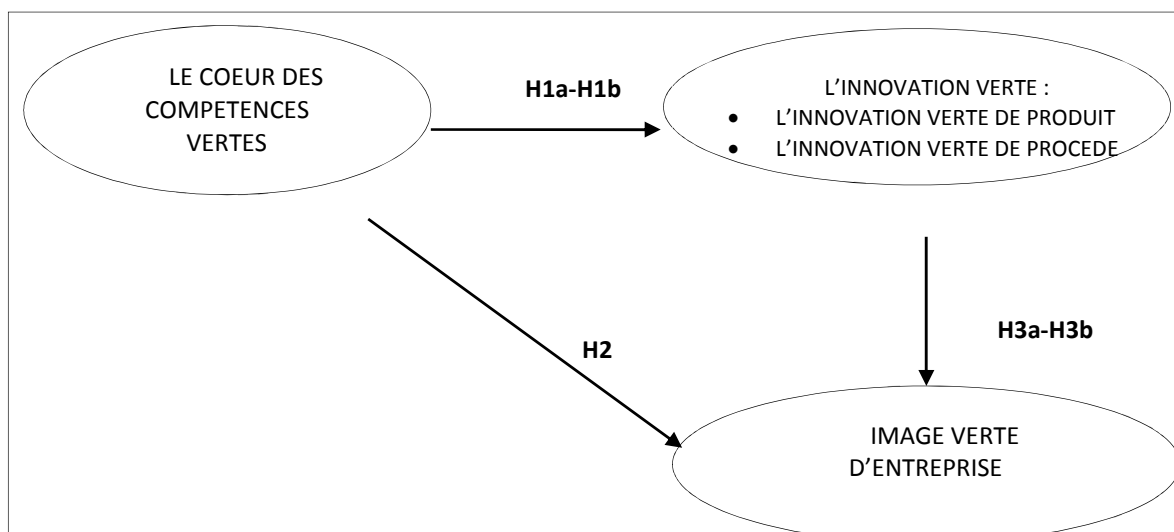


FIGURE 2: LE MODELE CONCEPTUEL DE LA RECHERCHE

8 LA METHODOLOGIE DE LA RECHERCHE

Nous avons utilisé une méthodologie de recherche bien déterminée en choisissant un échantillon de 109 entreprises industrielles et en les interrogeant via un questionnaire pour savoir la relation entre le cœur des compétences vertes, l'innovation verte et l'image verte d'entreprise. Ainsi, pour élaborer notre questionnaire, nous avons précisé les différentes échelles de mesure pour les variables existantes dans notre modèle, les interviewés sont appelés à répondre, selon une échelle de Likert à 5 points allant de « pas du tout d'accord » à « tout à fait d'accord ». L'enquête principale pour la collecte des données s'est produite durant la période de 13 Avril jusqu'au 20 Mai 2011 La collecte des données était difficile à cause de la révolution dans notre pays.

L'analyse factorielle est une démarche qui reste, fondamentalement, empirique et exploratoire ayant comme objectif l'extraction des facteurs latents à partir des variables initiales observables, de manière à restituer le maximum d'information (la variance expliquée). L'objectif principal étant de découvrir les dimensions latentes contenues dans l'ensemble des variables initiales. La mise en œuvre de l'analyse factorielle nous permet de résoudre trois problèmes : s'assurer que les données collectées sont factorisables (c'est-à-dire si les variables forment un ensemble suffisamment cohérent) ; choisir la méthode appropriée à l'analyse factorielle ; retenir les facteurs adéquats.

9 LES RESULTATS DE LA RECHERCHE

Pour notre étude, nous avons jugé la régression linéaire comme la méthode d'analyse des données la plus appropriée. Les mesures d'association les plus courantes sont celles qui correspondent à deux variables ayant les mêmes niveaux de mesure (métrique/métrique), elles permettent tout d'abord de mettre en évidence l'existence d'une association par une procédure de test, ensuite, de mesurer sa force (le plus souvent par un indicateur d'association variant entre 0 et 1, c'est-à-dire allant d'une association nulle à une association parfaite). La mesure d'association la plus connue est le coefficient de corrélation de Pearson [22].

L'analyse de régression est utilisée pour l'identification des variables indépendantes qui contribuent le plus à expliquer les variations et les valeurs de la variable dépendante. En effet, son objectif consiste à expliquer une variable dépendante par d'autres variables indépendantes [22]. Il s'agit de prédire les valeurs de la variable à expliquer à travers une combinaison linéaire des variables explicatives.

Toutes les données se présentent sous la forme d'une matrice de valeurs pour la variable à expliquer (y) et les variables explicatives (x1, x2,..., xn). La régression établit une relation linéaire entre la variable à expliquer et les variables explicatives. La relation cherchée est donc de la forme :

$$y = \beta_1 x_1 + \epsilon \quad \text{où}$$

n : le nombre des variables explicatives

β_i : coefficient de régression standardisé tel que $-1 < \beta_i < 1$

ϵ : le poids de la variable résiduelle (le terme d'erreur exprimant l'effet des variables non prises en compte).

L'objectif de l'analyse de régression est de déterminer la valeur des paramètres β_i , permettant d'identifier le lien entre la variable dépendante et la variable indépendante.

La méthode de régression linéaire se base sur les indicateurs statistiques suivants :

- **Le coefficient de détermination (R²m)** : c'est l'indicateur usuel de la qualité de l'ajustement global. Plus il est proche de 1, plus les valeurs observées et les valeurs calculées par le modèle sont proches [22].
- **Le test de Fisher-Snédecor (F)** : permet de répondre à cette fin, en vérifiant l'hypothèse nulle H₀ selon laquelle H₀ : R²m = 0 à un seuil d'erreur inférieur à 0,05. Le pouvoir explicatif d'une régression est significatif si H₀ est rejetée [22].

Dans ce qui suit, nous présenterons les résultats de régression linéaire relatifs au test des hypothèses.

Les résultats de la régression linéaire relative à l'hypothèse H_{1.a} sont présentés dans le tableau ci-dessus :

TABLEAU 1: L'INNOVATION DE PRODUIT

Variables à expliquer	Innov1
Variables explicatives	
comp	,508***
Coefficient de détermination	,258
Coefficient F de Fisher	37,220
Signification de F	,000
Durbin-Watson	2,255

***p < 0,01 **p < 0,05 *p < 0,1

Dans ce modèle, le pourcentage de la variance expliquée est de 25,8%. Aussi le coefficient de régression estimé est significatif et positif ($\beta = ,508$, $p = ,000 < 0,05$). Donc nous pouvons conclure que l'hypothèse (H_{1.a}) stipulant que : « H_{1.a} : le cœur des compétences vertes a une influence positive sur l'innovation de produit » est donc acceptée.

L'évaluation de la relation entre le construit « la compétence » et la deuxième dimension l'innovation de procédé est résumée dans le tableau suivante :

TABLEAU 2: L'INNOVATION DE PROCEDE

Variables à expliquer	Innov2
Variables explicatives	
comp	,083
Coefficient de détermination	,007
Coefficient F de Fisher	,746
Signification de F	,390
Durbin-Watson	2,250

***p < 0,01 **p < 0,05 *p < 0,1

Le coefficient de détermination $R^2 = 0,007$: nous pouvons dire que 0,7 % de la variabilité de l'innovation de procédé est expliquée par la compétence verte.

Ainsi, l'hypothèse (H.b) stipulant que : « H1.b : le cœur des compétences vertes a une influence positive sur l'innovation de procédé » est rejetée: $\beta = ,083$; $t = 0,864$; $p = 0,390$.

L'hypothèse (H2) prédit l'existence d'une relation entre la variable dépendante (la compétence fondamentale verte) et la variable indépendante (l'image verte). Ceci est confirmé par les résultats présentés dans le tableau 6 ci-dessus, d'une régression entre ces variables puisque le pourcentage de la variance expliquée est de 7,4%. Le coefficient de régression estimé est significatif et positif ($\beta = ,271$ $p = ,004 < 0,05$). En d'autres termes, la compétence fondamentale verte a un impact significatif et positif sur l'image verte. L'hypothèse (H2) est donc acceptée.

TABLEAU 3: L'IMAGE VERTE/COMPETENCE

Variables à expliquer	imagvert
Variables explicatives	
comp	,271**
Coefficient de détermination	,074
Coefficient F de Fisher	8,514
Signification de F	,004
Durbin-Watson	1,743

*** $p < 0,01$ ** $p < 0,05$ * $p < 0,1$

Nous vérifions l'effet de l'innovation verte avec ses deux dimensions (l'innovation verte de produit et l'innovation verte de procédé) sur l'image verte d'entreprise.

TABLEAU 4: L'IMAGE VERTE/INNOVATION

Variables à expliquer	comp
Variables explicatives	
Innov1	,280**
Innov2	,132
Coefficient de détermination	,108
Coefficient F de Fisher	6,421
Signification de F	,002
Durbin-Watson	1,772

*** $p < 0,01$ ** $p < 0,05$ * $p < 0,1$

Le tableau ci-dessus montre les deux dimensions « l'innovation verte de produit » et « l'innovation verte de procédé » du construit « l'innovation verte » ont des Bêta qui sont respectivement :

- **innov1**: $\beta = ,280^{**}$; $p = 0,003 < 0,005$
- **innov2**: $\beta = ,132$; $p = 0,160 > 0,005$

L'hypothèse **H3** est donc partiellement acceptée. En effet, l'hypothèse **H3.a** est confirmée alors que l'hypothèse **H3.b** est rejetée. En d'autres termes, l'innovation verte a un impact partiellement significatif sur l'image verte de l'entreprise.

10 LA DISCUSSION DES RESULTATS

L'analyse des résultats a montré que l'effet du cœur des compétences vertes sur l'innovation de produit est significatif. Ceci corrobore avec les travaux de plusieurs auteurs ([45], [14]) qui ont soutenu l'idée de l'existence d'une relation positive entre ces deux variables. Ce résultat semble logique, puisque, comme nous le signalions précédemment, la recherche d'une diminution des nuisances conduit l'entreprise à travailler au niveau de la conception des produits. Les compétences acquises progressivement par l'équipe de recherche et développement ont un effet bénéfique sur la capacité d'innovation et, par conséquent, sur la compétitivité de la firme. Les compétences fondamentales vertes ont des conséquences positives sur la performance de l'innovation. En effet, la prévention de la pollution, la reconnaissance d'une responsabilité vis-à-vis du produit tout au long de son cycle de vie et l'intégration de la notion de « développement durable » consiste à éviter la production d'effluents nocifs plutôt que d'opter pour le traitement des polluants générés lors de la phase de production, permet à l'entreprise de réaliser des économies substantielles. Celles-ci trouvent leur origine dans une diminution de la consommation de matières premières, dans une élimination des coûts de retraitement de déchets ou de mise en décharge et dans une diminution des coûts d'investissement, les installations de dépollution devenant alors inutiles. Ensuite, au niveau de la responsabilité, les législations tendent désormais à rendre les entreprises responsables du devenir des biens mis sur le marché, celles-ci conservant un certain nombre d'obligations vis-à-vis du produit après l'acte de vente. L'intégration des exigences de régénération devient dès lors un élément de compétitivité puisqu'elle permet d'éviter les surcoûts générés en fin de cycle de vie, compte tenu d'une conception inadaptée des produits. Enfin, par la mise en œuvre d'une stratégie basée sur la notion de développement durable, l'entreprise tunisienne affirme son ancrage dans la société et démontre qu'au-delà de sa mission économique, elle participe activement au développement de la société et qu'elle agit simultanément pour la préservation des milieux naturels.

D'après les résultats obtenus, le cœur des compétences vertes n'affecte pas l'innovation de procédé. Cette relation est infirmée par les travaux passés [14] qui ont montré le lien positif entre ces deux variables. La sous-hypothèse H2.b qui a souligné l'idée que le cœur des compétences vertes a un effet sur l'innovation de procédé est rejetée. Cette vision ne se converge pas avec celle constatée dans la littérature [14]).

Or ceci peut être expliqué par le fait que le poids des dépenses nécessaire pour améliorer de façon substantielle les performances écologiques d'une usine est le principal obstacle qui s'oppose à la réalisation d'investissement en faveur de l'environnement. A cela s'ajoute la difficulté de prévoir la rentabilité de ces investissements écologiques qui est parfois négative et se mesure généralement à L.T. Ainsi, il s'avère difficile de justifier les dépenses engagées surtout lorsque la direction générale ne semble pas être convaincue de leur utilité ni du fait de faire du respect de l'environnement l'un de ses choix stratégiques. Aussi nous remarquons que l'entreprise se trouve en face d'une résistance aux changements liée essentiellement au poids des habitudes et aux problèmes de transition des objectifs stratégiques aux actions opérationnelles de ce fait, pour réussir le passage à une organisation éco respectueuse il faut qu'il y ait, en plus de la contribution des ingénieurs, juristes, managers et techniciens, une implication, de l'ensemble du personnel depuis le plus bas échelon. Il est indispensable de changer donc les habitudes et les comportements de l'ensemble du personnel vis-à-vis de l'environnement, ainsi qu'introduire le respect de la nature dans la culture générale de l'entreprise ce qui n'est pas le cas des entreprises tunisiennes.

Aussi les actions environnementales des entreprises nécessitent des qualifications très spécialisées et pas toujours disponibles dans la firme. De plus, de nombreux responsables d'entreprise affirment qu'ils ne sont pas au courant des solutions technologiques existantes sur le marché. Ces obstacles technologiques sont les plus importantes dans les industries ayant un processus de production complexe ou l'amélioration des performances est liée à des modifications importantes des installations. Cependant, les solutions technologiques environnementales existent le plus souvent, le problème étant en réalité l'importance des investissements requis pour les mettre en œuvre.

Suite à une revue de la littérature ([49], [14]), nous avons supposé que le cœur des compétences vertes affecte positivement l'image verte d'entreprise. En effet, cette hypothèse a été vérifiée dans le contexte tunisien.

Ce résultat corrobore avec les travaux antérieurs [14]. Ces auteurs ont montré qu'il existe un lien significatif entre ces deux variables. Ce résultat semble logique parce que généralement une bonne maîtrise du cœur des compétences de l'entreprise se traduit par avoir une bonne image de l'entreprise. Ainsi pour avoir une image verte de l'entreprise, cette dernière doit posséder des compétences fondamentales vertes qui lui permettent de faire face à la concurrence et de se positionner sur le marché.

D'après nos résultats obtenus, l'innovation verte affecte partiellement l'image verte. Alors que les travaux passés [14] ont montré un lien positif entre ces deux variables.

En effet, l'analyse des résultats a montré que l'effet de l'innovation de produit et l'image verte est significatif. Ceci corrobore les études passées [14] qui ont soutenu l'idée de l'existence d'une relation positive entre ces deux variables. Face aux exigences des consommateurs en matière du respect de l'environnement, les entreprises industrielles, qui ont déjà une image négative envers la nature, se trouvent obligées de prendre en compte la contrainte écologique. Ainsi, avoir une image verte est devenu un argument de vente incontestable. En fait, les entreprises qui sont pionnier dans certains nouveaux produits verts pourrez profiter des avantages qui leur permettent de demander des prix plus élevés pour les produits verts, à concrétiser la notion de produits écologiques dans la conception et le paquet de leurs produits pour augmenter leurs avantages de différenciation de leurs produits, et d'améliorer encore leurs images de marque ([15], [32], [44], [48], [56], [55]).

La sous-hypothèse H3.b qui a souligné l'idée que l'innovation verte du procédé a un effet sur la l'image verte est rejeté. Cette vision ne se converge pas avec celle constatée dans la littérature [14]. Selon le résultat que nous avons trouvés, nous remarquons qu'il n'ya pas un lien direct entre l'innovation verte du procédé et l'image verte de l'entreprise cela peut être due au manque de conviction et d'implication des dirigeants dans le processus de l'innovation verte de procédé pour des critères stricts de rentabilité-risque, ou à cause du manque des compétences et connaissances nécessaires et suffisantes, ou due à l'incapacité de les combiner en raison de rigidités organisationnelles et aux résistances des ouvriers aux changements. Par contre nous ne pouvons pas nier la possibilité de l'existence d'un lien indirecte entre ces deux variables.

11 CONCLUSION

Cette étude résume la littérature sur l'écologie et son intégration dans la gestion et la stratégie d'entreprise dans un nouveau cadre du management des compétences fondamentales.

Bien que **Prahalad et Hamel (1990)** aient proposé le concept du cœur des compétences et plusieurs autres études antérieures avaient prêté beaucoup d'attention à explorer les questions pertinentes des compétences fondamentales, il y avait des lacunes au niveau de l'étude explorant l'impact du cœur des compétences sur l'innovation verte et l'image verte de l'entreprise au sein des firmes industrielles tunisiennes.

Cette étude appuyée sur l'étude de **Chen (2008)**, vérifie le degré d'implication des entreprises tunisiennes dans la protection de l'environnement sous l'angle des compétences écologiques et son impact sur l'innovation verte et l'image des entreprises.

Ainsi **Chen et al. (2008)** ont classé l'innovation verte en innovation verte de produit et innovation verte de procédé pour examiner les effets positifs du cœur des compétences vertes sur ces deux types d'innovation verte ainsi que sur l'image verte des entreprises.

En outre, cette recherche a également exploré, si l'innovation verte de produit et l'innovation verte de procédé ont eu des effets de médiation partielle entre le cœur des compétences vertes et images verte des entreprises.

Les résultats empiriques de cette étude montrent que le cœur des compétences vertes des entreprises avait des effets positifs sur l'innovation verte de produit, et leurs images vertes.

Par contre cette variable n'a pas un effet positif sur l'innovation verte de procédé. En outre, les résultats montrent que l'innovation verte du produit est positivement corrélée à l'image d'entreprise socialement responsable. Dans un autre volé, nous avons trouvé que l'hypothèse de l'effet positif de l'innovation de procédé des entreprises sur leurs images vertes n'a pas été vérifiée.

En fait, les entreprises tunisiennes se trouvent astreintes de prendre en compte les considérations écologiques cela va leur permettre de bénéficier des avantages compétitifs, car leur ouverture sur l'économie internationale les obligent dans tous les cas à être conformes à la réglementation et à la législation internationale. Face aux différentes pressions environnementales, les entreprises industrielles, qui ont déjà une image négative envers la nature, se trouvent obligées de

prendre en compte la contrainte écologique. Ainsi, avoir une image verte est devenu un argument de vente incontestable. En fait, les entreprises qui sont pionnières dans certains nouveaux produits verts pourront profiter des avantages qui leur permettent de demander des prix plus élevés pour les produits verts, à concrétiser la notion de produits écologiques dans la conception et le paquet de leurs produits pour augmenter leurs avantages de différenciation de leurs produits, et d'améliorer encore leurs images de marque ([15], [32], [44], [48], [55], [56]).

La non vérification de certaines hypothèses est peut-être due au manque de conviction et d'implication des dirigeants dans le processus de l'innovation verte de procédé pour des critères stricts liés aux risques de rentabilité, ou à cause du manque des compétences et connaissances nécessaires et suffisantes, ou due à l'incapacité de les combiner en raison de rigidités organisationnelles et aux résistances des salariés aux changements.

De plus, de nombreux responsables d'entreprise affirment qu'ils ne sont pas au courant des solutions technologiques existantes sur le marché. Ces obstacles technologiques sont les plus importants dans les industries ayant un processus de production complexe où l'amélioration des performances est liée à des modifications importantes des installations. Cependant, les solutions technologiques environnementales existent le plus souvent, le problème étant en réalité l'importance des investissements requis pour les mettre en œuvre.

L'appréciation de nos résultats et apports de notre recherche doit cependant tenir compte des **limites de l'étude**.

Sur le plan méthodologique, le nombre des établissements enquêtés (109) est assez réduit pour pouvoir généraliser les résultats. Une taille de l'échantillon plus élevée dans les futures recherches peut garantir la généralisation des résultats.

Certaines hypothèses non vérifiées nous amènent à penser qu'il pourrait être pertinent d'enrichir le modèle par des variables de contrôle tels que : les caractéristiques personnelles du preneur de décision, la taille de l'organisation, le type d'activité (services), la culture verte, ect.

Ainsi, ces limites que présente notre étude peuvent être dépassées dans des futures recherches et peuvent aussi constituer aux intéressés **des nouvelles perspectives de recherches**.

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