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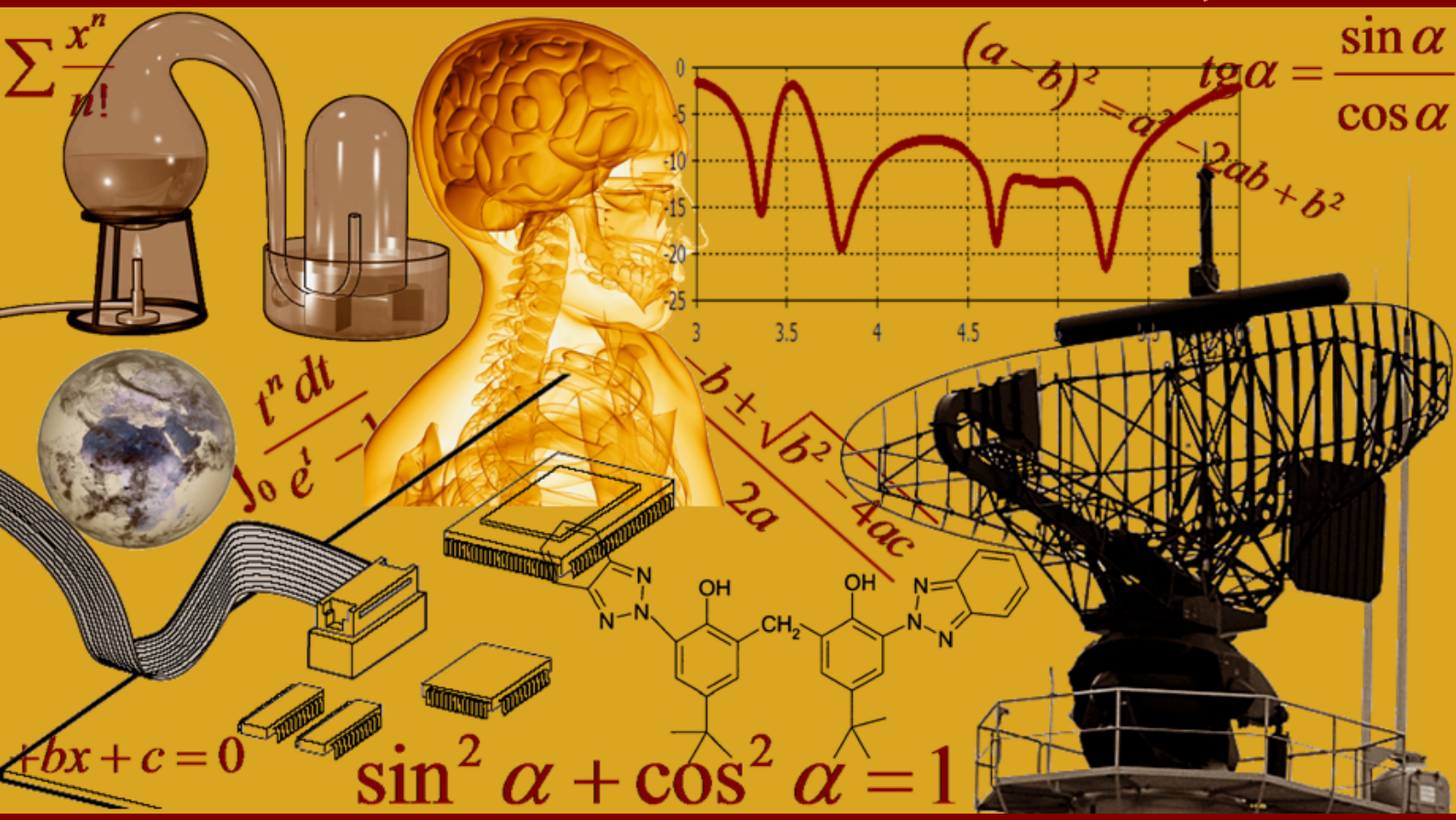

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Improvements of two fatigue criteria based on material parameters

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ABSTRACT: Most of mechanical components in the engineering are frequently subjected to the fatigue damaging process because of the great number of stress cycles they have to undergo. This paper presents an elaboration of two of the most studied methods for the computation of fatigue life in multiaxial fatigue. We describe the reformulation of Sines and Crossland fatigue criteria, which have been adapted so that they could preserve the observed detrimental influence of a tensile mean stress and the observed beneficial effect of a compressive mean bending stress. The proposed reformulation of Crossland and Sines criteria is applied to a general sinusoidal in-phase or out-of-phase bending and torsion stress state, for which analytical formulae can be derived. From the theoretical results calculated according to the present propositions, the criterion proposed by Sines was found to be the most precise in preserving the detrimental influence of a tensile mean stress and the observed beneficial effect of a compressive mean bending stress. On the other hand, the criterion proposed by Crossland was found to be precise in the multiaxial fatigue limit prediction. This analysis shows that the proposed procedure is very efficient, suggesting that Sines and Crossland fatigue criteria remain valuable fatigue evaluation tools for the mechanical design industry.

KEYWORDS: high-cycle fatigue, mean stress effect; fatigue limit; proportional loading, non-proportional loading.

1 INTRODUCTION

A major part of mechanical components in the engineering is subjected to fluctuating loads, which can lead to sudden fatigue failure phenomenon. The durability analysis of these components and structures against fatigue is nowadays a main checking point of the design-engineering field [1], [2], [3].

Multiaxial fatigue criteria are generally associated to the estimate of the fatigue strength under complex loading. Hence, efficient and accurate methodologies for the account of the main factors influencing the fatigue strength of materials (type of loading, temperature, microstructural heterogeneities, residual stresses) under multiaxial stress states are required for use in engineering design application [4], [5], [6].

Many formulation of fatigue criteria have been proposed over years [2], [7]. Two of them that have been widely studied are those proposed by Sines [8] and Crossland [9]. These criteria are well-known criteria and are attractive for engineering design of high cycle fatigue components because easy-to-use; however these solutions are generally the weakest methods; unsafe when used for complex stress states. The main limitation in using the best solutions see [2], [7], [10], in situations of practical interest is that their application requires the definition of nominal parameters such as reference section, nominal stress, equivalent amplitude, etc. Lengthy and quite complicated calculations are required. Crossland and Sines criteria had over years been widely studied for a large number of loading cases: tension, bending, torsion, and combined tension/torsion, in phase or out of phase.

Sines [8] postulated that a mechanical component is in its fatigue limit condition when the following condition is assured:

$$\sqrt{J_{2a}} + \alpha_S \sigma_{H,max} \leq \beta_S . \quad (1)$$

where α_s, and β_s are material constants which can be calculated considering two fatigue limits. The errors between experimental data and the predictions of the Sine's criterion under non-proportional loading are bigger than for proportional loading; dependent on the material [10]. The Sines criterion provides non-conservative predictions for brittle materials [2].

Crossland [9] proposed a popular high-cycle fatigue criterion by considering that the influence of the hydrostatic stress must appear in the fatigue formula by its maximum value.

$$\sqrt{J_{2a}} + \alpha_C \sigma_{H,max} \leq \beta_C \quad (2)$$

This criterion is not sensitive to the detrimental effect of non-zero out-of-phase angles [2], [7]. Using the Papadopoulos minimum circumscribed hyper-ball approach [7] for fatigue damage evaluation, it appears that for biaxial tension with high mean stress, this criterion is too conservative.

The formulation of the Sines criterion is very close to the Crossland criterion, and only the mean stress effect incorporation differs. To preserve the observed detrimental influence of a tensile mean stress, parameters α_s, and α_c are required to be non-negative for a given material; this condition gives the range of applicability of these criteria [11]. A study of the formulation of these two criteria reported in the literature [7], [11] have shown that these two criteria does not give positive values for material parameters as required by the condition of validity of the criteria. Also, the fatigue life prediction widely underestimate the fatigue life [7], [2], [10].

The purpose of this contribution is to present a fatigue analysis procedure in the study of Crossland and Sines criteria, when adapted so as to preserve the observed detrimental influence of a tensile mean stress and the observed beneficial effect of a compressive mean bending stress. For this task the criteria are modified by virtue of a stress transformation that yields equivalent criteria when used to predict the fatigue strength of components subjected to combined tension/torsion, in phase or out of phase cyclic loading.

2 BACKGROUND

The Sines criterion [8] is one of the oldest and best-known criteria [2]. This criterion is written using the fatigue strength proposed in [12] as

$$E_S = \frac{\sqrt{J_{2a}} + \alpha_S \sigma_{H,mean}}{\beta_S} . \quad (3)$$

Where α_s and βs are material parameters derived from two simple uniaxial tests: the fully repeated bending limit f_o and the fully reversed torsion limit t_{-1},

$$\beta_S = t_{-1} \text{ and } \alpha_S = 6\frac{t_{-1}}{f_0} - \sqrt{3} . \quad (4)$$

To preserve the observed detrimental influence of a tensile mean stress the parameter α_s should be non-negative. Sines criterion range of applicability is given by the condition $\alpha_s > 0$, i.e.

$$\frac{t_{-1}}{f_0} > \frac{1}{2\sqrt{3}} . \quad (5)$$

In Eq. (1), $\sqrt{J_{2a}}$ is the amplitude of the square root of the second invariant of the alternating deviator stress tensor and $\sigma_{H,mean}$ is the mean hydrostatic stress. If the fatigue limit in fully repeated bending f_0 is not provided, the Smith-Watson-Topper (SWT) parameter defined in [13] as $f_0 = f_{-1} 2^{0.5}$, is used.

Instead of the mean hydrostatic stress, the Crossland criterion considers the combination of the amplitude of the second invariant of the stress tensor deviator and the maximum hydrostatic stress. Crossland criterion is mathematically expressed through the fatigue strength as:

$$E_C = \frac{\sqrt{J_{2a}} + \alpha_C \sigma_{H,max}}{\beta_C} \ . \tag{6}$$

The material parameters in Crossland criterion are defined as:

$$\beta_C = t_{-1} \text{ and } \alpha_C = 3\left(\frac{t_{-1}}{f_{-1}} - \frac{1}{\sqrt{3}}\right) . \tag{7}$$

$\sigma_{H,max}$ in the expression of Crossland criterion is the maximum hydrostatic stress; and f_{-1}, is the fatigue limits in fully reversed bending. To preserve the observed beneficial effect of a compressive mean bending stress the parameter α_c must be positive. Crossland criterion is valid when $\alpha_c > 0$, i.e.:

$$\frac{t_{-1}}{f_{-1}} > \frac{1}{\sqrt{3}} \ . \tag{8}$$

The preference of Crossland to use the maximum hydrostatic stress instead of the mean hydrostatic stress as Sines has a tremendous effect on the prediction when compared to experimental fatigue tests from literature.

3 MATERIAL AND METHODS

The material parameters α_S and α_c in the criteria proposed Sines and Crossland have to be positive to ensure that the observed detrimental influence of a tensile mean stress and the observed beneficial effect of a compressive mean bending stress is preserved [11]. However as reported in Table 1, for some materials, these constants in Crossland criterion are negative. The principle for the formulation of the adapted criteria presented in this section, is to modify the Sines and Crossland criteria, by introducing a function of √J2a, $\sigma_{H,max}$ / $\sigma_{H,mean}$ and material independent parameter λ, such that the condition of validity will now be λ dependent.

We then calibrate the modified criteria so as to ensure that the adapted formulation renders positive values of the criteria parameters, α'_S and α'_c. In Appendix A and B, derivation of the constants appearing in the adapted criteria are presented.

3.1 ADAPTED SINES CRITERION

Based on the above considerations, the following expression with the same fatigue damage indicator as E_s, was proposed for adapted Sines criterion:

$$\mathrm{E'_S} = \frac{\sqrt{\mathrm{J}_{2a}}\left(1 + \lambda_s\left(\frac{\sigma_{H,mean}}{\sqrt{\mathrm{J}_{2a}}} - \xi\right)\right) + \alpha'_S \sigma_{H,mean}}{\beta'_S} . \tag{9}$$

The parameters α'_S and β'_c can be also obtained from two uniaxial fatigue limits t_{-1} and f_0 (see appendix A). The Sines criterion in Eq. (9), is an extension of the classical Sines criterion Eq. (3).

$$\beta'_S = t_{-1}(1 - \lambda_s \xi) \ ; \tag{10}$$

$$\alpha'_S = 6(1 - \lambda_s \xi)\frac{t_{-1}}{f_0} - \frac{3}{\sqrt{3}}\left(1 + \lambda_s\left(\frac{\sqrt{3}}{3} - \xi\right)\right) \ . \tag{11}$$

For simplicity, ξ in Eq. (11) is chosen such that ξ =√3/3. In other words, $\xi = \sigma_{H,mean} / \sqrt{J_{2a}}$ under fully repeated bending. Thus the adapted Sines criterion is now expressed as:

$$E'_S = \frac{\sqrt{J_{2a}}\left(1+\lambda_s\left(\frac{\sigma_{H,mean}}{\sqrt{J_{2a}}}-\frac{\sqrt{3}}{3}\right)\right)+\alpha'_S\sigma_{H,mean}}{\beta'_S}. \quad (12)$$

The following restrictions

$$\begin{cases}\alpha'_S > 0\\ \beta'_S > 0\end{cases}; \quad (13)$$

give the new range of applicability of the criterion, and now ensure that α'_S is positive for any material, as far as the real λ is chosen so that

$$\lambda_s < \left(\sqrt{3}-\frac{1}{2}\frac{f_0}{t_{-1}}\right). \quad (14)$$

3.2 ADAPTED CROSSLAND CRITERION

Just as in the precedent section, the expression of the extended Crossland criterion is in the form

$$E'_C = \frac{\sqrt{J_{2a}}\left(1+\lambda_c\left(\frac{\sigma_{H,max}}{\sqrt{J_{2a}}}-\xi\right)\right)+\alpha'_C\sigma_{H,max}}{\beta'_C}. \quad (15)$$

Constants α'_c and β'_c are calculated based on material constants under fully reversed torsion t_{-1} and fully reversed bending f_{-1} (see appendix B).

$$\beta'_C = t_{-1}(1-\lambda_c\xi); \quad (16)$$

$$\alpha'_C = 3(1-\lambda\xi)\frac{t_{-1}}{f_{-1}}-\frac{3}{\sqrt{3}}\left(1+\lambda_c\left(\frac{\sqrt{3}}{3}-\xi\right)\right). \quad (17)$$

The restrictions on the values of α'_c and β'_c given in Eq. (16) provides the new range of validity of the adapted criterion, and ensures that α'_c is always positive.

$$\begin{cases}\alpha'_C > 0\\ \beta'_C > 0\end{cases} \quad (18)$$

For simplicity, the value of the real parameter ξ is taken to be √3/3 and the Crossland criterion now preserves the experimental observation that requires a positive value for α'_c. The real lambda have to satisfy

$$\lambda_c < \left(\sqrt{3}-\frac{f_{-1}}{t_{-1}}\right). \quad (19)$$

Thus the adapted Crossland criterion is simply expressed as:

$$E'_C = \frac{\sqrt{J_{2a}}\left(1+\lambda_c\left(\frac{\sigma_{H,max}}{\sqrt{J_{2a}}}-\frac{\sqrt{3}}{3}\right)\right)+\alpha'_C\sigma_{H,max}}{\beta'_C}. \quad (20)$$

4 RESULTS AND DISCUSSION

In other to show the accuracy of the adapted criteria to preserve the observed beneficial effect of a compressive mean bending stress or the observed detrimental influence of a tensile mean stress in estimating high cycle fatigue strength under multiaxial fatigue loading, results from a systematic bibliographical investigation on un-notched samples reported in [14] are used.

Table 1 summarizes the fatigue properties of the materials, that is the values α_C, α'_C, α_S and α'_S obtained from the original and adapted criteria. The value of parameter lambda in the computation was taken to be $\lambda_s = \lambda_c = -2$.

One can clearly see from Table 1 the negative values of the parameter α_C in Crossland criterion, obtained for different materials. These negative values are now made positive, α'_C, using the adapted Crossland criterion. The criterion proposed by Sines criterion is most precise in preserving the detrimental influence of a tensile mean stress and the observed beneficial effect of a compressive mean bending stress since the computed values of α_S, α'_S are positive.

Further, the accuracy of the new adapted fatigue criteria to coincide with the original formulations when predicting fatigue failure is determined by comparing the proximity of the predicted total damage *E*, to unity, Eq. (21). The predicted fatigue damage indicator *I* measures the relative difference between the estimation of the criterion and the experimental data. A negative value of the damage indicator *I* means that, the criterion predicts a greater fatigue limit than experimental one; resulting in a non-conservative prediction.

$$I = \frac{E-1}{1}\times 100\%. \quad (21)$$

Conversely, a positive value of *I* corresponds to a conservative prediction. If the error index *I* is close to zero, it means that the agreement is good between prediction and experimental results. The error index *I* is expressed as:

Table 1. Material parameters of un-notched materials [14], where α_C is the Crossland material parameter, α'_C the adapted Crossland material parameter, α_s the Sines material parameter, α'_s the adapted Sines material parameter

Material	t_{-1}	f_{-1}	t_{-1}/f_{-1}	α_C	α'_C	α_s	α'_s
0.1% C steel (normalised)	151.3	268.6	0.56	-0.04	1.91	53.66	117.62
0.4% C steel (spheroidized)	155.9	274.8	0.57	-0.03	1.94	54.70	119.85
NiCrMoVa steel	342.7	660.7	0.52	-0.18	1.62	78.26	170.63
NiCr steel (Solid samples)	369.7	666.7	0.55	-0.07	1.85	84.18	183.37
NiCr steel (Hollow samples)	339.6	653.2	0.52	-0.17	1.63	77.99	170.05
0.34% C steel	218	378	0.58	-0.00	2.00	65.54	143.23
Mild Steel	137.3	235.4	0.58	0.02	2.04	51.86	113.96
St35	130	230	0.57	-0.04	1.92	49.70	109.09
XC18	186	332	0.56	-0.05	1.89	59.52	130.24
High strength steel	364	630	0.58	0.00	2.00	85.28	185.75

Table 2 represent relevant experimental results, available in the literature, concerning synchronous in-phase or out-of-phase sinusoidal loading experiments on different materials coming from [6]. The out-of-phase bending and torsion, as is known, is the starting point for the theoretical study of many researchers [4]. Therefore this loading case is considered in the following for the prediction of the fatigue limit.

The following non-proportional to proportional stress transformation that can improve stress invariants based criteria accurately for fatigue evaluation under out-of-phase multiaxial loading is used to compute the error index in Sines and Crossland criteria. Under bending-torsion sinusoidal signals, the time histories of the axial stress, $\sigma_{xx}(t)$, and of the shear stress, $\tau_{xy}(t)$, can be expressed as follows:

$$\begin{cases}\sigma_{xx}(t) = \sigma_{xx,m} + \sigma_{xx,a}\sin(\omega t);\\ \tau_{xy}(t) = \tau_{xy,m} + \tau_{xy,a}\sin(\omega t - \beta).\end{cases} \quad (22)$$

Where *m* identifies the mean value of the signals, *a* the amplitudes and, finally, β is the phase shift between the applied stress components, n is a material dependent parameter.
We proposed to take into account the effect of the non-proportionality of the applied load in the computation of Sines and Crossland criteria [3] ,[7], [10], by proposing the following equivalent fatigue proportional stress state of Eq. (22), as:

$$\begin{cases}\sigma'_{xx}(t) = \sigma_{x,m} + \sigma_{x,a}\,sin(\omega t);\\ \tau'_{xy}(t) = \tau_{xy,m} + \tau_{xy,a}\left(\left|cos\,\beta' + sin\,\beta'\right|\right)^{n} sin(\omega t);\\ \beta' = (\delta_{0\beta} - 1 + \beta);\\ n = f_{-1}^{\,-0.60}.\end{cases} \quad (23)$$

In the above expression, $\delta_{0\beta}$ is the kronecker delta defined for an arbitrary phase shift angle β as

$$\delta_{0\beta} = \begin{cases}1 \;\; if \;\; \beta = 0\\ 0 \;\; if \;\; \beta \neq 0\end{cases}. \quad (24)$$

For the results of predictions grouped together in Table 2, the error index I_c *(%)*, refers to the results of Crossland criterion, I'_c*(%)* to the adapted Crossland criterion; I_s*(%)* to Sines criterion, I'_s*(%)* to the adapted Sines criterion.

Table 2. Fatigue strength of hard steel (f_{-1}=313.19 MPa, t_{-1}=196.2 MPa, R_m= 680 MPa)

$\sigma_{xx,a}$	$\sigma_{xx,m}$	$\sigma_{xy,a}$	$\sigma_{xx,m}$	β(°)	I_c(%)	I'_c(%)	I_s(%)	I'_s(%)
138.1	0	167.1	0	0	-2.3	-2.3	-5.6	-5.6
140.4	0	169.9	0	30	0.1	0.1	-3.3	-3.3
145.7	0	176.3	0	60	3.9	3.9	0.4	0.4
150.2	0	181.7	0	90	6.3	6.3	2.7	2.7
245.3	0	122.6	0	0	1.4	1.4	-4.5	-4.5
249.7	0	124.8	0	30	3.7	3.7	-2.4	-2.4
252.4	0	126.2	0	60	4.8	4.8	-1.3	-1.3
258.0	0	129.0	0	90	6.7	6.7	0.5	0.5
299.1	0	62.8	0	0	0.9	0.9	-6.3	-6.3
304.5	0	63.9	0	90	2.7	2.7	-4.7	-4.7

The predicted fatigue damage indicators using the original Crossland criterion I_c are equivalent to the values obtained using the proposed adapted Crossland criterion, I'_c. Similarly, the same agreement between I_s and I'_s values is observed using the Sines criterion. This results indicate that our proposition of the adapted criteria are successful in accounting the mean stress effect while preserving the good predictions for in phase proportional loadings. The non - proportional to proportional stress transformation was useful in accounting the non-zero-out-of-phase effects by the studied criteria.

From the results reported in Table 2, we calculated the average error index I^{avr} *(%)*. For the criterion proposed by Crossland, we obtained $I_c^{\,avr}$ *= 2.82 % (%)*; whereas for Sines criterion we had $I_s^{\,avr}$ *= -2.45 %***.** The positive value of the error index obtained from Crossland criterion ($I_c^{\,avr}$ *= 2.82 %)*, means that the criterion yields conservative results. Thus Crossland criterion with the non-proportional to proportional computation approach is the most successful in the fatigue limit prediction as widely reported in the literature for results obtained with the minimum circumscribed ellipse approach [6] and minimum circumscribed hyper-ball approach [7].

5 CONCLUSIONS

The proposed and tested method of adapted criteria seems to be easy in application. Its implementation give positive values for material parameters as required by the condition of validity of the criteria. The use of the adapted criteria to predict fatigue limits shows that the adapted criteria is an extension of the studied classical fatigue criteria as expected.

With the use of the non-proportional to proportional stress transformation, results reported in Table 2 shows that a stress invariant-based multiaxial fatigue criterion, such as the Sines criterion can be applied with improved accuracy for fatigue evaluation under out-of-phase multiaxial loading. The approach allow the Sines criterion to behave correctly under out-of-phase loading, by the reduction of the very large scatter of results due to the too strong phase shift effect, which is further increased by the improper mean stress effect [2], [7]. The method proposed in the present paper must be generalized for asynchronous fatigue loads with random stress waveforms. The other problem is the study of materials under fluctuating thermal loads, by using the proposed adapted criteria. These topics are in-progress.

REFERENCES

[1] I.V. Papadopoulos, "Long life fatigue under multiaxial loading," *International Journal of Fatigue*, vol. 23, pp. 839 – 849, 2001.

[2] J. Papuga, "A survey on evaluating the fatigue limit under multiaxial loading," *International Journal of Fatigue*, vol. 33, pp. 153 – 165, 2011.

[3] L. Augustins, "An empirical multiaxial high cycle fatigue criterion for automotive cylinder head design," *Engineering Failure Analysis*, vol. 28, pp. 264–274, 2013.

[4] D. Skibicki, A fatigue failure criterion for multiaxial loading with phase shift and mean value, "*Journal of Theoretical and Applied Mechanics*," vol. 42, no. 2, pp. 295 - 314, 2004.

[5] M. Mrzygłód and A. P. Zieliński, "Numerial implementation of multiaxial high-cycle fatigue criterion to structural optimization," *Journal of Theoretical and Applied Mechanics*, vol. 44, no. 3, pp. 691 - 712, 2006.

[6] B. Li, L. Reis, M. de Freitas, "Comparative study of multiaxial fatigue damage models for ductile structural steels and brittle materials," *International Journal of Fatigue*, vol.31, pp. 1895–1906, 2009.

[7] I.V. Papadopoulos, P. Davoli, C. Gorla, M. Filippini, A. Bernasconi, "A comparative study of multiaxial high-cycle fatigue criteria for metals," *International Journal of Fatigue*, vol. 19, no. 3, pp. 219 - 235, 1997.

[8] G. Sines, Behaviour of metals under complex stresses, In: Sines G, Waisman JL, Editors, Metal fatigue, New York McGraw-Hill, 1959.

[9] B. Crossland, "Effect of large hydrostatic pressures on the torsional fatigue strength of an alloy steel," In: Proceedings of the *International Conference on fatigue of metals*, Institution of Mechanical Engineers, London, 13849, 1956.

[10] Y.Y. Wang and W.X. Yao, "Evaluation and comparison of several multiaxial fatigue criteria," *International Journal of Fatigue,* vol. 26, no.1, pp. 17-25, 2004.

[11] L. Yongming, S. Brant, M. Sankaran, "Fatigue crack initiation life prediction of railroad wheels," *International Journal of Fatigue*, vol.28, pp. 747 – 756, 2006.

[12] I. V. Papadopoulos, "A High-Cycle Fatigue Criterion applied in Biaxial and Triaxial Out-of-Phase stress conditions", *Fatigue Fracture Engineering Material Structures*, vol. 18, pp. 79-91, 1995.

[13] N. E. Dowling, "Mean Stress Effects in Stress-Life and Strain-Life Fatigue", SAE, no. 2004-01-2227, Fatigue 2004: Second *SAE Brazil International Conference on Fatigue*, São Paulo, Brazil, 2004.

[14] L. Susmel, "On the overall accuracy of the modified Wöhler curve method in estimating high-cycle multiaxial fatigue strength", *Frattura ed Integrità Strutturale*, VOL; 16, PP; 5-17, 2011.

APPENDIX. A DETERMINATION OF THE CONSTANTS OF SINES CRITERION

The new constants of the Sines criterion are determined from the limit of fatigue in fully reversed torsion t_{-1} and repeated bending f_0.

For fully reversed torsion, one has

$$\sqrt{J_{2a}} = t_{-1} \; and \; \sigma_{H,m} = 0 \, . \tag{A.1}$$

From the application of the adapted criterion, given in Eq. (7), with a maximum allowable damage of unity one finds that

$$\beta'_S = t_{-1}\left(1 - \lambda\xi\right). \tag{A.2}$$

For fully repeated bending test,

$$\sqrt{J_{2a}} = \frac{f_0}{2\sqrt{3}} \; and \; \sigma_{H,m} = \frac{f_0}{6} \; . \tag{A.3}$$

And the expression of parameter α'_S obtained from Eq. (7), assuming a maximum allowable damage of unity is given as

$$\alpha'_S = 6\left(1 - \lambda\xi\right)\frac{t_{-1}}{f_0} - \frac{3}{\sqrt{3}}\left(1 + \lambda\left(\frac{\sqrt{3}}{3} - \xi\right)\right). \tag{A.4}$$

APPENDIX. B DETERMINATION OF THE CONSTANTS OF CROSSLAND CRITERION

The identification of the parameters α'_c and β'_c of the adapted Crossland criterion, we needs the knowledge of two uniaxial fatigue limits, t_{-1} and f_{-1}.

From fully reversed torsion, one has

$$\sqrt{J_{2a}} = t_{-1} \; and \; \sigma_{H,\max} = 0 \, . \tag{B.1}$$

Application of the criterion, as expressed in Eq. (13) provides the material parameter β'_c as

$$\beta'_C = t_{-1}\left(1 - \lambda\xi\right). \tag{B.2}$$

From fully reversed bending test,

$$\sqrt{J_{2a}} = \frac{f_{-1}}{\sqrt{3}} \; and \; \sigma_{H,\max} = \frac{f_{-1}}{3} \, . \tag{B.3}$$

One finds the expression of parameter α'_c using Eq. (13) as:

$$\alpha'_C = 3\left(1 - \lambda\xi\right)\frac{t_{-1}}{f_{-1}} - \frac{3}{\sqrt{3}}\left(1 + \lambda\left(\frac{\sqrt{3}}{3} - \xi\right)\right). \tag{B.4}$$

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Extension anisotherme des critères pour la fatigue polycyclique isotherme

[Anisothermal extension of criteria for isothermal high cycle fatigue]

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ABSTRACT: In many situations encountered in engineering practice, structures or structural elements are under thermomechanical cycles of loading. The use in this condition of traditional fatigue criteria in high cycle fatigue is no more advisable because on structures, these criteria are formulated for the prediction of the number of cycles for the nucleation of cracks in the isothermal situation. In this paper, we propose an extension of stress invariants based criteria, for the anisothermal high cycle fatigue. Our proposal is essentially based on the hypothesis of accommodation at macroscopic and microscopic levels. The simulation made from the fatigue strength of the proposed ansiothermal criterion reproduced qualitatively the expected results. The proposed modified criteria will enhance the account the account of the multiaxial and anisothermal character of thermomechanical loadings.

KEYWORDS: thermomechanical fatigue, Crossland, fatigue limit, accommodation, fatigue strength.

RESUME: Dans beaucoup de situations couramment rencontrées en ingénierie, les structures ou éléments de structures sont soumis à des chargements thermomécaniques cycliques. L'utilisation dans ces conditions des critères traditionnels en fatigue polycyclique n'est plus indiqué, car ils sont formulés pour la prédiction sur structure de l'amorçage de fissure de fatigue dans le cas isotherme. Dans cet article, nous proposons une extension des critères de l'approche par invariants de contraintes pour la fatigue polycyclique anisotherme. La proposition est essentiellement fondée sur l'hypothèse d'adaptation aux échelles macroscopique et mésoscopique. Les simulations faites à partir de la fonction de fatigue du critère anisotherme proposé reproduisent qualitativement les résultats attendus. Les critères ainsi proposés permettront une prise en compte du caractère multiaxial et anisotherme des chargements thermomécaniques.

MOTS-CLEFS: fatigue thermomécanique, Crossland, limite d'endurance, adaptation, fonction de fatigue.

1 INTRODUCTION

Les critères en fatigue polycyclique des métaux ont historiquement été formulés pour la prédiction sur structure de l'amorçage de fissures de fatigue dans le cas isotherme. Dans le cas de chargements multiaxiaux cycliques thermomécaniques ou anisothermes, le comportement du matériau est en général élastoplastique ou viscoplastique.

Comme le indiqué par [1], [2], Il devient assez difficile de généraliser les critères classiques de la fatigue polycyclique pour prendre en compte les effets de la température.

D'après [3], les structures soumises à des chargements cycliques présentent différents types de comportement asymptotique: l'adaptation, l'accommodation ou le rochet. Lorsque la structure soumise à des chargements anisotherme endure un grand nombre de cycles, les déformations plastiques se stabilisent et le comportement cyclique redevient purement élastique avec apparition de contraintes résiduelles. On parle alors d'adaptation élastoplastique. Ce comportement est à la base de phénomènes de fatigue à grand nombre de cycles.

Les critères en fatigue polycyclique sont traditionnellement utilisés pour la prédiction sur structure de l'amorçage de fissure de fatigue dans le cas isotherme. Ils peuvent être utilisés pour les chargements thermiques lorsque les variations de température influent peu sur les caractéristiques du comportement en fatigue à grand nombre de cycles des matériaux constitutifs [4], [5].

Les problèmes de structures soumises à des chargements thermomécaniques sont nombreux: moteurs, réacteurs, rail soumis au roulement d'une roue, pneu soumis à la pression de la route, engrenages, disque de frein, courroie de distribution, pompes à chaleur, [1], [6]. Ces chargements thermomécaniques produisent des écarts de températures dont l'influence est non négligeable sur les caractéristiques de la fatigue du matériau. Pour toute prédiction fiable de la tenue en fatigue, cette influence doit être prise en compte.

Une approche multi-échelle des critères de fatigue polycyclique a été proposée voir [4], puis reprise [4]. Cette approche permettait une généralisation des critères de Dang Van et de Papadopoulos aux chargements anisotherme.

Le critère de Crossland [7] largement utilisé en fatigue polycyclique isotherme à cause de sa mise en œuvre assez simple, est construit tout comme les critères de Dang Van et de Papadopoulos à partir de la combinaison linéaire de deux paramètres, dont la pression hydrostatique maximale. Nous exploitons les résultats obtenus dans les travaux précédant [4], [5] pour proposer une reformulation du critère de Crossland dans le cas de structures subissant des chargements cycliques anisotherme. Les modèles sont validés par simulation numérique sur le cas d'une éprouvette encastrée et soumise à des cycles thermiques.

2 DESCRIPTION DE L'APPROCHE ISOTHERME – ANISOTHERME

L'extension anisotherme des critères de Dang Van et Papadopoulos [4] repose sur l'utilisation de la condition locale d'adaptation écrite dans le cas anisotherme, voir [8]. Plus Concrètement, les auteurs imposent la compatibilité entre le critère en fatigue polycyclique isotherme avec l'écriture anisotherme de la condition locale d'adaptation qui prend en compte les variations des limites d'élasticité en fonction de la température. Cette compatibilité se traduit dans la formulation des critères en fatigue polycyclique anisotherme par la dépendance à la température des caractéristiques en fatigue du matériau.

Dans le cas d'un chargement anisotherme, l'extension du critère de fatigue de Dang Van macroscopique [4], [5], prenant en compte l'écriture anisotherme de la condition d'adaptation s'écrit:

$$\min_{S^T}\left\{\max_t\left[\frac{\left\|\tau\left[S(t)-S^T\right]\right\|}{\beta_D(\theta(t))}-1\right]\right\}+\max_t\left\{\alpha_D(\theta(t))P(t)\right\}<0 \tag{1}$$

Les nouvelles fonctions caractéristiques du matériau *(α_D ($\vartheta(t)$),* β_D *($\vartheta(t)$))* dépendent de la température, *$\vartheta(t)$*. La détermination de ces paramètres du matériau à partir des limites d'endurance en flexion alternée *$f_{-1}(\vartheta)$* et en torsion alternée *$t_{-1}(\vartheta)$* évaluées sur des essais effectués à différentes températures *ϑ* constantes donnent :

$$\beta_D(\theta)=t_{-1}(\theta) \text{ et } \alpha_D(\theta)=\frac{t_{-1}(\theta)-\frac{f_{-1}(\theta)}{\sqrt{3}}}{t_{-1}(\theta)\frac{f_{-1}(\theta)}{3}}. \tag{2}$$

L'extension du premier critère de Papadopoulos en fonction des contraintes macroscopique proposé jusqu'ici [4], s'écrit sous la forme:

$$\frac{1}{\sqrt{2}}\min_{S^T}\left\{\max_t\left[\frac{\left\|\tau\left[S(t)-S^T\right]\right\|}{\beta_P(\theta(t))}-1\right]\right\}+\max_t\left\{\alpha_P(\theta(t))P(t)\right\}<0\,. \tag{3}$$

$\alpha_P(\vartheta(t))$ et $\beta_P(\vartheta(t))$ sont des fonctions caractéristiques du matériau. À partir des limites d'endurance en flexion alternée $f_{-1}(\vartheta)$ et en torsion alternée $\tau_{-1}(\vartheta)$ évaluées sur des essais effectués à différentes températures ϑ constantes on a :

$$\beta_P(\theta)=t_{-1}(\theta)\text{ et }\alpha_P(\theta)=\frac{t_{-1}(\theta)-\frac{f_{-1}(\theta)}{\sqrt{3}}}{t_{-1}(\theta)\frac{f_{-1}(\theta)}{3}} \tag{4}$$

Nous constatons que les critères de Dang Van et Papadopoulos en fatigue polycyclique anisotherme résultant de la condition locale d'adaptation écrite dans le cas anisotherme ont permis de justifier la réécriture des critères en fatigue polycyclique anisotherme avec une dépendance à la température des constantes du matériaux. Nous proposons les modifications ci-dessus du critère de Crossland pour l'intégration du caractère anisotherme de l'histoire du chargement.

3 FORMULATION ANISOTHERME DU CRITÈRE DE CROSSLAND

Le critère de Crossland, en fatigue polycyclique isotherme s'exprime par

$$\sqrt{J_{2a}}+\alpha_C\sigma_{H,max}<\beta_C\,; \tag{5}$$

$$\beta_C=t_{-1}\text{ et }\alpha_C=\frac{3}{f_{-1}}\left(t_{-1}-\frac{f_{-1}}{\sqrt{3}}\right). \tag{6}$$

À partir des limites d'endurance en flexion alternée à f_{-1} et en torsion alternée t_{-1} évaluées sur des essais effectués à la température ϑ, constantes. L'expression équivalente du critère de Crossland peut s'obtenir sous la forme

$$\sqrt{J_{2a}}\left(1+\lambda\left(\frac{\sigma_{H,max}}{\sqrt{J_{2a}}}-\frac{\sqrt{3}}{3}\right)\right)+\alpha'_C\sigma_{H,max}<\beta'_C\;\; ; \tag{7}$$

$$\beta'_C=t_{-1}\left(1-\lambda\frac{\sqrt{3}}{3}\right)\text{ et }\alpha'_C=3\left[\left(1-\lambda\frac{\sqrt{3}}{3}\right)\frac{t_{-1}}{f_{-1}}-\frac{1}{\sqrt{3}}\right]\,. \tag{8}$$

Dans l'expression du critère équivalent, Eq. (6), le paramètre λ est une constante sans influence sur les prédictions faites avec le critère. La particularité du chargement anisotherme étant les fluctuations thermiques, les fluctuations pourraient désormais être prises en compte par une réinterprétation du paramètre λ.

En postulant la dépendance du paramètre λ à la température dans le cas de la fatigue anisotherme, la dépendance à la température des constantes du critère tel que prédit par [4], [5], s'exprime comme

$$\begin{cases}\beta'_C(\lambda)=\tau_{-1}(\theta)\left(1-\lambda(\theta)\frac{\sqrt{3}}{3}\right)=\beta'_C(\theta)\\ \alpha'_C(\lambda)=3\left[\left(1-\lambda(\theta)\frac{\sqrt{3}}{3}\right)\frac{t_{-1}(\theta)}{f_{-1}(\theta)}-\frac{1}{\sqrt{3}}\right]=\alpha'_C(\theta)\end{cases}. \tag{9}$$

L'expression (9) suggère deux possibilités d'intégration de l'information thermique dans un critère. La première modélisation se fait à partir des limites d'endurance à la température constante ϑ, i.e., t_{-1} et f_{-1};

$$\begin{cases} \beta''_C(\theta) = t_{-1}\left(1-\lambda(\theta)\dfrac{\sqrt{3}}{3}\right) \\ \alpha''_C(\theta) = 3\left[\left(1-\lambda(\theta)\dfrac{\sqrt{3}}{3}\right)\dfrac{t_{-1}}{f_{-1}} - \dfrac{1}{\sqrt{3}}\right] \end{cases}. \quad (10)$$

L'expression du critère de Crossland anisotherme étant

$$\sqrt{J_{2a}}\left(1-\lambda(\theta)\left(\frac{\sigma_{H,max}}{\sqrt{J_{2a}}}-\frac{\sqrt{3}}{3}\right)\right)+\alpha''_C(\theta)\sigma_{H,max} < \beta''_C(\theta). \quad (11)$$

Dans la deuxième modélisation du critère, nous intégrons dans l'expression du critère la variation continue des limites de fatigue avec la température, et le critère est formulé sous la forme:

$$\sqrt{J_{2a}}\left(1-\lambda(\theta)\left(\frac{\sigma_{H,max}}{\sqrt{J_{2a}}}-\frac{\sqrt{3}}{3}\right)\right)+\alpha'''_C(\theta)\sigma_{H,max} < \beta'''_C(\theta)\ ; \quad (12)$$

$$\begin{cases} \beta'''_C(\theta) = \max\left(t_{-1}(\theta)\right)\left(1-\lambda\dfrac{\sqrt{3}}{3}\right) \\ \alpha'''_C(\theta) = 3\left[\dfrac{\max\left(t_{-1}(\theta)\right)}{\min\left(f_{-1}(\theta)\right)}\left(1-\lambda\dfrac{\sqrt{3}}{3}\right)-\dfrac{1}{\sqrt{3}}\right] \end{cases}. \quad (13)$$

4 RÉSULTATS ET DISCUSSION

Les chargements réels, multiaxiaux et d'amplitude variables, sont des chargements relativement complexes. D'après [9], on peut admettre en première approximation qu'un modèle pourra décrire une situation de chargement complexe s'il peut décrire un ensemble d'essais de base.

Ainsi cette dernière section nous nous proposons de valider les différentes modifications faites sur le critère de Crossland pour son extension aux sollicitations anisothermes. Les critères isotherme et anisotherme sont appliqués aux cycles de contraintes et de température issus des calculs thermomécaniques. A notre connaissance, très peu d'études expérimentales sont consacrées au comportement cyclique des matériaux en fatigue anisotherme polycyclique.

L'étude faite par [4] porte sur le cas simple d'une éprouvette encastrée ; initialement à la température T_0, et soumise à des cycles de variations sinusoïdales de température uniforme:

$$T(t) = 140\,°C + T_a \sin(t)\ ; \quad (14)$$

$$\begin{cases} T_{moy} = 140°C \\ T_a \in [68.5\,°C, 120\,°C]. \\ T_0 = 120\,°C \end{cases} \quad (15)$$

Dans ce cas, l'expression proposée pour la prise en compte de température dans les modèles proposés (Eq. (11), Eq. (12)) est:

$$\lambda(\theta) = \max T(t) = T_{moy} + T_a \quad (16)$$

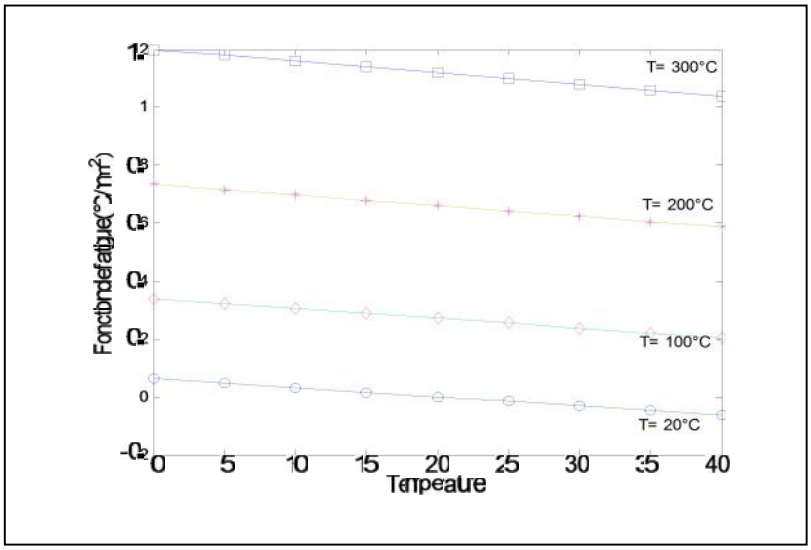

Fig. 1 : Variations de la fonction de fatigue en fonction de la température ambiante

Les limites d'endurance en flexion alternée f_{-1} et en torsion alternée τ_{-1} à différentes températures du matériau sont donnée au Tableau 1. Les figures ci-dessous présentent l'influence de la température initiale sur le comportement en fatigue anisotherme, lorsque la température de l'éprouvette est 20 °C, 100 °C, 200 °C, et 300 °C.

Table 1 : Variation des limites d'endurance a différentes températures [4]

Temperature	f_{-1}(MPa)	t_{-1}(MPa)
20°C	312	200
100°C	294.3	188.5
200°C	272.2	174.2
300°C	250	160

Les deux formulations anisotherme du critère donnent une estimation de la tenue dont la sévérité est encadrée par celles des critères isothermes pris à température minimale et maximale tel que représenté à la Fig. 2 et Fig. 3. Cette simulation reproduit qualitativement les résultats attendus.

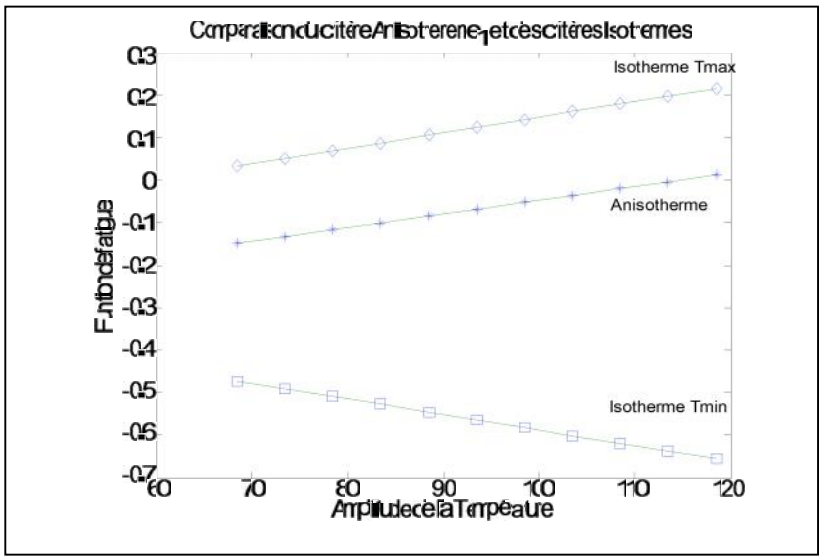

Fig. 2 : Comparaison du critère anisotherme et du critère isotherme, Eq. (11) (à $T=T_{min}$ et $T=T_{max}$).

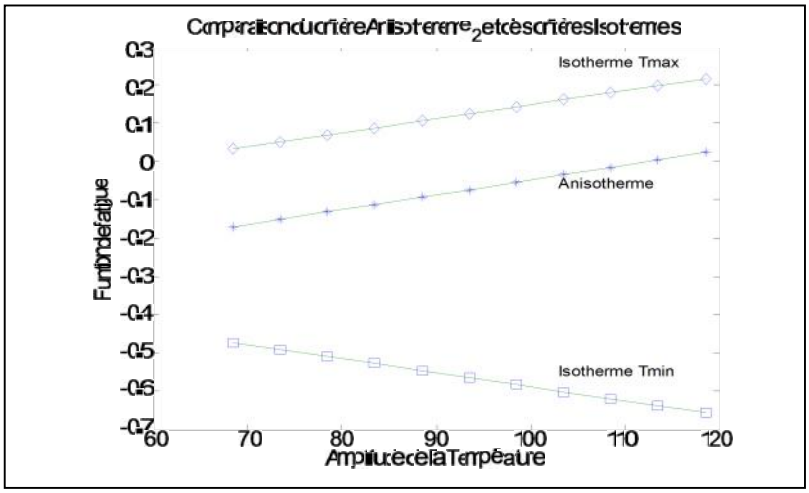

Fig. 3 : Comparaison du critère anisotherme et du critère isotherme, Eq. (12) (à $T=T_{min}$ et $T=T_{max}$)

5 CONCLUSION

Le modèle équivalent du critère de Crossland a permis dans cette étude, la proposition d'une extension anisotherme du critère de Crossland, qui initialement est un critère isotherme purement mécanique. Le paramètre λ, représente pour nous, le paramètre d'extension du critère purement mécanique pour une prise en compte du caractère thermomécanique des sollicitations en fatigue polycyclique à grand nombre de cycles.

Les simulations obtenues reproduisent qualitativement les résultats attendus, car les deux formulations anisotherme du critère donnent une estimation de la tenue dont la sévérité est encadrée par celles des critères isothermes pris à température minimale et maximale. L'utilisation de ces deux modèles pour la prédiction de la l'imite d'endurance en fatigue anisotherme permettra de comparer quantitativement leur capacité de prédiction. En outre, l'intégration des incertitudes affectant le comportement en fatigue anisotherme font l'objet de travaux en cours.

REFERENCES

[1] A. Benoit, M.H. Maitournam, L. Remy, F. Oger, "Cyclic behaviour of structures under thermomechanical loadings: Application to exhaust manifolds," *International Journal of Fatigue*, vol. 38, pp. 65–74, 2012.

[2] M.H. Maitournam, C. Krebs, A. Galtier, "A multiscale fatigue life model for complex cyclic multiaxial loading," *International Journal of Fatigue*, vol. 33, no. 2, pp. 232-240, 2011.

[3] C. Bouby, "Adaptation élastoplastique de structures sous chargements variables avec règle d'écrouissage cinématique non linéaire et non associée, " Thèse de Doctorat, Université des Sciences et Technologies de Lille, 2006.

[4] M.H. Maitournam, T. M. L. Nguyen-Tajan, "Approche multi-échelle en fatigue polycyclique anisotherme, " *C. R. Acad. Sci. Paris, Série IIb, Mécanique des solides et des structures*, pp. 373-379, 2000.

[5] T. M. L. Nguyen-Tajan, "Modélisation thermomécanique des disques de frein par une approche eulérienne", Thèse de Doctorat, Ecole Polytechnique, 2002.

[6] A. Constantinescu, E. Charkaluk, G. Lederer, L. Verger, "A computational approach to thermomechanical fatigue," *International Journal of Fatigue*, vol. 26, pp. 805–818, 2004.

[7] B. Crossland, "Effect of large hydrostatic pressure on the torsional fatigue strength of an alloy steel," *In: Proc int conf on fatigue of metals. London: Institution of Mechanical Engineers, pp.* 138–49, 1956.

[8] J. Mandel, J. Zarka, B. Halphen, "Adaptation d'une structure élastoplastique à écrouissage cinématique, " *Mechanics. Research Communications*, vol. 4, pp. 309–314, 1977.

[9] Z. Guéde, B. Sudre, M. Lemaire, "Life-time reliability based assessment of structures submitted to thermal fatigue," *International Journal of Fatigue*, vol. 29, pp. 1359–1373, 2007.

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GAZANIA RIGENS, UN NOUVEL HOTE D'*OROBANCHE MINOR* AU MAROC

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ABSTRACT: In this study we noted, for the first time in Morocco, the parasitism of *Orobanche minor* on *Gazania rigens*, an ornamental plant in urban spaces.

KEYWORDS: Gazania rigens, Orobanche minor, parasitism.

RESUME: Dans cette étude, nous avons noté pour la première fois au Maroc, le parasitisme *d'Orobanche minor* sur *Gazania rigens*, une plante ornementale des espaces urbains.

MOTS-CLEFS: Gazania rigens, Orobanche minor, parasitisme.

1 INTRODUCTION

Les orobanches sont des phanérogames holoparasites qui se développent sur les racines de plusieurs espèces végétales [1]. Ce sont des dicotylédones de la famille des *Orobanchacées* qui contient quinze genres. Le genre *Orobanche* est estimé à 150 espèces [2].

Les orobanches parasitant les dicotylédones ont une large gamme d'hôtes appartenant aux Fabacées, Solanacées, Astéracées et d'autres familles [3]. Plusieurs espèces sont reconnues très dangereuses et provoquent de nombreuses dégâts sur les espèces cultivées et également sur des espèces spontanées [4]. Les espèces *Orobanche crenata*, *O. ramosa, O. aegyptiaca, O. foetida, O. cernua et O. minor*, sont les plus redoutables et posent de sérieux problèmes à un grand nombre de cultures et de plantes ornementales [2].

Au Maroc beaucoup d'études se sont penchées sur le parasitisme de différentes espèces d'Orobanche, particulièrement dans les cultures des légumineuses alimentaires, vu les dégâts qu'elles occasionnent [5] et [6]. Par contre, les études sur le parasitisme des plantes ornementales par les orobanches au Maroc sont inexistantes.

Sur le pourtour méditerranéen, des études signalent le parasitisme des plantes sauvages [7] par différentes espèces d'orobanche et aussi des plantes ornementales et cultivées [8] et [9].

2 MATERIEL ET METHODES

Durant les prospections effectuées dans les différents espaces verts de la ville de Kénitra et Rabat, nous avons pu observer un type de parasitisme d'une espèce d'orobanche sur *Gazania regens*, plante ornementale bien répondue dans les espaces urbains de la ville de Kénitra et Rabat. L'espèce d'orobanche qui parasite cette plante ornementale est une plante herbacée annuelle, hermaphrodite, de taille très variable (10-50 cm). La tige est dressée, jaunâtre, souvent teintée de rouge ou de pourpre, poilue-glanduleuse, renflée à la base. Les feuilles sont alternes, sessiles, à limbe ovale à lancéolé.

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L'inflorescence est un épi simple, lâche dans le bas; bractée environ aussi longue que la fleur; corolle longue de 10 à 18 mm velue-glanduleuse, jaunâtre teinté de violet, tubuleuse, bilabiée à lèvre inférieure trilobée, non ciliée et lèvre supérieure dirigée en avant dans le prolongement du tube; les étamines sont au nombre de quatre insérées vers le tiers inférieur du tube de la corolle, à filet subglabre, le stigmate est jaune, rarement pourpre, le fruit est une capsule, il s'agit d'*Orobanche minor*.

Des spécimens de ce parasite sont conservés dans l'herbier du Laboratoire de Botanique et de Protection des Plantes (Faculté des Sciences de Kenitra).

Figure 1 : Gazania rigens parasitée par Orobanche minor

Figure 2 : A et B; Racines de Gazania rigens parasitée par Orobanche minor

3 RESULTATS ET DISCUSSION

Orobanche minor est largement répondue en Europe sur le trèfle [3]. De même, parmi les hôtes les plus touchés par cette espèce parasite, on trouve la famille des Apiacées (carotte, céleri), Solanacées (Tabac), Fabacées (lentille, luzerne, fève, arachide et trèfle) et Astéracées (tournesol, carthame et laitue) [2] et [3].

C'est la première fois qu'on signale le parasitisme d'une espèce d'orobanche connue plutôt par son parasitisme des plantes sauvages sur une plante ornementale au Maroc. Il est fort plausible que d'autres régions urbaines du Maroc soient également touchées. En effet, *Orobanche minor* est une espèce qui a été signalée comme parasite de plantes sauvages notamment dans la forêt de Mamora [10], ce qui nous pousse à émettre l'hypothèse que cette espèce inconnue dans le secteur des plantes ornementales au Maroc est en train de migrer pour parasiter des plantes ornementales des espaces urbains, telle que nous venons de le constater avec *Gazania rigens*. Des études approfondies sur l'extension de cette espèce d'orobanche dans le milieu urbain s'imposent pour bien appréhender la migration de cette espèce parasite habituellement connue dans le domaine forestier.

4 CONCLUSION

Dans cette étude, nous avons mis en évidence le parasitisme de l'espèce *Gazania rigens* par *Orobanche minor* (Fig. 1 & 2), ce qui constitue une nouveauté par rapport aux données déjà connues sur le parasitisme du genre *Gazania* par le genre *Orobanche*.

REFERENCES

[1] Fer A., Thalouarn P., 1997. L'orobanche, une menace pour nos cultures. Phytoma, 499:34-40.
[2] Foy C. L., Jain R., Jacobson R., 1989. Recent approaches for chemical control of broomrape (*Orobanche* spp.). Rev. Weed Sc., 4: 123-152.
[3] Parker C., Riches C.R., 1993. *Orobanche* species: the broomrapes In : Parasitic weeds of the world. Biology and control. Wallingford, U K: CAB International, pp. 111-164.
[4] Sauerborn J., Linke K.H., Saxena M.C., Koch L., 1989. Solarisation, a physical control method for weeds and parasitic plant (*Orobanche* sp.) in Mediterranean agriculture. Weed Research, 29: 391-397.
[5] Zemrag A. 1999. L'Orobanche. Monographie et gestion dans la culture des légumineuses alimentaires. Transfert de technologie en Agriculture. Bulletin mensuel d'information et de liaison du PNTTA 63: 1-4.
[6] Saffour K., 2003. Utilisation des herbicides et des sous-produits d'olive (Grignon et Margines) dans le contrôle d'Orobanche sur fève. Doctorat National, Université Sidi Mohamed Ben Abdelah, Faculté des Sciences, Dhar Elmahraz, Fes, Maroc, 179 p.
[7] Pujadas salvà A.J., 2001. A botanical survey in order to improve the knowledge of the genus *Orobanche* L. in the Catalonian countries (in Spanish) Orsis 15:71-88. (A careful analysis of the taxonomy and occurrence of 25 *Orobanche* spp. In Spanish).
[8] Dor E., Eizenberg H., Joel D.M., Lande T., Achdari G., Smirnov E., Hershenhorn J., 2007. Parasitic plant *Orobanche palaestina* Rut as a potential threat to agriculture in Israel. Novel and sustainable weed Management in Arid and Semi-Arid Ecosystems, Rehovot, Israel, p 51.
[9] Eizenberg H., Plakhine D., Hershenhorn J., Kleifeld Y., Rubin B., 2003. La résistance à l'orobanche (*Orobanche* ssp.) chez le tournesol (*Helianthus annuus* L.) dépend de la température. Journal of Experimental Botany, 54 (385):1305-1311.
[10] Aafi A., Achhal el Kadmiri A., Benabid A., Rochdi M., 2005. Richesse et diversité floristique de la subéraie de la Mamora (Maroc). Acta Botanica Malacitana, 30 :127-138.

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INCIDENCE SOCIO-ECONOMIQUE DE L'ENVIRONNEMENT SUR LA SANTE: CAS DU PALUDISME DANS LA ZONE DE SANTE DE LA FOMULAC / KATANA

[INCIDENCE SOCIO-ECONOMIC OF THE ENVIRONMENT ON THE HEALT: CASE OF MALARIA IN FOMULAC / KATANA HEALTH ZONE]

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ABSTRACT: This study has been carried out in the rural health area of Katana. Its objective is to determine the socio-economic impact of the environment on the population's health and to clean up the milieu (area, environment) in which the concerned population lives. The study has been carried out due to malaria endemism (endemicity) in the area and its frequency in each family. The results obtained prove that malaria as endemic disease is one of the major causes of the population's poverty, children's lack of schooling, morbidity (un-healthiness), social conflicts and negative impact on family economic.

KEYWORDS: Rural health area, malaria, poverty, morbidity, endemism.

RESUME: Cette étude a été effectuée dans la Zone de Santé Rurale (ZSR) de katana. L'objectif est de déterminer l'incidence socio-économique de l'environnement sur la santé, l'économie familiale, les rapports sociaux,… et des mesures à prendre pour garder la communauté en bonne santé et s'assainir le milieu dans lequel elle vit. C'est dans ce cadre, qu'au vu de l'endémicité du paludisme dans le milieu et sa fréquence dans chaque ménage. La méthode d'enquête a été effectuée auprès de cette population. Les résultats obtenus montrent que cette endémie est une des causes majeures de la pauvreté de la population, du non scolarisation des enfants, de la morbidité, des conflits sociaux, de la malnutrition et de l'impact négatif sur l'économie familiale.

MOTS-CLEFS: Zone de Santé Rurale, paludisme, pauvreté, morbidité, endémicité.

1 INTRODUCTION

L'Environnement étant un ensemble des caractéristiques physiques, chimiques et biologiques plus au moins modifiées par l'action de l'homme [1].

Une mauvaise gestion de l'environnement a des conséquences sur la modification des plants, des animaux et de l'homme aussi bien qu'à l'échelle de l'individu ou de l'écosystème que toute la biosphère [1].

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La contribution de l'assainissement du milieu à la baisse sensible de la mortalité et de la morbidité a un impact compatible au développement du milieu et de la technologie. Dès lors, les problèmes d'assainissement diffèrent selon le degré du développement du milieu et de la technologie [2].

Si la fréquence des maladies transmissibles est élevée, leur origine est à rechercher dans l'environnement, qui comporte des facteurs favorisant la transmission de ces maladies. Parmi ces facteurs on peut citer: les habitudes des gens, notamment la tendance à boire n'importe quelle eau, l'habitude de faire ses besoins hors des installations sanitaires, le manque de propriété des mains, du corps, de la cuisine, la cohabitation avec les animaux domestiques, l'utilisation des eaux stagnantes et contaminées.

Dans les pays développés, les maladies dues au manque d'hygiène de base étaient autrefois fréquentes. Maintenant, elles ont fortement diminué par grâce à la médecine mais grâce à l'assainissement. Dans presque toutes les zones de santé rurale de notre pays, les sanitaires montrent que les principales causes de morbi-mortalité sont les maladies diarrhéiques, la mauvaise gestion de l'environnement et le manque d'hygiène surtout chez les enfants de 0 à 5 ans et les femmes enceintes [3].

Le paludisme est une maladie parasitaire potentiellement mortelle, il affecte la santé et la richesse des personnes et des pays. Actuellement deux milliards d'individus soit 40% de la population mondiale vivant dans les régions tropicales ou subtropicales sont exposés à la malaria et on estime à plus de trois cent millions (300.000.000), le nombre des cas cliniques survenant chaque année dont au moins 1.000.000 de décès. Il est la huitième morbidité la plus lourde au monde [4].Le paludisme touche essentiellement les pays en voie de développement de la zone intertropicale : Afrique subsaharienne, dans une moindre mesure de l'Asie du Sud-Est et l'Amérique du Sud. 80 à 90% du taux de décès dû au *Plasmodium falciparum* sont africains et dans la grande majorité les enfants et les femmes enceintes. Une autre entrave au développement économique est le *Plasmodium vivax.* Il est responsable de 80.000.000 des cas de paludisme par an dont 80% en Asie du Sud-Est et en Amérique du Sud et 20% en Afrique. Cette forme de paludisme contrairement à *Plasmodium falciparum* est rarement mortelle mais responsable d'infection répétée et récidivante entrainant une lourde morbidité et un retentissement économique majeur sur ces pays fragiles[4].Au total, le paludisme est endémique dans 101 pays et territoires : 45 pays de la région africaine de l'OMS ; 21 de la région des Amériques ; 4 de la région européenne ; 14 de la région de la Méditerranée orientale ; 8 de la région de l'Asie du Sud-Est et 9 de la région du Pacifique occidentale. Plus de 90% de tous les cas du paludisme surviennent en Afrique subsaharienne [4].90% de décès dus au paludisme surviennent en Afrique au Sud du Sahara, principalement chez les jeunes enfants. Le paludisme tue un enfant toutes les trente secondes, il est aussi la cause majeure de mortalité périnatale, de faible poids de naissance et d'anémie maternelle [5].

Ainsi, la présence du paludisme présenterait la première cause de la morbidité et de la mortalité, en plus le coût élevé de traitement par épisode accentuerait l'appauvrissement de la population et la paupérisation des communautés entrainerait des conflits dans la société.

Etant donné que le paludisme est devenu endémique dans la région de Katana et touche toutes les familles avec plusieurs épisodes au cours de l'année, ainsi, l'objectif de ce travail est de connaître l'incidence socio-économique sur les ménages et surtout le coût direct et indirect du paludisme.

2 MATERIELS ET METHODES

2.1 ETUDE DU MILIEU

La Zone de Santé Rurale (ZSR) de Katana est située au Nord du territoire de Kabare avec le Bureau Central de Zone de Santé (BCZS) installé sur la colline Mahero dans le groupement de Bugorhe, de la collectivité-chefferie de Kabare et du territoire qui porte le même nom. Elle couvrait dorénavant l'actuelle Zone de Santé de Katana, Miti-Murhesa et Kalehe, mais avec le découpage intervenu en 2003, la Zone de Santé s'est vue amputée de nombreuses de ses Formations Sanitaires (FOSA) pour constituer ces deux dernières.

Le BCZS de Katana se situe à 45 km de la ville de Bukavu. La Zone de Santé Rurale(ZSR) de Katana limitée au Nord par la Zone de Santé Rurale(ZSR) de Kalehe (par la rivière Nyabarongo) ; par la Zone de Santé Rurale(ZSR) d'Idjwi (par le lac Kivu) ; à l'Ouest par la grand-route Bukavu-Goma et au Sud par la Zone de Santé Rurale(ZSR) de Miti-Murhesa (par la rivière Kalengo).

L'agriculture et le petit élevage étaient jadis considérés comme source principale source d'existence de près de 65% de la population. La présence des fonctionnaires de l'Etat et des petits commerçants représentent 35% dans cette Zone de Santé Rurale (ZSR).

Le relief varié, la Zone de Santé Rurale(ZSR) de Katana est traversée par des rivières et des ruisseaux tel que : Bidabanga, Cirhanyobwa, Cirindiro, Coga, Cikumbo,… Le climat est doux, pluvieux tempéré à une altitude comprise entre 1500 à 2000m, des précipitations annuelles varient entre 1300 et 1800 mm et des températures annuelles de 80,5°C.

2.2 METHODES

Au cours de notre enquête, nous avons utilisé la technique de l'échantillonnage aléatoire simple selon la méthode des quatre points cardinaux. Il s'agit d'une étude descriptive transversale réalisée dans la Zone de Santé Rurale (ZSR) de Katana au cours de la période de Janvier 2012 à Décembre 2012. Notre étude s'est déroulée en deux étapes dont l'élaboration du questionnaire d'enquête et la descente sur terrain et collecte proprement dite des données.

La population de notre étude est constituée de tous les ménages de la Zone de Santé Rurale(ZSR) de Katana répartis sur les 17 Aires de Santé (AS) et dont la tranche d'âge varie entre 18 à 45 ans.

Il s'agit d'un échantillon en groupe à 2 degrés: Au premier degré nos groupes sont constitués des Aires de Santé(AS) et au deuxième degré des ménages.

La formule de [6] été utilisée pour déterminer la taille de l'échantillon.

$N = \dfrac{N}{n/1 + Ne^2}$ Avec N = population totale, e = précision souhaitée = 0,05

Si n est supérieur à 10%, on prend : $nr = \dfrac{1+N}{N}$ nr = échantillon réduit.

Selon les enquêtes menées en République Démocratique du Congo par les Fonds des Nations Unies pour l'Enfance(UNICEF) et l'Organisation Mondiale de la Santé(OMS), le nombre moyen d'enfants dans un ménage congolais est de 6 à 7.

Pour trouver le nombre de ménages, il nous suffit de diviser la population totale de la Zone de Santé Rurale(ZSR) de Katana par 7, ce qui donne

$\dfrac{138567\,habi\tan ts}{7} = 26224 ménages$,

$n = \dfrac{N}{1+Ne^2}$,

$e^2 = 0{,}05 = 0{,}0025$,

$N = \dfrac{26224 ménages}{1 + 26224x0.0025} = 65.56$,

$n = \dfrac{26224}{6.565} = 394 ménages$

Pour rendre notre échantillon plus faible, nous trouvons 400 ménages dans toute la ZSR de Katana.

3 RESULTATS

Les résultats obtenus sont représentés dans les tableaux ci-après :

3.1 IDENTITÉ DES ENQUÊTÉS

Tableau 1. Age des enquêtés

N°	Variables/Tranche d'âges (an)	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
01	18-30	82	86.4	90	85.5	1.34	NS
02	31-40	45	54.7	64	54.2	3.48	NS
03	41-50	38	32.6	27	32.3	9.75	S
04	51-60	25	18.5	12	17.4	3.97	NS
05	Plus	11	8.5	6	8.4	1.41	NS
Total		201		199			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif,S=Significatif et x^2 tabulaire =9.488 au seuil 0.5, dl =4

Il ressort de ce tableau que l'âge des personnes enquêtées varie entre 41 à 50 ans. Les personnes des deux sexes (masculin et féminin) forment un grand nombre.

Tableau 2. Etat civil des enquêtés

N°	Variables/Etat civil	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Marié(e)s	119	123.1	164	159.8	0.24	NS
2	Célibataires	40	34.8	40	45.2	1.36	NS
3	Divorcé(e)s	3	2.17	2	2.82	0.54	NS
4	Union libre	4	3.04	3	3.95	0.52	NS
5	Veuf (ve)s	8	10.8	17	14.1	1.31	NS
Total		174		226			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =9.488 au seuil 0.5, dl =4

De ce tableau, il ressort que chi-carrée calculée étant non significative entre l'état civil des enquêtés c'est-à-dire que l'état civil des enquêtés varie les marié(e)s, les célibataires, les divorcé(e)s, les personnes en union libre et les veuf(ve)s.

Tableau 3. Nombre d'enfants dans les ménages

N°	Variable/Nombre d'enfants	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Aucun enfant	50	48.4	52	53.5	0.09	NS
2	1 à 3 enfants	30	37.5	49	41.4	2.7	NS
3	4 à 7 enfants	70	68.8	75	76.1	0.03	NS
4	8 et plus d'enfants	40	35.1	34	38.8	1.27	NS
Total		190		210			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatifet x^2 tabulaire =7.815 au seuil 0.5, dl =3

La différence est non significative entre le chi-carrée calculé de nombre d'enfants dans les ménages c'est-à-dire que le nombre d'enfants dans les ménages varie d'aucun enfant, soit de 1 à 3 enfants, soit encore de 4 à 7 enfants et soit enfin de 8 et plus d'enfants.

Tableau 4. Activitéprofessionnelle des enquêtés

N°	Variables/Activités professionnelles	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Cultivateurs	70	86.5	84	77.4	3.6	NS
2	Eleveur	17	13.1	8	11.8	2.3	NS
3	Commerçant	10	21.6	31	19.3	13.2	NS
4	Ménagère	3	5.2	13	4.7	15.5	NS
5	Agent de l'ordre	8	3.1	0	2.8	10.4	NS
6	Enseignant	28	23.2	16	20.7	2.05	NS
7	Fonctionnaire de l'Etat	9	6.3	3	5.6	2.2	NS
8	Professionnel de santé	10	8.9	7	8.0	0.2	NS
9	Débrouillardise	7	6.8	13	6.1	7.8	NS
10	Sans	3	1.5	5	1.4	10.7	NS
11	Cultivateur et petit commerçant	7	4.2	2	3.7	2.5	NS
12	Cultivateur et éleveur	5	1.0	1	0.9	16	NS
13	Eleveur et petit commerçant	5	0.5	1	0.4	41.3	HS
14	Cultivateur et débrouillard	4	1.0	1	0.9	9	NS
15	Cultivateur et professionnel de la santé	3	0,5	1	0.4	13.4	NS
16	Petit commerçant et fonctionnaire de l'Etat	16	8.4	0	7.5	14.2	NS
17	Pécheur	3	2.1	2	1.8	13.4	NS
18	Cultivateur et fonctionnaire de l'Etat	3	0.5	1	0.4	0.32	NS
Total		211		189			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 :Chi-carré,dl : degré de liberté ,NS=Non Significatif,HS=Hautement Significatif et x^2 tabulaire =27.587 au seuil 0.5, dl =17

chi-carrée calculée est hautement significative soit 41.3 c'est-à-dire que l'activité principale des enquêtés est l'élevage et le petit commerce.

Tableau 5 Niveau d'étude des enquêtés.

N^O	Variable	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Primaire	50	67.8	69	51.1	10.8	S
2	Secondaire	140	115.7	63	87.2	11.8	S
3	Supérieur et Universitaire	20	17.1	10	12.9	1.00	NS
4	Sans	18	27.3	30	20.6	7.30	NS
Total		228		172			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif,S=Significatif et x^2 tabulaire =7.815 au seuil 0.5, dl =3

Il ressort de ce tableau que la majorité des enquêtés ont étudié mais ils sont du niveau primaire et secondaire car chi-carrée calculée est hautement significative soit 10.8 et 11.8.

Tableau 6. Personnes ayant souffert du paludisme

N^O	Variables/Opinions	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Oui	171	176.2	200	194.7	0.2	NS
2	Non	19	13.7	10	15.2	3.7	NS
Total		190		210			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 :Chi-carré,dl : degré de liberté ,NS=Non Significatif et x^2 tabulaire =3.841 au seuil 0.5, dl =1

La différence est non significative c'est-à-dire qu'il y a des enquêtés qui ont déjà souffert du paludisme et d'autres pas encore.

Tableau 7. Connaissance des responsables des ménages sur le paludisme

N°	Variables/Opinions	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Oui	200	200.4	193	192.5	0.0019	NS
2	Non	4	3.5	3	3.4	0.75	NS
Total		204		196			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 :Chi-carré,NS=Non Significatif et x^2 tabulaire =3.841 au seuil 0.5, dl =1

En rapport avec la connaissance que possèdent nos enquêtés sur le paludisme c'est-à-dire que les uns le connaissent et les autres ne les connaissent pas car la différence est non significative donc chi- carré tabulaire est supérieur à chi-carré calculé.

Tableau 8. Signes de reconnaissance du paludisme par nos enquêtés

N°	Variables/Signes de reconnaissance du paludisme	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Fièvre et frisson	50	49.1	72	72.8	0.024	NS
2	Céphalée	30	30.9	47	46.0	0.047	NS
3	GE positive	36	34.6	50	51.3	0.088	NS
4	Douleurlombaire	9	11.6	20	17.3	1	NS
5	Nausée et vomissement	36	34.6	50	51.3	0.088	NS
	Total	161		239			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =9.488 au seuil 0.5, dl =4

De ce tableau, les enquêtés connaissent les signes de manifestation du paludisme chez une personne victime, ils ont la fièvre soit le frisson, soit ensuite la céphalée, soit le Gout Epaisse (GE) positive, soit encore la douleur lombaire, la nausée et le vomissement car la différence est non significative pour le chi-carré calculé.

3.2 COUT SOCIAL DU PALUDISME PESANT SUR LES MENAGES

Tableau 9. Nombre de fois qu'un membre de famille souffre du paludisme par an

N°	Variables/Nombre de fois le mois	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	1	31	32.5	46	44.4	0.110	NS
2	2	28	26.1	34	35.8	0.220	NS
3	3	25	25.3	35	34.6	0.007	NS
4	4	13	13.9	20	19.0	0.110	NS
5	5	7	6.7	9	9.2	0.170	NS
6	6	40	38.4	51	52.5	0.070	NS
7	12	12	13.5	20	18.4	0.305	NS
8	Plus de 12	7	8.8	14	12.1	0.650	NS
9	Abstention	6	3.3	2	4.6	3.600	NS
Total		169		231			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =15.507 au seuil 0.5, dl =8

En rapport avec la fréquence ou l'épisode maladie par personne et par an dans ce tableau ci-dessus, les uns ne savent pas et les autres, c'est une fois ,deux fois ,trois fois,quatre fois,cinq fois, six fois , douze fois et /ou plus de douze fois ,car chi-calculée a une différence non significative.

Tableau 10. Personnes plus frappées par le paludisme par ménages

N^0	Variables/Ages/an	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Supérieur à 18	50	47.1	71	73.8	0.27	NS
2	Inférieur à 18	59	54.2	80	84.7	0.68	NS
3	Femme enceinte	20	18.3	27	28.6	0.23	NS
4	Enfants et femmes	10	21.8	46	34.1	10.5	NS
5	Inférieur à 18 et Supérieur à 18	15	13.6	20	21.3	0.21	NS
6	Abstention	2	0.7	0	1.2	3.6	NS
Total		156		244			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =9.488 au seuil 0.5, dl =4

Il ressort de ce tableau que la différence est non significative entre chi-carré calculé et chi-carré tabulaire c'est-à-dire que les personnes les plus frappées par le paludisme ont l'âge inférieur à 18 ans et supérieur à 18 ans surtout les femmes, les femmes enceintes et les enfants.

3.3 SOURCES DES REVENUS DONT DISPOSENT LES MENAGES POUR PARTICIPER AUX SOINS DE SANTE

Tableau 11. Moyen de paiement des soins de santé pour une personne malade du paludisme

N^0	Variables/Moyen de paiement	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Agriculture	200	201.8	113	111.1	0.04	NS
2	Agriculture et élevage	30	24.5	8	13.4	3.3	NS
3	Agriculture, élevage et pêche	8	9.6	7	5.3	0.7	NS
4	Débrouillard	20	21.9	14	12	0.4	NS
Total		258		142			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =7.815 au seuil 0.5, dl =3

De ce tableau, il ressort que le moyen de payement des soins de santé pour une personne malade du paludisme provient des fruits et/ou des produits d'agriculture, de pêche et d'élevage et aussi du débrouillardise car la différence est non significative entre chi-carré calculé et chi-carré tabulaire.

Tableau 12. Nombre de personnes mortes du paludisme par ménage

N^o	Variables/Nombre des personnes	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Zéro	150	133.2	105	121.7	4.3	NS
2	1	30	39.1	45	35.8	4.4	NS
3	2	18	22.9	26	21.0	2.1	NS
4	3	10	114	12	10.5	0.3	NS
5	5 et plus	1	2.0	3	1.9	1.1	NS
Total		209		191			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =9.488 au seuil 0.5, dl =4

De ce tableau, le nombre des personnes mortes du paludisme par ménage montre une différence non significative entre chi-carré calculé par rapport au chi-carré tabulaire c'est-à-dire dans certains ménages il n'y a pas de morts du paludisme et dans d'autres il existe des morts soit un, deux, trois, cinq et plus de personnes mortes du paludisme.

Tableau 13. Effets négatifs du paludisme sur la vie d'une famille selon les enquêté(e)s.

N°	Variables/Nombre effets négatifs	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	1	91	84.0	100	106.9	0.9	NS
2	2	30	32.1	43	40.8	0.2	NS
3	3	15	15.4	20	19.6	0.018	NS
4	4	10	11.0	15	14.0	0.16	NS
5	Supérieur ou égal à 5	30	33.4	46	42.5	0.5	NS
Total		176		224			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =9.488 au seuil 0.5, dl =4

Ce tableau montre que nos enquêtés reconnaissent plusieurs effets négatifs du paludisme (souffrance, paie des frais médicaux par vente du bétail, des produits agricoles, manque de sommeil, garde malade, morbidité, immobilisme, dépendance, mort, faim, inquiétude, malnutrition…) car la différence est non significative entre le chi-carré calculé par rapport au chi-carré tabulaire.

Tableau 14. Facteurs de présence du paludisme dans les ménages

N°	Variables/Nombre des facteurs de présence	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Plus au moins 1	80	94.0	158	143.9	3.46	NS
2	2	20	20.1	31	30.8	0.0017	NS
3	Supérieur à 2	30	27.6	40	42.3	0.33	NS
4	Moins 1	18	11.0	10	16.9	5.26	NS
5	Abstention	10	5.1	3	7.8	7.6	NS
Total		158		242			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =9.488 au seuil 0.5, dl =4

Ce tableau montre qu'il existe plusieurs facteurs (eaux stagnantes, des déchets agro ménagers, …) de présence du paludisme dans les ménages.

Tableau 15. Nombre des jours de travail perdus par épisode

N°	Variables/Nombre des jours	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	1	2	2.4	4	3,5	0.130	NS
2	2	6	7.2	12	10.7	0.300	NS
3	3	8	9.6	16	14.3	0.300	NS
4	4	14	13.6	20	20.3	0.014	NS
5	5	22	25.7	42	38.2	0.800	NS
6	6	50	51.1	77	75.8	0.030	NS
7	7	57	49.9	67	74.0	1.600	NS
8	Abstention	2	1.2	1	1.7	0.700	NS
Total		161		239			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =9.488 au seuil 0.5, dl =4

Le nombre des jours prdus par épisode varie par malade de quatre à sept jours voire plus mais cela n'empêche de considérer les malades qui ont perdu un, deux, trois jours car cela constitue aussi un manque à gagner d'où la différence est non significative entre le chi-carré calculé par rapport au chi-carré tabulaire.

3.4 COUT ÉCONOMICO-FINANCIER DU PALUDISME SUR LES MÉNAGES (SACHANT QU'UNE JOURNÉE DE LABOUR VAUT 1000 FC POUR UN PAYSAN)

Tableau 16. Nombre des jours de travail perdus par épisode en franc congolais

N°	Variables/nombre des jours de travail perdus par épisode	Valeur en FC	Fréquences				x^2 Calculé	Signification
			Masculin		Féminin			
			Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	1	1000	2	2.4	4	3.5	0.130	NS
2	2	2000	6	7.2	12	10.7	0.300	NS
3	3	3000	8	9.6	16	14.3	0.300	NS
4	4	4000	14	13.6	20	20.3	0.014	NS
5	5	5000	22	25.7	42	38.2	0.800	NS
6	6	6000	50	51.1	77	75.8	0.030	NS
7	7	7000	57	49.9	67	74.0	1.600	NS
8	Abstention	0	2	1.2	1	1.7	0.700	NS
Total			161		239			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif , x^2 tabulaire =14.067 au seuil 0.5, dl =7 et Fc= Francs Congolais

En évaluant le nombre de jours perdus par épisode en Franc congolais(Fc), sachant qu'une journée de labour vaut 1000Fc pour un paysan, il ressort que le nombre des Francs congolais perdu varie en fonction de 1000 à 7000Fc donc de un à sept jours.

Tableau 17 .Nombre de jours de travail perdu par équipe en FC par le visiteur

N°	Variables/Nombre des jours de travail perdus par équipe	Valeur en FC	Fréquences				x^2 Calculé	Signification
			Masculin		Féminin			
			Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	1	1000	1	1.6	5	4.3	0.30	NS
2	2	2000	3	4.8	15	13.1	0.80	NS
3	3	3000	6	6.4	18	17.5	0.03	NS
4	4	4000	10	9.0	24	24.9	0.13	NS
5	5	5000	15	17.1	49	46.8	0.30	NS
6	6	6000	37	33.9	90	93.0	0.29	NS
7	7	7000	34	33.1	90	90.8	0.027	NS
8	Abstention	0	1	0.8	2	1.4	0.3	NS
Total			107		293			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire

En évaluant le nombre des jours de travail perdu par équipe en Franc congolais c'est-à-dire celui qui rend visite au malade hospitalisé perd de la même façon que le malade, sachant qu'une journée de labour vaut 1000Fc pour un paysan, il ressort de ce tableau que le nombre des Francs congolais perdu varie en fonction de 1000 à 7000Fc donc un à sept jours ; sans oublier que le transport coute aussi cher au ménage.

3.5 NIVEAU PRATIQUE PAR LES ENQUETES (ES) AU SUJET DU PALUDISME

Tableau 18. Actes posés par les enquêtés pendant la maladie

N°	Variables/Actes posés par les enquêtés	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
01	L'amener vers une FOSA	113	107.1	150	155.8	0.53	NS
02	Automédication	20	23.6	38	34.3	0.8	NS
03	Traitement traditionnel	10	12.2	20	17.7	0.5	NS
04	Chambre de prière	3	4.4	7	6.5	0.43	NS
05	L'amener chez le traditionnel	6	3.6	3	5.3	2.5	NS
06	L'amener à la FOSA et faire l'automédication	4	3.6	5	5.3	0.05	NS
07	L'amener à la FOSA et pratiquer le traitement traditionnel	5	4.4	6	6.5	0.11	NS
08	L'amener à la FOSA et vers la chambre de prière	0	0.8	2	1.1	1.5	NS
09	L'amener à la FOSA, pratiquer l'automédication et le traitement traditionnel	1	1.6	3	2.3	0.4	NS
10	L'amener à la FOSA et chez le tradipraticien	1	0.8	1	1.1	0.059	NS
11	Traitement traditionnel et pratique la chambre de prière	0	0.8	2	1.1	1.5	NS
Total		163		237			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =18.307 au seuil 0.5, dl =10

Il ressort de ce tableau que la différence est non significative entre chi-carré calculé par rapport au chi-carré tabulaire c'est dire les actes posés par les malades varient d'un enquêté à un autre.

Tableau 19. Personnes malades du paludisme hospitalisées de six derniers mois

N°	Variables/Déclaration des ménages	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Aucune déclaration	104	98.7	105	110.2	0.52	NS
2	Déclaration d'un membre	40	38.7	42	43.2	0.07	NS
3	Déclaration de deux membres	25	28.3	35	31.6	0.74	NS
4	Déclaration de plus de deux membres	20	23.1	29	25.8	0.8	NS
Total		189		211			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =7.815 au seuil 0.5, dl =3

Ce tableau montre que la différence est non significative entre chi-carré calculé par rapport au chi-carré tabulaire c'est dire que une ou plus déclare avoir connu des membres de leur famille victime du paludisme ces six derniers mois et la grande partie des enquêtés affirment de n'en avoir pas connu.

Tableau 20. Motif principal pour le recours aux soins de santé dans les ménages

N°	Variables/Motif principal	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Maladie	130	126.6	168	171.3	0.15	NS
2	Suivre les soins	40	42.5	60	57.5	0.25	NS
3	Gonfler la caisse de la FOSA	0	0.8	2	1.1	1.5	NS
Total		170		230			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =5.991au seuil 0.5, dl =2

Ce tableau montre que nos enquêtés se rendent à la Formation Sanitaire que pour par le motif des soins médicaux ; une différence non significative entre le chi-carré calculé par rapport au chi-carré tabulaire c'est dire nos enquêtés n'y vont pas pour gonfler la caisse de la Formation Sanitaire (FOSA).

Tableau 21. Degré de morbidité selon les raisons

N^{O}	Variables/Degré de morbidité	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Saison sèche	30	26.4	45	48.5	0.60	NS
2	Saison de pluies	80	79.6	146	146.3	0.002	NS
3	Les deux à la fois	30	34.5	68	63.4	0.8	NS
4	Abstention	1	0.3	0	0.6	2.2	NS
Total		141		259			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =7.815 au seuil 0.5, dl =3

La différence étant non significative entre le chi-carré calculé et celui tabulaire, ce tableau montre que la saison de pluies est celle où la morbidité est élevée.

Tableau 22. Mode de protection utilisé par les ménages contre le paludisme

N^{O}	Variable	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Ne font rien	60	54.6	51	56.3	0.9	NS
2	Utilisent un mode de prévention contre le paludisme	130	134.9	144	139.0	0.34	NS
3	Utilisent deux modes de prévention contre le paludisme	6	6.8	8	7.1	0.2	NS
4	Abstention de prévention contre le paludisme	1	0.4	0	0.5	1.4	NS
Total		197		203			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =7.815 au seuil 0.5, dl =3

Chi-carré calculé par rapport au chi-carré tabulaire présentant une différence non significative, ce tableau montre que nos enquêtés reconnaissent et utilisent au moins un seul mode de protection contre le paludisme (dormir sous Moustiquaire Imprégnée d'Insecticide MII, fumigans=méthode traditionnelle, usage d'insecticides, port des habits de manche longues et de couleur blanche…).

Tableau 23. Usage de la MII

N°	Variables/Usage de la MII	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Oui	96	102.9	100	93.1	0.97	NS
2	Non	84	80.8	70	73.1	0.25	NS
3	Abstention	30	26.2	20	23.7	1.12	NS
Total		210		190			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =5.991 au seuil 0.5, dl =2

De ce tableau, certains utilisent la Moustiquaire Imprégnée d'Insecticide(MII), les autres pas et les autres n'en connaissent même pas d'où la différence est non significative entre le chi-carré calculé du tabulaire c'est-à-dire faire beaucoup de sensibilisions pour protéger la couche la plus vulnérable au paludisme.

Tableau 24. Causes de la non utilisation de la MII

N°	Variables/Causes de la non utilisation	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Manque de moyen	68	102.9	110	95.0	4.51	NS
2	Rareté de la MII	90	83.7	71	77.2	0.96	NS
3	Refus d'utilisation	30	21.3	11	19.6	7.2	NS
Total		208		192			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =5.991 au seuil 0.5, dl =2

De ce tableau, la différence est non significative entre le chi-carré calculé au chi-carré tabulaire car plusieurs causes sont à la base du non utilisation de la Moustiquaire Imprégnée d'Insecticide (MII) comme le manque de moyen, la rareté de MII et/ou refus d'utilisation de MII.

Tableau 25 .Prévention de la prolifération des MII dans les ménages.

N°	Variables/Prévention de la prolifération des MII	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Ménages exécutant un mode de prévention	110	118.0	91	82.9	1.33	NS
2	Ménages exécutant deux modes de prévention	47	39.3	30	27.6	1.7	NS
3	Ménages exécutant trois modes de prévention	18	17.6	12	12.3	0.016	NS
4	Ménages exécutant plus de trois modes de prévention	50	47.5	31	33.4	0.3	NS
5	Ménages ne recouvrant à aucun mode de prévention	8	10.5	10	7.4	1.4	NS
6	Abstention	2	1.7	1	1.2	0.08	NS
Total		235		165			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =11.070 au seuil 0.5, dl =5

Il ressort de ce tableau que la différence est non significative entre le chi-carré calculé et chi-carré tabulaire c'est-à-dire plusieurs modes sont utilisés pour la prolifération des Moustiquaires Imprégnée d'Insecticide(MII) et certains n'en utilisent même pas.

Tableau 26. Actes posés par les ménages pour éviter le paludisme

N°	Variables/Actes posés	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Prise hebdomadaire d'un traitement	60	49.4	44	54.6	4.2	NS
2	Prise mensuelle d'un traitement	30	24.2	21	26.7	2.3	NS
3	Rien	100	116.3	145	128.6	4.2	NS
Total		190		210			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =5.991 au seuil 0.5, dl =2

Plusieurs actes sont utilisés par les ménages pour éviter le paludisme hebdomadairement et/ou mensuellement et la majorité n'en utilisent pas car la différence est non significative entre le chi-carré calculé par rapport au chi-carré tabulaire.

Tableau 27. Source de revenue par ménage

N°	Variables/Source de revenu	Fréquences				x^2 Calculé	Signification
		Masculin		Féminin			
		Initiales (f_o)	Cumulées (f_c)	Initiales (f_o)	Cumulées (f_c)		
1	Ménages avec une source de revenu	131	131.6	100	99.3	0.008	NS
2	Ménages avec deux sources de revenus	45	48.4	40	36.5	0.56	NS
3	Ménages avec plus de deux sources de revenu	42	35.3	20	26.6	2.8	NS
4	Ménages recourant à la débrouillardise	10	12.5	12	9.4	1.2	NS
Total		228		172			

Légende

f_o : Fréquence initiale, f_c : Fréquence cumulée ou théorique, x^2 : Chi-carré,dl : degré de liberté,NS=Non Significatif et x^2 tabulaire =7.815 au seuil 0.5, dl =3

Les ménages ont plusieurs sources de revenus à savoir l'agriculture (source principale), l'élevage, le petit commerce, le débrouillardise car la différence est non significative entre le chi-carré calculé au chi-carré tabulaire.

3.6 COUTS DIRECTS

La population de la Zone de Santé Rurale (ZSR) de Katana est constituée en grande majorité des agriculteurs. Le revenu journalier par personne est de 144Fc soit 0,16$ U.S.D. Considérant la fréquence de la malaria par ménages et les soins médicaux en ambulatoire et en hospitalisation, nous trouvons ce qui suit :

Tableau 28. Coûts directs des soins médicaux

Catégories	Ambulatoire		Hospitalisation		Transfusion		Curettage	
Enfant	450Fc	0.5$	6750Fc	7,5$	4500Fc	5$	0Fc	0$
Adulte	900Fc	1$	12600Fc	14$	4500Fc	5$	27000Fc	30$

Légende

$=Dollars U.S.A. et Fc= Francs Congolais

Pour un épisode du paludisme d'un enfant soigné en ambulatoire, ceci lui priverait de sa ration alimentaire (900Fc : 144Fc) pendant 6.25 jours ;
Pour un enfant hospitalisé, ces frais lui priveraient de sa ration alimentaire (6750Fc :144Fc) pendant 6.25 jours ;
Pour un enfant hospitalisé, transfusé ces frais lui priveraient de sa ration alimentaire (11250Fc :144Fc) pendant 100 jours ;
Pour un adulte hospitalisé, ces frais lui priveraient de sa ration alimentaire (1260Fc :144Fc) pendant 87.5 jours ;
Pour un adulte hospitalisé, transfusé, ces frais lui priveraient de sa ration alimentaire (17100Fc :144Fc) pendant 125 jours ;
Pour le curetage d'une femme après avortement, les soins médicaux lui priveraient de sa ration alimentaire (2700Fc :144Fc) pendant 187.5 jours ;
Pour un ménage de 8 membres qui connait deux épisodes de la malaria par an avec hospitalisation, transfusion nous aurons :
Pour les parents : (1260Fc+4500Fc+900Fc) ×2 =36000Fc soit 40$
Pour les enfants : (6750Fc+4500Fc+450Fc) ×6 =70200Fc soit 78$
Total : 36000Fc+68400Fc=104400Fc soit 118$ par épisode×2 =208800Fc soit 236$
208800Fc:1,44= 1475 jours : 8= 184.3 jours ceci entraine que la famille doit rester 184.3 jours sans manger. A ceci, il faut ajouter les frais des actes techniques, l'achat des médicaments et les documents administratifs.

Ce qui amener les gens à contracter des dettes, à hypothéquer leurs biens dans les formations sanitaires, à vendre leurs lopins de terre et à entrer en prison ou en conflit avec les voisins pour non remboursement des dettes contractées.

L'hospitalisation due au paludisme plus ou moins 7 jours. Le malade est toujours accompagné d'une autre personne qui assure sa garde. Les deux personnes sont immobilisées et deviennent indépendantes de celles qui sont restées à la maison. Ainsi, l'évaluation des couts indirects peut se résumé comme suit :

a) L'alimentation : tenant compte que chaque personne pourra consommer 900Fc soit 1$ USD par jour, nous trouvons 900Fc ×7 jours × 2 personnes= 12600Fc soit 14$; ce qui priverait un membre de la famille de sa ration alimentaire (12600Fc :144Fc) pendant 87.5 jours.

b) Le transport : pour rendre visite au malade, il faut utiliser le moyen de transport. Celui-ci coute 1000FC par course pour aller et retour, il faudra 2000FC. Au taux de 900FC/$USD, ceci nous donne 1998Fc× 7 jours= 13986Fc soit 15.54$USD. Ce qui priverait à un membre de la famille de sa ration alimentaire (13986Fc :144Fc) pendant 97.12 jours.

c) L'immobilisme : pendant l'hospitalisation, les deux personnes vivent au dos de celles qui sont restées à la maison. Elles ne travaillent pas et constituent un manque à gagner pour la famille. Un ouvrier agricole gagne dans le milieu 1000FC/jour. Ce qui fait un manque à gagner 2000FC/jour × 7jours= 13986Fc soit 15.54$USD. Ce qui priverait un membre de la famille de sa ration alimentaire de 97.12 jours.

Si l'on comptabilise les couts indirects, nous trouvons 12600Fc+113986Fc+13986Fc=40572Fc soit 45.08$. Donc le manque à gagner est de 40572Fc soit 45.08$. Pour une famille de 8 membres, on trouvera (40572Fc :144Fc) :8=35.21 jours de privation de la ration alimentaire journalière ; ce qui fait qu'une hospitalisation d'un individu pendant 7 jours affamera toute la famille pendant plus d'un mois.

C'est ainsi que les gens s'engagent dans des dettes, vendent des lopins de terre familiale ou préfèrent mourir à la maison tranquillement. D'autres deviennent oisives, voleuses et permanentes dans les débits de boisson, les enfants abandonnent les études par manque des frais scolaires et deviennent les enfants de la rue.

Une épisode de la malaria n'entame pas seulement le moyen financier et matériel mais aussi affaiblit l'homme mais surtout les enfants. Pour l'adulte, son organisme est affaibli et ne peut pas travailler. Pour l'enfant, il ne mange pas convenablement, vomit ce qu'il a mangé. Ce qui entraine la kwashiorkor et comme conséquence de tous ces faits, c'est l'hospitalisation et par fois la mort, source de l'arrêt du développement d'un pays.

Enfin, le paludisme a un impact énorme sur l'appauvrissement de la population, son économie, sa santé, sa nutrition et son éducation, son habitat et ses conflits surgissent lorsqu'on n'est pas à mesure de rembourser les dettes.

La mort d'un individu a des conséquences néfastes sur l'économie du ménage qui perd un bras qui devait rapporter.

Suite aux séances de sensibilisation par les Eglises les écoles et les Associations paysannes, la majorité de la population amène les malades vers les Formations Sanitaires (FOSA). Mais suite à la pauvreté qui se vit dans les milieux on pratique l'automédication, la médecine traditionnelle. Avec les mauvaises prédications de certains pasteurs surtout protestants, on amène les malades dans des chambres de prières.

Selon les déclarations des enquêtés, la prévalence est plus accentuée pendant la saison de pluie que pendant la saison sèche. Ceci est dû au fait qu'il y a prolifération des moustiques pendant cette période par la présence des eaux stagnantes, la poussée des herbes, mais, sorgho, haricots et bananiers.

4 DISCUSSION

Les enquêtés exercent une certaine activité professionnelle en agriculture, élevage, commerce, travaux ménagers et de l'ordre, enseignement, santé, pêche, débrouillardise… ceci s'explique par le fait que [7] et [8] montre que l'activité des enquêtés n'est autre que l'agriculture et le débrouillardise.

Quant au niveau d'étude des enquêtés, la majorité a étudié. Ceci s'explique du fait que [9] et [10] prouve que le niveau d'étude varie du primaire au secondaire.

Les raisons avancées pour les personnes plus frappées par le paludisme et par ménage varient selon l'âge et l'état physique des personnes. [11] et [12] a montré aussi que les enfants et les femmes enceintes sont les personnes les plus frappées par le paludisme.

De la non utilisation de la MII, son utilisation est timide. Ceci s'explique par le fait que[7],[12],[13] prouvent que les raisons de la non utilisation de la MII ne sont autres que : la disposition de l'état du lit dans la maison, la coutume, le manque des moyens financiers pour leur payement.

Selon [14], plus de la moitié de la population en Afrique noire vit avec moins de900Fc soit moins de 1$ USD par jour. Pourtant la santé est un secteur clé de la vie. En cas de déficience, elle freine le développement physique et mental de l'homme. La mauvaise santé a des conséquences économiques car elle affecte l'attitude, l'initiative, l'énergie, la créativité, la faculté d'apprendre, l'aptitude à effectuer un effort physique ou intellectuel important et prolongé.

Le rapport de [15] montre que le niveau de revenu par habitant et par jour est passé de 1179Fc soit 1,31$ USD en 1973 ; 819Fc soit 0,91$ USD en 1974 ; 270Fc soit 0,30$ en 1998 et baisse de2772Fc soit 3,08$ USD en moyenne par an.

[16] a mené des recherches sur le revenu moyen de la population de Bugorhe ; il a trouvé que ce revenu est de 144Fc soit 0,16$ USD par jour et par personne. La situation de la population de Bugorhe n'étant pas très différente de celle de la ZSR de Katana, nous pouvons extrapoler ce revenu pour la ZSR de Katana. Suite à la situation socio-économique et politique qui se dégrade chaque jour, ce revenu peut encore être revu à la baisse et montre que la population vit en dessous du seuil de l'intolérance comparativement aux normes de l'OMS.

Ainsi [17] , confirme que le Sud-Kivu est l'une de trois provinces les plus pauvres de la RDC.

Le paludisme est une réalité dans la ZSR de Katana. Le rapport annuel 2011 du BCZ de Katana montre que 66186 cas ont été traités au cours de cette année dont 1 cas de décès. Ceci montre que tous les frais de santé sont engloutis par la malaria et de surcroit appauvrit la population étant donné qu'elle est devenue endémique et se présente en plusieurs épisodes dans les ménages.

Ce paludisme n'entame pas seulement la situation économique, mais aussi affaiblit l'homme, crée des conflits sociaux, entraine des risques de contamination par la transfusion, entraine la morbidité et la mortalité surtout chez les enfants de moins de 5 ans et les femmes enceintes.

Notre enquête montre que plus de la moitié des ménages ont un malade souffrant du paludisme tous les quatre mois. Ceci a un impact négatif sur l'économie du ménage.

Les personnes enquêtées ont déjà perdu au moins un membre de leur ménage à cause du paludisme. Ce qui montre que cette maladie est plus meurtrière. Si on se réfère à la situation du Sud-Kivu en 2005 ; 469 décès dus au paludisme ont été enregistrés dans les FOSA contre 262 décès à domicile. Ce qui donne un total de 731 décès.

Tenant compte du revenu journalier estimé à 144Fc soit 0,16$ US et vu la fréquence et le frais médicaux alloués uniquement au paludisme, nous suggérons ce qui suit :

- Les membres prophylactiques en débroussaillant les alentours des maisons ;
- La destruction des gites larvaires par la canalisation des eaux stagnantes ;
- L'utilisation des Moustiquaires Imprégnées d'Insecticide (MII) qui viennent de faire leur preuve dans les centres hospitaliers de la ZSR de Katana où le taux de la malaria diminue sensiblement ;
- L'utilisation des plantes médicinales qui sont moins couteuses et disponibles comme *: Vernonia amygdalina, Lebrunia bushaie, Artemisia annua, Aspilia africana, Cissampelos mucronata, Hygrophyla auriculata, Microglosa pyrifolia* et ces plantes sont d'usages dans nombreux pays africains[18] et [19] ;
- Le drainage de marais ;
- La constitution des mutuelles de santé ;
- La constitution des mini-projets de développement.

5 CONCLUSION

La grande préoccupation du présent travail était l'étude de l'incidence socio-économique de l'environnement sur la santé : cas du paludisme dans la ZSR de Katana.La prévalence du paludisme par rapport aux autres maladies, sa fréquence au sein des ménages et les frais médicaux y afférents entrainent non seulement la pauvreté de la population, mais aussi la vente de leurs lopins de terre, les dettes contractées, les conflits sociaux, les tribunaux de genre, l'hypothèque des biens des familles, la mort de personnes, la transmission des maladies telles que l'hépatite, la filariose, le cancer du sang (leucémie), les anémies, le paludisme, etc.

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REFERENCES

[1] Ramade F., Dictionnaire encyclopédique des Sciences de la nature et de la Biodiversité ,Dunod ,Paris, pp. 726,2008.
[2] http://www.who.int/water_sanitation_health/publications/facts2004/fr/, Novembre 2014
[3] http://www.unicef.org/french/wash/index_documents.html, Novembre 2014
[4] OMS(Organisation Mondiale de la Santé). Module de formation sur l'entomologie du paludisme et lutte antivectorielle,pp. 200 (Guide du participant), pp. 52 (Guide de l'instructeur), 2014
[5] http://emiradamo.com/2013/09/14/rdc-le-paludisme-a-tue-21-000-personnes-en-2012/ ,Novembre 2014
[6] Yamane, T.. Statistics: An Introductory Analysis, 2nd Ed., New York: Harper and Row.S ,1967.
[7] OMS(Organisation Mondiale de la Santé). Surveillance épidémiologique en vue de l'élimination du paludisme: manuel opérationnel,pp. 65,2014
[8] http://mag.plantes-et-jardins.com/conseils-de-jardinage/fiches-conseils/rotation-des-cultures, Novembre 2014
[9] H. Giles, Le paludisme, OMS, Kinshasa, 1991
[10] Anonyme, « Plan national stratégique de lutte contre le paludisme », 2011
[11] B. Patrice, « Maladies tropicales », Paris 1987
[14] Anonyme, Rapport de la Banque Mondiale, 1998
[15] Anonyme, Rapport de l'International Rescue Commity, 2001
[16] A. Vanden, S. Courtejoie et Rotsart de Hertaing, la malaria , Kangu Mayumbe 1990
[17] Anonyme, Programme des Nations Unies pour le Développement, 1997
[18] A. Sofowara, Plantes médicinales et médecine traditionnelle d'Afrique. Karthala.Académie suisse des sciences naturelles 1999
[19] I. K. Balagizi, V. Kambale et R. Emilio, Les plantes médicinales du Bushi. Genova, Emiliami, Italy ,2007

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DEGATS ACTUELS DE CAFIEIR (*Coffea arabica*) ET SAVOIR FAIRE PAYSANS DANS LA LUTTE DES RAVAGEURS INSECTES DU CAFIEIR A KABARE NORD, COTE OCCIDENTALE DU LAC KIVU, EST DE LA R.D. CONGO

[CURRENT DAMAGE OF COFFEE (*Coffea arabica*) AND FARMERS EXPERTISE IN THE FIGHT OF INSECT PESTS OF COFFEE, NORTH KABARE, WESTERN COASTLINE OF LAKE KIVU, EASTERN D.R. CONGO]

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ABSTRACT: The pest survey was used, preceded by one month of a pre-survey in North Kabare . In addition, the method of direct and detailed observation, systematic sampling and identification key was used. The aim of this study is to know the damage and the use of extracts of plants by coffee farmers farmers North of Kabare .The result of the study shows that the family of Arthropods (*Thumbtack of the coffee* and *Thumbtack lace*) causes enough damage to *arabica* coffee than other families like Thysanoptera (*Thrips reel*), Lepidoptera (*Chenille rodent leaves* and *moth drupe*) and Coleoptera (*Hanneton of the coffee*) and farmers have knowledge in combating insect pests coffee but they have no notion of the active principles of plants and the dose to be used .dropoff window Furthermore, the leaves of *Tephrosia voegeli* , *Tithonia diversifolia, Tabacum nicotiana* and *Capsicum frutensis* mixed with local know the name of "Kifebe" are effective.

KEYWORDS: Systematic, Heteroptera, Thysanoptera, Coleoptera, Lepidoptera.

RESUME: L'enquête phytosanitaire a été utilisée, précédée d'une pré-enquête d'un mois, conduite dans les groupements de Kabare Nord. De plus, la méthode d'observation directe et détaillée, l 'échantillonnage systématique ainsi que la clé d'identification ont été utilisées et l 'objet de cette étude est de connaître les dégâts et l'utilisation des extraits des plantes par les paysans caféiculteurs du Kabare Nord .Le résultat de l'étude montre que la famille des Hétéroptères*(Punaise du caféier et Punaise à dentelle)* cause assez des dégâts au *café arabica* que les autres familles comme celles des Thysanoptères *(Thrips enrouleur)* , les Lépidoptères *(Chenille rongeuse des feuilles et Pyrale de drupe)* et les Coléoptères *(Hanneton du caféier)* et les paysans ont de connaissance dans la lutte des ravageurs insectes du cafié mais, ils n'ont pas de

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notions sur les principes actifs des plantes et sur la dose à utiliser. De plus, les feuilles de *Tephrosia voegeli*, de *Tithonia diversifolia*, de *Tabacum nicotiana* et de *Capsicum frutensis* mélangées avec savons locales du nom de " Kifebe " sont efficaces.

MOTS-CLEFS: Systématique, Hétéroptères, Thysanoptères, Coléoptères, Lépidoptères.

1 INTRODUCTION

L'importance relative, dans le monde, des trois principales espèces cultivées de caféier est comme suit : *C. arabica* : 90 % du café mondial ; *C. robusta* : 9 % ; *C. liberica* : 1 %[1].

En République Démocratique du Congo, les plantations et champs des cultures agro-industrielles (café, cacao, palmier à huile, canne à sucre, hévéa) sont exploités dans des zones où les conditions édaphoclimatiques sont propices auxdites cultures. Les cultures de rente contribuent à l'augmentation des revenus des ménages, à l'amélioration de l'économie des provinces et du pays. A titre illustratif, la production moyenne était estimée, en 2001, à 162.000 tonnes d'huile de palme, 1,5 million de tonnes de cannes à sucre, 39.000 tonnes de café (80% *robusta*), 6.250 tonnes de cacao, 4.200 tonnes de caoutchouc, 3.800 tonnes de tabac et 1.800 tonnes de thé [2].

Les graines du café comme bon nombre de drupes des plantes tropicales, ont une valeur nutritive particulièrement appréciable. L'apport significatif en potassium, magnésium, phosphore, chlore, silice, calcium, sodium, fer, azote, caféine, acide choréique, glucides, lipides, etc à l'organisme humain explique l'intérêt de café [3] et [4].

A l'horizon 2025, la consommation globale de café vert pourrait atteindre 10 millions de tonnes pour une production de 9,4 à 9,8 millions de tonnes. Il s'avère qu'il surgira un risque de déficit de l'offre [5].

En 1989, [6] ont monté que les caféiers de la région des Grands Lacs d'Afrique Central et en 2014,[7] à Kabare Nord, au Sud Kivu, sont sujettes aux attaques des ravageurs comme *Antestiopsis orbitalis ghesquierei* (Punaise du caféier), *Habrochila ghesquierei*(Punaise à dentelle), *Haplandothrips marshalli* (Thrips enrouleur) , *Saissetia coffeae* , *Asterolecanium coffeae*,*Coccus alpinus*, *Coccus viridis*,*Planococcus citris* ,*Planococcus kenyae* , *Ferrisia virgata* (Cochenilles), *Leucoptera* spp. (Chenilles mineuses des feuilles), *Leucoplema dohertyi* (Chenille rongeuse des feuilles),*Epicampoptera* spp .(Chenilles défoliantes), *Prophantis smaragdina* (Pyrale des drupes), *Pseudotrochalus schulbotzi* (Hanneton du caféier),*Hypothenemus(Stephanoderes) hampei* (Scolyte des graines), *Anthores leuconotus* (Borer du tronc) , *Ceratitis (Trirbitbrum) coffea,Ceratitis capitata* (Mouches des fruits)et *Apate monachus* (Borer noir du tronc).Selon[7] en 2014 ,dans la région de Kabare Nord au Sud Kivu sur les caféières, la punaise du caféier présente une incidence la plus élevée (32%) suivi de thrips enrouleur (15%), puis le hanneton du caféier et la chenille rongeuse des feuilles qui sont exa-equo (respectivement 14%), ensuite le pyrale de drupe (13%) et enfin la punaise à dentelle (12%).

De plus, dans la province du Sud Kivu en général, quelques plantes sont utilisées d'une façon brute pour faire fouire les insectes comme *Eucalyptus citriodora*, *Tagetes minuta, Ocimum gratissimum, Mentha aquatica* et *Chenopodium ugandae* ([8] et [9]) et dans les plantations des caféiers de Kabare Nord en particulier , quelques caféieculteurs utiliseraient et compareraient les effets des plantes insectifuges comme la plantation de Bwengehera .

Ainsi, la connaissance des ravageurs insectes ,leur incidence par famille à Kabare Nord serait importante ainsi que le mode d'utilisation des plantes insectifuges par les paysans et la durée de son effet observé par les paysans sur les ravageurs .De plus , aucune étude n'a été faite sur l'utilisation des plantes insectifuges par les paysans dans la lutte des ravageurs insectes du café.

L'objet de cette étude est de connaître les dégâts et l'utilisation des extraits des plantes par les paysans caféiculteurs du Kabare Nord.

2 MATERIEL ET METHODES

2.1 MATERIEL

L'étude a été conduite à partir du mois de Juin 2012 jusqu'au mois de Juin 2013 dans la région de Kabare Nord plus précisément dans les groupements de Lugendo, d'Irhambi-Katana, de Bugorhe, de Luhihi, de Miti et de Bushumba où les caféiers sont cultivés. Les groupements de Bugorhe, de Miti et d'Irhambi-Katana se trouvent à une altitude d'environ 2000 m

et sont proches du Parc National de Kahuzi-Biega. Les trois autres groupements ont une altitude relativement basse pouvant varier entre 1460 m et 1600 m, de même ils sont voisins du lac Kivu([7], [10]).

La région de Kabare Nord est caractérisée par un climat tropical humide, tempéré par les montagnes. L'altitude varie entre 1460 m au niveau du lac Kivu et plus de 1900 m au niveau de Tshibati, le climat est du type AW suivant la classification de Köppen. Il est aussi caractérisé par deux saisons dont une courte saison sèche allant de juin jusqu'en août et une longue saison de pluies allant de septembre à mai. Les pluies sont abondantes et atteignent une hauteur moyenne annuelle de 1500 mm [11]. Toutefois, suite aux phénomènes des perturbations climatiques dont la ville de Bukavu et ses environs connaissent ces derniers temps, il s'observe un changement de la distribution annuelle des pluies ainsi que l'augmentation de la température moyenne dans ladite région [12]. Le sol de Kabare Nord est très fertile à cause de son origine volcanique [13].

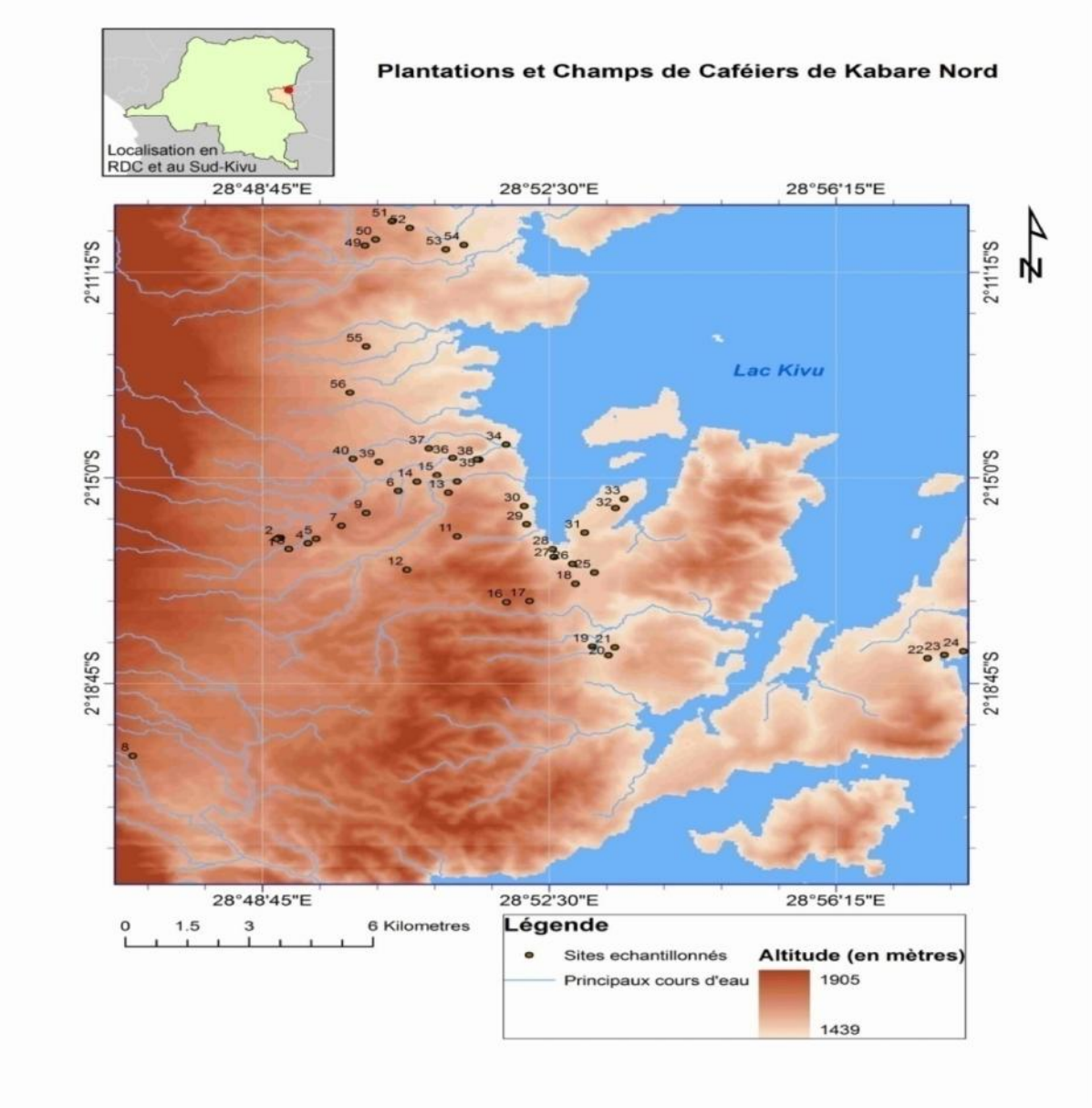

Fig 1. Caféiers de Kabare Nord

2.2 METHODES

L'enquête phytosanitaire a été utilisée, précédée d'une pré-enquête d'un mois, conduite dans les groupements de Kabare Nord. De plus, la méthode d'observation directe et détaillée,l 'échantillonnage systématique proposée par [14] ainsi que la clé d'identification proposée par [6] ont été utilisées. Elle a consisté à choisir une première unité et ensuite à partir de celle-ci, de façon régulière les autres unités qui constituent l'échantillon, la raison de la progression arithmétique choisie était 2 et le deuxième caféier comme le début de tri des caféiers.

L'incidence des ravageurs insectes du café a été calculée.Et ,cette incidence (I) correspond au nombre des plants malades sur le nombre total des plants enquêtés (pour notre cas 150 plants dans 6 ares) multipliés par cent et a été calculé et la formule est :(I)= $\frac{\sum_{t-1}^{n} Pt}{N} x100$ Avec Pt= Nombre de pieds ravagés à la période de contrôle et N= Nombre total de plant du carré. De même, la distribution de Poisson et la constante de distribution de Kurtosis (υ) ont été utilisées pour les incidences par familles.

3 RESULTS

3.1 DÉGÂTS ACTUELS DU CAFÉIER *ARABICA*

Tableau 1. Incidences des plants attaqués par les ravageurs insectes par famille

N^{O}	Incidence de Thysanoptères (*Thrips enrouleur*) en %	Incidence des Hétéroptères (*Punaise du caféier et Punaise à dentelle*) en %	Incidence des Lépidoptères (*Chenille rongeuse des feuilles et Pyrale de drupe*) en %	Incidence des Coléoptères (*Hanneton du caféier*) en %
1	13.33	0,00	6.66	0.00
2	0.00	23.33	0.00	0.00
3	0.00	30.00	20.00	0.00
4	8.00	10.67	4.33	3.33
5	8.67	13.33	5.67	6.67
6	10.00	18.33	8.33	1.33
7	10.00	8.33	3.33	2.00
8	6.67	30.00	11.66	20.00
9	20.00	9.00	4.00	6.67
10	13.33	24.33	7.66	13.33
11	8.00	6.00	2.00	3.33
12	5.33	11.67	6.67	3.33
13	9.33	11.66	3.00	4.00
14	8.67	18.33	5.66	2.67
15	6.67	15.66	1.66	4.67
16	1.33	3.33	5.00	2.00
17	2.67	7.00	5.33	3.33
18	1.33	2.33	2.33	3.33
19	13.33	10.00	13.33	13.33
20	6.67	6.67	6.67	6.67
21	10,00	11.66	10.00	6.67
22	6.67	21.66	10.67	6.67
23	6.67	18.67	6.33	6.67
24	6.67	17.33	6.33	6.67
25	3.33	18.67	6.33	6.67
26	3.33	20.00	6.33	6.67

27	6.67	23.33	6.33	6.67
28	3.33	25.00	6.33	6.67
29	3.33	6.67	6.33	6.67
30	6.67	21.66	3.33	6.67
31	6.67	12.00	3.33	6.67
32	10.00	13.33	13.33	20.00
33	13.33	11.66	16.67	20.00
34	13.33	8.33	4.98	13.33
35	40.00	40	33.33	40.00
36	6.00	5.33	5.00	5.33
37	6.00	7.33	5.00	5.33
38	6.00	6.33	5.00	5.33
39	6.00	5.66	5.00	5.33
40	6.00	6.00	5.00	5.33
41	6.00	9.00	5.00	5.33
42	6.67	10.00	9.33	13.33
43	6.67	10.00	8.33	13.33
44	6.67	10.00	6.67	0.00
45	6.67	10.00	8.33	13.33
46	6.67	6.66	10.00	13.33
47	6.67	10.00	8.33	13.33
48	6.67	10.00	5.66	13.33
49	6.67	10.00	5.00	13.33
50	6.00	6.66	5.00	5.33
51	6.00	3.66	5.00	5.33
52	6.00	6.33	5.00	5.33
53	6.00	5.66	5.00	5.33
54	0.00	0.00	58.33	0.00
55	13.33	13.33	0.00	0.00
56	4.67	16.66	0.00	30.00
Moyenne ± Ecart type	7.28±2.69	13.00±3.60	7.53±2.74	7.73±2.78
constante de distribution de Kurtosis (υ)	0.13	0.07	0.13	0.12

De ce tableau, il ressort que les incidences des plants attaqués par les ravageurs insectes par famille diffèrent entre elles pour les Thysanoptères(Thrips enrouleur) ,la moyenne est de 7.28±2.69 ,pour les Hétéroptères 13.00±3.60 et la constante de distribution de Kurtosis (υ) est de 0.07,pour les Lépidoptères 7.53±2.74 et pour les Coléoptères 7.73±2.78

3.2 SAVOIR-FAIRE PAYSANS DANS LA LUTTE DES RAVAGEURS INSECTES DU CAFÉIER

Dans la plantation Bwengehera, trois nouvelles variétés des caféiers sont cultivées : *Mancrojip, BMJ* et *Hybride d'Abyssinie* . Pour lutter contre les ravageurs insectes et la maladie comme la rouille du caféier, ladite plantation utilisaient le thiodan 20cc dans 20 litres d'eau à raison d'1cc par litre associé avec une mesure (boîte de tomate) de Maconzèbe. Le constant est qu' à peu près une semaine soit 5 à 6 jours, il y apparition des ravageurs et l'inconvénient est que les produits chimiques détruisent la fève donc elle perd d'abord le poids ensuite l'arôme du café est perdu d'où la perte dans la vente du café. Ainsi, la plantation Bwengehera a adopté l'utilisation des plantes insectifuges, ayant les principes actifs de faire fouir les insectes.

Mode d'utilisation des plantes insectifuges

- Plantes insectifuges : Elle utilise *Tephrosia voegeli*, Tithonia *diversifolia*, *Tabacum nicotiana* et 1 Kilogramme de *Capsicum frutensis*.
- Mode opératoire : 10 kilogrammes des feuilles de *Tephrosia voegeli* , de *Tithonia diversifolia*, de *Tabacum nicotiana* et 1 Kilogramme de *Capsicum frutensis* sont pilées ensuite mis dans un gros bassin (60 litres) mélangés avec 3 savons locales du nom de " Kifebe " dans 25 à 30 litres d'eau. Ce mélange est conservé quelque part pour la fermentation.
- Fermentation : dure 3 jours puis s'ensuit le triage et le tamisage des particules. Le produit fini est mis dans un pulvérisateur pour être pulvérisé sur les caféiers.

Efficacité de produit observé par les paysans sur les ravageurs

Le produit est efficace ; une fois pulvérisé sur les caféiers les ravageurs insectes apparaissent après 28 à 35 jours. De plus, la fève ne perd pas le poids et elle garde toujours l'arôme mais l'inconvénient est que la variété arabica ne résiste pas à cette dose.

4 DISCUSSION

L'incidence de la famille des Hétéroptères*(Punaise du caféier et Punaise à dentelle)* est grande (13.00±3.60) et la constante de distribution de Kurtosis (υ) est de 0.07 donc la distribution de Poisson approche la distribution normale en le comparant aux Thysanoptères *(Thrips enrouleur)* ,qui a 7.28±2.69, les Lépidoptères *(Chenille rongeuse des feuilles et Pyrale de drupe)* 7.53±2.74 et les Coléoptères *(Hanneton du caféier)* 7.73±2.78 car selon [6], les Hétéroptères ,comme d'une part l'*Antestiopsis orbitalis ghesquierei* se nourrit préférentiellement sur les drupes et ses populations s'accroissent en période de fructification des caféiers. Ses piqûres provoquent la chute des jeunes drupes. Les dégâts occasionnés aux drupes plus âgées ne sont visibles qu'à la récolte sous la forme de fèves détériorées ou pourries suite à l'introduction du champignon *Nematospora* dans les fruits lors des piqûres .En raison de sa mobilité et de son mode de nutrition par piqûres répétées, la punaise peut s'alimenter sur les bourgeons, les boutons floraux ,les fleurs, les feuilles ou les jeunes rameaux et en saison sèche ,elle peut aussi survivre sur des plantes hôtes spontanées telle que *Pavetta ternifolia* ; d'autre part, le *Habrochilla ghesquierei* vit à la face inférieure des feuilles qui jaunissent sous l'effet de leurs piqûres, et montrent de nombreux petits points noirs qui sont les excréments desséchés de l'insecte. Les fortes infestations souvent localisées en début d'attaque sur le feuillage de la base de quelques arbres, provoquent la chute des feuilles, ainsi, elle cause rarement des dégâts importants.

Les feuilles de *Tephrosia voegeli* , de *Tithonia diversifolia*, de *Tabacum nicotiana* et de *Capsicum frutensis* mélangées avec savons locales du nom de " Kifebe " sont efficaces car,d'après [15] , la mortalité de la punaise du caféier variait très significativement selon le traitement, la concentration ainsi qu'avec l'interaction des traitements et les concentrations des substances insecticides.). Les stéroïdes ont une mortalité de 57 % à la dose 0,636g/ml , les saponines et terpènes ont un effet minimal à ladite dose. L'activité insecticide de Supadip était supérieure à tous les autres produits insecticides testés aux doses de 0,01ml/l et 0,1ml/l (100% de mortalité), à la dose 0,636g/l, les alcaloïdes extraits de *Capsicum* ont un effet similaire à celui de Supadip et Diméthoate (100%) de mortalité. Les alcaloïdes présentent une faible dose létale DL 50 (0,21±0,015g/ml) par rapport aux autres principes actifs extraits des fruits de Capscicum testés sur la punaise (0,54 ±0,012g/ml pour les stéroïdes ; 0,93 ± 0,054g/ml pour les saponines et 1,70± 0,277g/ml pour les terpènes). De plus, [15] a montré après analyse chimique des fruits de *Capscicum*, les alcaloïdes, phénols, flavonoïdes, terpènes, stéroïdes, caroténoïdes et lipoïdes sont fortement présents les saponines sont moyennement présentes et enfin les tanins, les quinones et les glucosides sont faiblement présents.

5 CONCLUSION

L'étude montre que la famille des Hétéroptères *(Punaise du caféier et Punaise à dentelle)* cause assez des dégâts au *café arabica* que les autres familles comme celles des Thysanoptères *(Thrips enrouleur)*, les Lépidoptères *(Chenille rongeuse des feuilles et Pyrale de drupe)* et les Coléoptères *(Hanneton du caféier)* et les paysans ont de connaissance dans la lutte des ravageurs insectes du cafié mais, ils n'ont pas de notions sur les principes actifs des plantes et sur la dose à utiliser. De plus, le système de lute par le savoir paysanne contre les ravageurs insectes du café est efficace par utilisation des feuilles de *Tephrosia voegeli*, de *Tithonia diversifolia*, de *Tabacum nicotiana* et de *Capsicum frutensis* mélangées avec savons locales du nom de " Kifebe".

Ainsi, que les chercheurs fassent des essais avec la population sur les extraits plantes insectifuges pour avoir assez de plantes efficaces et la dose precise contre la punaise du caféier car les substances organiques insecticides biodegradables

sont non nocifs à l'homme,ne détruisent pas l'arôme du café, les ne polluent pas l'environnement et alternatives aux pesticides synthétiques pollueurs de l'environnement.

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REFERENCES

[1] Reamaeker R.H., Agriculture en Afrique tropicale, Direction générale de Coopération Internationale (DGCI), Bruxelles, Belgiques, pp.1634, 2001.
[2] E. Makumbelo, L. Lukoki, J. Paulus, N. Luyindula, "Apport des arbres fruitiers à la sécurité alimentaire en milieu urbain tropical : cas de la commune de Limete-Kinshasa, RD Congo", *Tropicultura*, 23, 4, pp.245-252, 2005.
[3] F.A.O, Table de composition des aliments à l'usage de l'Afrique, Document sur la nutrition 3, F.A.O, Rome, Italie, pp.81-97, 1970.
[4] Degroote V A., Table de composition alimentaire pour la République Démocratique du Congo, Concordia, Kinshasa, pp.21-25, 1970.
[5] Daviron B. et Ponte S., The coffee paradox: Global markets, commodity trade and the elusive promise of development. Londres, Zed Books, pp.288, 2005.
[6] Autrique A. et Perreaux D. Maladies et ravageurs des cultures de la région des Grands Lacs d'Afrique Centrale, AGCD n° 24, ISABU, Burundi, pp.232, 1989.
[7] M. Nsambu, B. Muhigwa, K. Rubabura, M. Bagalwa et S. Bashwira, " Etat phytosanitaire des plantations et champs de caféier de Kabare Nord,Sud Kivu, Est de la RD. Congo ",*International Journal of Innovation and Applied Studies*, Vol. 8 No. 3, pp. 1219-1230, 2014.
[8] M. Bagalwa, S. Bashwira et K. Chifundera, " Insecticidal activity of *Ocimum gratissimum*,*Mentha aquatica* and *Haumaniastrum galeosifolium*(Lamiaceaea),plants from Kivu-province,Democratic Republic of Congo".*Annales de l'UCB*,1,72-76, 2001.
[9] M. Bagalwa, S. Bashwira et M. Cirimwami, " Toxicité des extraits organique et aqueux de quelques plantes insecticides contre *Sitophilus zeamais* et *Acanthoscelides obtectus* insectes ravageurs des denrées stockées", *Cahiers du CERUKI,Numéro Spécial*,pp.27-33, 2009.
[10] Bultot F., Régimes normaux et cartes de précipitations dans l'Est du Congo Belge (Longitude 26° à 31°Est, latitude 4°Nord à 5°Sud) pour la période 1930 à 1960, Communication n°1du Bureau Climatique, Publ.INEAC, Coll. n°4, pp.300, 1950a.
[11] Bultot F., Carte des régions climatiques du Congo Belge établie d'après les critères de Köppen, Communication n°2 du Bureau Climatique, Publ.INEAC, Coll.n°4, pp. 250, 1950b.
[12] J B. Muhigwa, " Perturbations climatiques autour de Bukavu". *Annales Sci et Sci Appl. U.O.B*, 2, pp.54-60, 2010.
[13] Pecrot A. et Léonard A., Carte des sols et de la végétation du Congo Belge et du Rwanda-Urundi, 1-Dorsale du Kivu A, B et C. Notice explicative de la carte des sols et de la végétation, Bruxelles, pp.124-130, 1960.
[14] Dagnelie P., Statistique théorique appliquée, tome 1, Presse Agronomique Gembloux, Belgique, pp.492, 1992.
[15] M. Nsambu, B. Muhigwa, K. Rubabura, M. Bagalwa et S.Bashwira, " Terpenoïdes et steroïdes extraits de *capscicum frutescens* l. (*Solanaceae*)contre *Antestiopsis orbitalis ghesquierei*, insectes ravageurs des cafeiers", *International Journal of Innovation and Applied Studies*, Vol. 8 No. 3, pp. 1231-1243, 2014.

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SYSTEME CULTURALE ET MALADIES SEVISSANT LES CAFIEIRS (*Coffea arabica*) A KABARE NORD, COTE OCCIDENTALE DU LAC KIVU, SUD - KIVU, EST DE LA R.D. CONGO

[CROP SYSTEM AND THE CAFEE'S DISEASES (*Coffea arabica*) AT NORTH KABARE, WESTERN COASTLINE OF LAKE KIVU, SOUTH - KIVU, EASTERN D.R. CONGO]

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ABSTRACT: The pest survey was used, preceded by one month of a pre-survey in North Kabare. In addition, the method of direct and detailed observation, systematic sampling and identification key was used. The aim of this study is to know the culture system and to assess the impact and severity of the disease raging coffee (*Coffea arabica*). The study shows that the cropping system as practiced is associated coffee and the majority of Kabare Northern coffee plantations suffer of *Anthracnose*, the *rust* and *leaf spot* thus fungal diseases. Coffee trees suffering with *Die back*, their branches, sometimes their branches, black and dry out gradually from the end and lose leaves, those of *Anthracnose*, green drupes growth appear small dark brown spots, black, rounded oval, markedly depressed that expand quickly. For *rust*, small yellow circular spots appear on the underside of leaves and *leaf spot*, small chlorotic points that extend and turn brown.

KEYWORDS: Anthracnose, rust, leaf spot, Die back, branches, chlorotic.

RESUME: L'enquête phytosanitaire a été utilisée, précédée d'une pré-enquête d'un mois, conduite dans les groupements de Kabare Nord. De plus, la méthode d'observation directe et détaillée, l'échantillonnage systématique ainsi que la clé d'identification ont été utilisées et l'objet de cette étude est de connaitre le système de culture et d'évaluer l'incidence et la sévérité des maladies sévissant les cafiéirs (*Coffea arabica*). L'étude montre que le système de culturale le plus pratiqué est les caféiers associés et la majorité des plantations des caféiers de Kabare Nord souffrent de l'*Anthracnose*,de la *Rouille* et la *Cercosporiose* donc de maladies cryptogamiques. Les caféiers atteintent par *Die back*, leurs rameaux, parfois leurs branches, noircissent et se dessèchent progressivement depuis l'extrêmité et perdent les feuilles,ceux d' *Anthracnose*,les drupes vertes en croissance apparaissent de petites taches brun foncé, à noires, arrondies à ovales, nettement déprimées qui s'étendent rapidement. Pour la *Rouille*, les petites taches circulaires jaunâtres apparaissent à la face inférieure des feuilles et pour la *Cercosporiose*, les petits points chlorotiques qui s'étendent et brunissent.

MOTS-CLEFS: *Anthracnose*, *Rouille*, *Cercosporiose*, *Die back,* rameaux, chlorotiques.

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1 INTRODUCTION

La maladie la plus grave est l'*anthracnose* des fruits, due à un champignon: le *Colletotrichum kahawae*. Elle sévit principalement en Afrique de l'Est. Certaines années, elle peut entraîner jusqu'à 90% de perte en période de récolte. La voie privilégiée pour résoudre ce problème est la recherche de variétés résistantes. Il existe encore bien d'autres ennemis du caféier, comme les nématodes qui s'attaquent aux racines, la rouille orangée, autre maladie fongique qui attaque les feuilles, les punaises, pucerons et cochenilles, etc. Cependant, en règle générale, rares sont les producteurs qui les contrôlent et le café est bien souvent cultivé de façon « naturelle » [1].

Selon [2] en 1989 et [3] en 2014 ont monté que les caféiers de la région des Grands Lacs d'Afrique Central en générale et à Kabare Nord, au Sud Kivu, à l' Est de la République Démocratique du Congo en particulier, sont sujettes aux maladies telles que non parasitaire, le dépérissement par surproduction (*Die-back*), bactérienne , l'Elgon die-back(*Pseudomonas syringae pv. garcae*),cryptogamique, la rouille (*Hemileia vastatrix*) , la Cercosporiose (*Cercospora coffeicola*),l'Antrachnose (*Colletotrichum coffeanum*)et l'Ascochytose (*Ascochyta tarda*).

En République Démocratique du Congo, les plantations et les champs des cultures agro-industrielles (café, cacao, palmier à huile, canne à sucre, hévéa) sont exploités dans des zones où les conditions édapho-climatiques sont propices auxdites cultures. Les cultures de rente contribuent à l'augmentation des revenus des ménages, à l'amélioration de l'économie des provinces et du pays [2].Et le café représente actuellement le principal produit agricole d'exportation (25 à 50 % de la valeur des exportations agricoles).Le Sud-Kivu connaît quatre cultures de rente en fonction de ses différents climats et sols: Le café,le quinquina, le thé et le coton. Les deux premiers sont des produits d'exportation, les deux deniers sont consommés sur le marché intérieur. A partir des années 1920, des colons implantèrent des plantations de café au Sud-Kivu, de la variété *arabica* dans les hautes terres d'abord, puis de la variété *robusta* dans les contrées moins élevées (Plaine de la Ruzizi et bord du lac Tanganika en territoire de Fizi) [4].

L'*Arabica* aime les climats frais, sans gel et se plaît dans les écologies des zones de montagne. Il est planté à des densités variant de 3 000 à 10 000 pieds par hectare. Il commence à produire au bout de 2 ou 3 ans. La floraison est provoquée soit par le froid, soit par une période sèche. Lorsque la saison sèche est bien marquée, il peut y avoir une ou deux floraisons par an. Dans les climats froids et toujours pluvieux des hautes montagnes, on peut assister à 4 ou 5 floraisons, voire plus, étalées sur plusieurs mois. La nouaison (durée de maturation du fruit) dure de 6 à 10 mois. L'entretien annuel se limite à de la taille, des désherbages, de la fertilisation et, éventuellement, des traitements phytosanitaires contre les insectes et les maladies. Les graines du café comme bon nombre de drupes des plantes tropicales, ont une valeur nutritive particulièrement appréciable. L'apport significatif en potassium, magnésium, phosphore, chlore, silice, calcium, sodium, fer, azote, caféine, acide choréique, glucides, lipides,…, à l'organisme humain explique l'intérêt de café [5] et [6].

A l'horizon 2025, la consommation globale de café vert pourrait atteindre 10 millions de tonnes pour une production de 9,4 à 9,8 millions de tonnes. Il s'avère qu'il surgirait un risque de déficit de l'offre [7].

Ainsi, pour améliorer la caféiculture dans la partie du Kabare Nord, il serait utile de connaître le système de culture et/ou les maladies du caféier ainsi que leur incidence et sévérité. Peu de recheches ont fait l'objet de l'étude phytopathologique du caféier dans ledit milieu de Kabare.

L'objet de cette étude est de connaitre le système de culture et évaluer l'incidence et la sévérité des maladies sévissant les cafiéirs (*Coffea arabica*) à Kabare Nord, côte occidentale du lac Kivu au Sud – Kivu à l'Est de la République Démocratique du Congo.

2 MATERIEL ET METHODES

2.1 MATERIEL

La prospection phytosanitaire a été faite durant le mois de Juin 2012 jusqu'au mois de Juin 2013, soit une année, dans la région de Kabare Nord plus précisément dans les groupements d'Irhambi-Katana, de Bugorhe, de Luhihi, de Lugendo, de Miti et de Bushumba où les caféiculteurs pratiquent ladite culture.

Les groupements de Bugorhe, de Miti et d'Irhambi-Katana se trouvent à une altitude d'environ 2000 m et sont proches du Parc National de Kahuzi-Biega tandis que les trois autres groupements ont une altitude relativement basse pouvant varier entre 1460 m et 1600 m, de même ils sont voisins du lac Kivu[8].

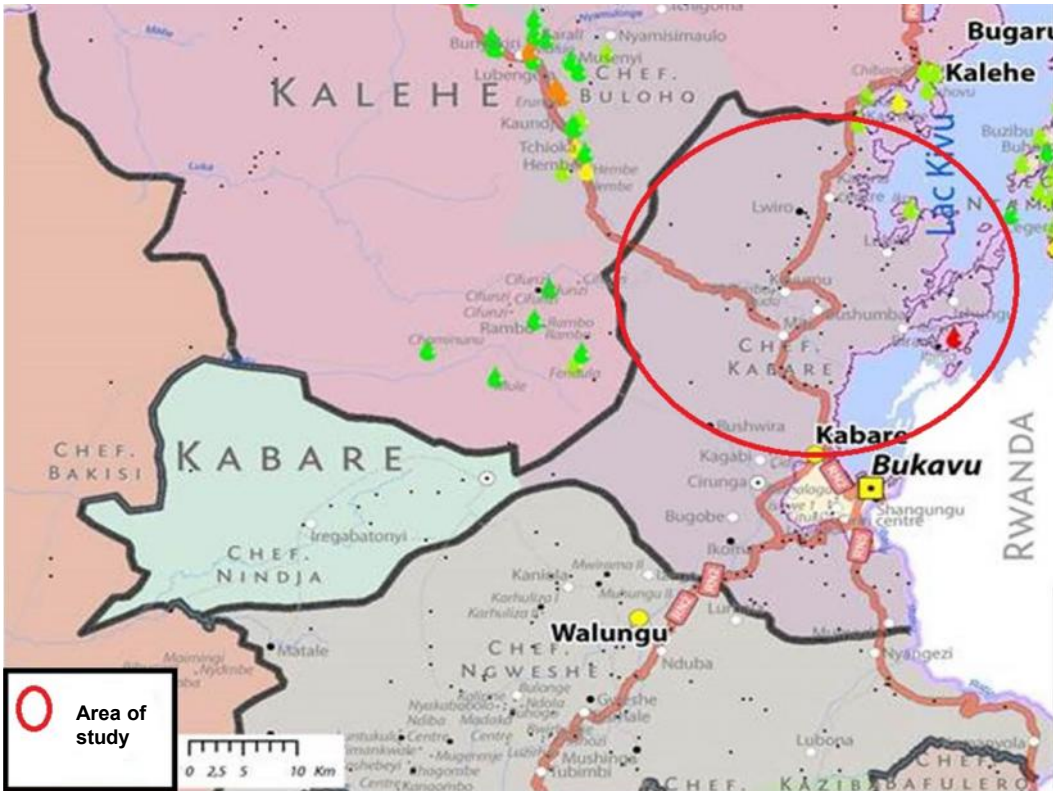

Fig 1. Milieu d'étude, Kabare Nord

La région de Kabare Nord est caractérisée par un climat tropical humide, tempéré par les montagnes. L'altitude varie entre 1460 m au niveau du lac Kivu et plus de 1900 m au niveau de Tshibati, le climat est du type AW suivant la classification de Köppen. Il est aussi caractérisé par deux saisons dont une courte saison sèche allant de juin jusqu'en Août et une longue saison de pluies allant de Septembre à Mai. Les pluies sont abondantes et atteignent une hauteur moyenne annuelle de 1500 mm [8]. Toutefois, suite aux phénomènes des perturbations climatiques dont la ville de Bukavu et ses environs connaissent ces derniers temps, il s'observe un changement de la distribution annuelle des pluies ainsi que l'augmentation de la température moyenne dans ladite région [9]. Le sol de Kabare Nord est très fertile à cause de son origine volcanique [10] et la figure 2 présente les plantations, sites échantillonnés dans la région de Kabare Nord.

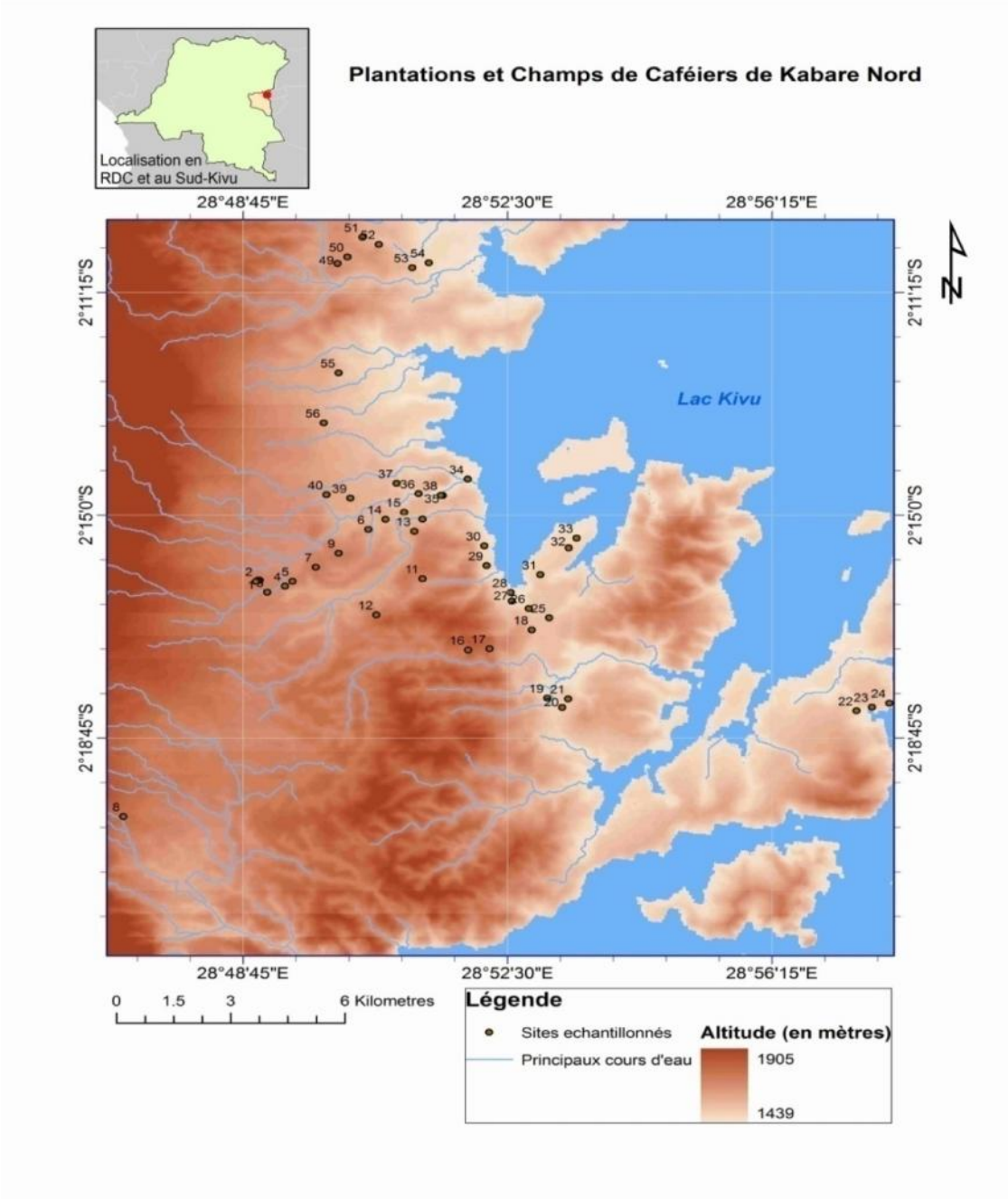

Fig 2. Plantation de Café de Kabare Nord

2.2 METHODES

La ronde phytosanitaire [11] a été précédée d'une pré-enquête dans les groupements de la région de Kabare Nord. La méthode d'observation directe et détaillée [12] et l'identification des maladies a été faite par la clé proposée par [2].

Le travail a été effectué selon la technique d'échantillonnage systématique proposée par [11] et [12]. Elle a consisté à choisir une première unité et ensuite à partir de celle-ci, de façon régulière les autres unités qui constituent l'échantillon, la raison de la progression arithmétique choisie était 3 et le deuxième caféier comme le début de tri des arbres. L'incidence et la sévérité des maladies ont été calculées par les formules suivantes. Et Incidence (I) correspond au nombre des plants

malades sur le nombre total des plants enquêtés (pour notre cas 150 plants dans 6 ares) multipliés par cent et a été calculé, la formule (I)= $\frac{\sum_{t-1}^{n} Pt}{N} x100$

Avec Pt= Nombre de pieds ravagés à la période de contrôle et N= Nombre total de plant du carré.

Le degré de sévérité de symptômes foliaires a été évaluée sur les plants en plantation en utilisant nos propres échelles , pour la maladie bactérienne *Die back*(Drupes, rameaux et branches sains: 0 soit 0 % , Rameaux, parfois les branches ,noircissent et se dessèchent progressivement depuis leur extrêmité et perdent leurs feuilles: 1-3 soit 1 à 30 % ,Drupes ne murissent pas et se nécrosent: 4-5 soit 40 à 50 % ,Port de plus de drupes par le caféier qu'il ne peut en nourrir : 6-7 soit 60 à 70 %, Reserves de l'arbre s'épuisent et sa vitalité est affecté parfois jusqu'à la mort de la plante) et pour les maladies cryptogamiques [*Anthracnose*(Drupes vertes: 0 soit 0 % ,Drupes vertes en croissance apparaissent de petites taches brun foncé , à noires,arrondies à ovales, nettement déprimées qui s'étendent rapidement: 1-4 soit 1 à 49 %, Drupes attaquées tombent ou demeurent sur l'arbre,noircies et désséchées: 5 soit 50 %,Fèves sont détruites: 6-7 soit 60 à 70 %, Drupes déprimées, à surface brillante et d'apparence humide: 8 soit 80 à 97 %,Drupe noircit et se ride,mais les fèves ne sont pas atteintes de plus grandest aches brunes à anneaux concentriques sur les feuilles et une nécrose des rameaux: 9 soit 98 à 100 %),*Rouille*(Pas de petits taches: 0 soit 0 %, Petites taches circulaires jaunâtres apparaissent à la face inférieure des feuilles: 1-4 soit 1 à 25%, et s'agrandissent en se recouvrant d'une poussière orange:5 soit 26 à 70%, Face supérieuren les taches chlorotiques vert pale à jaunâtre ,nécrotiques en vieillissant: 8 soit 75 à 97 %, Fortes attaques provoquent une defoliation prématurée de l'arbre qui s'affaiblit: 9 soit 100 %),*Cercosporiose*(Pas de points chlorotique: 0 soit 0 %,Petits points chlorotiques qui s'étendent et brunissent: 1-4 soit 1 à 40 % ,Taches pleinement dévelàppées montrent un centre blanc grisâtre,bored d'un anneau brun foncé,parfois entouré d'un halo chlorotique diffus: 5-7 soit 50 à 70 %, Une défiscience nutritionnelle et mal entretien,conditions de stress physiologique: 8-10 soit 80 à 100 % ,)] ainsi la sévérité (S) traduit qualitativement la pression des symptômes ou des dégâts caractéristiques d'une maladie ,par exemple en pourcentage de la surface foliaire nécrosée [13] , calculée par la formule suivante:

$$(S)=\sum \frac{des}{du}\frac{produits}{npmbre}\frac{entre}{d'unités}\frac{les}{de}\frac{fréquences}{l'échantillon}\frac{observées}{por\tan t}\frac{à}{les}\frac{chaque}{sympt\hat{o}mes}\frac{niveau}{de}\frac{de}{la}\frac{\cot ation}{maladie}\frac{à}{}\frac{l'}{}\frac{échelle}{}$$

3 RESULTATS

Tableau 1. Pratique de culture dans les plantations des caféiers, Kabare Nord

Groupements	Champs	Répétitions	Age en année	Système de culture	Entretien	Application des mesures phytosanitaires
Lugendo	Butorangwe	site1	69	Association (Caféiers, *Eucalyptus* sp, et *Maesopscis* sp)	Quelques fois	Non
		site2	69	Association (Caféiers, *Eucalyptus* sp, et *Maesopscis* sp)	Quelques fois	Non
		site3	69	Association (Caféiers, *Eucalyptus* sp, et *Maesopscis* sp)	Quelques fois	Non
Irhambi/katana	Musimbo/Kajuchu	Musimbo/Kajuchu	40	Association, cultures vivrières	Oui	Non

	Tchaziga/Kadjucu	Tchaziga/Kadjucu	69	Association, cultures vivrières	Oui	Non
	Zibera centre	Zibera centre	51	Association, cutures vivrières	Oui	Quelques fois
	Buhini	Buhini	38	Association, cultures vivrières	Oui	Quelques fois
	Munanira	Munanira	62	Association, cultures vivrières (haricot-maïs)	Non	Quelques fois
	Itanganyika	Itanganyika1	60	Association, cultures vivrières (haricot-maïs), quinquina	Non	Quelques fois
		Itanganyika2	60	Association, cultures vivrières (haricot-maïs), quinquina	Non	Quelques fois
	Kaboneke/Mabingu	Kaboneke/Mabingu	38	Association, cultures vivrières, bananiers	Oui	Non
	Kalengera	Kalengera	46	Association, cultures vivrières, bananiers	Oui	Non
	Ntagalulwa	Ntagalulwa	32	Association, cultures vivrières, bananiers	Oui	Non

	Nyamurondo	Nyamurondo	51	Association, cultures vivrières, bananiers	Oui	Non
	Kashongolera0	Kashongolera1	46	Association, cultures vivrières, bananiers	Oui	Non
	Kashongolera1	Kashongolera2	39	Association, cultures vivrières, bananiers	Oui	Non
	Cibimbi/Katana	Cibimbi/Katana	40	Association, cultures vivrières, bananiers	Oui	Non
	Katana centre	Katana centre	50	Monoculture	Quelques fois	Quelques fois
Bugorhe	Nyakaliba	Nyakaliba1	35	Association, cultures vivrières	Oui pour les cultures vivrières	Non
		Nyakaliba2	41	Association, cultures vivrières	Oui pour les cultures vivrières	Non
		Nyakaliba3	65	Association, cultures vivrières	Oui pour les cultures vivrières	Non
	Bwengehera	Bwengehera1	10	Association, cultures vivrières	Oui pour les cultures vivrières	Oui

		Bwengehera2	10	Association, cultures vivrières	Oui pour les cultures vivrières	Oui
		Bwengehera3	10	Association, cultures vivrières	Oui pour les cultures vivrières	Oui
		Bwengehera4	10	Association, cultures vivrières	Oui pour les cultures vivrières	Oui
	Buhandahanda	Buhandahanda1	58	Association, cultures vivrières et bananiers	Oui	Non
		Buhandahanda2	58	Association, cultures vivrières et bananiers	Oui	Non
		Buhandahanda3	58	Association, cultures vivrières et bananiers	Oui	Non
		Buhandahanda4	58	Association, cultures vivrières et bananiers	Oui	Non
	Ruvuma	Ruvuma1	63	Association des cultures vivrières	Oui pour les cultures vivrières	Non
		Ruvuma2	63	Association des cultures vivrières	Oui pour les cultures vivrières	Non

	Kankule	Kankule1	40	Association des cultures vivrières	Oui pour les cultures vivrières	Non
		Kankule2	42	Association des cultures vivrières	Oui pour les cultures vivrières	Non
	KakondoIII	KakondoIII	68	Association des cultures vivrières	Oui pour les cultures vivrières	Quelques fois
Miti	INERA/ Mulungu	INERA/ Mulungu	65	Association, cultures vivrières (haricot-maïs)	Oui pour les cultures vivrières	Quelques fois
Luhihi	Luhihi centre	Luhihi centre	42	Association, cultures vivrières, bananiers	Oui	Non
	Bukonzikonzi	Bukonzikonzi	38	Association, cultures vivrières, bananiers	Oui	Quelques fois
	Mirumba	Mirumba	40	Association, cultures vivrières, bananiers	Oui	Quelques fois
	Cikumbo centre	Cikumbo centre	50	Association, cultures vivrières, bananiers	Oui	Non
	Biyenga	Biyenga	65	Association, cultures vivrières, bananiers	Oui	Quelques fois
		Biyenga centre	59	Association, cultures vivrières, bananiers, *Eucalytus* sp,	Oui	Non

	Kakondol	Kakondol_(1)	68	Association, cultures Vivrières	Oui pour les cultures vivrières	Quelques fois
		Kakondol_(2)	68	Association, cultures vivrières (haricot-maïs)	Oui pour les cultures vivrières	Quelques fois
		Kakondol_(3)	68	Association, cultures vivrières (haricot-maïs)	Oui pour les cultures vivrières	Quelques fois
	KakondolI	KakondolI (1)	68	Association, cultures vivrières (haricot-maïs)	Oui pour les cultures vivrières	Quelques fois
		KakondolI (2)	68	Association, cultures vivrières (haricot-maïs)	Oui pour les cultures vivrières	Quelques fois
	Mwirunga	Mwirunga1	67	Association, cultures vivrières (haricot-maïs)	Oui pour les cultures vivrières	Quelques fois
		Mwirunga2	67	Association, cultures vivrières (haricot-maïs)	Oui pour les cultures vivrières	Quelques fois
		Mwirunga3	67	Association, cultures vivrières (haricot-maïs)	Oui pour les cultures vivrières	Quelques fois
	Nzinzi	Nzinzi1	30	Association, cultures vivrières, bananiers	Oui	Non
		Nzinzi2	40	Association, cultures vivrières, bananiers	Oui	Non
		Nzinzi3	35	Association, cultures vivrières, bananiers	Oui	Non

		Nzinzi4	49	Association, cultures vivrières, bananiers	Oui	Non
Bushumba	ITAV-Mushweshwe	ITAV-Mushweshwe1	65	Association (Caféiers, *Eucalyptus* sp, et *Maesopscis* sp)	Oui pour les cultures vivrières	Non
		ITAV-Mushweshwe2	65	Association (Caféiers, *Eucalyptus* sp, et *Maesopscis* sp)	Oui pour les cultures vivrières	Non
		ITAV-Mushweshwe3	65	Association (Caféiers, *Eucalyptus* sp, et *Maesopscis* sp)	Oui pour les cultures vivrières	Non

De ce tableau 1,il ressort que le système de culturale pratiquée est d'une part les caféiers associés soit aux cultures vivrières et aux bananiers, soit encore aux cultures vivrières, bananiers et aux *Eucalytus* sp ,soit ensuite aux *Eucalyptus* sp et aux *Maesopscis* sp et aussi aux cultures vivrières (haricot-maïs) et soit enfin aux cultures vivrières (haricot-maïs) et quinquina, et d'autre part les caféiers en monoculture. Seule la plantation de Bwengehera où est appliquée des mesures phytosanitaires, d'autres plantations quelques fois ou pas. De plus, l'entretien s'est fait soit pour les cultures vivrières, soit encore pour toutes les cultures associées, soit ensuite quelques fois et soit enfin il n'est pas fait.

Tableau 2. Nombre des plants attaqués par les maladies

Plants attaqués par les maladies														
Maladies cryptogamiques												Maladie bactérienne		
Numéros	*Anthracnose*	Incidence (I) en %	Sévérité (S)	*Rouille*	Incidence (I) en %	Sévérité (S)	*Cercosporiose*	Incidence (I) en %	Sévérité (S)	Incidence (I) en % moyenne	Sévérité (S) moyenne	*Die back*	Incidence (I) en %	Sévérité (S)
1	65	43.33	6	75	50.00	8	40	26.67	4	60	6	10	6.67	3
2	70	46.67	6	15	10.00	4	60	40.00	5	48 .33	5	20	13.33	3
3	55	36.67	6	10	6.67	4	40	26.67	4	23.33	5	20	13.33	3
4	30	20.00	5	20	13.33	4	22	14.67	4	24	4	15	10.00	3
5	20	13.33	4	25	16.67	4	21	14.00	4	14.66	4	12	8.00	3

6	15	10.00	4	15	10.00	4	15	10.00	4	10.00	4	13	8.67	3
7	30	20.00	6	30	20.00	5	18	12.00	4	17.33	5	20	13.33	3
8	20	13.33	4	65	43.33	5	20	13.33	4	23.33	4	12	8.00	3
9	70	46.67	6	65	43.33	5	45	30.00	4	39.99	5	28	18.67	3
10	60	40.00	6	80	53.33	8	35	23.33	4	38.88	6	20	13.33	3
11	32	21.33	5	35	23.33	5	30	20.00	4	21.55	5	17	11.33	3
12	28	18.67	5	25	16.67	4	16	10.67	4	15.33	4	13	8.67	3
13	30	20.00	5	20	13.33	4	10	6.67	4	13.33	4	6	4.00	3
14	25	16.67	4	30	20.00	5	20	13.33	4	16.66	4	4	2.67	3
15	35	23.33	5	5	3.33	4	30	20.00	4	15.55	4	5	3.33	3
16	30	20.00	5	8	5.33	4	35	23.33	4	16.22	4	5	3.33	3
17	45	30.00	5	4	2.67	4	13	8.67	4	13.78	4	7	4.67	3
18	40	26.67	5	3	2.00	4	30	20.00	4	16.22	4	3	2.00	3
19	44	29.33	5	50	33.33	5	50	33.33	5	47.99	5	40	26.67	5
20	44	29.33	5	60	40.00	5	70	46.67	5	38.66	5	44	29.33	5
21	44	29.33	5	40	26.67	5	30	20.00	4	25.33	5	60	40.00	7
22	25	16.67	4	10	6.67	4	14	9.33	4	10.89	4	25	16.67	3
23	20	13.33	4	5	3.33	4	5	3.33	4	6.66	4	8	5.33	3
24	20	13.33	4	10	6.67	4	3	2.00	4	7.33	4	2	1.33	3
25	20	13.33	4	20	13.33	4	5	3.33	4	9.99	4	7	4.67	3
26	25	16.67	4	10	6.67	4	30	20.00	4	14.44	4	10	6.67	3
27	10	6.67	4	10	6.67	4	5	3.33	4	5.55	4	10	6.67	3
28	30	20.00	5	15	10.00	4	5	3.33	4	7.77	4	20	13.33	3
29	10	6.67	4	17	11.33	4	3	2.00	4	6.66	4	4	2.67	3
30	15	10.00	4	18	12.00	4	6	4.00	4	8.66	4	10	6.67	3
31	25	16.67	4	35	23.33	5	4	2.67	4	14.22	4	4	2.67	3
32	44	29.33	5	70	46.67	5	40	26.67	4	34.22	5	60	40.00	7
33	44	29.33	5	20	13.33	4	40	26.67	4	23.11	4	6	4.00	3
34	45	30.00	5	10	6.67	4	5	3.33	4	13.33	4	5	3.33	3
35	85	56.67	8	90	60.00	8	75	50.00	5	55.55	7	68	45.33	7
36	38	25.33	5	30	20.00	5	23	15.33	4	20.22	5	15	10.00	3
37	40	26.67	5	32	21.33	5	20	13.33	4	20.44	5	5	3.33	3
38	23	15.33	4	38	25.33	5	4	2.67	4	14.44	4	10	6.67	3
39	40	26.67	5	50	33.33	5	10	6.67	4	22.22	5	12	8.00	3
40	40	26.67	5	14	9.33	4	20	13.33	4	16.44	4	8	5.33	3
41	40	26.67	5	40	26.67	5	20	13.33	4	22.22	5	10	6.67	3
42	10	6.67	4	13	8.67	4	5	3.33	4	6.22	4	15	10.00	3
43	8	5.33	4	12	8.00	4	25	16.67	4	10.00	4	25	16.67	3
44	12	8.00	4	18	12.00	4	15	10.00	4	10.00	4	5	3.33	3
45	30	20.00	5	20	13.33	4	8	5.33	4	12.88	4	10	6.67	3
46	20	13.33	4	17	11.33	4	7	4.67	4	9.77	3	5	3.33	3
47	20	13.33	4	15	10.00	4	12	8.00	4	10.44	3	30	20.00	3
48	15	10.00	4	20	13.33	4	13	8.67	4	10.66	3	10	6.67	3
49	30	20.00	5	15	10.00	4	10	6.67	4	12.22	4	5	3.33	3
50	38	25.33	5	36	24.00	5	12	8.00	4	19.11	5	15	10.00	3
51	40	26.67	5	40	26.67	5	18	12.00	4	21.78	5	5	3.33	3
52	42	28.00	5	45	30.00	5	16	10.67	4	22.66	5	10	6.67	3
53	39	26.00	5	35	23.33	5	17	11.33	4	20.22	5	10	6.67	3

54	65	43.33	6	65	43.33	5	35	23.33	4	36.66	5	15	10.00	3
55	75	50.00	8	70	46.67	5	25	16.67	4	37.78	6	20	13.33	3
56	20	13.33	4	60	40.00	5	20	13.33	4	22.22	4	5	3.33	3
Moyenne ± Ecart type		23.03±4.79		20.19±4.49			14.46±3.08			21.23±4.60		10.21±3.19		
Constante de distribution de Kurtosis (υ)		0.043		0.049			0.069			0.047		0.097		

Incidences

- Incidence des maladies cryptogamiques (*Cercosporiose, Rouille* et *Anthracnose*)

Au regard des moyennes et des écarts types, les maladies cryptogamiques different entre eux comme pour l' *Anthracnose* , soit 23.03±4.79, la *Rouille*, soit20.19±4.49 et la *Cercosporiose* ,soit, 14.46±3.08 c'est- à-dire que la majorité des plantations des caféiers de Kabare Nord souffrent de l' *Anthracnose*, de la *Rouille* et la *Cercosporiose*.

- Incidence des maladies cryptogamiques (*Cercosporiose, Rouille* et *Anthracnose*) et bactérienne (*Die back*)

Les moyennes et des écarts types montrent que les maladies cryptogamiques sont élévées soit 21.23±4.60 que la maladie bactérienne, soit 10.21±3.19 donc le majorité des plantations des caféiers de Kabare Nord souffrent des maladies cryptogamiques

Sévérités

$S_{\text{Die back}} = \frac{3 \times 51 + 5 \times 2 + 7 \times 3}{3 + 5 + 7} = 12.26$; ainsi, les rameaux, parfois les branches, noircissent et se dessèchent progressivement depuis leur extrêmité et perdent leurs feuilles.

$S_{\text{Antracnose}} = \frac{4 \times 21 + 5 \times 26 + 6 \times 7 + 8 \times 2}{4 + 5 + 6 + 8} = 11.82$; donc les drupes vertes en croissance apparaissent de petites taches brun foncé, à noires, arrondies à ovales, nettement déprimées qui s'étendent rapidement.

$S_{\text{Rouille}} = \frac{4 \times 31 + 5 \times 22 + 8 \times 3}{4 + 5 + 8} = 15.17$; d'où les petites taches circulaires jaunâtres apparaissent à la face inférieure des feuilles.

$S_{\text{Cercosporiose}} = \frac{4 \times 52 + 5 \times 4}{4 + 5} = 22.33$; ainsi on a des petits points chlorotiques qui s'étendent et brunissent.

4 DISCUSSION

Le système de culturale le plus pratiqué est les caféiers associés ; soit aux cultures vivrières et aux bananiers, soit encore aux cultures vivrières, bananiers et aux *Eucalytus* sp ,soit ensuite aux *Eucalyptus* sp et aux *Maesopscis* sp et aussi aux cultures vivrières (haricot-maïs) et soit enfin aux cultures vivrières (haricot-maïs) et quinquina, et peu de champs de caféier est en monoculture. Seule la plantation de Bwengehera où est appliquée des mesures phytosanitaires, d'autres plantations quelques fois ou pas. De plus, l'entretien s'est fait soit pour les cultures vivrières, soit encore pour toutes les cultures associées, soit ensuite quelques fois et soit enfin il n'est pas fait car selon [14], différents systèmes de culture utilisés dans les régions tropicales d'altitude d'Afrique sont à expliquer par les préférences culturales prévalent dans les différents pays, tels que les cultures en pur, les mélanges variétaux et les associations de cultures.

L'incidence des maladies cryptogamiques diffèrent entre eux ; pour l' *Anthracnose* , soit 23.03±4.79, la *Rouille*, soit20.19±4.49 et la *Cercosporiose* ,soit, 14.46±3.08 c'est- à-dire que la majorité des plantations des caféiers de Kabare Nord souffrent de l' *Anthracnose* suivi de la *Rouille* et la *Cercosporiose* est moindre. De même, les maladies cryptogamiques sont

élévées soit 21.23±4.60 que la maladie bactérienne, soit 10.21±3.19 donc la majorité des plantations des caféiers de Kabare Nord souffrent des maladies cryptogamiques ceci s'explique par des températures fraîches et plus élevées [2].

La sévérité des maladies montre que les caféiers atteintent de *Die back* ,leurs rameaux, parfois leurs branches, noircissent et se dessèchent progressivement depuis l'extrêmité et perdent les feuilles, selon [2] , cette maladie est prédispose par les defoliations dues aux insectes et les maladies parasitaires ainsi que tout facteur empêchant une nutrition normale de la plante comme la secheresse,les mauvais enracinenement, la compétition des plantes adventices,la faible fertilité du sol et une plantation en condition marginale . Ceux d' *Anthracnose*, les drupes vertes en croissance apparaissent de petites taches brun foncé, à noires, arrondies à ovales, nettement déprimées qui s'étendent rapidement. [2] montre que des températures fraîches favorisent la multiplication du champignon,la maladie est donc plus fréquente et plus dommageable dans les regions d'altitude. De plus, la pluie dissémine le champignon et l'humidité joue un rôle essential dans le processus d'infection.

Pour la *Rouille*, les petites taches circulaires jaunâtres apparaissent à la face inférieure des feuilles.Cette maladie se manifeste surtout à la fin de la grande saison des pluies, ou au début de la saison sèche et elle est plus dommageable dans les basses et moyennes altitudes où les températures plus élevées favorisent son développement.De plus,des sites ombragés ou confines,où l'eau persiste plus longtemps sur les feuilles ,sont aussi plus propices à l'infection [2] . Et afin ,pour la *Cercosporiose* , les petits points chlorotiques qui s'étendent et brunissent ; d'après [2],l'apparition de cette maladie en plantation est généralement liée à une déficience nutritionnelle et concerne le plus souvent des caféières agées , mal entretenues ou en conditions de stress physiologique.

5 CONCLUSION

L'étude montre que le système de culturale le plus pratiqué est les caféiers associés et la majorité des plantations des caféiers de Kabare Nord souffrent de l'*Anthracnose*,de la *Rouille* et la *Cercosporiose* donc de maladies cryptogamiques. Les caféiers atteintent par *Die back*, leurs rameaux, parfois leurs branches, noircissent et se dessèchent progressivement depuis l'extrêmité et perdent les feuilles, ceux d' *Anthracnose*,les drupes vertes en croissance apparaissent de petites taches brun foncé, à noires, arrondies à ovales, nettement déprimées qui s'étendent rapidement. Pour la *Rouille*, les petites taches circulaires jaunâtres apparaissent à la face inférieure des feuilles et pour la *Cercosporiose*, les petits points chlorotiques qui s'étendent et brunissent.

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REFERENCES

[1] Raemaekers R H., Agriculture en Afrique Tropicale, Direction Générale de la Coopération Internationale, Bruxelles,pp. 163-190, 2001.

[2] Autrique A. et Perreaux D. Maladies et ravageurs des cultures de la région des Grands Lacs d'Afrique Centrale, AGCD n° 24, ISABU, Burundi, pp.232, 1989.

[3] M. Nsambu, B. Muhigwa, K. Rubabura, M. Bagalwa et S. Bashwira, " Etat phytosanitaire des plantations et champs de caféier de Kabare Nord,Sud Kivu, Est de la RD. Congo ",*International Journal of Innovation and Applied Studies*, Vol. 8 No. 3, pp. 1219-1230, 2014.

[4] Didier de Failly, L'économie du Sud-Kivu 1990-2000: Mutations profondes cachées par une panne , l'Afrique des Grands Lacs. *Annuaire* 1999-2000

[5] F.A.O, Table de composition des aliments à l'usage de l'Afrique, Document sur la nutrition 3, F.A.O, Rome, Italie, pp.81-97, 1970.

[6] Degroote V A., Table de composition alimentaire pour la République Démocratique du Congo, Concordia, Kinshasa, pp.21-25, 1970.

[7] Daviron B.,et Ponte S., The coffee paradox: Global markets, commodity trade and the elusive promise of development.Londres, Zed Books, pp.288, 2005.

[8] Bultot F., Régimes normaux et cartes de précipitations dans l'Est du Congo Belge (Longitude 26° à 31°Est, latitude 4°Nord à 5°Sud) pour la période 1930 à 1960, Communication n°1 du Bureau Climatique, Publ.INEAC, Coll. n°4, pp.300, 1950a.

[9] Bultot F., Carte des régions climatiques du Congo Belge établie d'après les critères de Köppen, Communication n°2 du Bureau Climatique, Publ.INEAC, Coll.n°4, pp. 250, 1950b.
[10] Pecrot A. et Léonard A., Carte des sols et de la végétation du Congo Belge et du Rwanda-Urundi, 1-Dorsale du Kivu A, B et C. Notice explicative de la carte des sols et de la végétation, Bruxelles, pp.124-130, 1960.
[11] Dupriez H. et Simbizi J., Ravageurs aux champs *In* Carnets écologiques. Terre et Vie, 13 rue Laurent Delvaux, 1400, Belgique, pp. 116, 1998.
[12] Dagnelie P., Statistique théorique appliquée, tome 1, Presse Agronomique Gembloux, Belgique, pp.492, 1992.
[13] Lepoivre P., Phytopathologie, les presses agronomiques de Gembloux, éd. De Boeck et Larcier, Belgique, pp.427 , 2003.
[14] Nyabyenda P., Les plantes cultivées en régions tropicales d'altitudes d'Afrique, Presses Agronomiques de Gembloux, Collection CTA, Belgique, pp.223, 2009.

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MESURES PLUVIOTHERMIQUES DE LA COLLECTIVITE-CHEFFERIE DE LUHWINDJA (2011)

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ABSTRACT: The present work proposes the determination of the rainy thermical rhythm in three parts in Luhwindja based on the North, Center and South which has not been known for a long time.
The south area of Luhwindja is better watered to some extent with 1753mm of water a year and the more less hot has got the everage yearly temperature of 17.4 degree centigrade. As the matter of fact three is not any month which is dry and scows can be transcorried the whole year; the monthly "ETP" being inferior to precipitations of all the twelve months of a year.
The North's area of Luhwindja with a yearly rainy thermical of 1553mm the everage temperature is 19.2 degree centigrade. It is the part less watered with three months which are affected by atmospherically drought during (June, July and August) are affected by pedological drougth; the "ETP" being superior to precipitations for the three dry months.
The Center receives on the one hand, precipitations coming from the North and on the other hand those of the South. It realizes 1611mmof water per a year and an everage temperature of 20.5 degree centigrade with three months affectedby atmospherically drought (June, July and August).
On average the whole Collectivity of Luhwindja receives 1639mm of water per year and a temperature of 19, 03 degree centigrade.

KEYWORDS: Measure-Rainy thermical, LUHWINDJA.

RESUME: Le présent travail se propose de déterminer le rythme pluviothérmique dans trois parties de la Chefferie de Luhwindja (le Nord, le Centre et le Sud) longtemps inconnu pourtant important pour les activités agropastorales en milieu surtout rural.
Le Sud de la chefferie de Luhwindja est mieux arrosé avec 1753mm d'eau par an et le moins chaud avec une température moyenne annuelle de 17,4°C. Aucun mois n'est sec et les végétaux peuvent être verdoyants toute l'année, les ETP mensuelles étant inférieures aux précipitations tous les douze mois de l'année.
Le Nord de ladite Chefferie avec un total pluviométrique annuel de 1553mm d'eau et une température moyenne annuelle de 19,2°C est la partie la moins arrosée avec trois mois affectés de la sécheresse atmosphérique (Juin, Juillet et Aout) dont deux mois (Juillet et Aout) affectés de la sécheresse pédologique ; les ETP étant supérieures aux précipitations pour les trois mois secs.
Le Centre reçoit d'une part les précipitations venant du Nord et d'autre part celles du Sud. Il totalise 1611mm d'eau par an et une température de 20,5°C avec trois mois affectés de la sécheresse atmosphérique (Juin, Juillet et Aout).
En moyenne, toute la Chefferie de Luhwindja reçoit 1639mm d'eau par an et une température de 19,03°C.

MOTS-CLEFS: Mesure-pluviothérmique, LUHWINDJA.

1 INTRODUCTION

Avec ses 183km²; la Collectivité-chefferie de Luhwindja est localisée au Nord-est du Territoire de Mwenga en Province du Sud-Kivu. Elle est située entre 2°49'43'' et 3° de latitude Sud et entre 28°28'44'' et 28°31'58'' de longitude Est.

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Le Nord-est du Territoire de Mwenga (Chefferies de Burhinyi et Luhwindja) est longé par la chaine de Mitumba et la chefferie de Luhwindja abrite le point culminant du territoire à son extrême sud (Mont Muhi à 3120m d'altitude).

La Chefferie de Luhwindja est limitée par les Chefferies de Ngweshe au Nord, Kaziba à l'Est (Territoire de Walungu), Burhinyi à l'Ouest et Lwindi au Sud (Territoire de Mwenga).

A Luhwindja, le relief se soulève brusquement vers le Nord où il culmine à 2800m d'altitude (Mont Kahinga) et vers le Sud (Mont Muhi) pour laisser une vallée large de 2km au centre drainée par la rivière Namunana. Ce relief se présente comme un amphithéâtre montagneux. Cette vallée est occupée en grande partie par les eaux thermales renfermant ainsi des sols très fertiles **(ILUNGA, 1991).**

Il est à noter que la vallée de la Namunana est à 1775m d'altitude, ce qui donne une dénivellation de 1025m au Nord et 1345m d'altitude au Sud.

L'extrême Sud est occupé par la forêt des bambous, les activités agro-pastorales et al société aurifère BANRO, le centre par les activités agricoles et socio-administratives et le Nord par les activités agro-pastorales.

Il pleut souvent à de temps différents au Nord au Centre et au Nord de ladite Chefferie et les rivières descendant dans les montagnes en traversant les vallées dénudées par les activités agricoles sont très turbides à eaux froides au Sud avec des crues redoutables au centre causant tant de dégâts matériels qu'humains. Les inondations y sont fréquentes de Novembre à Mai avec beaucoup de plantes, bestiaux, hommes,…emportés parles rivières étranges.

Les précipitations et les températures jouent un rôle très important dans la répartition spatiale de l'habitat et en climatologie et sont très localisées en Zone Intertropicale même si les stations sont proches **(Jean TRICART, 1974).** La connaissance de ces éléments constitue donc un moteur agro-pastoral dans ce milieu surtout tempéré par l'altitude. Ainsi, il est impérieux que la présente étude précède celle de l'habitat dans cette Chefferie moins connue scientifiquement. Le drame en est qu'il n'existe pas des données pluviothérmiques après 1945 sur un seul coin de Luhwindja et l'avenir agricole, pastoral,…s'annonce sinistré.

2 METHODOLOGIE

Chuzeville (1990), affirme qu'un pluviomètre couvre 5km de rayon. Il estime cette surface à πr^2, soit 5km x 5km x3, 14 = 78,5km².

Pour plus de précision, il a fallu trois stations pluviothérmiques dans la Chefferie de Luhwindja car sa superficie divisée par trois donne une superficie de 61km² déjà inférieure à 78,5km². Nous avons utilisé les pluviomètres de 24cm de diamètre et les thermomètres à mercure.

Pour obtenir les résultats fiables, nous nous sommes basés sur les conditions ci-après pour l'installation de nos trois stations pluviothérmiques :

- Choix d'un terrain aéré (pas de feuillage) et relativement plan (pour éviter les érosions) ;
- La construction d'une tablette de 1,80m de haut pour annuler les splash ;
- Fixation du récipient pluviométrique verticalement au-dessus de la tablette et le thermomètre en bas de la tablette à 1 mètre du sol sous l'ombrage afin de ne pas prélever les températures du sol ou avoir les sauts thermiques dus aux rayons solaires ;
- calcul du litrage du récipient cylindrique de 24cm de diamètre.

1 litre = 1 dm^3 (rapport entre mesures de capacité et de grandeur).

Surface cylindrique (SC) = πr^2

SC=144cm^2 x 3, 14

SC=452,16cm²

SC=4,5216dm²

Ainsi, $\frac{1dm^3}{4,5216dm^2}$ = 0,22dm =22mm

Donc, pour un récipient cylindrique de 12cm de rayon, 1l=22mm de hauteur dans le dit récipient.

- Le prélèvement des températures se faisait six fois par jour pour en constituer une moyenne et cela après chaque 4 heures en commençant par 6 heures du matin. Ces données brutes des températures journalières moyennes nous ont permis d'en construire les graphiques.

Pour déterminer les indices d'aridité, nous nous sommes servis des expériences de **Demartone (1980),** de **Lambert (1994)** et de **Gaussen,** cité par **Mwinyikondo et al. (2003).**

Tout indice d'aridité doit combiner les précipitations et les températures, ces dernières étant un élément fondamental dans le déclenchement des précipitations **(Demartone 1980).** Pour cet Auteur,

IA= $\frac{P}{T+10}$ et ia= $\frac{x12p}{t+10}$, avec :

IA : Indice d'aridité annuelle

P : Précipitations annuelles ;

T : Température moyenne annuelle ;

ia : indice d'aridité mensuelle ;

p : Précipitations mensuelles ;

t : température moyenne mensuelle.

Pour IA **: 0-5** : climat hyperaride ;

5-10 : climat aride ;

10-20 : climat semi-aride ou sec ;

20-30 : climat semi-humide ;

30 et plus : climat humide.

Pour ia, les désignations sont les mêmes mais alors mensuelles et semi-humide est remplacé par humide et humide par mois hyper humide.

Lambert (1994) distingue trois types de sécheresse entre autre

- **I**ndice de **S**écheresse **A**tmosphérique **(ISA) :** $P < 4T$;
- **I**ndice de **S**écheresse **P**édologique **(ISP)** $P < 3T$;
- **I**ndice de **S**écheresse **G**éologique **(ISG)** : $P < 2T$.

Gaussen, cité par **Mwinyikondo** et **al. (2003)** établit le diagramme ombrothérmique où un degré Celsius vaut deux précipitation en millimètres, pour mettre en évidence la saison sèche. L'indice de **Gaussen** est ce que **Lambert** appelle Indice de Sécheresse Géologique dans la zone chaude. Pour compléter les expérimentations de différents auteurs, **Joseph GOFFAUX (1990**) classifie les climats et sa classification nous sera utile pour la discussion des résultats en les comparant avec les autres climats d'ailleurs dont ils sont de la même classe.

La station du Nord était installée à 2800m d'altitude au Mont Nalunkulumbi et à 2°50' de latitude Sud à 1,8km de la frontière avec la Chefferie de Ngweshe. Celle du Sud était installée dans la localité de Muhi à 3100m d'altitude en pleines montagnes et 2°58' latitude Sud. Cette station était à 4,4km de la frontière Sud avec la Chefferie de Lwindi et la station du Centre était à 2°53' de latitude Sud à 8,9km de la station du Nord et à 13,3km de celle du Sud.

Pour interpréter les données pluviothérmiques, **THORNTHWAITE (1957)** utilise la table des bilans hydriques qui précise comment calculer les indice thermiques (i), la situation en latitude et/ou la constante (k), la somme de déficits hydriques (∑déficit) la réserve utile (RU) et la variation de cette réserve utile (DRU) :

- **L'Indice Thermique (i) :** sur la table des bilans hydriques de **THORNTHWAITE** n'existent que des températures entières et non décimales. Pour trouver l'indice d'une température décimale, il est question de travailler avec les températures ayant leurs indices sur la table dont la dite température décimale est au milieu. En prenant la différence des températures entières, cette différence est à diviser par dix car en principe, la température est une variable continue et l'auteur affirme qu'entre deux chiffres entiers existent dix (10) variables soit de 0,1 à 0,9 puis l'unité (1) et entre deux entier existent vingt (20) variables. En plus, le quotient obtenu est à multiplier par le dernier chiffre de la température décimale du mois et en fin le produit est additionné à l'indice de la basse température entière.

- **L'évapotranspiration potentille (etp) :** la marche à suivre est la même que pour les indices thermiques mais la petite nuance est que sur la table de **THORNTHWAITE** n'existent que les etp des températures paires. Comme signalé haut, après avoir divisé par 20 ; le quotient est à multiplier par le dernier chiffre de la température si celle-ci est décimale et par dix si elle est simplement entière et impaire.
- **La situation en latitude :** elle est constituée des valeurs rangées dans la table de Janvier en Décembre. Pour toute station située entre 0° et 10° de latitude, la valeur du 10° de chaque mois est à soustraire de celle du 0°. Le reste est à diviser par dix, le quotient à multiplier par la situation en latitude et en fin, le produit est à soustraire de la valeur du mois **(k)** au 0°.
- **L'évapotranspiration potentielle (ETP) :** l'**etp** ne tient pas compte de la latitude alors que la répartition thermique sur la Terre en tient compte ; c'est pourquoi l'auteur affirme que pour trouver l'**ETP** définitive à considérer pour établir le bilan de l'eau, l'etp doit être multiplier par la situation en latitude, c'est-à-dire **ETP=etp x k**
- La somme de déficits est la somme des différences **P-ETP**
- **La réserve utile (RU) :** elle est calculée uniquement pour les mois déficitaires (partout où P< ETP) et la table de **THORNTHWAITE** recommande de mettre la RU 100 (100% de réserve) pour les mois dont les ETP sont nférieures aux précipitations. Comme seules les réserves paires sont reprises dans ladite table, la marche à suivre est la même que pour les etp.
- **La variation de la réserve utile (DRU) :** c'est la différence des RU. Quand la DRU devient zéro ou négative, on note tout simplement zéro (0) pour dire que la réserve devient stable et la perte par évaporation est nulle et/ou inférieure aux précipitations reçues. Cela revient à dire que l'écoulement correspond aux mois à fortes précipitations n'affectant pas la RU ; d'où **Ecoulement=p-ETP.**

3 RESULTAS ET DISCUSSIONS

3.1 LES INDICES D'ARIDITÉ

Demartone (1980) affirme que les températures restent un élément déterminant dans le déclenchement des précipitations ; il ne suffit pas de lire les chiffres des hauteurs pluviométriques pour déterminer un mois sec ou humide. A l'aide des températures moyennes mensuelles, les indices d'aridité mensuels sont représentés dans le tableau 1.

Tableau 1 : Indice d'aridité mensuel de DEMARTONE

	Mois	Janv.	Févr.	Mars	Avril	Mai	Juin	Juil.	Aout	Sept.	Oct.	Nov.	Déc.	IA
NORD	Ia	58,0	59,6	75,6	65,9	41,7	20,5	20,8	16,0	51,9	64,0	69,6	77,5	51,7
	Qualif.	HYP.	HYP.	HYP.	HYP.	HYP.	HUM.	HUM.	SEC	HYP.	HYP.	HYP.	HYP.	HUM.
SUD	Ia	73,24	71,15	78,0	72,8	53,3	41,5	37,4	31,4	57,6	72,8	81,5	90,9	63,9
	Qualif.	HYP.	HYP.	HYP.	HYP.	HYP.	HYP.	HYP.	HYP.	HYP.	HYP.	HYP.	HYP.	HUM.
CENTRE	Ia	58,1	56,8	67,5	65,8	44,0	28,9	26,5	16,8	63,0	69,2	78,3	52,8	52,3
	Qualif.	HYP.	HYP.	HYP.	HYP.	HYP.	HUM.	HUM.	SEC	HYP.	HYP.	HYP.	HYP.	HUM.

HYP. = Hyperhumide ;
HUM. = Humide ;
Qualif. = Qualification.

En bref, le seul mois d'Aout est sec, deux mois sont humides (Juin et Juillet), les autres mois restent hyperhumides dans la station du Nord et toute l'année est humide. Tous les mois sont hyperhumides dans la station du Sud et l'année est humide. Aucun mois n'y est affecté par une des trois sécheresses déterminées par Lambert (1994). Dans ce milieu, les végétaux peuvent pousser tous les mois selon leurs exigences pluviothérmiques, édaphiques,…

Dans la station du Centre, l'année est en général humide alors que le mois d'Aout est sec, ceux de Juin et Juillet humides et tous les autres hyperhumides.

Dans les stations du Nord et du Centre, l'eau reste uniquement dans les couches géologiques au mois d'Aout et les végétaux flétrissent. Cependant, les mois de Juin et Juillet, l'eau atmosphérique diminue mais celle stockée dans les couches géologiques reste utilisable par les plantes.

3.2 LES BILANS HYDRIQUES

Il est aisé et pratique de présenter les valeurs de l'évapotranspiration potentielle constituant l'eau perdue pour les végétaux et les stocks d'humidité du sol qui est l'eau utilisable par les plantes dans le tableau des bilans hydriques pour donner plus de sens aux données moyennes pluviothérmiques. Ainsi, le tableau 2 détermine mieux ces deux variables.

Tableau 2 : Valeurs de l'évapotranspiration et de variation des stocks d'humidité du sol

Mois	Janv.	Fév.	Mars	Avr.	Mai	Juin	Juil.	Aout	Sept.	Oct.	Nov.	Déc.	Ann.
La Station du Nord													
T°C	21,2	20,0	20,0	19,5	19,0	17,6	16,5	17,0	18,2	20,0	20,5	21,1	19,2
I	8,9	8,16	8,16	7,85	7,55	6,72	6,1	6,38	7,07	8,16	8,47	8,84	92,36
Etp	2,56	2,5	2,5	2,37	2,25	1,9	1,62	1,75	2,05	2,5	2,65	2,83	
K	30,86	27,99	31,11	30,46	31,53	30,72	31,53	31,45	30,38	31,31	30,04	30,77	
ETP	79,00	69,97	77,77	72,19	70,94	58,36	51,07	55,03	62,27	78,27	79,06	87,07	
Pmm	151	149	189	162,2	101	58,7	46	36	122,1	160	177	201	1553
P-ETP	72	79,03	111,23	90,01	30,06	0,34	-5,07	-19,03	59,83	81,73	97,04	113,93	
∑déficit	0	0	0	0	0	0	5,07	24,1	0	0	0	0	24,1
RU	100	100	100	100	100	100	5,3	19,99	100	100	100	100	
DRU	0	0	0	0	0	0	94,7	74,71	0	0	0	0	
Ecoulement	72	79,03	111,23	90,01	30,06	0,34	-5,07	-19,03	59,83	81,73	97,04	113,93	
La Station du Sud													
T°C	19	18,5	18	17,5	17	16	15	15,2	16	18	19	19,5	17,4
I	7,55	7,25	6,95	6,66	6,82	5,82	5,28	5,38	5,82	6,95	7,55	7,85	79,4
Etp	2,25	2,12	2	1,87	1,75	1,5	1,3	1,34	1,5	2	2,25	2,37	
K	30,84	27,93	31,11	30,47	31,55	30,74	31,55	31,46	30,38	31,31	30,03	30,75	
ETP	69,39	59,21	62,22	56,97	55,21	46,11	41,01	42,15	45,57	62,62	67,56	72,87	
Pmm	177	169	182	167	120	90	78	66	125	170	197	223	1753
P-ETP	107,61	109,79	119,78	110,03	64,79	43,89	36,99	23,85	79,43	107,38	129,44	150,13	
∑déficit	0	0	0	0	0	0	0	0	0	0	0	0	0
RU	100	100	100	100	100	100	100	100	100	100	100	100	
DRU	0	0	0	0	0	0	0	0	0	0	0	0	
Ecoulement	107,61	109,79	119,78	110,03	64,79	43,89	36,99	23,85	79,43	107,38	129,44	150,13	
La Station du Centre													
T°C	23,0	22,1	22,0	21,0	21,0	19,0	18,0	18,5	18,0	21,0	21,0	22,0	20,5
I	10,08	9,48	9,42	8,78	8,15	7,55	6,95	7,25	6,95	8,78	8,78	9,42	10,59
Etp	3,35	3,125	3,1	2,8	2,5	2,25	2,0	2,12	2,0	2,8	2,8	3,1	
K	30,85	97,94	31,11	30,47	31,54	34,62	31,54	31,45	30,38	31,31	30,04	30,76	
ETP	103,34	87,31	96,44	85,31	78,85	77,89	62,08	60,67	60,76	87,66	84,11	95,35	
Pmm	160	152	180	170	110	40	62	40	116	163	179	209	1611
P-ETP	56,66	64,69	83,56	84,69	31,15	-37,89	-1,08	-26,67	55,24	75,34	94,89	111,65	
∑déficit	0	0	0	0	0	37,89	38,97	65,61	0	0	0	0	65,61
RU	100	100	100	100	100	37,1	1,2	27,3	100	100	100	100	
DRU	0	0	0	0	0	62,9	61,7	34,4	0	0	0	0	
Ecoulement	56,66	64,69	83,56	84,69	31,15	-37,89	-1,08	-26,67	55,24	75,34	94,89	111,65	

Au Nord, trois mois sont affectés par la sécheresse atmosphérique (Juin, Juillet et Aout), deux mois (Juillet et Aout) par la sécheresse pédologique créant une pénurie d'eaux aux végétaux cultivés, ces derniers étant incapables de soutirer l'eau dans les couches géologiques pendant les deux mois et les végétaux peuvent flétrir mais ceux à racines moins pivotantes peuvent tout simplement séchés. Cette station a une température moyenne annuelle (TMA) de 19,2°C. Le total des précipitations annuelles s'élève à 1553mm d'eau avec une moyenne mensuelle de 129,4mm d'eau et cinq mois se situent en dessous de cette moyenne (de Mai à septembre). La lame d'eau restituée à l'atmosphère est supérieure aux précipitations aux mois de Juillet et Aout avec une variation des stocks d'humidité du sol de 29,17mm. Cette quantité moins importante n'atteint aucun

total des précipitations mensuelles mais affecte un peu la production agricole ainsi que les débits des rivières. Au Nord, la température moyenne annuelle est de 19,2°C avec une amplitude thermique annuelle (ATA) de 4,6°C.

A la station du Sud, les écarts thermiques restent moins élevés comme à celle du Nord et l'ATA est de 4,5°C. Cependant, la TMA est de 17,4°C ; tous les mois étant modérés par l'altitude. Cinq mois (de Mai à Septembre) ont des températures inférieures à cette moyenne et le mois de juillet reste le plus frais avec 15,0°C comme au Nord avec 16,5°C. Ceci s'explique par l'albédo élevé au sol en pleine saison sèche.

Les précipitations annuelles s'élèvent à 1753mm d'eau et leur moyenne est de 146mm d'eau par mois dont cinq mois se situent en-dessous de celle-ci.

Pour tous les mois, l'eau restituée à l'atmosphère est de loin inférieure aux précipitations. La réserve utile ne peut pas être affectée dans ce milieu (Sud de Luhwindja) et les végétaux restent verts, même si aux mois de Juin, Juillet et Aout l'écoulement est quasi hypodermique à cause de la diminution sensible des précipitations qui se situent alors très bas de la moyenne pluviométrique annuelle.

Au Centre, les températures ne sont plus constantes et l'ATA s'élève jusqu'à 5°C avec une TMA de 20,5°C. Cela proviendrait non seulement de l'altitude moins élevé mais aussi de la présence des eaux thermales dans la grande partie de la vallée de la Namunana.

Les mois chauds restent ceux à faibles pluviosités entre autre de Mai jusqu'à Septembre étant même en-dessous de la moyenne pluviométrique (134,2mm). Les précipitations s'y élèvent à 1611mm d'eau l'an. Les précipitations du Centre est la conjugaison de celles du Nord et du Sud qui descendent jusque dans la vallée de la Namunana, raison pour laquelle elles varient entre celles du Nord et celles du Sud.

Ainsi, quand il pleut au Nord, il pleut aussi au Centre et quand il pleut au Sud, il pleut aussi au Centre. La lame d'eau restituée à l'atmosphère est supérieure aux précipitations mensuelles en Juin, Juillet et Aout. Cependant, la variation des stocks d'humidité du sol y représente 65,61mm affectant la croissance végétative et les débits des rivières.

Du tableau 2, ressort les diagrammes ombrothérmiques respectifs très parlants des stations du Nord, du Sud et du Centre pour déterminer les mois pluvieux et moins pluvieux, les mois chauds et frais.

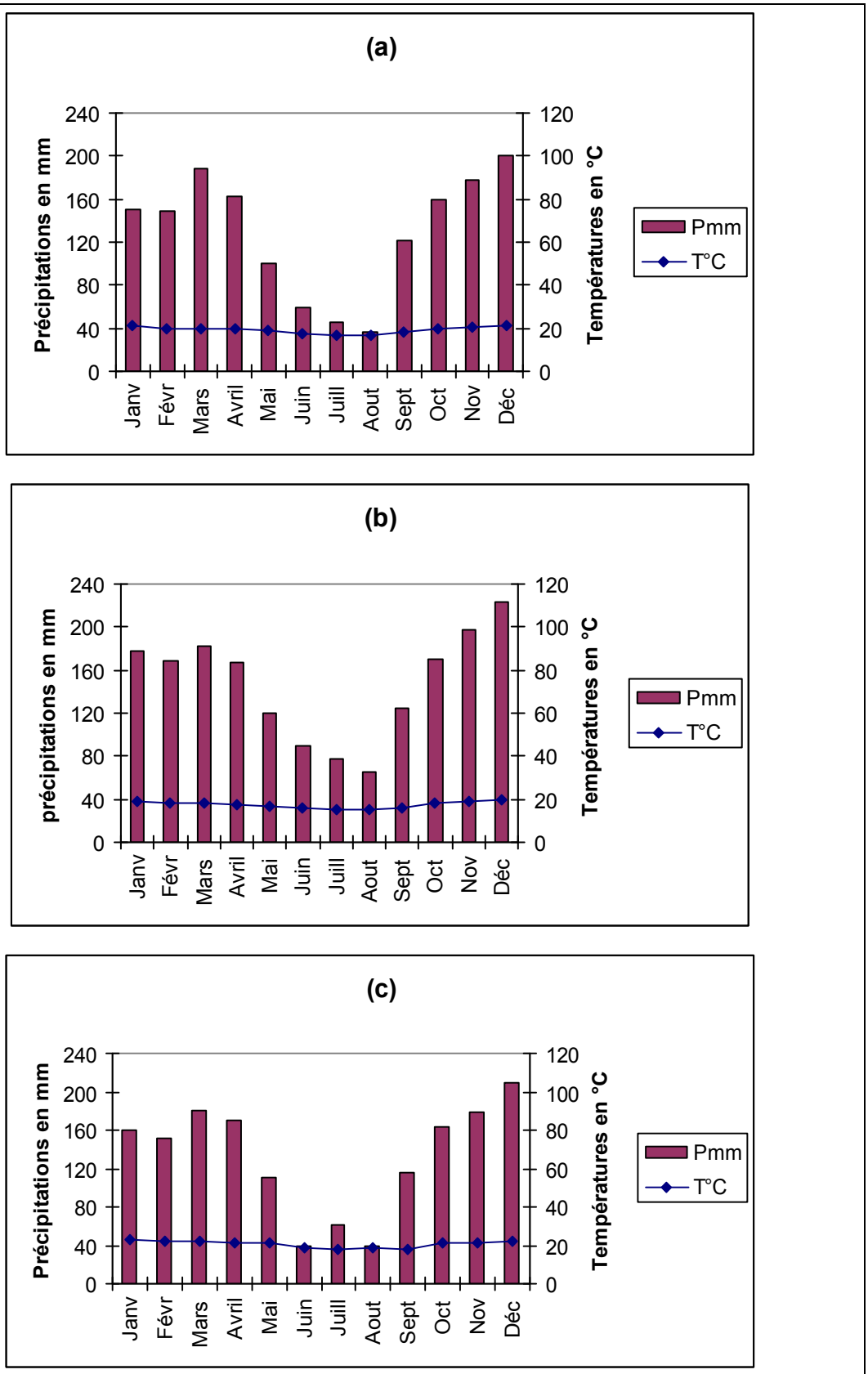

Fig. 2. diagrammes ombrothérmiques : (a) le Nord ;(b) le Sud et (c) le Centre

D'une manière générale, l'évolution pluviothérmique des trois stations est la même. Les mois moins pluvieux et ceux frais sont les mêmes dans toutes les stations ainsi que les plus pluvieux et chauds malgré certaines nuances. Les températures journalières suivent la même évolution dans les trois stations.

Sur les 365 jours de l'an 2011, les températures journalières variaient d'une station à une autre et d'un jour à un autre mais ces amplitudes n'étaient pas énormes.

D'une manière générale, la station du Centre enregistre les mois les plus chauds étant la moins élevée en altitude et la présence des eaux thermales dans cette vallée, celle du Sud les plus frais étant la plus perchée en altitude et les températures de la station du Nord sont intermédiaires entre celles du Sud et celles du Centre. Sur les trois diagrammes ombrothérmiques utilisant l'indice de Gaussen, aucun mois n'est sec.

Quand à la quantité d'eau tombée à Luhwindja en 2011 avec ses 183 km² de superficie et chaque pluviomètre avec ses 452,16cm² de surface, la moyenne d'eau tombée sera :

$$Et = \frac{183000000000cm^2 \times 497mm}{1356,48cm^2}$$

Et = 6 633 426 221 000mm alors que ce chiffre implique 301 519 373 700 litres d'eau pour l'an 2011 avec un pluviomètre de 1 l = 22mm ; la moyenne journalière sera :

$$\frac{301519373700 \text{ litres d'eau}}{365 \text{ jours}} = 826080475{,}9 \text{ litres d'eau par jour,}$$ soit 16476 litres d'eau par an au mètre carré ou 36247,2mm d'eau par an au mètre carré et 99,308mm ou 4,514 litres d'eau par jour au mètre carré.

Dans le souci d'une interprétation objective, nous pensons qu'il est bon de comparer ces résultats avec les données pluviothérmiques des régions se trouvant dans les mêmes conditions géographiques que Luhwindja comme par exemple, les villes de Bogota en Colombie et Quito en Equateur.

De ce fait, le choix de ces deux villes latino-américaines se greffe sur trois raisons fondamentales :

- **La Situation en latitude** : en principe, le climat équatorial s'étend entre 5° de latitude Sud et 8° de latitude Nord **(Bonard N. en 1990) ;** Or toute la chefferie de Luhwindja se situe entre 2°49'43'' et 3° de latitude Sud et donc dans les latitudes du climat Equatorial.

En outre, en climat Equatorial, les précipitations sont supérieures à 1200mm d'eau l'an et toutes les trois stations installées à Luhwindja ont plus de 1500 mm d'eau l'an.

- **volcans :** ces deux villes ci-haut citées sont localisées dans une zone à volcanisme actif et éteint dans une région montagneuse appelée cordillères des Andes. Or, le Professeur **ILUNGA** en 1991 affirme que les chefferies de LUHWINDJA, KAZIBA et BURHINYI sont stannifères grâce aux coulées des laves anciennes. De ce qui précède, nous osons croire que les conditions pédologiques de LUHWINDJA peuvent être les mêmes que ces villes précitées.
- **La situation en altitude :** l'ouest de l'Amérique Latine où se situent ces villes, est tout montagneux avec une altitude moyenne de 2800 mètres modifiant ainsi les conditions thermiques équatoriales **(Bonard N. en 1990)** Or la Chefferie de LUHWINDJA se trouve aussi en pleines montagnes avec les altitudes supérieures à 2500 m dans tous les coins de la Chefferie.

Tableau 3 : données pluviothérmiques de Bogota et Quito

La station de Bogota : 2°30'N Alt.1789m													
MOIS	Janv.	Févr.	Mars	Avril	Mai	Juin	juil.	Aout	Sept.	Oct.	Nov.	Déc.	Année
Pmm	161	149	199	174	161	92	40	31	94	296	306	312	2015
T°C	17,0	17,2	17,3	17,2	17,2	17,1	17,3	17,7	17,7	16,9	16,7	16,9	17,2
La station de Quito : 0°10'S Alt.2818m													
Pmm	119	131	154	185	130	54	20	25	81	134	96	104	1233
T°C	13,0	13,0	12,9	13,0	13,1	13,0	12,9	13,1	13,2	12,9	12,8	13,0	13,0

Dans ces villes, règne un climat Equatorial modifié par l'altitude que BONARD Nguvu appelle climat Colombien.

Vue l'évolution pluviothérmique de ces données moyennes et leurs totaux annuels et ceux de la Chefferie de LUHWINDJA, cette dernière connait aussi un climat colombien.

La présente étude ne s'agit pas seulement d'une simple comparaison mais il nous est impérieux de faire allusion aux activités agropastorales liées à ce climat et pratiquées en Colombie et en Equateur. En effet, ces deux pays se sont spécialisés en culture maraichères, en agrumes et en élevage bovins et ovins jusqu'à satisfaire leurs habitants en besoins de ces denrées alimentaires ci-haut citées.

De cela, les données pluviothérmiques de Luhwindja sont restées longtemps inconnues mais la Chefferie reste un grenier agropastoral pour suppléer aux besoins alimentaires de la Province du Sud-Kivu.

Le seul moyen noble de résoudre les problèmes alimentaires en province est l'étude climatique et pédologique du milieu suivie de la mise en pratique des résultats de la recherche par la politique du développement de la Province en particulier et de tout le Pays en général.

4 CONCLUSION

Les totaux pluviothérmiques diffèrent dans les trois stations installées dans la Chefferie de Luhwindja avec 1753mm d'eau l'an et 17,4°C au Sud, 1553mm et 19,2°C au Nord et 1611mm et 20,5°C au Centre. Cette différence peut s'expliquer par la superficie de la Chefferie qui mérite l'installation de plus de trois pluviomètres et les pluies sont bien localisées dans la zone intertropicale.

Le Nord connait une sécheresse atmosphérique de trois mois (Juin, Juillet et Aout) et une sécheresse pédologique de deux mois (Juillet et Aout) affectant ainsi les stocks d'humidité du sol avec une perte de 29,17mm d'eau utile aux plants l'an. Celle du Sud (partie la plus humide de la Chefferie et la plus fraiche), la perte en eau utile est nulle et la végétation y est verdoyante toute l'année. Le Centre reçoit la conjugaison des précipitations du Nord et celles du Sud et la lame d'eau y restituée à l'atmosphère est de 65,61mm l'an avec une sécheresse pédologique d'un mois (Aout).

La chefferie reste un grenier agropastoral vu ses caractéristiques pluviothérmiques avec 1647,6 litres d'eau par an au mètre carré soit 4,514 litres d'eau par jour au mètre carré considérant la superficie totale de la Chefferie de Luhwindja (183km²).

REFERENCES

[1] BIRINDWA C., Pluviométrie et Hydrologie de la rivière Wesha, ISP/Bukavu, Mémoire, Inédit 2010.
[2] BUHALAGARHA V. MWINYIKONDO K., Géographie générale 4è secondaire, LOYOLA, Kinshasa, 2003.
[3] CHUZEVILLE B., Hydrologie tropicale et appliquée en Afrique Subsaharienne, AGRIDOC International, Paris, 1990.
[4] DURAND D., Géographie des aires, PUF, Paris, 1969.
[5] ESCOUROU G., Climat et environnement, les facteurs locaux du climat, Masson, Paris, 1981.
[6] GOFFAUX J., Notion de climatologie, CRP, Kinshasa, 1990.
[7] HUFLY A., Introduction à la Climatologie, PUF, Paris, 1976.
[8] ILUNGA L., Morphologie, volcanisme et sédimentation dans le rift du Sud-Kivu, Bulletin de la Société Géographique de Liège, 1991, vol.27.
[9] LAMBERT R., L'écoulement, cours/Université de la Sorbonne, 1994.
[10] PAGNEY P., Les climats de la terre, Masson, Paris, 1976.
[11] TRICART J., Le modelé des régions chaudes forêts et Savanes, SEDES, Paris, 1974.

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Effects of Green Purchasing Strategies on Sustainable Supply Chain Performance at Unilever Tea Kenya Limited

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ABSTRACT: The purpose of this study was to determine the effects of green purchasing strategies on sustainable supply chain performance at Unilever Tea Kenya Limited. The general objective of the study was to analyze the effects of green purchasing strategies on sustainable supply chain performance at Unilever Tea Kenya Limited. Environmental compliance, systems development and implementation, integration into core corporate function and total quality approach were identified as the key variables that guided the study. The target population was (120) from which a sample size of (92) was arrived at. The instrument for data collection was a questionnaire sent out to supply chain departments at Unilever Tea Kenya Limited through stratified random sampling. Data was analyzed using both descriptive statistics (mean, frequencies, percentages and standard deviation) and inferential statistics (Pearson correlation). After correlation tests were run, all four hypotheses were rejected and the alternative hypotheses accepted. The study established that environmental compliance, systems development and implementation, integration into core corporate function and total quality approach affects sustainable supply chain performance. The study recommended that more organizations especially in developing countries like Kenya could adopt and fully implement green purchasing strategies when sourcing for goods or services. The study further suggests for similar studies in other tea buying companies in Kenya which are in the process of implementing green business practices.

KEYWORDS: Environment Compliance, Implementation, Integration, Quality, Supply Chain.

1 INTRODUCTION

According to Walker *et al.,* 2008, it is either due to forced regulations by the state corporations or the growing concern on the deterioration of the natural environment, that organizations have increased their attention on practices with negative impact on the environment. This attention is not solely on an organization's activities such as production and marketing but also on its supplier activities. Common drivers in green procurement are regulatory compliance, customer pressure, risk minimization and the monitoring of green performance. The practice of environmental purchasing has been a much-neglected subject, but in the last few years significant progress has been made in developing tools and techniques to aid purchasing. The subject is acquiring its own intellectual credibility, although it remains a backwater for many environmental professionals (Morton, 2002). Previously, businesses assumed that incorporating 'green' into their business strategy would cost money, but they now realize that ignoring negative impacts on the environment will be costly in the future (Van der Zee, 2008).

Public concern for environmental issues has gradually but steadily increased over the past three decades since the inception of Earth Day appealing to preserve nature and biodiversity (Kim and Choi, 2005). To a large degree, private

organizations are permitted to invoke whatever criteria they like, and use what control procedures they deem appropriate, to govern the outflow of money to suppliers. They do, of course, have to demonstrate to the owners via the auditors that frauds have not been perpetrated and that arrangements have been made to the advantage of the company, but the precise form of commercial arrangements is open to considerable flexibility (Green, 1998). Consumers buy products based on a combination of cost, quality, availability, maintainability, and reputation factors. The companies along with their supply chains, which can provide these desired things, will ultimately be successful (Wisner *et al.,* 2008). But when confronted with risky purchase decisions, most firms consider first and foremost, sellers or suppliers with proven track record. Such firms are favoured as familiar suppliers help reduce perceived risks (Hutt and Speh, 2009). Supplier selection in particular is crucial in management of a supply chain. The decision is one of the most fundamental and important decisions made by buyers and organizations. This is because supplier selection and management can be applied to a variety of suppliers throughout a products' life cycle from initial raw materials acquisition to end-of-life service providers (Bai and Sarkis, 2009).

As a result of globalization the world is 'getting flat' (Friedman, 2005). Trade has become faster and easier, and has increased in volume. Various groups challenge globalization, claiming it creates inequalities between rich and poor. These groups seem to overlook that globalization creates opportunities for everyone, including the poor. Because developing countries have comparative advantages in terms of production, cheaper labour, natural resources and warm climates, companies relocate production there. Globalization thus creates a chance for the poor to participate in the world economy. Globalization has brought unparalleled opportunities for economic growth, but has highlighted widening income gaps between rich and poor. Improved technology and transportation have boosted exports from developing countries to wealthier parts of the world. This has sometimes brought more income for the poor. But in many cases, the rich have got richer, and the poor, poorer (Marije, 2008).

1.1 STATEMENT OF THE PROBLEM

Managing the supplier qualification and selection process is a necessary step for companies seeking to manage their corporate legitimacy and reputations. Increasingly more authors are addressing supplier selection issues in the light of environmental aspects (Sarkis, 2006). Social and environmental conditions in developing countries lag behind those in the West. Business leaders and public opinion increasingly acknowledge this, and agree that not just public actors, but also private companies need to engage in poverty alleviation. Corporate social responsibility (often referred to as CSR) also affects procurement by western companies in developing countries. As a result, a third element has joined the traditional strategic procurement elements of costs and quality as an influence on global procurement strategies which focuses on social and environmental issues. But globalization and liberalization also involve risks such as the overuse of natural resources, pollution, and the exploitation of people through human rights violations and setting unfair wages and prices. Partly due to pressure from civil society, the private sector is increasingly aware of these risks, and company boards are increasingly interested in developing sustainable businesses as was acknowledged during the Millennium Summit of the United Nations in the year 2000 (Marije, 2008). In Kenya, there has been a long-standing concern about land degradation and deforestation. Many large corporations have committed to sustainable development and show concerns on sustainability issues.

1.2 OBJECTIVES OF THE STUDY

The study was guided by one general objective and four specific objectives.

1.2.1 GENERAL OBJECTIVE

The general objective of this study was to assess the effects of green purchasing strategies on sustainable supply chain performance at Unilever Tea Kenya Limited.

1.2.2 SPECIFIC OBJECTIVES

i. To establish the influence of environmental compliance on sustainable supply chain performance at Unilever Tea Kenya Limited.
ii. To identify the role of systems development and implementation on sustainable supply chain performance at Unilever Tea Kenya Limited.
iii. To determine the relationship between integration into core corporate function and sustainable supply chain performance at Unilever Tea Kenya Limited.
iv. To assess the effect of total quality approach on sustainable supply chain performance at Unilever Tea Kenya Limited.

1.2.3 HYPOTHESES

H_{01}: There is no significant influence of environmental compliance on sustainable supply chain performance at Unilever Tea Kenya Limited.

H_{02}: There is no role of systems development and implementation on sustainable supply chain performance at Unilever Tea Kenya Limited.

H_{03}: There is no relationship between integration into core corporate function and sustainable supply chain performance at Unilever Tea Kenya Limited.

H_{04}: There is no direct effect of total quality approach on sustainable supply chain performance at Unilever Tea Kenya Limited.

1.3 THEORETICAL FRAMEWORK

Global environmental management initiative (GEMI) offers four-level classification of sustainable sourcing strategies and performance, from simple compliance with minimum standards to assigning green purchasing to strategic corporate function (Hamner, 2006):

Level 1: Compliance. In this case, buying firms verify supplier's performance based on compliance with environmental, health and safety regulations and grant preference to those sourcing companies that better match purchaser's own environmental policies and related standards.

Level 2: Systems Development and Implementation. At this level of development, purchasing strategy is based on well-developed systems of supplier evaluation. Delisting of suppliers is implemented in regard to those companies that do not comply with purchaser's environmental requirements.

Level 3: Integration into Core Corporate Function. At third level, environmental evaluation model is integrated with supplier selection models. This coordinated scheme of supplier evaluation is applied at all business units (not only by environmental managers, but supply management, purchasing and marketing departments etc.)

Level 4: Total Quality Approach. In this case only those suppliers are granted with purchasing contracts who have implemented integrated sustainability approaches in managerial practices. Supplier's environmental management and quality improvement systems are continuously monitored and evaluated to check consistencies with corporate environmental policies. Collaborative relationships with suppliers are developed to reveal and implement synergies for further sustainability improvements both in purchasing and selling companies.

Sustainable supply chain management expands the concept of sustainability from a company to the supply chain level (Carter and Rogers, 2008). The supply chain includes the flow and transformation of goods and information from raw material stage, through to the end user (Seuring and Muller, 2008). Discussions of sustainability are driven by the basic notion that a supply chain's performance should be measured not just by profits, but also by the impact of the chain on ecological and social systems (Jennings and Zandbergen, 2005). Exemplars are organizations that are well ahead of their industry on either social and/or environmental performance while still maintaining economic viability. Identifying exemplars in sustainable supply chain management is complicated because rigorous metrics of environmental and/or social performance are absent in many industries. Some of the potential respondent organizations had received third party certification and/or recognition. For instance, one firm was the first in their industry to receive the Environmental Protection Agency's (EPA) Green Seal, while others had certifications from Non-Governmental Organization's (NGO) such as the Rainforest Alliance.

1.4 CONCEPTUAL FRAMEWORK

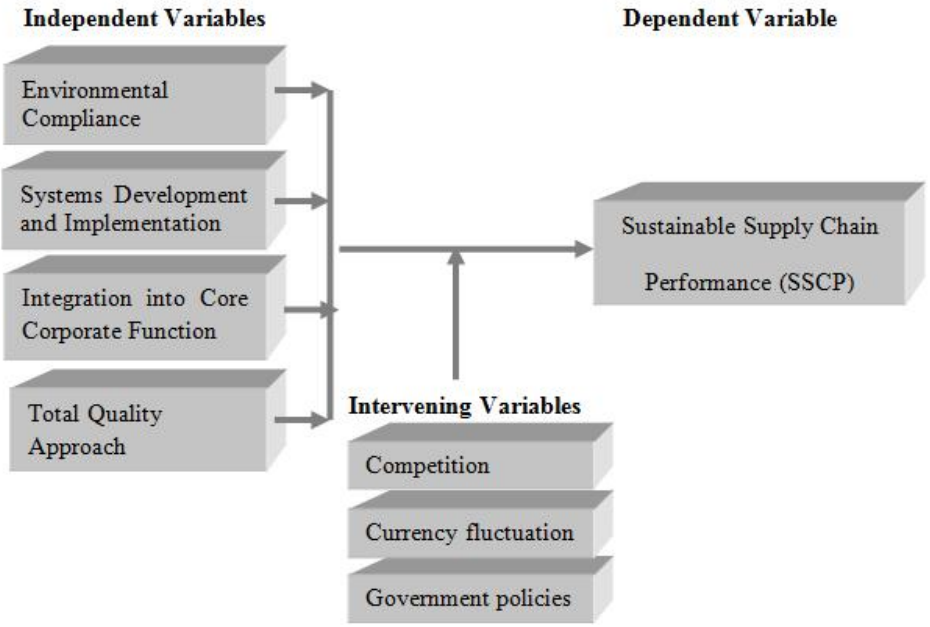

Figure 1.1: The Conceptual Framework

1.5 JUSTIFICATION OF THE STUDY

This study is significant especially to the supply chain staff of tea manufacturing companies in Kenya as it may guide in their steps to developing sustainable purchasing strategies. The basis of the study was to ascertain whether firms perform better or not through applying green purchasing strategies in decision making. The study was significant in that it can guide one on how to carry out a research in the future as scholars may revisit related topics in order to carry out further studies. The study was intended to contribute to the growing body of literature on sustainable supply chain performance in Kenya which is scarce. Gold *et al.,* (2010) referred to literature on SSCM as still limited, and literature reviews are scant with only nine comprehensive literature review papers on SSCM being available today. Kariuki (2014) study sought to analyze the key drivers of sustainable procurement in public institutions in Kenya: case of Kenya Electricity Generating Company olkaria, geothermal station Naivasha. The study's findings showed that environmental drivers, social drivers and economical drivers play a major role in the procurement processes of public organizations in Kenya.

1.6 RESEARCH METHODOLOGY

A research design is the blueprint used to guide a research study, and for fulfilling objectives and answering questions (Mugenda and Mugenda, 2003). The proposed study applied survey design which involves selecting a sample that is a representation of the population of the study who give their opinions. The instrument for data collection was a questionnaire sent out to the various supply chain departments at Unilever Tea Kenya Limited through stratified random sampling. The reason for sampling in this study was to lower cost, improve accessibility of study population and to enhance the speed of data collection. The target population was (120) from which a sample size of (92) was arrived at using Yamane, (1967)'s formula.

1.7 RESEARCH FINDINGS AND DISCUSSIONS

From a target population of 120 employees of Unilever Tea Kenya Limited, 92 were sampled. 77 fully completed questionnaires were received, analyzed and interpreted which represents a response rate of 83.70% which was acceptable.

1.7.1 DEMOGRAPHIC CHARACTERISTICS

This section provides the general characteristics of the respondents. The information was sort to establish the gender, age, academic qualifications, and duration of service, department and level of operation. The researcher sort to know the gender of the respondents and the findings were as follows: forty two (54.5%) of the respondents were male while thirty five

(45.5%) were female. The male dominated but this can be attributed to the nature of work especially in some departments such as logistics. This implies that there is relative gender parity in the organization since the difference is minimal.

1.7.2 AGE GROUP OF RESPONDENTS

The researcher established the age brackets of the respondents. This is a demographic that affects behaviors or perceptions of individuals on issues in organizations. The findings show that nine (11.7%) are between 18-24 years, twenty one (27.3%) are between 25-29 years, twenty nine (37.7%) are between 30-40 years while eighteen (23.4%) are above 40 years. This implies that the age group of staff is well distributed with a majority being below 40 years. These results indicate that the population is relatively young.

1.7.3 EDUCATION LEVEL OF RESPONDENTS

The study sort to determine the education level of the respondents. Education level can contribute to some of the purchasing strategies adopted by an organization. The findings indicated that three (3.9%) have secondary level education as their highest level of education, sixteen (20.8%) have reached certificate level, twenty two (28.6%) have diplomas, twenty four (31.2%) have degrees and twelve (15.6%) have attained post graduate level studies. This shows that majority of the respondents are well educated and capable of providing the relevant information. This implied that they were well equipped with the right skills and knowledge.

1.7.4 RESPONDENTS' DURATION OF SERVICE

The researcher sort to know the period of time that the employees have worked with the organization since this affects the understanding of a company's daily operations. The findings indicate that twenty four respondents have worked for 3-5 years at (31.2%), twenty (26.0%) have worked for 6-10 years, seventeen (22.1%) have worked for 0-2 years while sixteen (20.8%) have worked for more than 10 years. This indicates that majority of the respondents have a wider experience within the organization and have enough knowledge especially when filling out questionnaires.

1.7.5 RESPONDENTS' LEVEL OF OPERATION

Twenty seven supervisors had the highest percentage at (35.1%). Middle management had twenty five (32.5%); top management respondents were thirteen (16.9%) while entry level were twelve (15.6%). This response rate is attributed to the fact that most of the top management staff are busier The entry level lower response rate could be attributed to the fact that they may not have a wider experience in the company compared to the rest who have probably been in the industry longer. On the descriptive statistics results, all questions had a standard deviation of below one which indicates that the results were not significantly varied. The mean from all the respondents was between 3 and 5. 5 represented strongly agree while 4 represented agree which means that majority of the respondents agreed with the statements. 3 represented neutral, 2 represented disagree while 1 represented strongly disagree.

1.7.6 EFFECT OF ENVIRONMENTAL COMPLIANCE ON SUSTAINABLE SUPPLY CHAIN PERFORMANCE

When the respondents were asked to respond as to whether environmental compliance affects the sustainable supply chain performance. The mean from all the respondents was between 3 and 5. 5 represented strongly agree while 4 represented agree which means that majority of the respondents agreed with the statements. 3 represented neutral, 2 represented disagree while 1 represented strongly disagree.

Table 1 Correlation between Environmental Compliance and Sustainable Supply Chain Performance (SSCP).

		ENVIRONMENTAL COMPLIANCE	SSCP
ENVIRONMENTAL COMPLIANCE	Pearson Correlation	1	.529**
	Sig. (2-tailed)		.000
	N	77	77
SSCP	Pearson Correlation	.529**	1
	Sig. (2-tailed)	.000	
	N	77	77

**. Correlation is significant at the 0.01 level (2-tailed).

Table 1 shows the correlation coefficient (r) equals .529 indicating a significant relationship between environmental compliance and sustainable supply chain performance. The null hypothesis is rejected while the alternative hypothesis is accepted because the level of significance is less than 0.01. When the correlation is considered to be significant it means that the researcher can be 99% confident that the relationship between environmental compliance and sustainable supply chain performance at Unilever Tea Kenya Limited.

1.7.7 Effect of Systems Development on Sustainable Supply Chain Performance

When the respondents were asked to respond to various statements as to whether systems development affects the sustainable supply chain performance. The mean on a Likert scale of 1-5 from all the respondents was between 3 and 5. 5 represented strongly agree while 4 represented agree which means that majority of the respondents agreed with the statements. 3 represented neutral, 2 represented disagree while 1 represented strongly disagree.

Table 2 Correlation between Systems Development and Implementation with Sustainable Supply Chain Performance (SSCP)

Correlation analysis was used to establish the effect of systems development and implementation on sustainable supply chain performance as shown below.

		Systems Development and Implementation	SSCP
Systems Development and Implementation	Pearson Correlation	1	.559**
	Sig. (2-tailed)		.000
	N	77	77
SSCP	Pearson Correlation	.559**	1
	Sig. (2-tailed)	.000	
	N	77	77

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2 shows the correlation coefficient (r) equals .559 indicating a significant relationship between systems development and sustainable supply chain performance. The null hypothesis is rejected while the alternative hypothesis is accepted because the level of significance is less than 0.01. When the correlation is considered to be significant it means that the researcher can be 99% confident that the relationship between these two variables.

1.7.8 Effect of Integration on Sustainable Supply Chain Performance

When the respondents were asked to respond to statements as to whether integration into core corporate function affects the sustainable supply chain performance. The mean from all the respondents was between 3 and 5. 5 represented strongly agree while 4 represented agree which means that majority of the respondents agreed with the statements. 3 represented neutral, 2 represented disagree while 1 represented strongly disagree.

Table 3 Correlations between Integration into Core Corporate Function and Sustainable Supply Chain Performance (SSCP).

		Integration into Core Corporate Function	SSCP
Integration into Core Corporate Function	Pearson Correlation	1	.540**
	Sig. (2-tailed)		.000
	N	77	77
SSCP	Pearson Correlation	.540**	1
	Sig. (2-tailed)	.000	
	N	77	77

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3 shows the correlation coefficient (r) equals 0.540, indicating a strong relationship. P value which is the significance is <.01 and **means the null hypothesis can be rejected. Correlation evidence is significant because it can help identify potential causes of behavior. There is therefore a strong relationship between integration into core corporate function and the sustainable supply chain performance at Unilever Tea Kenya Limited.

1.7.9 Effect of Total Quality Approach on Sustainable Supply Chain Performance

When the respondents were asked to respond to various aspects on whether total quality approach affects the sustainable supply chain performance. The mean from all the respondents was between 3 and 5. 5 represented strongly agree while 4 represented agree, 3 represented neutral, 2 represented disagree while 1 represented strongly disagree on a likert scale of 1-5. This means that majority of the respondents agreed fully with the statements.

Table 4 Correlation between Total Quality Approach and Sustainable Supply Chain Performance (SSCP)

		Total Quality Approach	SSCP
Total Quality Approach	Pearson Correlation	1	.509**
	Sig. (2-tailed)		.000
	N	77	77
SSCP	Pearson Correlation	.509**	1
	Sig. (2-tailed)	.000	
	N	77	77

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4 shows the correlation coefficient (r) equals 0.509 indicating a significant relationship between total quality approach and sustainable supply chain performance P-value which is the significance level is <.01 and asterisks means we can reject the null hypothesis. When two variables are related, or correlated, one can make predictions for these two variables. There is therefore a strong relationship between total quality approach and the sustainable supply chain performance at Unilever Tea Kenya Limited.

2 Summary and Conclusions

The study was looking into the effects of green purchasing strategies on the sustainable supply chain performance. Based on the summary of the findings, it was concluded that environmental compliance had an influence on sustainable supply chain performance at Unilever Tea Kenya Limited. Systems development and implementation plays a role on sustainable supply chain performance at Unilever Tea Kenya Limited. Integration into core corporate function influences sustainable supply chain performance at Unilever Tea Kenya Limited. Total quality approach has an effect on sustainable supply chain performance at Unilever Tea Kenya Limited. All four hypotheses were rejected and the alternative hypotheses accepted.

Recommendations

Based on the findings and conclusions of the study, the following recommendations were made. All stakeholders in the tea industry can collaborate to ensure full implementation by working with suppliers to develop and implement corporate social, ethical and environmental reports for those suppliers who do not have such programs in place. Performance could be constantly measured and the experiences documented in order to communicate results and track progress.

REFERENCES

[1] Bai, C., & Sarkis, J. (2009). *Supplier Selection and Sustainability: A Grey Rough Set Evaluation.* Worcester. Massachusetts: Clark University, George Perkins Marsh Institute.

[2] Beamon, B. M. (1999). Measuring supply chain performance. *International Journal of Operations & Production Management, 19*(3), 275-92.

[3] Bell, S., & Morse S. (2003). *Measuring Sustainability: Learning by Doing.* London: Earth Scan Publications.

[4] Brooks, S. B. (2010). CSR and the Straight-Jacket of Economic Rationality. *International Journal of Sociology and Social Policy, 30*, 604-617.

[5] Buckman, J. (2009). Ford Finds its Way. *Quality Progress Journal, 42*(6), 14-15.

[6] Caldwell, F., & Eid, T. (2007). *Magic Quadrant for Finance Governance, Risk and Compliance Management Software.* Gartner.

[7] Carter, C., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving towards new theory. *International Journal of Physical Distribution and Logistics Management, 38*(5), 360-387.

[8] Chan, R. Y., & Lau, L. B. (2004). The effectiveness of environmental claims among Chinese consumers: Influences of claim type, country disposition and ecocentric orientation. *Journal of Marketing Management, 3*(20), 273-319.

[9] Checkland, P. (2000). Soft Systems Methodology: A 30 year retrospective. *Systems Research and Behavioural Science Journal, 17,* 11-58.

[10] Chen, C. (2005). Incorporating green purchasing into the frame of ISO 14000, *Journal of Cleaner Production, 13,* 927-933.

[11] Chen, T., & Huang, S. (2006). A fuzzy approach for supplier evaluation and selection in supply chain management. *International Journal of Production Economics, 102*(2), 289-301.

[12] Chien, M. K., & Shih, L. H. (2007). An empirical study of the implementation of green supply chain management practices in the electrical and electronic industry and their relation to organizational performances. *International Journal of Environmental Science and Technology, 4*(3), 383-394.

[13] Clem, W. (2008). *5 Things you need to know about going green.* Retrieved February 10, 2014, from http://www.greencar.com/articles/5-things-need-going-green

[14] Cohen, L., & Morrison, K. (2007). *Research Methods in Education.* London: Routledge.

[15] Cooper, R. D., & Schindler, P. S. (2003). *Business Research Methods* (8th ed.). New Delhi: McGraw-Hill.

[16] Crane, A. (2000). Facing the Backlash: green marketing and strategic reorientation in the 1990s. *Journal of Strategic Marketing, 8*(3), 277-296.

[17] Crouch, C. (2009). Privatised Keynesianism: An Unacknowledgement Policy Regime. *The British Journal of Politics and International Relations, 11*, 382-399.

[18] Currie, W. (2008). Institutionalization of I.T Compliance: A Longitudinal Study. Proceedings of the 29th International Conference on Information Systems (ICIS 2008).

[19] Dallas, N. (2008). *Green Business Basics: 24 Lessons for Meeting the Challenges of Global Warming.* New York: McGraw-Hill.

[20] Dolan, C. S., & Opondo, M. (2005). Seeking Common Ground: Multi-Stakeholder Initiatives in Kenya's Cut Flower Industry. *Journal of Corporate Citizenship, 18*, 87-98.

[21] El Kharbili, M., Stein, S., Markovic, I., & Pulvermüller, E. (2008). Towards a Framework for Semantic Business Process Compliance Management. In: Proceedings of GRCIS 2008, CASE Workshop on Governance, Risk and Compliance of Information Systems.

[22] Emmerich, W., Finkelstein, A., Montangero, C., Antonelli, S., Armitage, S., & Stevens, R. (1999). Managing Standards Compliance*. IEEE Transactions on Software Engineering*, *25*(6), 836-851.

[23] Faure, M., & Lefevere, J. (2005). *Compliance with Global Environment Policy*. The Global Environment: Institutions, Law, and Policy. Washington DC: CQ Press.

[24] Friedman, T. L. (2005). *The world is flat: A brief history of the 21st century.* New York: Farrar, Straus and Giroux.

[25] Giannakis, M., & Simon, R. (2004). Toward the development of a supply chain management paradigm: a conceptual framework. *Journal of supply chain management, 40*(2), 27-37.

[26] Green, K., Morton, B., & New, S. (1998). Green purchasing and supply policies: do they improve companies' environmental performance. *Supply Chain Management: An International Journal, 3*(2), 89-95.

[27] Gold, S., Seuring, S., and Beske, P. (2010). Sustainable supply chain management and inter-organizational resources: a literature review, *Corporate Social Responsibility and Environmental Management Journal, 17*(4), 230-245.
[28] Gunasekaran, A., Patel, C., & McGaughey, R. E. (2004). A framework for supply chain performance measurement. *International Journal of Production Economics, 87*(3), 33-47.
[29] Gunningham, N. K., Kagan, R. A., & Thornton, D. (2003). *Shades of Green: Business, Regulation and Environment.* California: Stanford University Press.
[30] Hamner, B. (2006). *Effects of Green Purchasing Strategies on Supplier Behaviour: Greening the supply chain*. London: Springer.
[31] Handfield, R., Walton, S. V., Sroufe, R., & Melnyk, S. A. (2002). Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process. European *Journal of Operational Research, 141*(1), 70-87.
[32] Hervani, A., & Helms, M. M. (2005). Perfomance measurement for green supply chain management. *Benchmarking: An International Journal, 12*(4), 330-353.
[33] Humphreys P. K., Wong, Y. K., & Chan, T. S. (2003). Integrating environmental criteria into the supplier selection process. *Journal of Materials Processing Technology, 138*, 1-3.
[34] Hurley, J. (2004). The Struggle to Manage Security Compliance for Multiple Regulations. White Paper, Symantec. URL: http://www.infoworld.com/pdf/white paper/StruggleToManage.pdf. Accessed: March 25nd 2014
[35] Hutt, M., & Speh, W. (2009). *Business Marketing Management: B2B*. Ohio, South- Western: Cengage Learning.
[36] Institute of Developing Economies-Japan External Trade Organization. (2013). African Growing Enterprises. Retrieved March 01, 2014, from IDE-JETRO: http://www.ide.go.jp/English/Data/Africa_file/Company/kenya06.html
[37] International Institute for Environment and Development, (2013). Profiles of Tools and Tactics for Environmental Mainstreaming: A product of the Environmental Mainstreaming Initiative: *Environmental Management Systems, 5.*
[38] Jennings, P., & Zandbergen, P. A., (2005). Ecologically Sustainable Organizations: An Institutional Approach. *Academy of Management Review, 20*(4), 1015-1052.
[39] Jabbour, A. B., & Jabbour, C. J. (2009). Are supplier selection criteria going green? Case studies of companies in Brazil. *Industrial Management and Data Systems. 109*(4), 477-495.
[40] Joyce, P., Rosamund, B., & Graham, W. (2006). A new construct for visualizing and designing e-fulfillment systems for quality healthcare delivery. *The TQM Magazine, 18*(6), 638-651.
[41] Kim, Y., & Choi, S. R. (2005). Antecedents of green purchase behaviour: An examination of collectivism, environmental concern and PCE. *Advances in Consumer Research, 32*(1), 592-599.
[42] Kleindorfer, P. K., Singhal, K., & Wassenhove, V. (2005). Sustainable Operations Management. *Production and Operations Management, 14*(4), 482-492.
[43] Kothari, C. R. (2004). *Research Methodology methods and Technique.* New Delhi: New International Publisher.
[44] Lang'at, N. K. (2007). Impact of tea processing machines on quality of black tea: A case of study of Unilever Tea Kenya Limited.
[45] Leonidou, L. (2011). Evaluating the green advertising practices of international firms: a trend analysis. *International Marketing Review, 28*(1), 6-33.
[46] Linton, J. D., Klassen, R., & Jayaraman, V. (2008). *Sustainable Supply Chains: An Introduction, 25*, 1075-1082.
[47] MacLean, T. L., & Behnam, M. (2010). The Dangers of Decoupling: The Relationship between Compliance Programs, Legitimacy Perceptions, and Institutionalized Misconduct. *Academy of Management Journal, 53*(6), 1499-1520.
[48] Maina, S. K. (2014). Analysis of the key drivers of sustainable procurement in public organizations in Kenya, Case of Kengen Olkaria geothermal station Naivasha. *International Journal of Science and Research, 3*(10).
[49] Malloy, T. F. (2003). Regulation, Compliance and the Firm. *Temple Law Review, 76*(3), 451-531.
[50] Marije, J. B. (2008). Development Policy and Practice. *Sustainable Procurement from developing countries practices and challenges for business and support agencies, Bulletin 385*.
[51] Markley, M., & Davis, L. (2007). Exploring future competitive advantage through sustainable supply chains. *International Journal of Physical Distribution and Logistics Management, 39*(9), 74-763.
[52] Min, H., & Galle, W (2001). Green purchasing practices of US firms. *International Journal of Operations and Production Management, 21*(12), 22-38.
[53] Mostafa, M. (2009). Shades of green: A psychographic segmentation of the green consumer in Kuwait using self-organizing maps. *Expert Systems with Applications, 36*(8), 1030-1038.
[54] Morton, B. (2002). An Analysis of Private Versus Public Sector Responses to the Environmental Challenges of the Supply Chain. *Journal of Public Procurement, 2*(1), 93-105.
[55] Mugenda, O. M., & Mugenda, A. G. (2003). *Research Methods: Quantitative and Qualitative Approaches.* Nairobi: Act Press.
[56] Mullerat, R. (2005). *Corporate Social Responsibility: The Corporate Governance of the 21st Century.* Boston: Kluwer Law International.

[57] Muthuri, J. N., & Gilbert, V. (2010). An Institutional Analysis of Corporate Social Responsibility in Kenya. *Journal of Business Ethics, 98*, 467-483.
[58] Neeraj, B. (2004). Investigating the decision criteria used in electronic components procurement. *Industrial Marketing Management, 33*(4), 317– 323.
[59] Oosterhout, J. H., & Heugens, P. M. (2008). Much Ado about Nothing: A Conceptual Critique of CSR. *The Oxford Handbook of Corporate Responsibility*, *1,* 197-223.
[60] Opondo, M. (2009). The Impact of Chinese Firms on CSR in Kenya's Garment Sector: Working Paper. *The International Research Network on Business and Development Society* , Series 7.
[61] Pagell, M. (2010). Thinking Differently About Purchasing Portfolios: An Assessment of Sustainable Sourcing. *Journal of Supply Chain Management 46*(1), 57-73.
[62] Peschel, D., & Irfan A. (2008). Total Quality Management and the Malcolm Baldrige National Quality Award Benefits and Directions for Banking Institutions. *Business Renaissance Quarterly, 3*(4), 49-66.
[63] Rainforest Alliance. (2009). *Unilever Tea Kenya Redefines Green.* Retrieved March 01, 2014, from Rainforest Alliance: http://www.rainforest-alliance.org/publications/kericho
[64] Read, B. (2010). Listening to Your Customers. *Customer Interaction Solutions, 29*(2), 22-26.
[65] Reynaldo, J & Santos A. (1999). Cronbach's Alpha: A Tool for Assessing the Reliability of Scales. *Extension Information Technology, 37*(2).
[66] Robinson, F. (2008). What does it really mean. Retrieved January 7, 2014, from Going Green: http://www.ezinearticles.com/?Going-green!-What-does-it-really-mean?
[67] Russel, T. (1998). *Greener Purchasing, Opportunities and Innovations.* Sheffield: Greenleaf Publishing.
[68] Sadiq, S., Indulska, M. (2008). The Compliance Enabled Enterprise: Process is the Product. *Compliance and Regulatory Journal, 5*, 27-31.
[69] Saghir, M. (2002). *Packaging Logistics Evaluation in the Swedish Retail Supply Chain.* Lund: Lund University.
[70] Sarkis, J. (2006). *Greening the Supply Chain.* London: Sping-Verlag London Limited.
[71] Sarkis, J.,& Kitazawa, S. (2000). The Relationship Between ISO 14001 and Continuous Source Reduction Programs. *International Journal of Operations & Production Management, 20*(2), 225-48.
[72] Sekaran, U. (2003). *Research Methods for Business.* New Jersey: John Wiley & Sons.
[73] Schwartz, S. (1977). *Normative influences on altruism. Advances in experimental social psychology.* New York: Academic Press.
[74] Schneiberg, M., & Bartley, T. (2008). Organizations, Regulation and Economic Behavior: Regulatory Dynamics and Forms from the Nineteenth to Twenty-First Century. *Annual Review of Law and Social Science, 4*, 31–61.
[75] Seuring, S., & Muller, M. (2008). From a literature review to a conceptual framework for sustainble supply chain management. *Journal of Cleaner Production, 16*, 1699-1710.
[76] Sousa, C. M. (2004). Academy of Market Science Review. *Export performance measurement: An Evaluation of the empirical research in the literature* .
[77] Specter, M. (2008). Big Foot. *In Measuring Carbon Emissions, Its Easy to Confuse Morality and Science*. 44-53.
[78] Stead, W. E., & Stead, J. G. (2004). *Sustainable Strategic Management*, New York: M. E. Sharpe.
[79] Tempel, A., & Walgenbach, P. (2007). Global standardisation of organizational forms and management practices? What new institutionalism and the business-systems approach can learn from each other. *Journal of Management Studies, 44*, 1-24.
[80] Turner, M., & Houston, P. (2008). *Start with Sourcing.* Retrieved March 07, 2014, from Strategy+ Business: http://www.strategy-business.com
[81] Unilever Kenya Tea Limited. (2014). *Forest Conservation at Unilever Kenya Tea.* Retrieved March 01, 2014, from http://www.unilever.com/sustainable-living/news/casestudies/agriculture/KenyaTeaplantationbiodiversityinitiatives.aspx
[82] Ulrich, W. (2003). Beyond methodology choice: critical systems thinking as critically systemic discourse. *Journal of the Operational Research Society, 54*(4), 325-342.
[83] Vachon, S., & Klassen, R. D. (2006). Extending green practices across the supply chain: The impact of upstream and down stream intergration. *International Journal of Operations and Production, 26*(7), 795-821.
[84] Van der Zee, B. (2008). *Green Business* (1st ed.). London: Dorling Kindersley.
[85] Vargo, S., & Lusch, R. (2011). It's all B2B…and beyond: Toward a systems perspective of the market. *Industrial Marketing Management, 40*(2), 181-187.
[86] Walker, H., Sisto, L., & Mcbain, D. (2008). Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors. *Journal of purchasing and supply management, 1*(14), 69-85.
[87] Wageningen, L. (2012). *Sustainable tea production in Kenya: Impact assessment of Rainforest Alliance and Farmer Field School training.* Hague: Plant Research International.

[88] Whiteman, G., Walker, B., & Perego, P. (2012). Planetary Boundaries: Ecological Foundations for Corporate Sustainability. *Journal of Management Studies,* 1-30.
[89] Wilson, M. (2003). Corporate Sustainability: What is it and where does it come. *Ivey Business Journal*, *1,* 1-20.
[90] Wisner, J. (2008). *Principles of Supply Chain Management.* Mason, South West Ohio: Cengage Learning.
[91] Yamane, T. (1967). Statistics: An Introductory Analysis. (2nd ed.). New York: Harper and Row.
[92] Zhu, Q., Lai, P., & Sarkis, J. (2008). Confirmation of a measurement model for green supply chain management practices implementation. *International Journal of Production Economics, 111*(2), 261-273.

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Various Factors Affecting E-commerce

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ABSTRACT: E-commerce is the procedure of doing business through computer networks and Internet. In this Paper, we have analyzed the various factors affecting the growth of E-commerce such as technology, market, supply chain and security. With the ability to track customer's activities, mapping their social networks and come close to them proactively, present personalized offerings and administer individual lifecycle has changed the E-commerce over the past few years. The success of the virtual store depends on many issues such as security, trust etc. Research was undertaken to authorize and create the relative significance of these attributes. E-commerce which was basically started in early 90's had taken an immense leap over the world but security and economic market are some of the hindrances which affects the growth of online business. The major advantage of E-commerce over traditional way of shopping is that customers can browse online shops, compare the prices and order the merchandise sitting at home with their laptops or PC's. This paper divulges that E-commerce is restricted and complex practice which involves the utilization of a focused cross-functional team to undertake a variety of barriers along the way.

KEYWORDS: E-commerce, Technology, Market, Supply Chain and Security.

1 INTRODUCTION

Introduction to E-Commerce provides current and prospect practitioners of E-Commerce a base establishment in every characteristics of conducting big business in the complex financial system. The content focuses on what an executive requires to be familiar with Internet communications, policy formulation and accomplishment, expertise perception, open guidelines concern, and wealth infrastructure in categorize to formulate efficient trading conclusions. This is depicted within an outline for the learning and practice of E-Commerce with production policy at the establishment enclosed by four infrastructures; "the technology infrastructure that bring about the Internet", "the supply chain infrastructure that offers the production for businesses", "market rules which presents both prospects and constraints", "and the security which builds the trust amongst the customers and suppliers."

E-commerce has chiefly altered all through the past few years with the ability to follow customers' actions, map their social networks and use social influence, approach them proactively, provide customized offerings and manage individual lifecycles. Stirring from supervising the community to managing its individual members inside the community is the general denominator in many associated developments [1]. In the rising universal market, e-commerce and e-business have more and more turn into an essential component of business stratagem and a strong catalyst for economic expansion. The assimilation of information and communications technology in commerce has transformed relationships within organizations and those between and among business and individual. With expansion in the Internet and Web-based technologies, distinction between conventional markets and the worldwide electronic marketplace-such as business capital size, amongst others-are progressively being lessened down. Amazon has been the greatest success story in this field after 5 years of loss making and more than USD 1bn in loses it finally turned profitable. Many e-commerce services provides in India wish to become giants in e-commerce sector in India. In India these providers are facing some very tough challenges that have raised due to lot many factors such as poor infrastructure, unclear tax structure, lack of access to internet to a majority of population and lack of awareness about these companies [2].

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1.1 E-COMMERCE AND ITS IMPORTANCE

E-commerce is accomplished using a range of variety of services For example: Electronic mail, shopping cart, online catalog, Electronic data Interchange and web services. To guarantee the privacy security, and efficacy of e-commerce, businesses must validate their business transactions, manage entrance to assets such as web pages for registered or special users, encrypt communications and execute security technologies such as the Secure Sockets Layer. The benefits of e-commerce include its around-the-clock availability, the speed of access, a wider selection of goods and services, accessibility, and international reach. It's perceived downsides comprise sometimes-limited customer service, not being able to see or touch a product prior to purchase, and the require wait time for product shipping.

E-commerce trade may utilize a few or all of the following:

- Online shopping web sites for retail sales straight to clients
- Business-to-business buying and selling of the product
- Assembly and using demographic data all the way through web contacts and public media
- Electronic data interchange for business to business
- Marketing to new and well-known clients by e-mail or fax (for example, with newsletters)
- Appealing in retail for launching novel goods and services

2 RESEARCH METHOD

This research paper scrutinizes the utility of documents as an information source in qualitative research and confers document investigation practice in the perspective of genuine research understanding. Aiming to research learners, the article obtains a nuts-and-bolts approach to document examination. It portrays the nature and variety of documents, delineates the benefits and constraints of document scrutiny, and presents detailed illustrations of the use of documents in the investigation course. The purpose of document study to a grounded speculation study is presented. Research on cutting edge e-commerce, customer engagement and social influence practices requires awareness of the realities and possibilities of information systems management. At marketing centric venues such as pure marketing and even ecommerce conferences, the starting point is often too much on the would-be-nice-to-have or who-uses-it the- most type of dialogues [3].

In this research paper, a new ontology based repeated item set technique is recommended to pact with research suggestion grouping difficulty. In the suggested technique, research ontology is firstly created to normalize explore keywords. Secondly, recurrent item sets through dissimilar hold quantity are taken out from research suggestion supported on research ontology. Thirdly, a novel evaluation of resemblance degree linking two research applications is constructed and then a grouping algorithm is suggested to categorize study suggestion based on the connection degree, within which a number of constraints are conferred, and the appropriate factors are chose. Lastly, whilst the quantity of research suggestions in several clusters is still huge, explore proposals are additionally separated into small clusters, inside which the number of study applications are roughly equivalent.

2.1 SURVEY METHOD

Under our survey we have discussed the of students and faculties perception towards online business and E-commerce, we have prepared a number of questions and asked them to faculties and students at university of Bridgeport. The main agenda of the research is to emphasize on the issues affecting E-commerce and web based trading such as security, technology, economic market and supply chain. Our questions were founded on specific factors depicting its advantages and disadvantages and what business and government organizations can do to overcome these hindrances.

3 SCIENTIFIC CASUAL MODEL OF E-COMMERCE

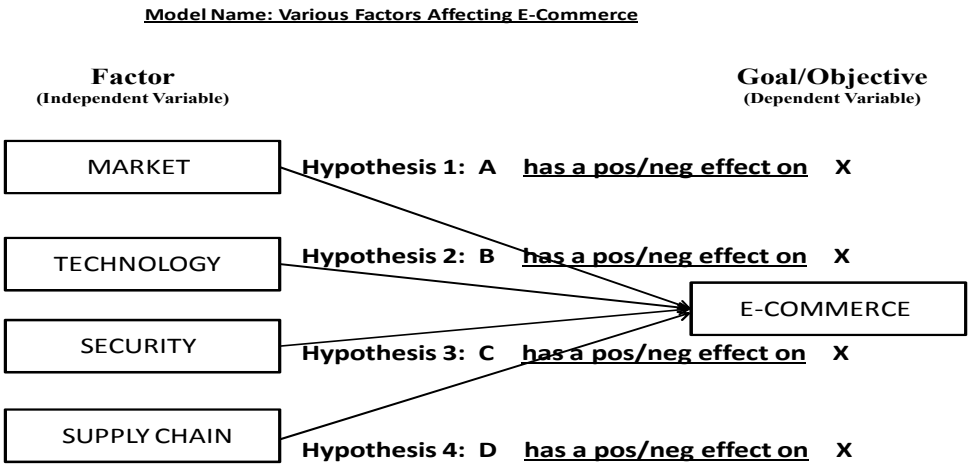

Figure 1.Various Factors Affecting E-Commerce

E-commerce is essential for enterprises because it improves their understanding of customer needs and of the products and services available in the market [4]. Now-a-days many traditional manufacturers have started taking the initiative of online business. Because of the E-commerce manufacturers have started eliminating wholesalers and distributors which has reduced the manufacturing period stock and circulation which has reduced the cost and thus this helps them to obtain higher profits. Adopting e-commerce may encounter a similar situation in that it can promote productivity only when the long-run benefits of computerization exceed the short run cost of learning by mistakes. The reason is that the cost savings of e-commerce through the Internet channel probably do not meet demand in every style, size, and color combination at a much lower cost in the short run [5]. A lot of benefits and features have been provided by E-commerce which is sufficient enough to attract massive interest, but there is always a fundamental problem of trust is associated with E-commerce this is one of the main reason of hindrance in the success of E-commerce.

3.1 GOAL OF AN ONLINE BUSINESS

An Online company's main goal is to achieve what business wants. A prime aim for each and every business association is to put in value and makes profit. Additional premeditated aims comprises growth, market management and brand construction.

A commerce purpose is a comprehensive depiction to set up your plan and proceed in a manner to achieve the desired aim.

There are three primary goals of social media. They are:

- **Driving Conversions:** Social media is one of the easiest ways for potential boost if it is to increase sales or to increase leads. Conversions are easily traceable when it comes to social media.
- **Increase the Conversation;** Social media is the only means which provides the space in the world where clients can talk with the company's employees in a tractable environment. Social media websites are the ones where companies can launch new product, reach the target audience or to share information about the offers and best selling deals.
- **Strengthening the Brand name:** To build up the brand name and value social media is one of the most powerful tools for marketing. Through social media websites the company can easily find the targeted audience. Via social media, companies get ways to interact with their customers and place online advertisements.

***Figure 2**: Strengthening The Brand Name*

3.2 FACTOR 1: MARKET

The growth of electronic-markets (e-markets) necessitates the processing of much commerce protocols (processes). Each protocol handles different messages and flows of transactions among customers, merchants and intermediaries. Developing applications for each commerce protocol is costly and impractical [6]. Consequently, mounting a flexible model of Internet commerce to sustain a variety of trading protocols is imperative. Furthermore, the appearance of intermediaries is expected as e-markets cultivates. This effort analyzes a range of trading method and the task of intermediaries, and proposes a flexible agent-based model of intermediary–centric trading. Market orientation could be divided into consumer orientation, competitor orientation, and cross-functional coordination, and pointed out that market orientation is the value system of an organization. Market orientation denotes market information regarding the present and future needs of consumers, the dispersion of cross-department information, and the reaction of the organization towards information [7]. The emerging knowledge economy is a new phenomenon in the financial markets and poses new issues in various aspects of financial decision-making. The financial sector plays an important role in macroeconomic management but many studies on financial issues relate to the microeconomic level, where the study of markets under asymmetric information has provided insights into the significance of financial factors for corporate investment decision-making [8].

3.3 FACTOR 2: SECURITY

Now-a-days, Commerce is getting dependent on information systems in a new way; with the introduction of electronic commerce Information security is thus becoming more and more essential to companies' Self-protection. In contrast to earlier systems, this is also openly perceptible to the customer. The shifting situation means, conversely, that the requirements for security cannot be solely filled by new policies and risk analysis. We have presented a number of very significant and essential security problems in the X.509 solutions being provided today for security in E-commerce. Many of the problems originate in the fact that those building the security solutions understand little business and trading, electronic or not. It has also been anticipated that signatures will find a widespread use in emails. To use a digital signature, there must be a motivation, e.g. an application [9]. Our expansion to the novel scheme have improved the security of the new scheme by requiring two pieces of authentication (i.e. two certificates and demonstrated possession of associated private keys) to be presented in order to acquire an additional certificate in the most capable way. In this way, the danger of an invader fallaciously obtaining an unidentified certificate by means of a compromised private key has been much reduced. The ambiguity and liability properties of the novel scheme have been preserved without deterioration. Security administrators need to prioritize which feature to focus on amidst the various possibilities and avenues of attack, especially via Web Service in e-commerce applications [10].

3.4 FACTOR 3: TECHNOLOGY

Understanding the effective adoption of technological innovations, such as e-business, is arguably one of the key challenges facing organizations. The literature indicates that the relationship between firm capabilities and firm performance is mediated by the effects of the adopted innovation (e.g., e-business). However, the complementarily effects of capabilities

on the adoption of innovation have received little attention [11]. Technological opportunism potential permits firms to attain, attract, and incorporate inner and outer facts and market information about new technologies to organize their assets in order to react to the technological opportunity and/or threats that can appear. Though, in spite of its impending inferences for business, there is little investigation about technological opportunism and its impact on performance. Only in recent times, studies have observed the consequence of technological opportunism on performance procedures. The capability of firms to sense and respond to changes in technologies, called technological opportunism, is of growing importance to managers as a source of competitive advantage. However, exactly how technological Opportunism impacts firm performance is still not clearly understood. Furthermore, the role of marketing in this relationship, if any, has yet to be examined. Understanding this relationship is critical for marketing managers not only for determining strategic investments of resources but also for demonstrating marketing return on activities. The results show that technological opportunism has a strong positive impact on key measures of performance such as firm sales, profits and market value [12].

3.5 FACTOR 4: SUPPLY CHAIN

Supply-chain management is a composite procedure due to the several qualms it involves. The ambiguity connected with inter-organizational management comes with reference to when the behavior of supply chain contributor are not in harmony Modern developments in e-commerce have added to Internet-based solutions to this trouble. Concerning e-commerce explanation to the supply chain can boost the effectiveness of synchronization and resource integration between partners. Since the success of e-commerce systems depends on whether the troubles that interrupt supply-chain integration can be prevail over, diagnosing supply-chain problems is significant in deploying e-commerce solutions. During the last decade, supply chain management (SCM) has changed significantly due to globalization and the pace of technological innovation. Competitive pressures have forced companies to increase supply chain collaboration throughout the whole product lifecycle. To improve their ability to integrate processes, businesses are also facing the challenge of shorter product lifecycles, globally dispersed design teams, a constant increase in outsourcing and the market demand for mass customization. This has forced companies to create demand driven and flexible supply chains that will be able to meet customers' expectations. Key business processes are integrated through the supply chain while strategic knowledge and issues are shared in order to achieve mutual benefits [13].

4 CONCLUSION

Today's businesses should always try hard to produce the next exceptional thing that clients will desire for the reason that customers persist to wish for their products, services etc. to constantly be enhanced, sooner, and cheaper. In this era of new technology, commerce involves accommodating to the new types of consumer requirements and trends since it will establish to be vital to their business's success and endurance. E-commerce is constantly making progress and is attracting more and more significance to businesses as technology persists to proceed and is impressive that should be taken benefit of and executed. The prospect of E-commerce will radically develop over the years as the quantity of internet users among businesses and customers flourish considerably every year. From the recent universal knowledge on the instability of e-commerce equity market, there is a call for for public strategy to develop participation in the e-commerce segment, so that the sector operates capably in an economically and socially pleasing way. The success of social and economic objectives in relation to e-commerce expansion must as a result require government involvement. The focus of public policy ought to be directed at diminishing the troubles of moral danger and adverse variety in the e-commerce equity market. These problems are further apparent because of the promising and developing nature of e-commerce progress creating a state of asymmetric information.

REFERENCES

[1] Rayport, J. F., & Jaworski, B. J. (2002). *Introduction to e-Commerce*: McGraw-Hill/Irwin marketspaceU. Reddy, N. A., & Divekar, B. R. (2014). A Study of Challenges Faced By E-commerce Companies in India and Methods Employed to Overcome Them. *Procedia Economics and Finance, 11*(0), 553-560. doi: http://dx.doi.org/10.1016/S2212-5671(14)00220-2

[2] Reddy, N. A., & Divekar, B. R. (2014). A Study of Challenges Faced By E-commerce Companies in India and Methods Employed to Overcome Them. *Procedia Economics and Finance, 11*(0), 553-560. doi: http://dx.doi.org/10.1016/S2212-5671(14)00220-2

[3] Hajli, N. (2015). Social commerce constructs and consumer's intention to buy. *International Journal of Information Management, 35*(2), 183-191. doi: http://dx.doi.org/10.1016/j.ijinfomgt.2014.12.005

[4] Yadav, M. S., de Valck, K., Hennig-Thurau, T., Hoffman, D. L., & Spann, M. (2013). Social Commerce: A Contingency Framework for Assessing Marketing Potential. *Journal of Interactive Marketing, 27*(4), 311-323. doi: http://dx.doi.org/10.1016/j.intmar.2013.09.001

[5] Liu, D.-R., & Hwang, T.-F. (2004). An agent-based approach to flexible commerce in intermediary–centric electronic markets. *Journal of Network and Computer Applications, 27*(1), 33-48. doi: http://dx.doi.org/10.1016/S1084-8045(03)00039-0

[6] Wu, J.-J. (2004). Influence of market orientation and strategy on travel industry performance: an empirical study of e-commerce in Taiwan. *Tourism Management, 25*(3), 357-365. doi: http://dx.doi.org/10.1016/S0261-5177(03)00144-4

[7] Oh, K. B., & Islam, S. M. N. (2004). THE EMERGENCE OF THE KNOWLEDGE ECONOMY IN THE FINANCIAL MARKETS AND ITS REFORM IMPLICATIONS. *Savings and Development, 28*(1), 21-46. doi: 10.2307/25830848

[8] Landrock, P. (2002). Electronic Commerce — How to Get the Security Right? *Computer Fraud & Security, 2002*(6), 6- 9. doi: http://dx.doi.org/10.1016/S1361-3723(02)00608-5

[9] Chan, G.-Y., Lee, C.-S., & Heng, S.-H. (2014). Defending against XML-related attacks in e-commerce applications with predictive fuzzy associative rules. *Applied Soft Computing, 24*(0), 142-157. doi: http://dx.doi.org/10.1016/j.asoc.2014.06.053

[10] Voola, R., Casimir, G., Carlson, J., & Anushree Agnihotri, M. (2012). The effects of market orientation, technological opportunism, and e-business adoption on performance: A moderated mediation analysis. *Australasian Marketing Journal (AMJ), 20*(2), 136-146. doi: http://dx.doi.org/10.1016/j.ausmj.2011.10.001

[11] Sarkees, M. (2011). Understanding the links between technological opportunism, marketing emphasis and firm performance: Implications for B2B. *Industrial Marketing Management, 40*(5), 785-795. doi: http://dx.doi.org/10.1016/j.indmarman.2010.09.001

[12] Madenas, N., Tiwari, A., Turner, C. J., & Woodward, J. (2014). Information flow in supply chain management: A review across the product lifecycle. *CIRP Journal of Manufacturing Science and Technology, 7*(4), 335-346. doi: http://dx.doi.org/10.1016/j.cirpj.2014.07.002

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ECOLOGIE DU MOLLUSQUE *Pila ovata* DANS LES ECOSYSTEMES AQUATIQUES DE LA REGION DE KATANA, SUD KIVU, EST DE LA R.D. CONGO

[ECOLOGY OF THE MOLLUSC *Pila ovata* IN THE AQUATIC ECOSYSTEMS OF KATANA REGION, SOUTH KIVU, EAST OF THE D.R. CONGO]

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ABSTRACT: An ecological study of the aquatic mollusk *Pila ovata* has been realized in the aquatic ecosystems of Katana region, south Kivu, East of the Democratic Republic of Congo, which shelters this species. Ten aquatic- ecosystems have been prospected in this region according to the current speed of water, the bottom's nature, the pH, the temperature, the depth, the aquatic vegetation, the altitude and the shade degree. Here, it's about the study of favorable ecological conditions to this species in the aquatic ecosystems of the Katana region. For ending at reliable results, the sampling of mollusks has been practiced using the standardized unity of time method. The harvesting of mollusks has been done generally with the help of cloudy water trickle with small stitch of 2 mm attached on an iron bar having a circular opening of 50cm of diameter fits with a lumber handle of 1.5m. The harvesting of mollusks has been done by manual picking, and then put back in their nature biotope after counting. The favorable ecological conditions which prevail to the proliferation and to the survival of the mollusk *Pila ovata* are respectively: a minimum lightning (minimum plant cover), an abundant died aquatic vegetation, a minimum current, a sandy bottom or muddy on the one hand and a moderate temperature ($\geq 16^0$C) on the other hand. A highly significant difference has been observed between aquatic ecosystems of the region all the more that the mollusks number differs between sites. The knowledge of the ecology of this mollusk is an asset for the study of the fight against the intermediate host mollusks of Schistosomiasis.

KEYWORDS: Mollusk, Gastropods, Pilidae, *Pila ovata*, Ecology, DR Congo.

RÉSUMÉ: Une étude écologique du mollusque dulcicole *Pila ovata* a été réalisée dans les écosystèmes aquatiques de la Région de Katana, au Sud Kivu, Est de la République Démocratique du Congo, qui abritent cette espèce. Dix écosystèmes aquatiques ont été prospectés dans cette région d'après la vitesse du courant, la nature de fond, le pH, la température, la profondeur, la végétation aquatique, l'altitude et enfin le degré d'ombrage. Il s'agit ici d'étudier les conditions écologiques favorables à cette espèce dans les écosystèmes aquatiques de la région. Pour aboutir aux résultats fiables, l'échantillonnage de mollusques a été pratiqué suivant la méthode d'unité de temps standardisée. La récolte des mollusques se faisait généralement à l'aide d'un filet troubleau à petite maille de 2mm accroché sur une barre de fer ayant une ouverture circulaire de 50cm de diamètre muni d'une manche de bois de 1,5m. La récolte des mollusques se faisait par ramassage manuel, ensuite remis dans leur biotope naturel après comptage. Les conditions favorables qui prévalent à la prolifération et à la survie du mollusque *Pila ovata* sont respectivement : un éclairement minimal (couverture végétale minimale), une végétation aquatique abondante (morte), un courant minimal, un fond sablonneux ou vaseux d'une part et une température modérée (≥16°C) d'autre part. Une différence hautement significative a été observée dans les récoltes entre les écosystèmes aquatiques prospectés de la région d'autant plus que le nombre des mollusques diffère entre les sites. La connaissance de

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l'écologie de ce mollusque est un atout pour les études de lutte contre les mollusques hôtes intermédiaires de la Schistosomiase.

MOTS-CLEFS: Mollusque, Gastéropodes, Pilidae, *Pila ovata*, Ecologie, RD congo.

1 INTRODUCTION

Les Gastéropodes dulcicoles et plus généralement les mollusques dulcicoles sont d'une très grande importance dans les écosystèmes aquatiques. Ce rôle est dû à l'énorme biomasse qu'ils représentent [1] et à leur place comme consommateurs de la production primaire. L'habitat des mollusques est d'une infinie variété car ils ont une énorme capacité d'adaptation.

Cependant, certains se rencontrent sur les types des substrats. Ils sont répartis en fonction du profil longitudinal des cours d'eau, de l'épaisseur de l'eau et du courant d'eau [2]; [3] ; [4].

L'application de l'état écologique de l'impact des activités humaines peut être atteinte en s'intéressant aux facteurs régissant la répartition des mollusques dulcicoles et leur écologie [5]; [6]. En général, les mollusques d'eau douce préfèrent l'eau stagnante où à courant lent [5] ; [7].

Quelques études ont été réalisées sur l'écologie des mollusques africains par des thèmes suivants : la distribution locale en fonction des facteurs environnementaux [8] ; [9] ; [10]; [11] ; [12] ; [13] ; les variations saisonnières [14] ; [15] , la dynamique des populations [16] ; [17] ; [18]; [19]; [20] , la biomasse et la production [21], l'association entre espèces [22], la dérive [23]; [24] , la diversité [25]; [26], la description de l'habitat [25]. Les études sur l'écologie des mollusques introduits en milieu naturel sont rares pour comprendre son invasion et son impact sur les autres macro-invertébrés aquatiques [1]; [3] ; [27]; [28] ; [29] ; [30].

Des études malacologiques réalisées dans les écosystèmes aquatiques (rivières, ruisseaux, marais et étangs piscicoles) de la région de Katana au Sud Kivu ont permis d'établir la cartographie des divers mollusques hôtes intermédiaires des Schistosomes dans la région [31] ; [32].

Le mollusque *Pila ovata* a été introduit en 1978 dans quelques écosystèmes aquatiques de la région de Katana au Sud Kivu, en provenance de la plaine de la Ruzizi (Rapport Laboratoire de Malacologie du Centre de Recherche en Sciences Naturelles de Lwiro, Inédit).

Les mécanismes d'adaptation de cette espèce ne sont pas encore élucidés dans la région afin de comprendre sa biologie pour son utilisation comme compétiteur, d'où ces genres d'études dans la province du Sud Kivu en général et à Katana en particulier sont rares, excepté celles de [33] sur l'écologie de *Biomphalaria pfeifferi.*

Ce travail est un des compléments indispensables aux travaux d'écologie. Il pourrait en effet permettre d'interpréter certaines observations de terrains et de préciser les facteurs sur lesquels il est judicieux d'intervenir lorsqu'on envisage un programme de lutte contre les vecteurs.

Le but de ce travail est d'étudier l'écologie de l'espèce *Pila ovata* introduite récemment dans les écosystèmes aquatiques de la région de Katana, dans la perspective de tester une méthode de lutte biologique contre les Schistosomoses qui soit à la fois peu coûteuse, sans risque pour l'environnement et dont les effets pourraient être plus durables que les traitements chimiques. En plus, elle fournira des bases écologiques solides pour le contrôle de ces écosystèmes aquatiques.

2 MATERIL ET METHODES

2.1 MILIEU D'ÉTUDE

La région de Katana où le travail a été réalisé est située autour du Centre de Recherche en Sciences Naturelles(CRSN) de Lwiro, sur la rive occidentale du Lac Kivu(Longitude entre 28°45' Est et 28°85' Est ; Latitude entre 02°15' Sud et 02°30' Sud ; Altitude entre 1465m au niveau du Lac Kivu et 1800 m à la lisière du Parc National de Kahuzi- Biéga ; et ayant une superficie de 141km^2). Son climat est du type tropical humide, caractérisé par une importante pluviosité moyenne supérieur à 1500 mm par an et une température moyenne modérée variable entre 18 et 20°C [34]. On y distingue deux saisons : Une longue saison pluvieuse de Septembre à Mai et une courte saison sèche de Juin à Août. Sa végétation est une savane cultivée qui remplace la forêt à *Albizzia grandibracteata*. La région est parcourue par de nombreux cours d'eau et parsemée par des nombreux

étangs piscicoles constituant ainsi nos sites de prospection. Les principales activités de la population sont surtout l'agriculture, l'élevage et la pêche. La figure 1 représente la carte de la région de Katana renfermant nos sites d'étude

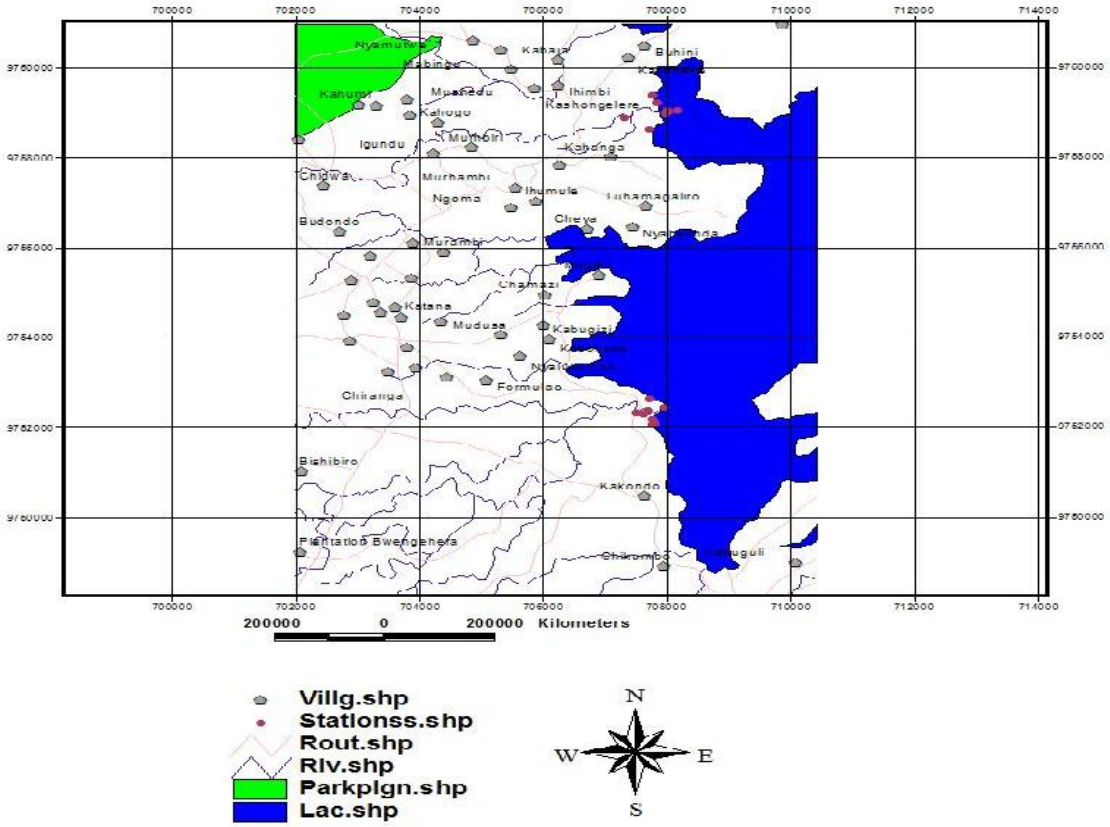

Fig. 1. Carte de la région de Katana

2.2 ECHANTILLONNAGE DES MOLLUSQUES

Les échantillonnages, basés sur l'économie de temps et de moyens disponibles ont été réalisés dans chaque site dans le cadre du suivi écologique de *Pila ovata* dans dix écosystèmes aquatiques de la région de Katana de Janvier à Décembre 2013. Ils ont été faits suivant la méthode d'unité de temps standardisé [35]. La récolte des mollusques se faisait généralement à l'aide d'un filet troubleau à petite maille de 2 mm accroché sur une barre de fer ayant une ouverture circulaire de 50 cm de diamètre muni d'une manche de bois de 1,5 m. Une fois récoltés, ces derniers étaient encore remis dans leur biotope naturel juste après comptage.

2.3 ETUDE DES FACTEURS ENVIRONNEMENTAUX

Divers matériels et méthodes ont été utilisés pour mesurer les facteurs environnementaux de nos différents sites à savoir :

-La température à l'aide d'un thermomètre à mercure gradué en °C ;
-Le pH à l'aide d'un pH-mètre ;
-La profondeur à l'aide d'une latte graduée en centimètre où d'un mètre ruban ;
-La végétation aquatique par abondance relative avec échelle d'estimation :

- : Absente
++ : Abondante
+++ : Très abondante

-La nature des fonds par estimation visuelle ;
-La couverture végétale par son degré de recouvrement ;
-La vitesse du courant par chronométrage du temps de déplacement d'un bouchon de liège sur une distance de 5m.

2.4 ANALYSE STATISTIQUE

Le traitement statistique des résultats fait à l'aide du logiciel Past pour l'analyse de la variance à un seul critère, ANOVA 1.

3 RESULTATS

Le nombre des mollusques récoltés mensuellement dans les dix écosystèmes aquatiques prospectés est présenté dans le tableau 1 ci- dessous :

Tableau 1. Nombre des mollusques récoltés de Janvier à Décembre 2013

MOIS - SITE	Étangs BIKA	Kamirihembye	Buloli	Birunga	Étangs Maziba	Gaho	Kayumaga	Kalengo	Lwiro	Kanyamalogo
Janvier	161	29	0	4	22	25	3	5	0	0
Février	135	10	4	1	41	15	2	6	0	1
Mars	105	45	0	6	47	8	4	3	0	0
Avril	86	15	0	4	10	25	0	4	0	0
Mai	118	10	1	15	9	23	1	10	0	0
Juin	41	7	0	3	14	23	0	27	0	0
Juillet	49	9	0	8	24	14	0	13	1	1
Aout	64	15	0	3	41	22	0	23	0	0
Septembre	54	22	2	4	35	26	0	13	1	0
Octobre	65	23	0	2	18	5	0	5	0	0
Novembre	54	27	0	2	13	10	0	17	0	0
Décembre	93	24	1	11	27	25	0	9	0	0
Total	1025	236	8	63	301	221	10	135	2	2
Moyenne	85	20	1	5	25	18	1	11	0	0

De ce tableau 1, il ressort que les étangs BIKA ont un effectif très élevé en mollusques récoltés soit la moyenne annuelle de 85 mollusques suivi de l'Etang Maziba (25 mollusques). Kamirihembye en a 20 et 18 mollusques pour Gaho. Buloli, Kayumaga, Lwiro et Kanyamalogo en ont un effectif inférieur à 6 mollusques. Analysons statistiquement les données du tableau 1.

Tableau 2. Analyse de la variance du nombre des mollusques récoltés

Source des variations	Df	Somme de carré	Carré moyen	F	Signification
Différence entre nombre des mollusques récoltés	9	72244	8027,11	42,92	HS
Différence de nombre des mollusques récoltés	110	20573,6	187,033		
Total	119	92817,6			

CV : 5,32E-32%, CV : Coefficient de Variation, HS : Hautement Significatif

De ce tableau, il ressort que la différence est hautement significative ; c'est-à-dire que le nombre des mollusques récoltés diffère entre les sites ; ainsi nous comparons les moyennes par le dendrogramme de similarité entre les écosystèmes aquatiques.

Au regard de la figure 2 ci-dessous, le dendrogramme montre les similarités entre les écosystèmes aquatiques. Il ressort que les étangs piscicoles BIKA ont des effectifs très élevés en mollusques récoltés (85 mollusques), ce qui les éloigne d'autres écosystèmes comme on peut l'observer dans le dendrogramme ci-dessous. Kamirihembye est similaire à l'Etang Maziba ; Gaho à Kalengo ; Lwiro à Kanyamalogo tandis que d'autres écosystèmes aquatiques ont des effectifs qui varient selon le courant d'eau comme on peut l'observer dans le dendrogramme. Cette différence serait probablement due à la différence des vitesses et des facteurs environnementaux entre les sites.

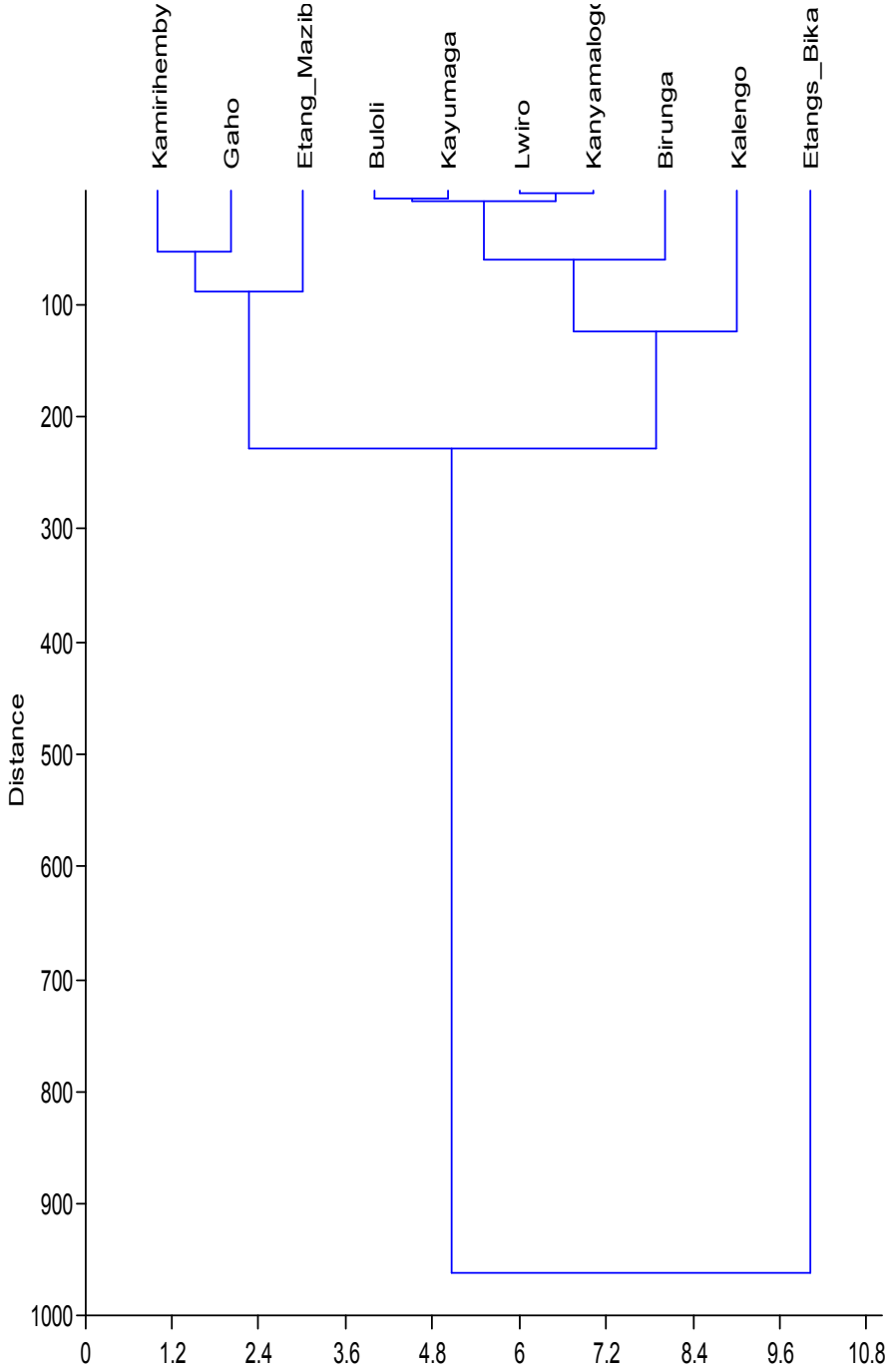

Fig. 2. Dendrogramme de similarité entre les écosystèmes aquatiques

Le mollusque *Pila ovata* a été récolté durant toute la période d'étude avec un pic plus élevé en Janvier. Mais les mollusques sont plus abondamment récoltés dans les étangs piscicoles (Kalengo et Maziba) que dans les cours d'eau de la région de Katana ; ceci se justifie par le fait que les eaux de ces étangs sont calmes avec une vitesse nulle.

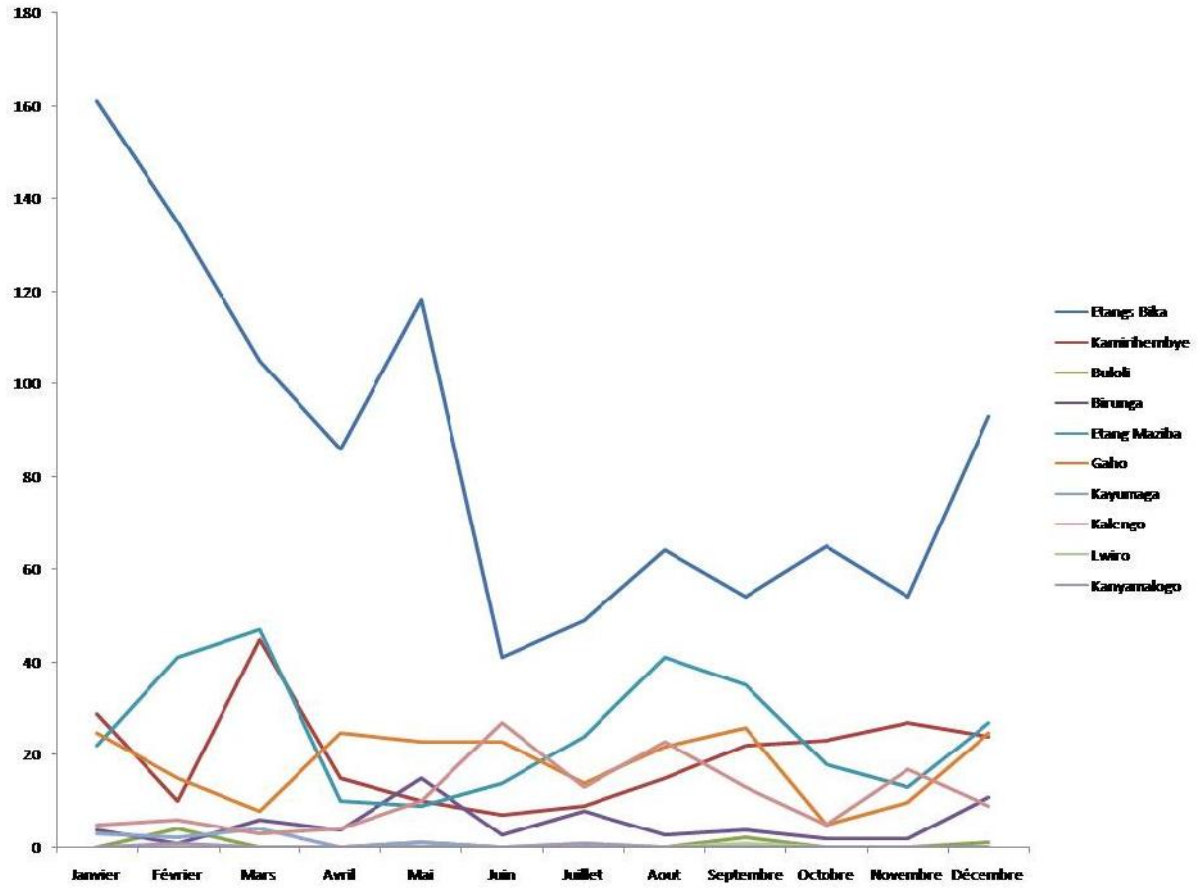

Fig. 3. Nombre d'individus récoltés mensuellement par site

La figure 4 présente les températures moyennes dans les sites et montre qu'elles se rapprochent, mais le site Gaho a la température la plus élevée par rapport aux autres

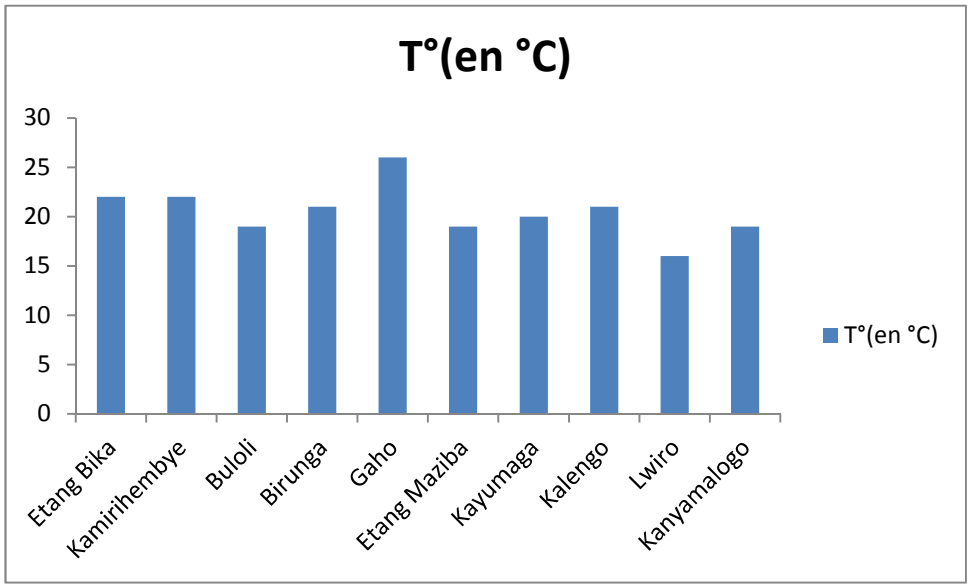

Fig. 4 .Température moyenne par site

Au vu de cette figure 5 ci-dessous, nous remarquons que les Etangs BIKA et Maziba ont des profondeurs plus élevées que les autres sites d'étude ;

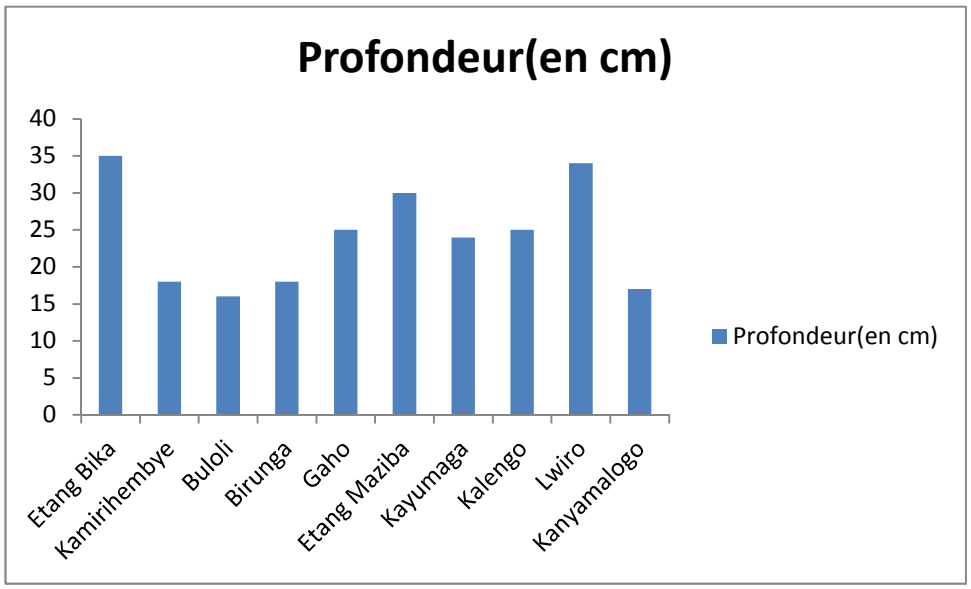

Fig. 5. Profondeur moyenne par site

Les potentiels d'hydrogène (pH) moyen de différents sites varient peu entre 7,5 et 8,8 comme nous montre la Figure 6 ci-dessous.

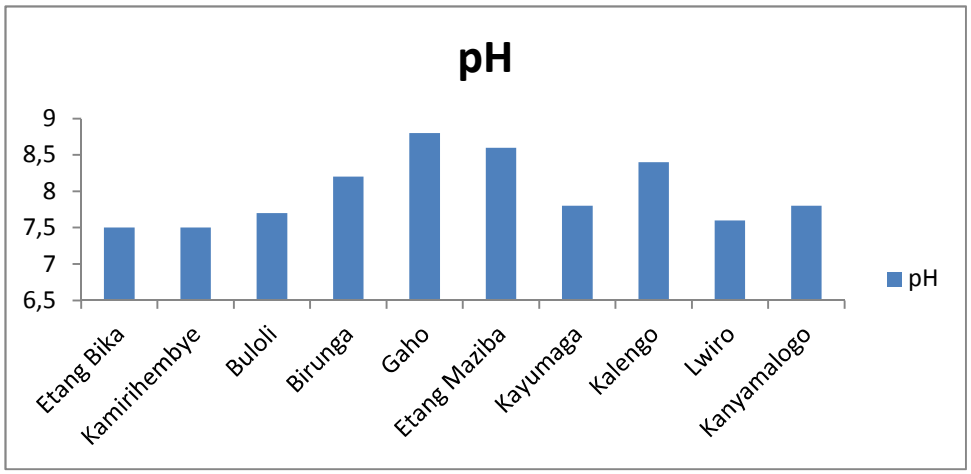

Fig. 6. pH moyen par site

Au regard de la figure 7 ci-dessous, il ressort que les vitesses dans tous les sites d'étude sont faibles, presque nulles ; sauf à Lwiro, Kamirihembye et Kanyamalogo.

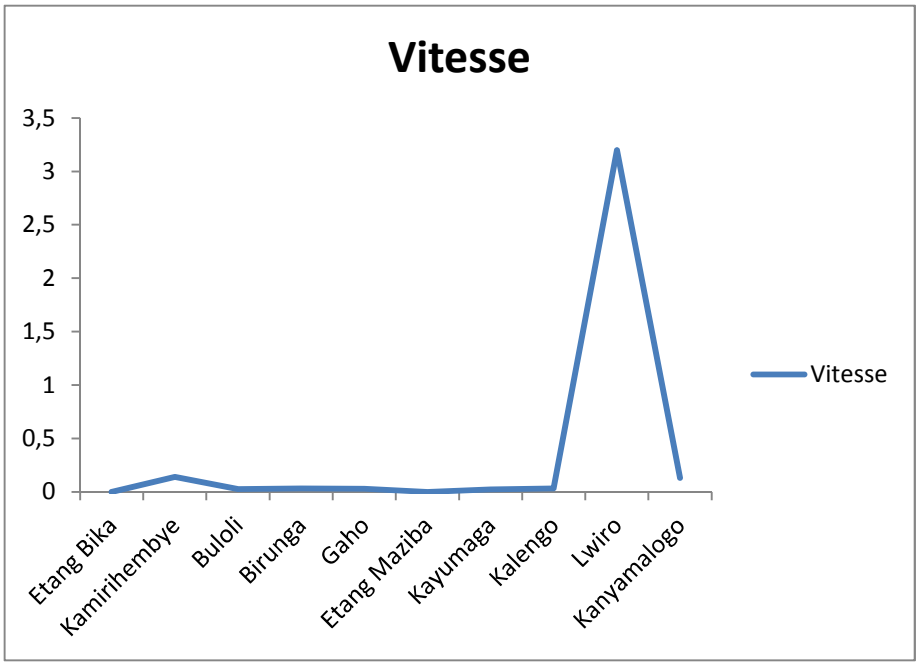

Fig. 7. Vitesse moyenne par site

Quant à l'altitude par site d'étude ; les résultats sont présentés dans la figure 8 ci-dessous. Tous nos sites d'étude se trouvent dans une région de haute altitude ; mais le site se trouvant à une altitude la plus élevée est l'étang Maziba.

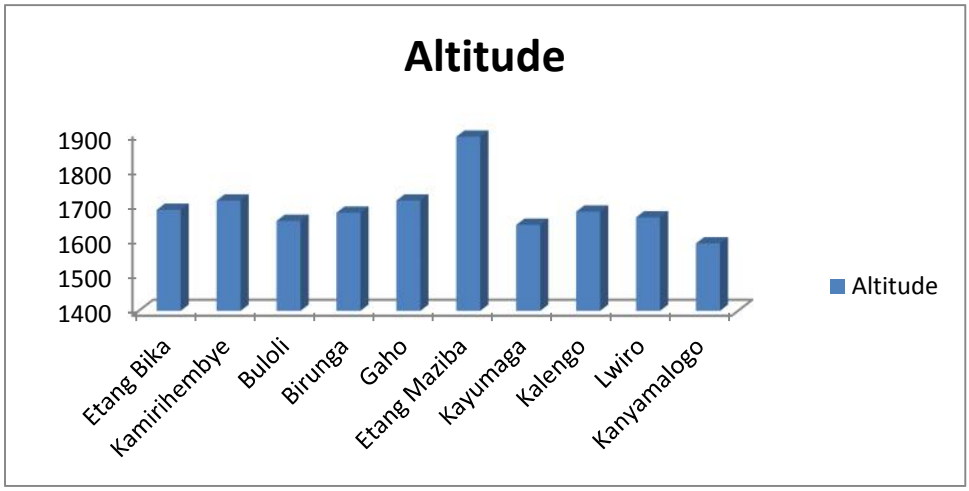

Fig. 8. Altitude par site

Le degré d'ombrage, étant l'un des facteurs favorisant l'écologie des mollusques dulcicoles ; les résultats y relatif sont présentés dans la figure 9 ci-dessous. Au vue de cette figure, nous constatons que le site de Kanyamalogo a un degré d'ombrage le plus élevé par rapport aux autres suivi de Lwiro.

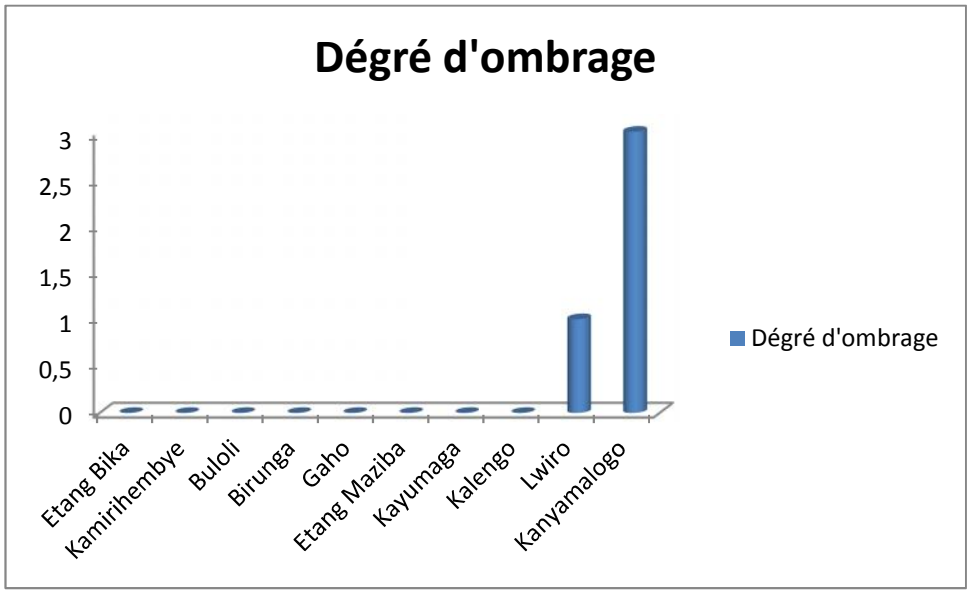

Fig. 9. Degré d'ombrage par site

Les conditions d'existence des mollusques *Pila ovata* en fonction du milieu naturel où ils vivent dépendent de plusieurs facteurs dont certains sont présentés dans le tableau 3 ci-dessous.

Tableau 3. Facteurs environnementaux influençant la croissance des mollusques

SITES	Étangs BIKA	Kamirihembye	Buloli	Birunga	Gaho	Étangs Maziba	Kayumaga	Kalengo	Lwiro	Kanyamalogo
T°(en °C)	22	22	20	21	26	21	20	21	16	20
Vv	-	++	++	+	+	-	+	+++	+++	+++
Vm	+++	++	-	++	+++	+++	-	+	-	-
Nature de fond	V	S	V	V	S	V	V	V	S	V

Légende: *- = absence ;* ***+*** *= peu abondante ;* ***++*** *= abondante ;* ***+++*** *= très abondante ;* ***Vm*** *= végétation aquatique morte ;* ***Vv*** *= végétation aquatique vivante ;* ***V*** *= Vase ;* ***S*** *= Sable.*

Les caractères physico-chimiques des sites d'étude sont présentés dans le tableau 4 ci-dessous.

Tableau 4. Relevés des quelques caractères physico-chimiques des sites prospectés

	pH	Vitesse (en m/sec)	Profondeur (en cm)	Degré d'ombrage(Om)	Altitude
Étangs Kalengo	7,5	0	35	0	1683
Kamirihembye	7,5	0,14	18	0	1709
Buloli	7,7	0,026	17	0	1652
Birunga	8,2	0,032	18	0	1675
Gaho	8,8	0,03	25	0	1709
Étangs Maziba	8,6	0	30	0	1888
Kayumaga	7,8	0,022	24	0	1641
Kalengo	8,4	0,031	25	0	1678
Lwiro	7,6	3,2	34	1	1662
Kanyamalogo	7,8	0,13	16	3	1589

Légende: 0 = degré d'ombrage 0; 1 = degré d'ombrage 1; 3 = degré d'ombrage 3. Om : degré d'ombrage

Il ressort de ce tableau 4 que les caractères physico-chimiques des sites d'étude tels que le Potentiel d'hydrogène (pH), la Vitesse, la Profondeur, le degré d'ombrage(Om) ainsi que l'altitude ont été prélevés. L'altitude de sites varie de 1641 à 1888m ; le pH de 7,5 à 8,8 ; la profondeur de 16 à 35cm ; la vitesse de 0 à 3,2m/seconde et enfin la luminosité de 0 à 3%.

4 DISCUSSION

Ce travail qui a consisté à l'étude de l'écologie du mollusque *Pila ovata* dans les écosystèmes aquatiques de la région de Katana de Janvier à Décembre 2013 montre que les peuplements et populations des mollusques *Pila ovata* dans les étangs piscicoles BIKA sont différents de ceux des autres écosystèmes. La différence réside dans les effectifs, La variation des mollusques diffère d'un site à l'autre comme nous montre la figure 3 ; ceci a été confirmé par nos prédécesseurs pour les mollusques *Biomphalaria pfeifferi, Bulinus truncatus, Melanoides tuberculata* [33]; [36] ; [3]. *Pila ovata* se comporte cependant de la même manière dans les étangs piscicoles ; cela suite aux vitesses nulles des eaux. Le ramassage simple des mollusques ; c'est-à-dire, le comptage des individus récoltés par temps de récolte standardisé [35] a été effectué. Les étangs BIKA ont un effectif très élevé en mollusques récoltés soit la moyenne annuelle de 85 mollusques suivis de l'Etang Maziba (25 mollusques). Kamirihembye en a 20 et 18 ; par contre Gaho, Buloli, Kayumaga, Lwiro et Kanyamalogo ont un effectif inférieur à 6 mollusques. Le test d'ANOVA one way montre une différence hautement significative ; c'est-à-dire que les mollusques *Pila ovata* diffèrent d'un site à l'autre (figure 3) ; ceci a été confirmé par nos prédécesseurs pour d'autres espèces des mollusques aquatiques [33]; [36]; [3]. La vitesse nulle est la plus favorable à l'écologie de *Pila ovata* (figure 7) ; un degré d'ombrage plus élevé constitue un impact négatif sur l'écologie de *Pila ovata* (figure 9) ; comme certaines espèces des mollusques aquatiques [37]; [1]. L'altitude n'a aucun impact négatif sur l'écologie de *Pila ovata* (figure 8).

Nos résultats ne peuvent être comparés qu'aux observations de [38] ; [34] ; les seules qui fournissent des données sur la densité de *Biomphalaria pfeifferi*. Nous y adjoindrons également les études de [25], ainsi que celles de [3], sur les effectifs et la présence des espèces qui est fonction des caractéristiques du milieu dont la nature des fonds et où la végétation aquatique joue un rôle extrêmement important. Les conditions d'existence des mollusques *Pila ovata* en fonction du milieu naturel où ils vivent dépendent aussi de plusieurs facteurs tels que :

La température ; dans le site Gaho, cette dernière s'explique par le fait que les eaux de ce site sont hypo thermales [39]. La température dans d'autres sites comme les étangs piscicoles BIKA, Maziba et autres sites étant inférieure à celle de Gaho ; peut s'explique par le fait que ces derniers sont fortement ensoleillés, subissant un réchauffement important pendant la journée [16] ;

La végétation aquatique (vivante et morte) : il ressort que les ruisseaux Buloli, Kayumaga, Lwiro et Kanyamalogo sont déminus en végétation aquatique morte ; ce qui constitue une des causes de la faible densité en mollusques observée dans ces sites, Sur ce point, notre constatation s'accorde avec celle de [33], qui avait bien souligné que l'insuffisance en nourriture suffirait pour exercer un effet négatif sur la croissance de mollusques aquatiques dont *Biomphalaria glabrata.* La végétation aquatique vivante est observée dans tous les sites excepté les étangs piscicoles (BIKA et Maziba) se caractérisant par l'abondance et la diversité de nourriture disponible pour les mollusques ; ils sont riche en matières végétales mortes d'origine endogène et exogène et n'étant pas ombragés par la couverture végétale ;

La nature des fonds : les sites ont de fonds vaseux, excepté ceux de Gaho, Kamirihembye et Lwiro qui ont des fonds sablonneux (tableau 2) ;

La vitesse du courant : il ressort que les vitesses dans tous les sites d'étude sont faibles, presque nulles, sauf à Lwiro, Kamirihembye et Kanyamalogo (figure 7). La rivière Lwiro possède la plus grande vitesse suite à son courant fort et sa position par rapport au relief de la région ; ce qui est défavorable à l'écologie de certaines espèces de mollusques dulcicoles [40] et cette rivière coule depuis le Parc National de Kahuzi-Biéga où elle prend sa source en altitude élevée, pour aller se jeter dans le lac Kivu se trouvant en altitude moins élevée. Toutefois il est important de spécifier que certaines des études déjà réalisées dans ce domaine fournissent des informations sur le courant de l'eau [40] ;

La profondeur : ceci s'explique par le fait que les étangs piscicoles étudiés augmentent de profondeur à cause des activités anthropiques de la pisciculture [39]. La profondeur de la rivière Lwiro est due d'une part à son courant fort ;

Le degré d'ombrage : étant l'un des facteurs favorisant l'écologie des mollusques dulcicoles (la figure 9). Les sites de Kanyamalogo a un degré d'ombrage le plus élevé par rapport aux autres. Ceci est dû par le fait que ce dernier est entouré des bambous ainsi que le boisement à *Eucalyptus sp*. Ce couvert végétal est à la base de l'amortissement des rayons solaires entrainant ainsi la réduction de la lumière dans le site ; ce qui constitue un impact négatif sur l'écologie de *Pila ovata* ainsi que certaines autres espèces des mollusques aquatiques [37] ; [1] ;

L'altitude : Tous nos sites d'étude se trouvent dans une région de haute altitude (Figure 8) ; mais le site se trouvant à une altitude la plus élevée est l'étang Maziba suite à sa position géographique vis-à-vis du relief de la région. C'est le site le plus rapproché du Parc National de Kahuzi-Biéga où l'altitude est toujours très élevée dans les environs de notre milieu d'étude (plus de 2200 m). Cette altitude n'a aucun impact négatif sur l'écologie de *Pila ovata* d'autant plus qu'il s'y prolifère facilement compte tenu de son effectif dans les récoltes.

Le potentiel d'hydrogène (pH) : le (pH) moyen de différents sites varient peu entre 7,5 et 8,8 (figure 6); ce qui représente des milieux neutres ou faiblement alcalins, tous en principe favorables aux mollusques dulcicoles [3]. Mais, le pH le plus élevé a été observé à Gaho suite à son fond sablonneux et sa température élevée. Ces résultats corroborent avec ceux de [41] sur la succession des communautés de Gastéropodes dans deux milieux différents par leur degré d'eutrophisation au Canada.

D'après ces résultats obtenus au cours de cette étude, nous pouvons déduire que les biotopes de *Pila ovata* sont caractérisés par : un courant lent ou nulle (Figure 7), une nature des fonds constituée du sable ou de la vase ; une couverture abordée nulle ou très partielle ; une végétation aquatique moyennement abondante comparée ainsi que des débris végétaux relativement abondantes, (tableau 3), une température modérée (Figure 4) et un degré d'ombrage nul (Figure 9). Si nous comparons certaines caractéristiques des sites de *Pila ovata* dans la Région de Katana à celles d'autres espèces des mollusques aquatiques [33], [18], [23], [28], [31], [38], [39], nous constatons qu'il ya en fait une bonne concordance pour les facteurs environnementaux.

5 CONCLUSION

A l'issu de notre travail qui a consisté à l'étude de l'écologie du mollusque *Pila ovata* dans les écosystèmes aquatiques de la Région de Katana de Janvier à Décembre 2013 ; nous avons constaté des importantes discordances qui ont apparu sur l'écologie de ce dernier dans les écosystèmes aquatiques de cette région. Après discussion de nos résultats, il ressort que les conditions favorables qui prévalent à la prolifération et à la survie du mollusque *Pila ovata* sont respectivement un éclairement minimal (couverture végétale minimale), une végétation aquatique abondante (morte), un courant minimal, un fond sablonneux ou vaseux d'une part et une température modérée (≥16°C) d'autre part, Ces conditions sont particulièrement bien remplies dans la majorité des écosystèmes aquatiques prospectés dans la Région de Katana. Une différence hautement significative a été observée d'autant plus que les effectifs des mollusques se diffèrent entre les sites. Un degré d'ombrage élevé peut entraver la prolifération de *Pila ovata* comme nous l'avons constaté dans les effectifs de Kanyamalogo ainsi que ceux de la Rivière Lwiro ; contrairement aux différentes altitudes des sites d'études qui n'ont aucun impact négatif sur les conditions écologiques du mollusque *Pila ovata*. Les étangs piscicoles de BIKA et Maziba remplissent toutes les conditions favorables à l'écologie des mollusques *Pila ovata,* ce qui justifie des effectifs les plus élevés dans les récoltes par rapport à d'autres sites prospectés.

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REFERENCES

[1] A Giovanelli, C. L. P. A. Silva., Leal, G. B. E., D. F Baptista. Habitat Preference of freshwater Snails in relation to environnemental factors and presence of the competition Snail *Melonoides tuberculata* (Muller, 1974) *Mem. Inst.* Oswaldo. Cruz; 100, 2-28, 2005.

[2] A Giovanelli, M.V Vieira, D.A Coelho and C.L.P.A Silva, "Interaction between the intermediate host of Schistosomiasis in Brazil *Biomphalaria glabrata* (Planorbidae) and possible competitor *Melanoides tuberculata* (Thiaridae): Laboratory Experiments", *Memorias do Instituto Oswaldo Cruz*, 97: 363-369, 2002.

[3] Ndiaga T & Diallo A, " Intégration de la Biodiversité d'eau douce dans le processus de développement en Afrique. Module de formation des formateurs sur les mollusques d'eau douce africain ; Gambie, 44p, 2010.

[4] Mouthon and Daufresne. Long- term changes in mollusk communities of the Ognon River (France) over a 30-year period», *Fundamental and Applied Limnology*, 178(1):67-79, 2010.

[5] OMS, Schistosomiase (Bilharziose). Organisation mondiale de la santé, Genève, *Aide-mémoire*, n°115, 4p, 2012.

[6] Dabouineau, L. & Ponsero, A. Synthèse sur la biologie des coques *Cerastoderma edule*. Réserve Naturelle Baie de St-Brieuc, 16 pages, 2004.

[7] J.P Pointier & J Jourdane, "Biological control of the snail hosts of Schistosomiasis in areas of low transmission: the example of the Caribbean area", *Acta Tropica*, 77: 53–60, 2000.

[8] Brown S.D., Freshwater Snails of Africa and their medical importance. *Taylor Francis*, 609p, 1994.

[9] Ponsero A., Vidal J., Allain J. Evaluation spatiale de la densité du gisement de coques de la baie de Saint-Brieuc, année 2003, Réserve Naturelle Baie de St-Brieuc, 20 pages, 2003.

[10] G Douget. Mollusques, " Gastéropodes aquatiques et bivalves. Invertébrés continentaux des P. de la Loir", *Gretia*, 371-378, 2009.

[11] P.R Hira, " *Schistosoma mansoni* in Lusaka Zambia",*Trop.geogr. Med*. 26 : 68-72, 1974.

[12] Kloos, C de Souza., A Gazzinelli, B. S. S Filho , P de Costa Temba., J Bethony, K Page , C Grzywacz, F Lewis, D Minchella, P Loverde & R. C Oliveira. "The distribution of *Biomphalaria* sp. In different habitats in relation to physical, biological, water contact and cognitive factors in a rural area in Minas Gerais, Brazil", *Mem. Inst*. Oswaldo Cruz, Rio de Janeiro, 96:57-66, 2001.

[13] A Lemma, M Demisse, B Mesengia, "Parasitological survery of Addis Abeba and Debre zeit schoolchildren with speciel emphasis on bilharziasis", *Ethiopian Med. J*. 6: 61-71, 1968.

[14] M.A Cantrel., "Bilharzias snails and water Level fluctuation in a tropical swamp", *Oikos* 36 (2): 226-232, 1981.

[15] C.C Appleton, "The population fluctuation of the freshwater snail species in eastern Transvaal lowveld and their relationship to known bilharzias transmission patterns", *S.Afr.J.Sci.zo*: 145-150, 1975.

[16] R.F Sturrock, "The influence of temperature on the biology of *Biomphalaria pfeifferi* (Krauss), an intermediate host of *Schistosoma mansoni*", *Ann. Trop.Med. Parasit*. 60:100-105, 1966.

[17] R Cañete, M Yong, J.Sánchez, L Wong. & A Gutiérrez, "Population dynamics of intermediate snail hosts of *Fasciola hepatica* and some environmental factors in San Juan Martinez Municipality, Cuba",*Mem. Inst.Oswaldo Cruz*, Rio de Janeiro, 99 (3): 257-262, 2004.

[18] G. R Karimi, M Derakhshanfar & H Paykari, "Population density, trematodal infection and ecology of *Lymnaea* snails in Shadegan, Iran", *Arch.Razi* Inc., 58: 125-129, 2004.

[19] Supian, Z. & Ikhwanuddin, A. M,Population dynamics of freshwater Mollusks (Gastropod: *Melanoides tuberculata*) in Crocker Range Park, Sabah. SEAN Review of Biodiversity and Environmental Conservation (ARBEC), 2002.

[20] A Mohamed, Hussein, H Ahmad, Obuid-Allah, A Amal. Mahmoud and M Heba. Fangary. "Population dynamics of freshwater snails (Mollusca: Gastropoda) at Qena Governorate, Upper Egypt", *Acad. J. Biolog. Sci*., 3(1): 11 -22, 2011.

[21] C. évêque, " Dynamique des peuplements, biologie, et estimation de la production des mollusques benthiques du lac Tchad", *Cah. O.R.S.T.O.M., Sér. Hydrobiol.,*VII, 2 : 117-147, 1973.

[22] J.A Van EEDEN and C Combrinck, "Distributional trends of four species of freshwater snails in South Africa with special reference to the intermediate host of bilharzias", *Zoological Afri*. 2: 95-109, 1966.

[23] B. C Dazo, N. G. Hairston & I. K Dawood, "The ecology of *Bulinus truncatus* and *Biomphalaria alexandrina* and its implications for the control of Bilharziasis in the Egypt- 49 Project Area", *Bull. Org. mond. Santé Bull. WldHlth Org*., 35: 339-356, 1966.

[24] A Fenwick and M.A Amin, "Marking snails with nail varnish as field experimental technique", *Ann. Trop. Med. Parasit*.77 (4): 387-390, 1982.

[25] Lévêque, C, Mollusques benthiques du Lac Tchad: écologie, production et bilans énergétiques. Thèse doc.Paris 6, CNRS, 0238p, 1972.

[26] Brown S.D., Freshwater Snails of Africa and their medical importance. *Taylor Francis*, 609p, 1980.

[27] Ramzy, R. R, Biological and ecological studies on land snails at Assiut,Egypt. M. Sc. Thesis, Zool. Dep., Sci. Fac., Assiut Univ., 190 p, 2009.

[28] J. P Pointier, A Théron & G Borel, "Ecology of the introduced snail *Melanoides tuberculata* (Gastropoda: Thiaridae) in relation to *Biomphalaria glabrata* in the marshy forest zone of Guadeloupe, French West Indies", *J.Moll. Stud*., 59: 421-428, 1993.

[29] F Kazibwe, B Makanga, C Rubaire-Akiiki, J Ouma, C Kariuki, N.B Kabatereine, M Booth, B. J Vennervald, R. F Sturrock, & J. R. Stothard, " Ecology of *Biomphalaria* (Gastropoda: Planorbidae) in Lake Albert, Western Uganda: snail distribution, infection with schistosomes and temporal associations with environmental dynamics", *Hydrobiologia,* 568: 433-444, 2006.

[30] E. U Imafidon, "Ecological studies of freshwater snails in Ibadan, Nigeria. *Nigerian Journal of Parasitology*", 12: 59-63, 1991.

[31] B Baluku, G Josens, M Loreau, "Etude préliminaire de la densité et de la répartition des mollusques dans deux cours d'eau du Zaïre oriental" *Rev. Zool. Afr.*, 103, 291- 302, 1989.

[32] M Bagalwa, B Baluku, N Mushayuma, "Distribution des mollusques dans le Lac Kivu et leur importance médicale", *Cahier de CERUKI*, Numéro Spécial, .CRSN-LWIRO, .pp 14-21, 2009.

[33] Baluku B, Contribution à l'étude des hôtes intermédiaires des bilharzioses. Ecologie des mollusques *Biomphalaria pfeifferi* dans deux cours d'eau du Zaïre Oriental. Thèse de Doctorat, *ULB*, 487p, 1987.

[34] Bagalwa et Baluku, "Distribution des mollusques hôtes intermédiaires des Schistosomoses humains à Katana, Sud-Kivu", *Méd. Trop*, 57, 369-372, 1997.

[35] L Olivier, M Scheiderman, "Method for estimation of the density of aquatic snail population", *Exp. Parasitol.*, 5, 109-117, 1956.

[36] C Lévêque, " Biologie de *Bulinus forskali* (Mollusque, Gastropode) de la région de Fort-Lamy (Tchad) ", *Cah. O.R.S.T.O.M., sir. Hydrobiol.,* II, 2 : 79-90, 1968.

[37] C Lévêque, J. P Pointier, J. L Toffart, "Influence de quelques facteurs du milieu sur la fécondité de *Biomphalaria glabrata* (Say, 1818) (Mollusca, Pulmonata) dans les conditions du laboratoire", *Annales de Parasitologie*, 53, 4, 393-402, 1978.

[38] N.O Crossland, "A large-scale Experiment in the control of aquatic snails by the use of molluscicides on sugar estate in the northern region of Tanganyika", *Bull.org.Mond.Santé*, 29:515-524, 1963.

[39] Bouyer T., Contribution à l'écologie des mollusques dulcicoles de Lwiro, R.D Congo, avec une référence spéciale à *Biomphalaria pfeifferi* ; Faculté des Sciences, Laboratoire de Zoologie systématique et d'Ecologie, *ULB,* 130p, 1990.

[40] M Strzelec & A Królczyk, " Factors affecting snail (Gastropoda) community Structure in the upper course of the Warta River (Poland) ", *Biologia, Bratislava,* 59(2): 159-163, 2004.

[41] Legendre, L. P., Planas, D. et Auclair, M. J., "Succession des communautés de Gastéropodes dans deux milieux différents par leur degré d'eutrophisation", *J. of Canada. Zool*., 62 (11): 2317, 1984.

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Population dynamics of land snails (Mollusca: Gastropoda) in Katana region, west coastline of Lake Kivu, Eastern of Democratic Republic of Congo

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ABSTRACT: Monthly and seasonal fluctuations in densities of land snails were recorded in four different sites (forest, fallow, cultivated area and wetland) in Katana region during the period of January to December 2013. The aim of this survey is to study the population dynamics of the land snails of the Katana region considering some geo-physical factors (rainfall, relative humidity and temperature) in different habitats. The study revealed the occurrence of 31 species of land snails belonging to 9 families of class Gasteropoda. The land snail species and their total catch were: *Limicolaria laeta medjensis* (225 specimens), *Limicolaria distincta* (195 specimens), *Ataxon faradjense* (159 specimens), *Achatina achatina* (147 specimens), *Lehmannia valentiana* (118 specimens), *Achatina tincta* (108 specimens), *Curvella bathytoma* (98 specimens), *Trichotoxon pardus* (78 specimens), *Trichotoxon ruwenzoriense* (75 specimens), *Burtoa nilotica emini* (72 specimens), *Nothapalus paucispira xanthophaes* (69 specimens), *Trichotoxon maculatum perforatum* (68 specimens) ,*Pachnodus rutshuruensis* (66 specimens), *Gymnarion aloysii-sabaudiae* (65 specimens), *Mesafricarion putzeysi* (64 specimens), *Cerastus bequaerti* (60 specimens), *Gullela pupa ituriensis* (58 specimens), *Helixarion insularis* (58 specimens), *Bukobia cockerelli* (56 specimens), *Mesafricarion maculifer pilsbry* (56 specimens), *Perideriopsis fallsensis* (56 specimens), *Achatina fulica* (54 specimens), *Burtoa nilotica obliqua* (52 specimens), *Pleuroprocta silvatica* (52 specimens), *Pseudoglessula walikalensis* (35 specimens), *Achatina osborni*(31 specimens), *Loevicaulis schnitzleri* (17 specimens), *Subulinuscus ruwenzorensis* (6 specimens), *Homorus amputatus* (4 specimens) , *Theba pisana* (4 specimens) and *Arion rufus* (3 specimens) in a descending order. The densities of the recorded land snails varied seasonally and the general seasonal peak was recorded during rainy while the lowest density observed during dry. Ecological factors which may influence the distribution or variation of the recorded land snails were also determined (temperature, relative humidity and rainfall). We remarked that the rainfall and the relative humidity were the two main ecological factors which influence the distribution or variation of the land snails in Katana region.

KEYWORDS: Population dynamics, snails, Katana region, Democratic Republic of Congo.

1 INTRODUCTION

Land snails have been known to play significant ecological roles as prey and nutrient cyclers [1] [2], including as a calcium source for bird eggshells [1]. It is also serving as food items for salamanders, small mammals, birds, humans and some arthropods as well as processing decaying plant material [3], [4] and serves as useful biological indicators of soil quality and chemistry [5] , [6]. Land snails constitute about six per cent of the total species on Earth [7]. Several factors are considered as affecting the ecology of land snails, hence their focal and seasonal distributions. These include geo-physical factors such as rainfall, temperature, light and hygrometry of the atmosphere, chemical factors such as ion concentration in the soil as well as biological factors such as availability of food, competition and predator-prey interactions [8], [9], [10], [11], [12]. Besides, the land macrophytes have been shown to play vital roles in the distribution of land snails in different parts of Africa [11], [13]. However, the importance of different ecological factors vary significantly from one ecological zone to the other and

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even from one soil body to the other, suggesting local investigations to identify important factors in each zone or soil bodies [14], [15], [16], [17], [18].

Many studies concerned with the ecology and population dynamics of the group of gastropods which play an important role as good indicators of areas of conservation importance and endemicity when compared to widely distributed groups such as vertebrates have been conducted by [19], [20], [21], [22], [23], [24], [2], [25], [11].

These studies have led to general opinion; that the development of an effective strategy of integrated control requires the study of population dynamics and its relation to environmental factors. Population dynamics of these animals depend on the geo-physical of a given region, also land contours; soil composition; hydrography and climate all have effect on snail population dynamics [1], [2], [19], [26], [27], [28], [11], [12].

In Democratic Republic of Congo in general and in Katana region in particular, studies related to the population dynamics of land snail doesn't exist except the studies of [29], [30], [31], [32], [33], [34] which presented some species collected in others region of Democratic Republic of Congo long time ago contrary to others region in the world where a large number of studies highlighting the need for mollusc conservation globally [14], [35], [36], [15], [37], [16], [38], [17], [18] and the study of [39] which presented a preliminary survey and distribution of land snails of katana region. It is hypothesized that population dynamics of land snails depends largely on geo-physical factors such as rainfall, relative humidity and temperature in the Katana region in the different existing habitats. The aim of this survey is to study the population dynamics of the land snails of the Katana region considering some geo-physical factors (rainfall, relative humidity and temperature) in different habitats.

2 MATERIALS AND METHODS

2.1 SITES OF INVESTIGATION

Katana region is located on the western flank of Lake Kivu, between latitudes 2°15' and 2°30'S and longitudes 28°45' and 28°85' E. It is bordered on the east by Lake Kivu and on the west by the Kahuzi-Biega mountain forest (Figure 1).

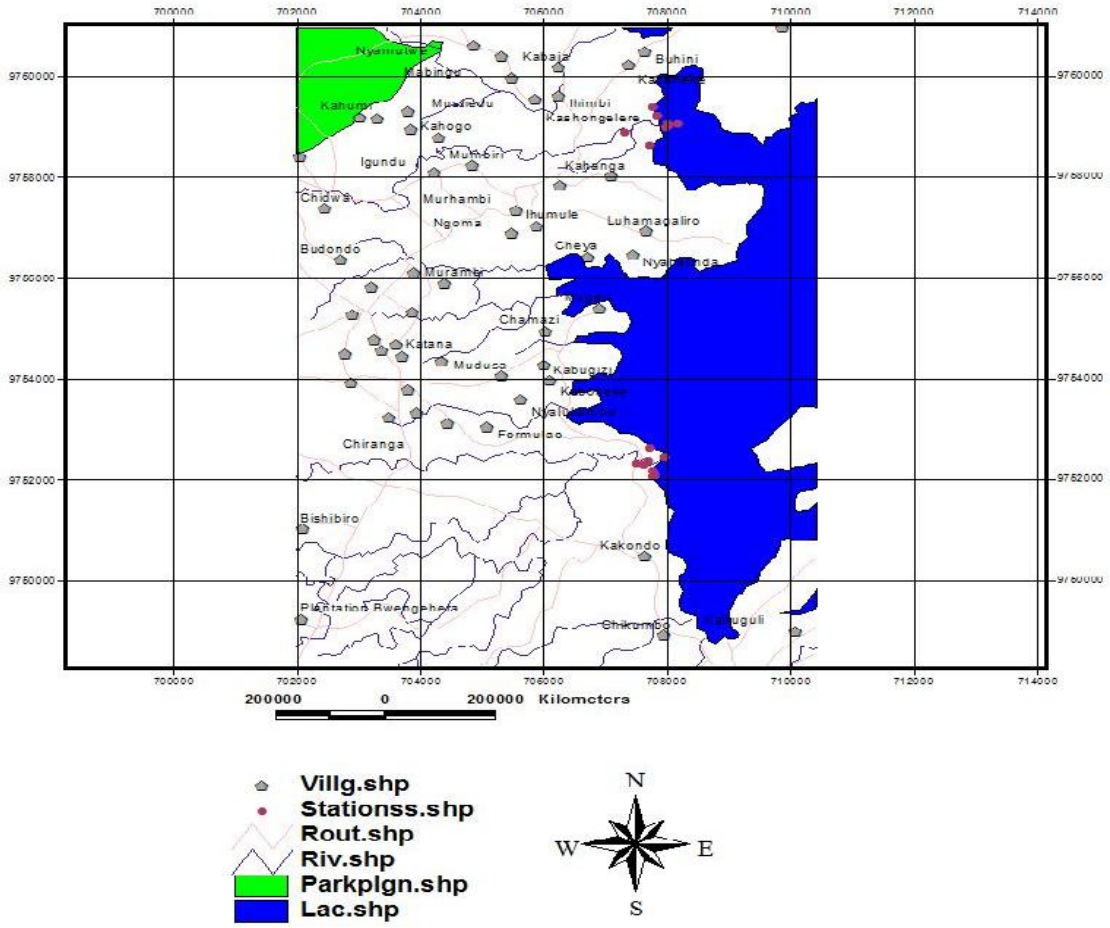


Figure 1. Katana region's Map

It is covered by four localities namely Irhambi/Katana, Bugorhe, Luhihi and Bushumba in the territory of Kabare, province of South-Kivu, Democratic Republic of Congo. Rainfall is about 1500 mm annually [40]. The soil comprises clay and rich volcanic soil, which is easily eroded. The geological composition is of Precambrian metamorphoses sediments (metamorphic rocks) and Preterozoic platform sediments [41]. [42] describes metamorphic limestone and numerous travertines along Lake Kivu and Lake Edward. Carbonates for the production of cement are also found at the north and north-west of Lake Kivu. The sampling sites include forest, fallow, cultivated area and wetland.

2.2 SAMPLING OF LAND SNAILS

Monthly samples of land snails were collected from the four sites during a period of one year (from January, 2013 till December, 2013). Systematic field collections were conducted in various ecological units were potentially interesting for mollusc habitats ranging from forest, wetland, and fallow to cultivated area. Collection techniques varied widely depending upon the habitat but included visual searches and leaf litter sieving [43]. A total of 24 sampling points were made in the four sites. For each point, two transects and five quadrats by transect and hunting sight have been made. This method is to collect the litter on a surface of 2m ² using a small shovel gardening. The quadrat method used stratified random sampling, which differs in that it will sample chosen microhabitat areas most likely to support snails, because at no site are gastropods completely homogeneous in distribution. The litter collected is then screened so most gastropods in this litter are collected [44], [45], [46], [47]. Hunting sight is a complementary method to quadrat widely used in entomology. It involves directly observe individuals in their habitat, tree trunks, under windfalls, under stones, on the old walls, etc. This method is very interesting and is complementary to quickly draw up an initial list; it is less accurate, especially for smaller species which are often ignored. The duration of the hunting sight was set at 10 minutes per habitat sampling. For identification, the shells of individuals are first sorted by morphological resemblance and studied most often using a binocular microscope. The

identification was carried out mainly by using the key of identification [29], [48], [47], [50]. Land snail species were sorted, counted, and entered into an Excel spreadsheet and presence and abundance was summarized for each habitat, month, season and plot. The relative density of each species was calculated by using the following relation [51]:

$$\text{Relative density} = \frac{\text{Total number of species individuals in the site}}{\text{The surface of all quadrats in the site}} \text{X100}$$

2.3 GEO-PHYSICAL FACTORS

Meteorological data were obtained from a global 0.5×0.5° gridded data set of monthly terrestrial surface climate [52], [53] for the 2013 period, those meteorological data concerned the rainfall, relative humidity and temperature which were measured by digital probe apparatuses[52], [53].

2.4 STATISTICAL ANALYSIS

Analysis of one-way ANOVA on past software was used to test the present data. Linear correlation coefficients were calculated between the densities of the recorded species and environmental factors using the past software.

3 RESULTS

3.1 THE RELATIVE DENSITIES OF THE SNAIL SPECIES RECORDED FROM THE STUDIED SITES DURING THE PERIOD OF INVESTIGATION.

Table 1. Relative densities of the land snail species recorded from the studied sites during the period of investigation

		Sites				
No	Species	Forest	Wetland	Cultivated area	Fallow	Total
1	*Perideriopsis fallsensis*	0	7.1	16.25	0	23.35
2	*Limicolaria distincta*	0	32.9	48.3	0	81.2
3	*Nothapalu spaucispira xanthophaes*	0	4.2	18.3	6.25	28.75
4	*Curvella bathytoma*	1.7	19.2	20	0	40.9
5	*Cerastus bequaerti*	0	7.9	17.1	0	25
6	*Burtoa nilotica emini*	4.2	0	19.2	6.7	30.1
7	*Achatina tincta*	3.8	2.9	38.3	0	45
8	*Pachnodus rutshuruensis*	0	5.4	22.1	0	27.5
9	*Mesafricarion putzeysi*	0	12.5	14.2	0	26.7
10	*Helixarion insularis*	0	10.4	13.75	0	24.15
11	*Gymnarion aloysii-sabaudiae*	0	2.9	24.2	0	27.1
12	*Arion rufus*	0	8.3	44.6	13.3	66.2
13	*Trichotoxon pardus*	0	10.8	15.4	6.25	32.45
14	*Trichotoxon maculatum perforatum*	0	4.2	24.2	0	28.4
15	*Pleuroprocta silvatica*	0	5.4	0	16.25	21.65
16	*Loevicaulis schnitzleri*	1.7	0	0	5.4	7.1
17	*Burtoa nilotica obliqua*	6.7	2.9	12.1	0	21.7
18	*Achatina osborni*	4.8	0	0	8.3	13.1
19	*Mesafricarion maculifer pilsbry*	0	5	18.3	0	23.3
20	*Ataxon faradjense*	0	1.25	0	0	1.25
21	*Lehmannia valentiana*	0	8.3	40.8	0	49.1
22	*Bukobia cockerelli*	2.1	0.8	20.4	0	23.3
23	*Theba pisana*	0	1.7	0	0	1.7
24	*Trichotoxon ruwenzoriense*	0	2.1	22.5	6.7	31.3
25	*Achatina achatina*	12.5	5.8	33.3	9.6	61.2
26	*Limicolaria laeta medjensis*	7.1	27.9	58.75	0	93.75
27	*Pseudoglessula walikalensis*	0	8.3	0	6.25	14.55
28	*Achatina fulica*	4.2	2.1	11.25	5	22.55

29	*Subulinuscus ruwenzorensis*	2.5	0	0	0	2.5
30	*Homorus amputatus*	1.7	0	0	0	1.7
31	*Gullela pupa ituriensis*	1.25	6.25	16.7	0	7.5
	Total	54.25	206.5	553.3	90	904.05

A total of 31 land snail species (*Gullela pupa ituriensis, Perideriopsis fallsensis, Achatina achatina, Achatina fulica, Achatina osborni, Achatina tincta, Arion rufus, Ataxon faradjense, Bukobia cockerelli*, *Pleuroprocta silvatica*, *Burtoa nilotica emini*, *Cerastus bequaerti*, *Burtoa nilotica obliqua Curvella bathytoma*, *Gymnarion aloysii-sabaudiae*, *Helixarion insularis*, *Lehmannia valentiana*, *Limicolaria distincta*, *Trichotoxon maculatum perforatum*, *Limicolaria laeta medjensis*, *Loevicaulis schnitzleri*, *Mesafricarion maculifer pilsbry*, *Trichotoxon pardus*, *Mesafricarion putzeysi*, *Nothapalus paucispira xanthophaes*, *Pachnodus rutshuruensis*, *Pseudoglessula walikalensis*, *Subulinuscus ruwenzorensis*, *Theba pisana*, *Trichotoxon ruwenzoriense*, *Homorus amputatus*) belonging to 9 families under class Gastropoda were collected from the sites of investigation during the study period.

As shown in table (1), the total relative density of the collected land snails was 904.05 specimens, from which 54.25, 206.5, 553.3 and 90 individuals were recorded at the different sites: forest, wetland, cultivated area and fallow respectively. By regarding these results, one can conclude that cultivated area site and wetland site were rich in land snails. It was observed that these two sites are characterized by a lot of plants on which land snails feed, a penetrate substrate with organic matter in which land snails can be hided during dry season, can penetrate for laying and clay-sandy substratum with decaying matter and a lot of vegetation and in Katana region, wetland is cultivated by human being.

3.2 THE VALUES RANGE OF GEO-PHYSICAL PARAMETERS RECORDED IN THE INVESTIGATED SITES

The values range of geo-physical parameters recorded in the investigated region are shown in the figure (2), and it was observed that the differences between monthly rainfall and relative humidity were highly significant except for temperature. The rainfall reached his summit in December and the relative humidity reached his summit in the same month; but it rained highly in December and March and the relative humidity was almost the same during the year, except in June, July and August during which it was low. Temperature was almost the same along the year and varied between 20.2 and 18.9.

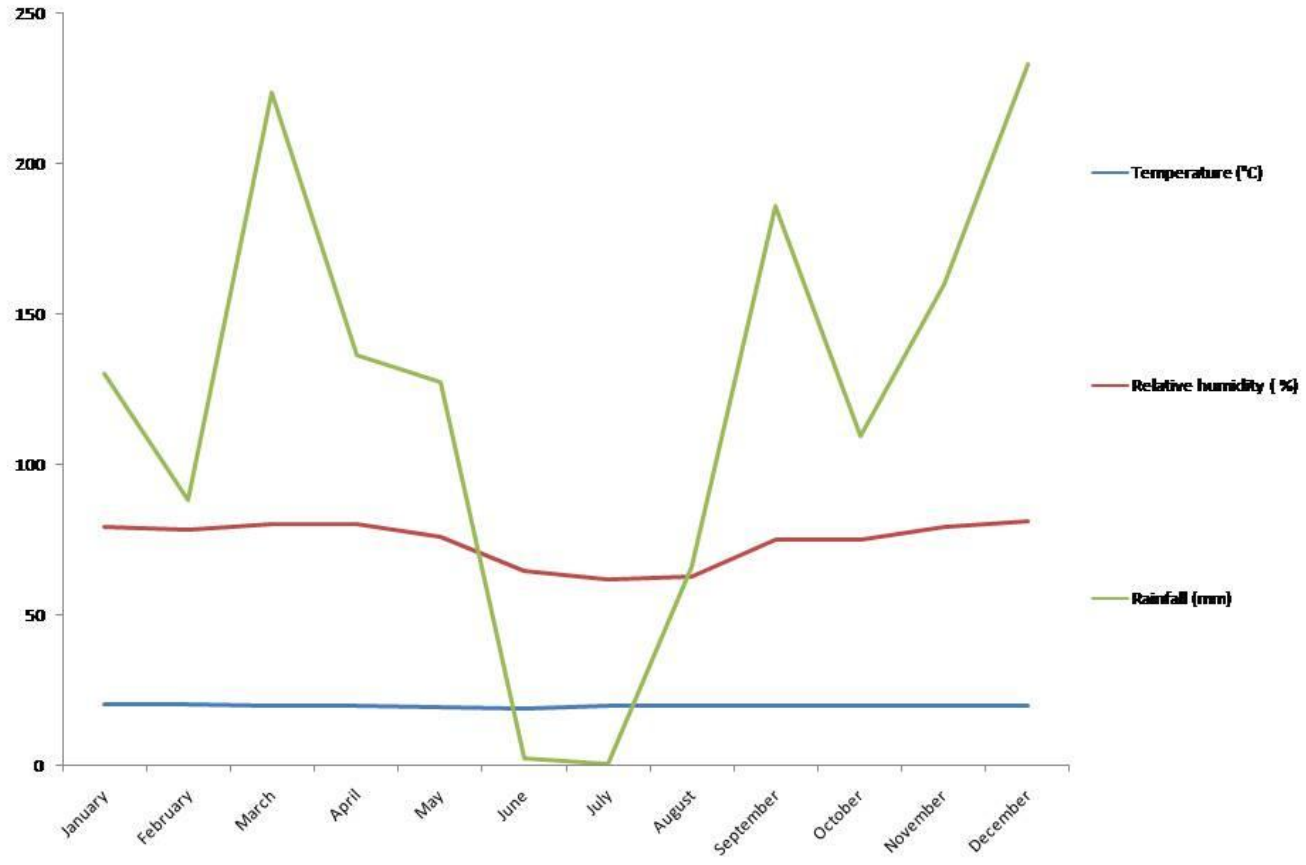


Figure 2.The values range of geo-physical parameters recorded in the investigated sites

3.3 MONTHLY, SEASONAL AND ANNUAL VARIATIONS OF THE RECORDED LAND SNAIL SPECIES

3.3.1 MONTHLY VARIATIONS OF THE RECORDED LAND SNAIL SPECIES

3.3.1.1 PER SITE IN TOTAL ANNUAL

Table 2. Land snails collected during the period of investigation per site.

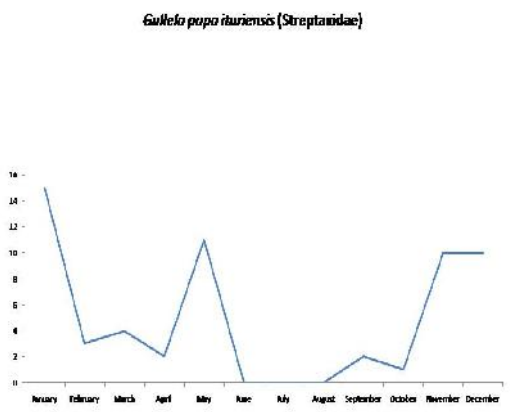
Sites	Forest	Wetland	Cultivated area	Fallow	Total
Gullela pupa ituriensis	3	15	40	0	58
Perideriopsis fallsensis	0	17	39	0	56
Limicolaria distincta	0	79	116	0	195
Nothapalus paucispira xanthophaes	0	10	44	15	69
Curvella bathytoma	4	46	48	0	98
Cerastus bequaerti	0	19	41	0	60
Burtoa nilotica emini	10	0	46	16	72
Achatina tincta	9	7	92	0	108
Pachnodus rutshuruensis	0	13	53	0	66
Mesafricarion putzeysi	0	30	34	0	64
Helixarion insularis	0	25	33	0	58
Gymnarion aloysii-sabaudiae	0	7	58	0	65
Ataxon faradjense	0	20	107	32	159
Trichotoxon pardus	0	26	37	15	78
Trichotoxon maculatum perforatum	0	10	58	0	68
Pleuroprocta silvatica	0	13	0	39	52
Loevicaulis schnitzleri	4	0	0	13	17
Burtoa nilotica obliqua	16	7	29	0	52
Achatina osborni	11	0	0	20	31
Mesafricarion maculifer pilsbry	0	12	44	0	56
Arion rufus	0	3	0	0	3
Lehmannia valentiana	0	20	98	0	118
Bukobia cockerelli	5	2	49	0	56
Theba pisana	0	4	0	0	4
Trichotoxon ruwenzoriense	0	5	54	16	75
Achatina achatina	30	14	80	23	147
Limicolaria laeta medjensis	17	67	141	0	225
Pseudoglessula walikalensis	0	20	0	15	35
Achatina fulica	10	5	27	12	54
Subulinuscus ruwenzorensis	6	0	0	0	6
Homorus amputatus	4	0	0	0	4
Total	129	496	1368	216	2209

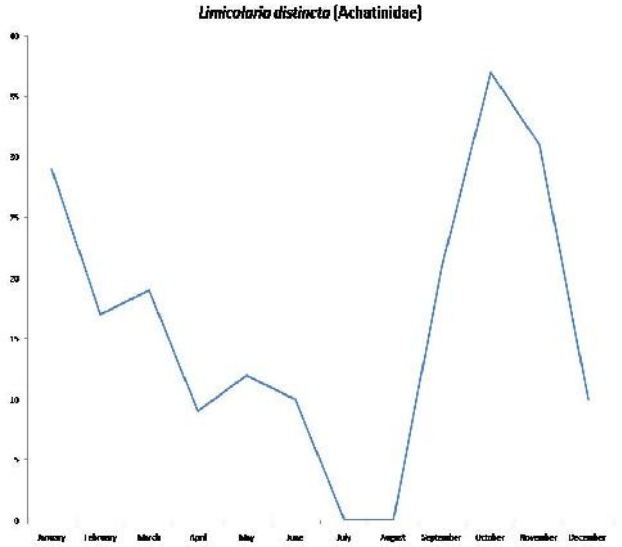
According to the numbers of collected snails in the different sites, the species were arranged in a descending order as: *Limicolaria laeta medjensis* (225 specimens), *Limicolaria distincta* (195 specimens), *Ataxon faradjense* (159 specimens), *Achatina achatina* (147 specimens), *Lehmannia valentiana* (118 specimens), *Achatina tincta* (108 specimens), *Curvella bathytoma* (98 specimens), *Trichotoxon pardus* (78 specimens), *Trichotoxon ruwenzoriense* (75 specimens), *Burtoa nilotica emini* (72 specimens), *Nothapalus paucispira xanthophaes* (69 specimens), *Trichotoxon maculatum perforatum* (68 specimens), *Pachnodus rutshuruensis* (66 specimens), *Gymnarion aloysii-sabaudiae* (65 specimens), *Mesafricarion putzeysi* (64 specimens), *Cerastus bequaerti* (60 specimens), *Gullela pupa ituriensis* (58 specimens), *Helixarion insularis* (58 specimens), *Bukobia cockerelli* (56 specimens), *Mesafricarion maculifer pilsbry* (56 specimens), *Perideriopsis fallsensis* (56 specimens), *Achatina fulica* (54 specimens), *Burtoa nilotica obliqua* (52 specimens), *Pleuroprocta silvatica* (52 specimens), *Pseudoglessula walikalensis* (35 specimens), *Achatina osborni* (31 specimens), *Loevicaulis schnitzleri* (17 specimens), *Subulinuscus ruwenzorensis* (6 specimens), *Homorus amputatus* (4 specimens) , *Theba pisana* (4 specimens) and *Arion rufus*

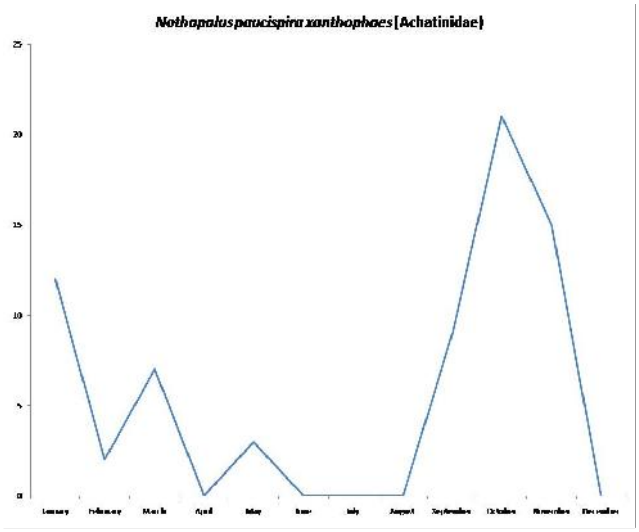
(3 specimens) that formed a total of 2209 specimens land snails among which 129 specimens of land snails have been recorded in the forest, 129 specimens of land snails have been recorded in the wetland, 1368 specimens of land snails have been recorded in the cultivated areas and 216 specimens of land snails have been recorded in the fallow as shown in table 3 bellow.

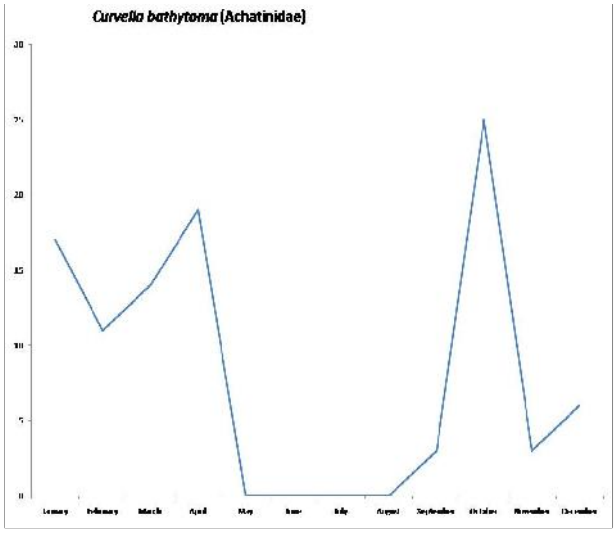
3.3.1.2 PER INDIVIDUAL MONTHLY

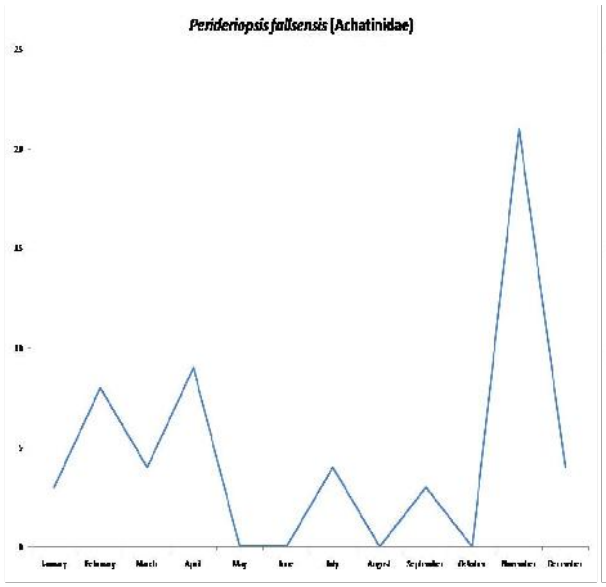
Gullela pupa ituriensis showed the highest peak in January, *Limicolaria distincta*s howed the highest peak in October, *Nothapalus paucispira xanthophaes* showed the highest peak in October, *Curvella bathytoma* showed the highest peak in october, *Perideriopsis fallsensis* showed the highest peak in November, *Cerastus bequaerti* showed the highest peak in October, *Burtoa nilotica emini* showed the highest peak in October, *Achatina tincta* showed the highest peak in January, *Pachnodus rutshuruensis* showed the highest peak in March, *Mesafricarion putzeysi* showed the highest peak in October, *Helixarion insularis* showed the highest peak in October, *Gymnarion aloysii-sabaudiae* showed the highest peak in November, *Ataxon faradjense* showed the highest peak in October, *Trichotoxon pardus* showed the highest peak in November, *Trichotoxon maculatum perforatum* showed the highest peak in March, *Pleuroprocta silvatica* showed the highest peak in October ,*Loevicaulis schnitzleri* showed the highest peak in November, *Burtoa nilotica obliqua* showed the highest peak in October, *Achatina osborni* showed the highest peak in October, *Mesafricarion maculifer pilsbry* showed the highest peak in October, *Arion rufus* showed the highest peak in January, *Lehmannia valentiana* showed the highest peak in October, *Bukobia cockerelli* showed the highest peak in October, *Trichotoxon ruwenzoriense* showed the highest peak in October, *Theba pisana* showed two peaks in October and November, *Achatina achatina* showed the highest peak in March, *Limicolaria laeta medjensis* showed the highest peak in March, *Pseudoglessula walikalensis* showed the highest peak in November, *Achatina fulica* showed the highest peak in October, *Subulinuscus ruwenzorensis* showed the highest peak in March and *Homorus amputatus* showed the highest peak in April, figures 3 beneath.

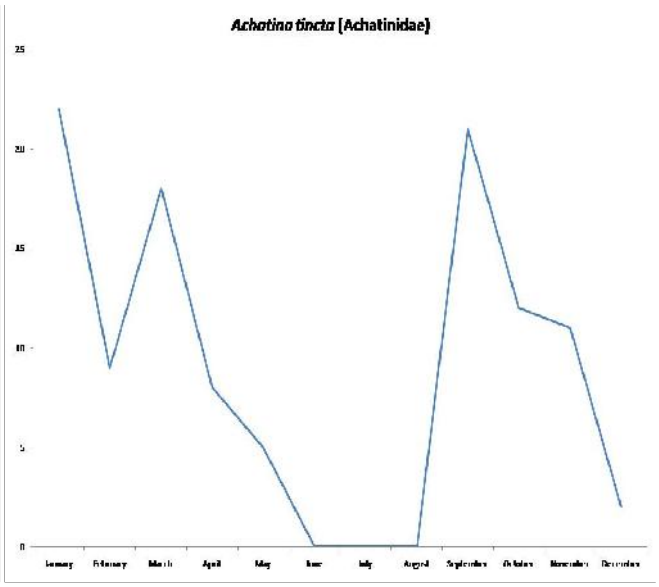


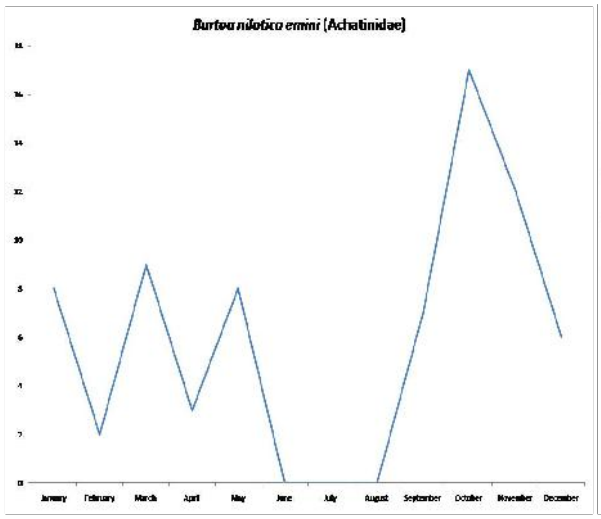


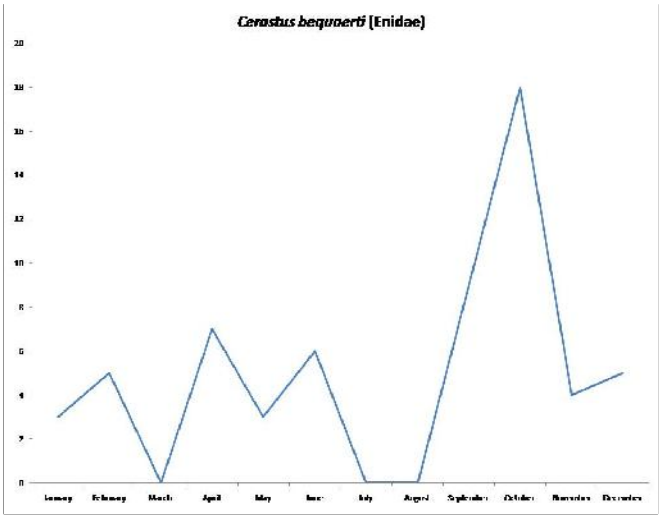

Nothapalus paucispina xanthophaes (Achatinidae)

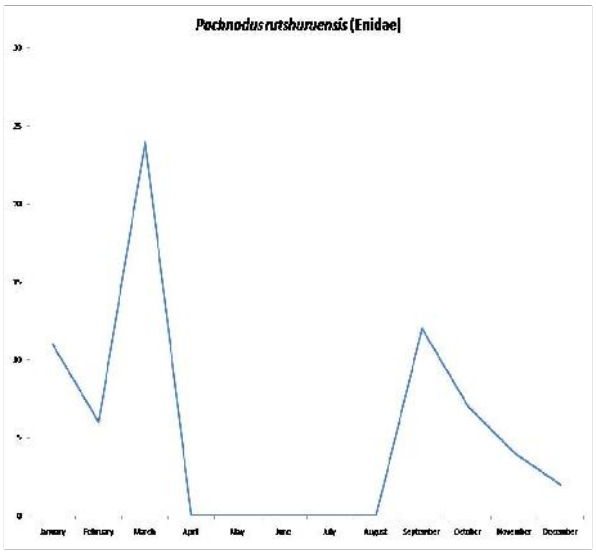

Curvella bathytoma (Achatinidae)


Perideriopsis fallsensis (Achatinidae)


Achatina tincta (Achatinidae)


Burtoa nilotica ermi (Achatinidae)


Cerastus bequaerti (Enidae)


Pachnodus rutshuruensis (Enidae)
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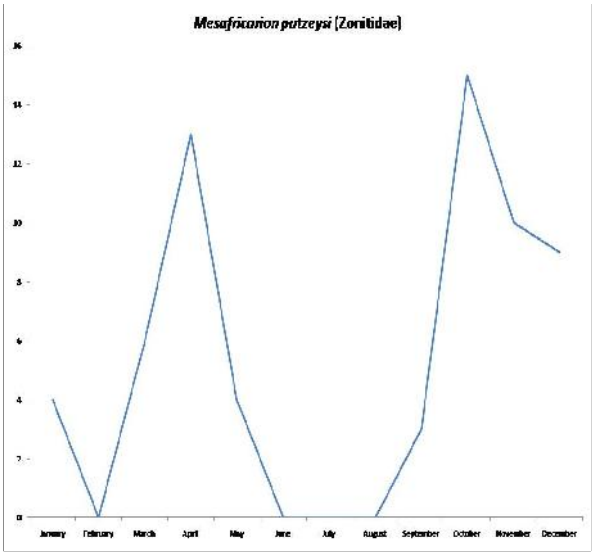
Mesafricarion putzeysi (Zonitidae)
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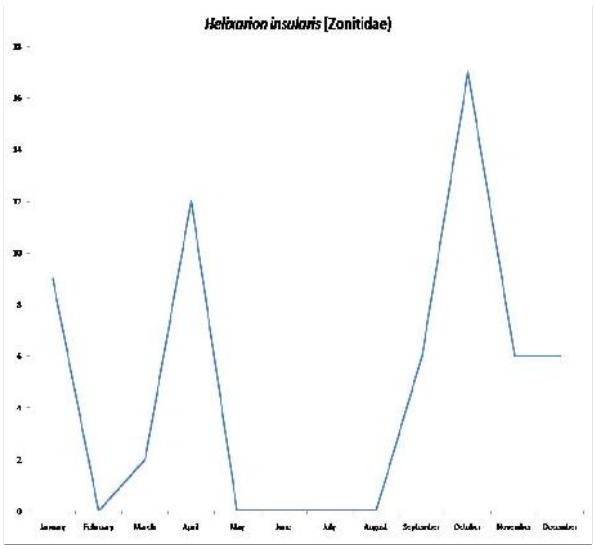
Helixarion insularis (Zonitidae)
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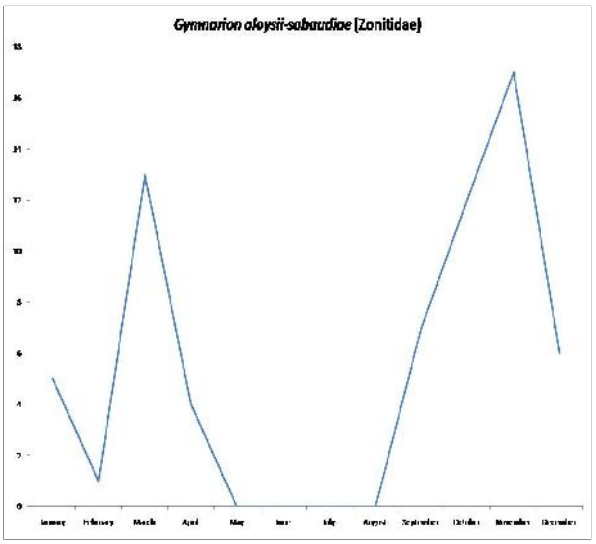
Gymnarion aloysii-sabaudiae (Zonitidae)
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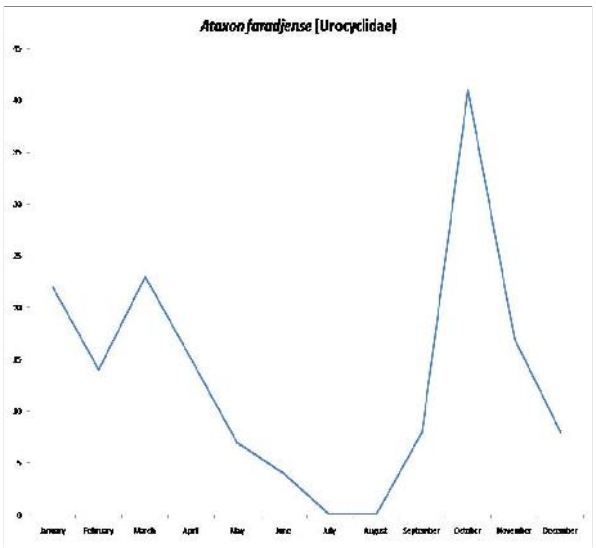
Ataxon farandjense (Urocyclidae)
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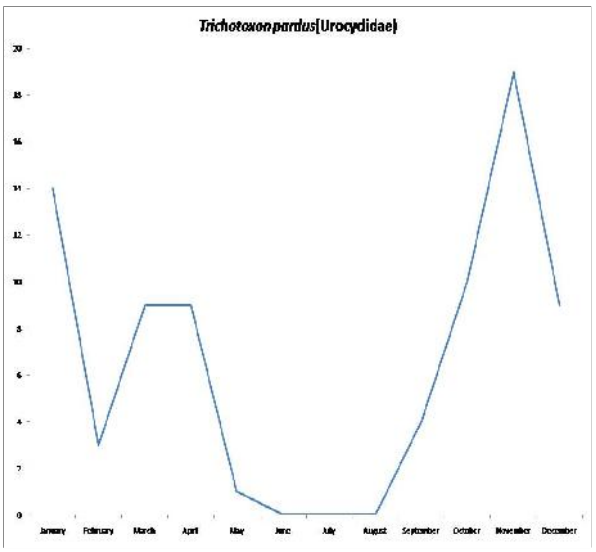
Trichotoxon pardus (Urocyclidae)
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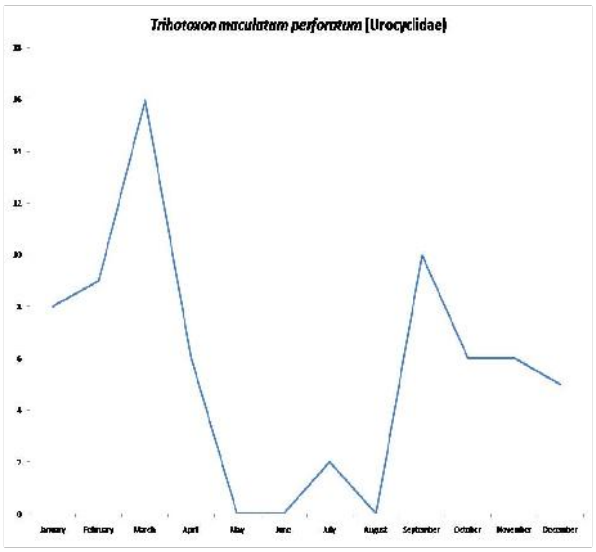
Trihotoxon maculatum perforatum (Urocyclidae)
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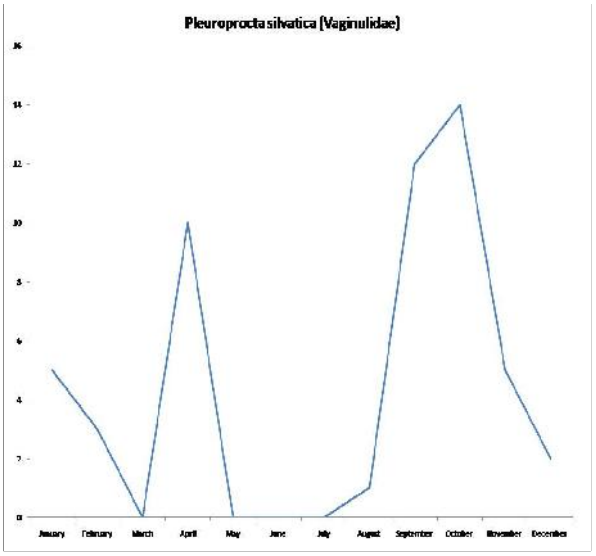
Pleuroprocta silvatica (Vaginulidae)
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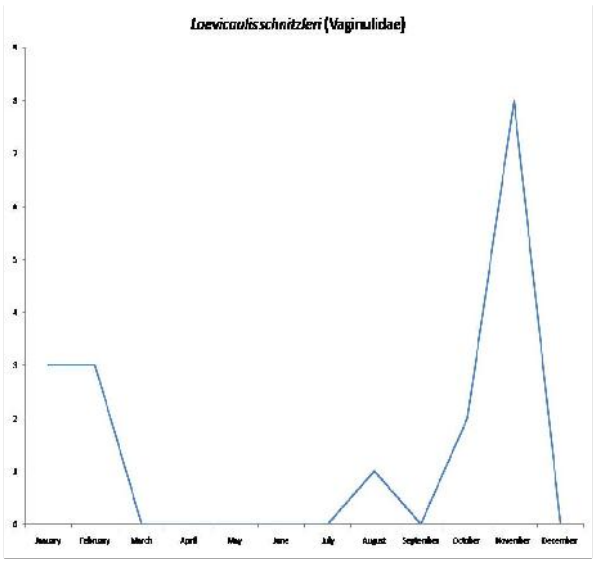
Loevicaulis schnitzleri (Vaginulidae)
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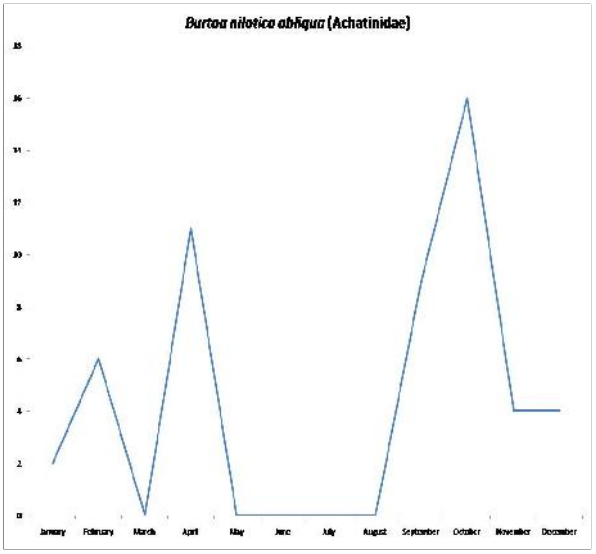
Burtoa nilotica obliqua (Achatinidae)
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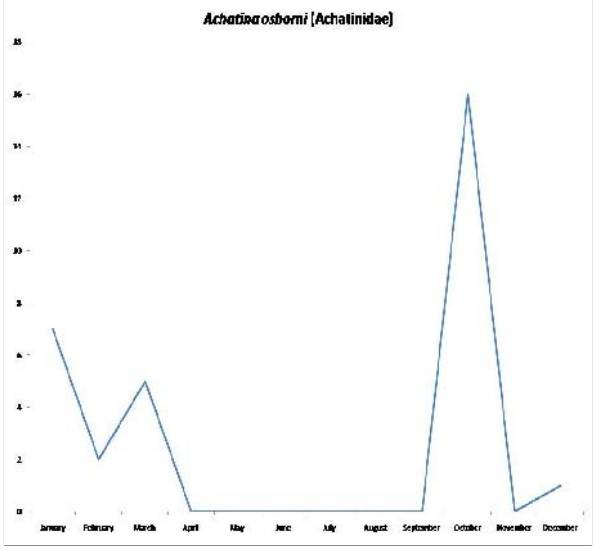
Achatina osborni (Achatinidae)
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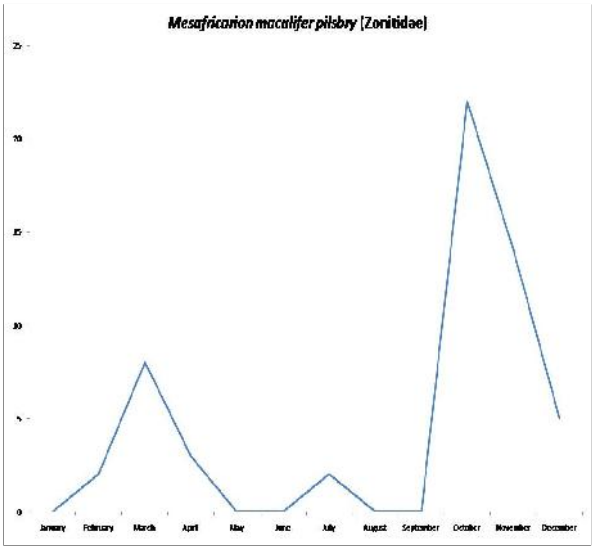
Mesafricarion macalifer pilsbry (Zonitidae)
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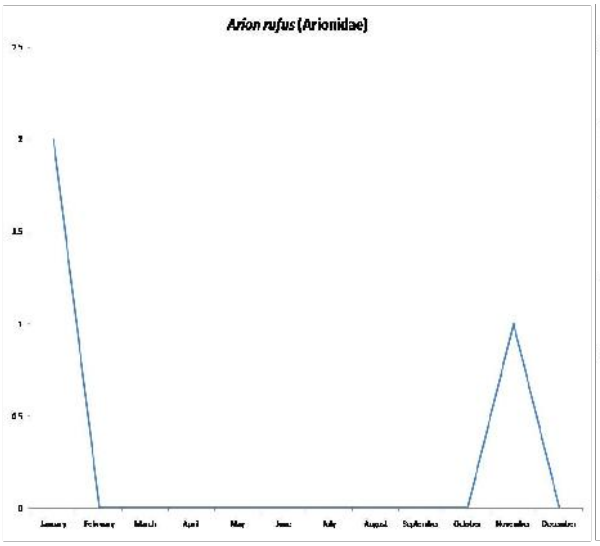
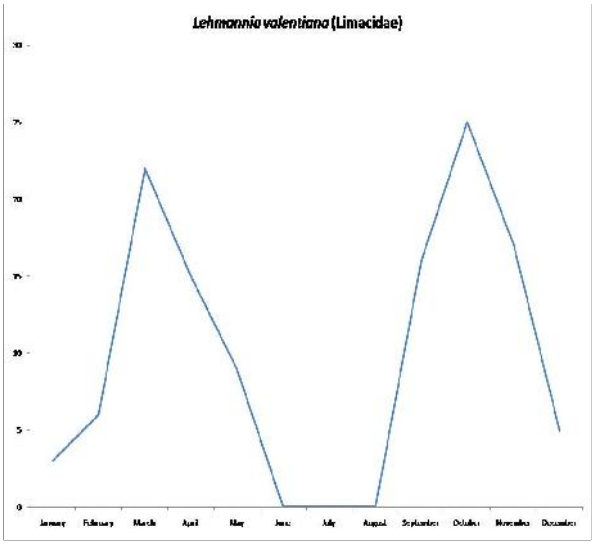
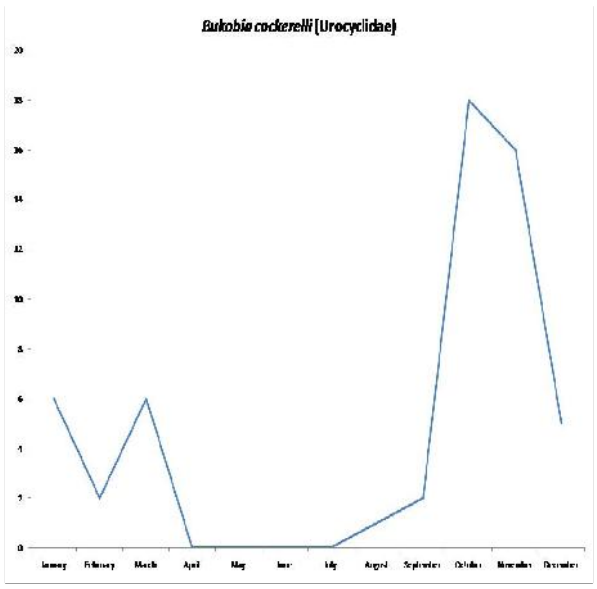
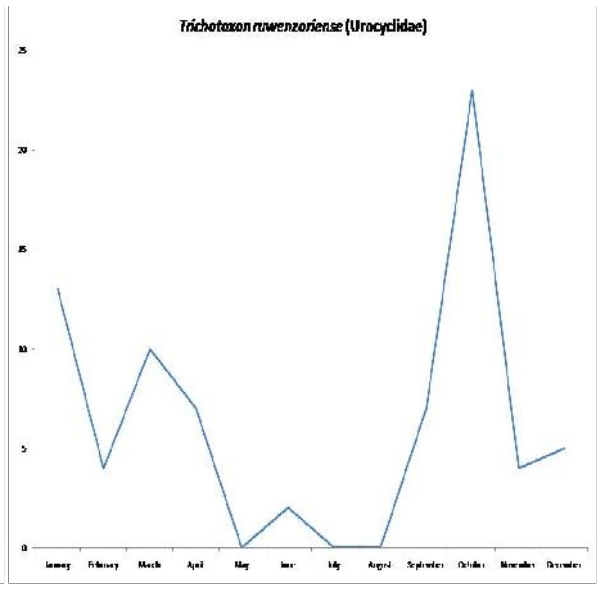
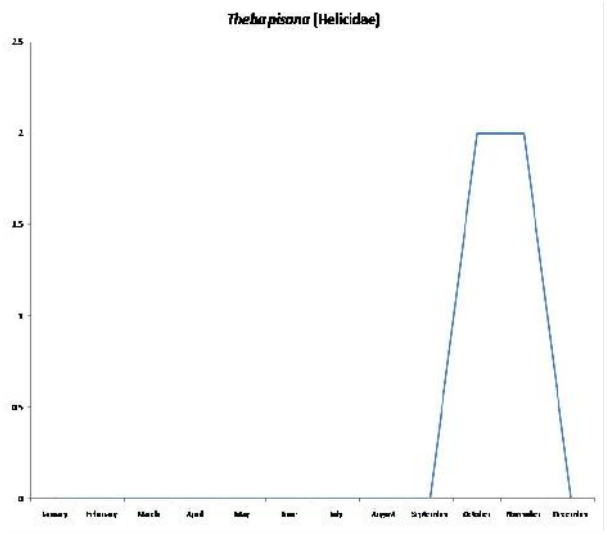
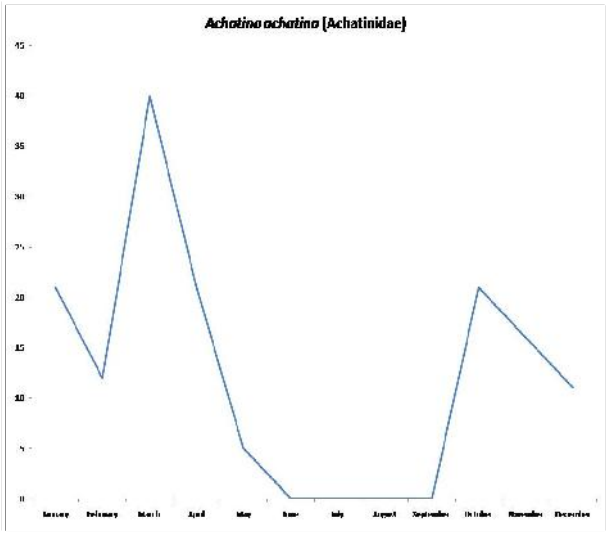

Arion rufus (Arionidae)

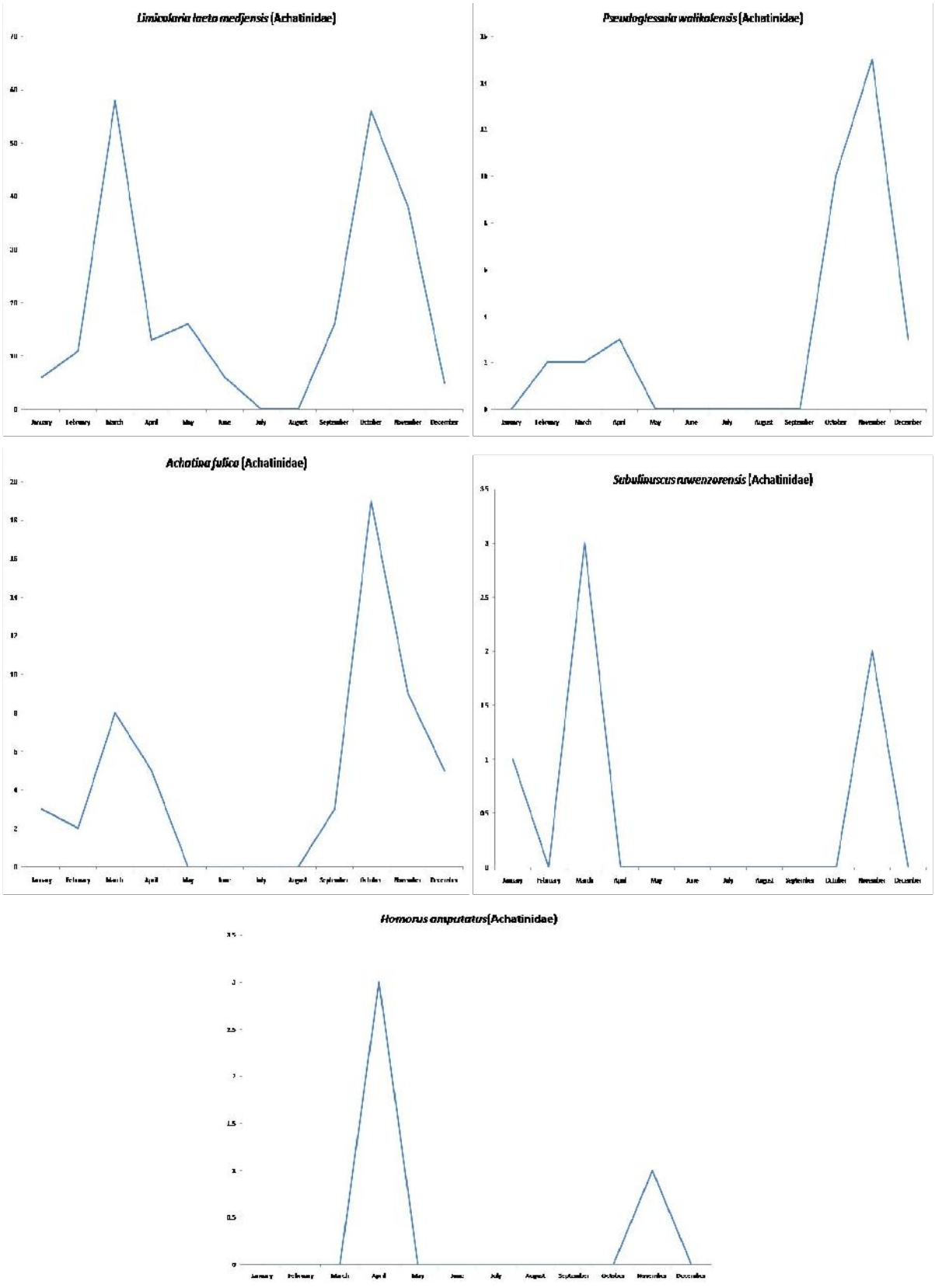

Lehmannia valentiana (Limacidae)


Bukobia cockerelli (Urocyclidae)


Trichotoxon ruwenzoriense (Urocyclidae)


Theba pisana (Helicidae)


Achatina achatina (Achatinidae)



Figures 3. Monthly variations of each land snail species collected from the studied sites

3.3.2 SEASONAL VARIATIONS OF THE RECORDED LAND SNAIL SPECIES.

Seasonally, the total catch of land snails showed its high value during rainy season (98.2%), whereas the low catch was recorded in dry season (1.8%), figure 4 beneath.

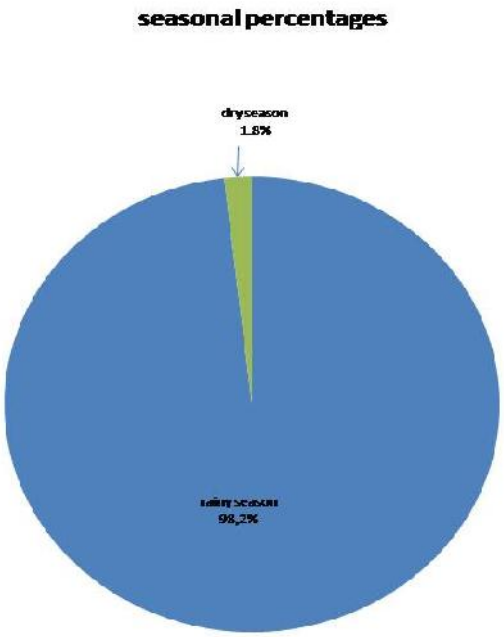


Figure 4. The seasonal percentages of the snail species collected from the studied sites.

3.3.3 ANNUAL VARIATIONS OF THE RECORDED LAND SNAIL SPECIES

In general, during all the year, the land snails showed the highest peak in October as shown by the figure 5 below and dry season has the high percentage of land snails than the dry season as shown by the figure 2 below too.

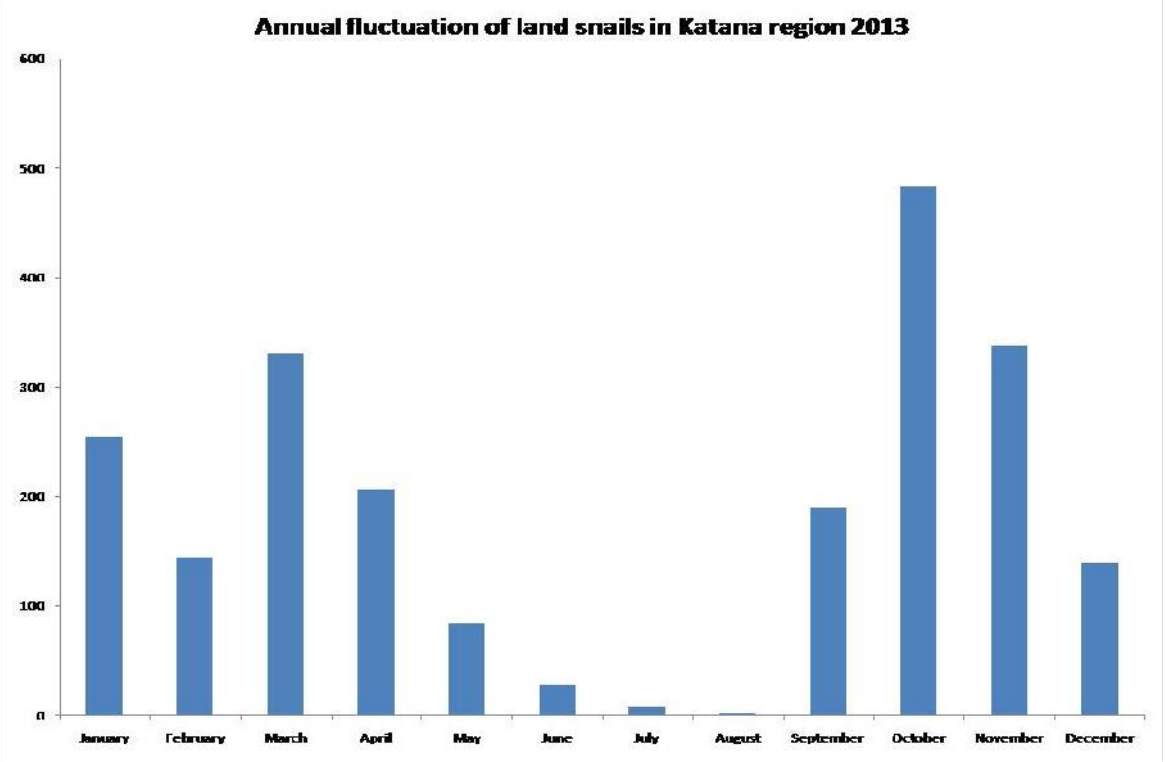


Figure 5. Annual variations in the density of each land snail species collected from the studied sites

3.4 RELATIONSHIP BETWEEN THE ENVIRONMENTAL FACTORS AND THE SNAIL SPECIES

Table4. Correlation coefficients for association between different species with geo-physical factors during the period of investigation

Species	Temperature (°C)	Relative humidity (%)	Precipitation (mm)
Perideriopsis fallsensis (Achatinidae)	0.6141	0.18077	0.42827
Gullela pupa ituriensis (Streptaxidae)	0.52318	0.036003	0.10302
Limicolaria distincta (Achatinidae)	0.73858	0.051809	0.21097
Nothapalus paucispira xanthophaes (Achatinidae)	0.86188	0.26213	0.37728
Curvella bathytoma (Achatinidae)	0.16661	0.063445	0.35305
Cerastus bequaerti (Enidae)	0.83016	0.48357	0.81248
Burtoa nilotica emini (Achatinidae)	0.95971	0.052739	0.069546
Achatina tincta (Achatinidae)	0.14911	0.041208	0.061961
Pachnodus rutshuruensis (Enidae)	0.39455	0.14803	0.056563
Mesafricarion putzeysi (Zonitidae)	0.83709	0.037879	0.08984
Helixarion insularis (Zonitidae)	0.46577	0.12877	0.29767
Gymnarion aloysii-sabaudiae (Zonitidae)	0.94387	0.060753	0.03113
Ataxon faradjense (Urocyclidae)	0.56044	0.061502	0.26422
Trichotoxon pardus (Urocyclidae)	0.45495	0.011439	0.051266
Trihotoxon maculatum perforatum (Urocyclidae)	0.11628	0.024237	0.021397
Pleuroprocta silvatica (Vaginulidae)	0.35339	0.28812	0.4357
Loevicaulis schnitzleri (Vaginulidae)	0.691	0.38337	0.81733
Burtoa nilotica obliqua (Achatinidae)	0.37574	0.23083	0.49686
Achatina osborni (Achatinidae)	0.7085	0.48285	0.74869
Mesafricarion maculifer pilsbry (Zonitidae)	0.73164	0.36136	0.45409
Arion rufus (Arionidae)	0.41179	0.36428	0.7417
Lehmannia valentiana (Limacidae)	0.83706	0.052004	0.049059
Bukobia cockerelli (Urocyclidae)	0.94569	0.24227	0.32156
Trichotoxon ruwenzoriense (Urocyclidae)	0.50625	0.16596	0.32175
Theba pisana (Helicidae)	0.56373	0.59142	0.80464
Achatina achatina (Achatinidae)	0.38012	0.0145	0.055701
Limicolaria laeta medjensis (Achatinidae)	0.73015	0.16041	0.15083
Pseudoglessula walikalensis (Achatinidae)	0.75848	0.25892	0.44354
Achatina fulica (Achatinidae)	0.93244	0.16778	0.23277
Subulinuscus ruwenzorensis (Achatinidae)	1	0.20147	0.12103
Homorus amputatus (Achatinidae)	0.63143	0.32231	0.73066

From table (4), there was a positive correlation between geo-physical factors (temperature, relative humidity and rainfall) and all land snail species. The present results indicated that abiotic factors (geo-physical factors: temperature, rainfall and relative humidity) are positively correlated with land snails, they increase with increasing abiotic factors.

4 DISCUSSION

The results of this study clearly indicate that the densities of the recorded land snails in Katana region underwent changes in numbers during the year of investigation. Several environmental factors appear to affect the land snail populations, in particular, the rainfall, temperature and relative humidity of the Katana region which maybe the cause of the number variation in population of land snails of Katana region. These are in accordance with [54] and [55] who suggested that gastropod variability may be explained by abiotic factors like rainfall, relative humidity and temperature. Also [56] indicated that the occurrence of many gastropod species is affected by the quality of vegetation abundance and reported that the most suitable substrate for snails in terrestrial medium is a moist soil covered with thin layer of organic matter, However, [23] found that faunal variation appears to be more closely related to rainfall levels, than to altitude per se or the other environmental variables examined. The effects of rainfall on land snails could either be direct, or indirect via its effects on soils or vegetation, but the study suggests that direct effects are more important. Land snails are sensitive to small changes in

microclimate and plant species composition, which are often brought about through edge effects and the invasion of non-indigenous plant species, accidentally carried as seeds via roadways; Furthermore, given the small geographical range sizes of many of Belau's land snail species, cutting down even small tracts of rainforest could severely impact some land snail populations [57].

Our results in different sites showed that cultivated area and wetland were rich in land snails, this observation is due to these two sites are characterised by fresh plants on which land snails feed, penetrate substrate with organic matter in which land snails can be hided during dry season can penetrate for laying and clay-sandy substratum with decaying matter and a lot of vegetations. The same conclusions have been observed by [58] who showed that land nails eat mostly living plants as well as decaying plants. They also chew on fruits and young succulent plant barks and that many molluscs eat plants (herbivores) or plant cell materials in the water; terrestrial snails like to eat fresh leaves and decomposing materials. This can be beneficial because they break down decomposable materials, but land snails can also become pests when they turn their attention to garden crops and vegetables.

However, the geo-physical factors influence the variation in land snail species fauna, our results shown that when rainfall increases in Katana region, the number of land snail species increases also, but the temperature is almost the same during all the year. Then, one can conclude that temperature does not influence the variation of the land snail species in Katana region, although among environmental factors, temperature affects the variation in land snail species [58]. Our data show no difference ($p = 0.0748 > 0.05$) in either abundance or diversity of land snails between the rainy and dry seasons. Indeed, the so-called "dry" season has the same level of atmospheric humidity as the rainy season [59]. There is dew in the morning all year long, and land snails probably do not suffer from a shortage of water in the "dry" season: for the period of investigation, on average, 8.3% (121.925 mm) of the annual rainfall occurred during the long rainy season. However, some species seem to be more abundant during one part of the year, probably because of such behavior as aestivation/hibernation (animals are more concealed part of the year), or because they have a life cycle of one year or less. The fact that in the twice-sampled sites, the number of species is significantly higher at the beginning of the dry season than during the rainy season also suggests that there could be seasonality in the life cycle of some species. The present result agrees with [60] where they found that late Summer and Autumn had the optimal temperature required for breeding and reproduction of snails, and partially agrees with [61]; they stated that April, May and June showed the highest number of snails in Sinai Peninsula, while the lowest number was recorded during January and February.

However, we cannot rule out the fact that results from the sites sampled twice could be influenced by disturbance, or recolonisation factors following the first sampling. The paucity of data regarding life history of land snails in tropical Africa prevents any firm conclusions on seasonality. But similar results have been found in other studies [62].

The results regarding seasonality are biased by the fact that sieving the leaf-litter produces many dead individuals (empty shells), which are not necessarily representative of the fauna at a given time of the year. Seasonality would be better studied with live individuals only, but as was indicated in the Methods section, it is difficult and time-consuming to sort out animals collected alive from those collected dead, especially for minute species.

All molluscs must have food, oxygen and moisture to be alive. Most molluscs live in the ocean or, if on land, in moist places such as under leaves or in soil, some need a sandy, ocean environment. All molluscs require moisture to stay alive [58]. The desert dwelling snails are no exception as they maintain their own moisture inside their shell by means of a trap doors or a mucus plug. Some mollusks are carnivores (eating such things as fish and other molluscs) and some are even parasites (living within another living host). Molluscs can be found in gardens, in ponds, deserts and oceans. Some live in the tops of trees and others high in the mountains. Snails have many natural enemies; they include ground beetles, snakes, toads, turtles and birds, including chickens, ducks and geese. Snails are among the animal groups that everybody knows a little. After rains, snails can be seen crawling around in bushes, trees, walls and roads at a proverbially slow pace and mainly at nights. Besides the characters typical for molluscs, there can also be found characters typical for all snails, whatever they may look like from outside [58]. Abundance and diversity of snails are likely to be lower in deserts. Because arid regions typically have high temperatures with extreme daily and monthly temperature ranges, low and infrequent rainfall, low humidity, and many sunny days with high light intensity, molluscs of arid regions consist mainly of forms with a wide tolerance for temperature, moisture, and sunshine. Snails can be found in the desert regions of the American southwest, in eastern and southeastern California, Arizona, New Mexico, northern Mexico, and the western parts of Texas [50]. Open meadows and pasturelands, including those with forest cover, are usually poor for snails unless there are many logs [46], but one can find a few species near grass roots [45]. Trampling may influence the low abundance of snails in pastures [23]. When humans clear forests for agriculture, snail diversity and abundance decrease, and species composition changes [63].

5 CONCLUSIONS

The results of this study clearly indicate that the densities of recorded land snails in Katana region underwent changes in numbers during the year of investigation. Several environmental factors appear to affect the land snail populations, particular the rainfall and the relative humidity which may be cleaned to reduce the populations of land snails. Thus, for informed conservation measures to be implemented, detailed studies on land snail systematics, on threats to survival and on identifying "hot-spots" for narrow range endemics are urgently needed.

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REFERENCES

[1] J.R. Graveland, van der Wal, J.H. van Balen, & A.J. van Noordwijk, ''Poor reproduction in forest passerines from decline of snail abundance on acidified soils''. *Nature*, 368: 446–448, 1994.
[2] J.R. Dunk, W.J. Zielinski & H.K. Preisler, ''Predicting the occurrence of rare mollusks in northern California forests''. *Ecological Applications*, 14: 713–729, 2004.
[3] Barker, G.M. *The biology of terrestrial molluscs.* Oxon, UK: CABI Publishing.558 pp, 2001.
[4] V. Deepak, K. Vasudevan, B. Pandav, ''Preliminary observation on the diet of the cane turtle (Vijayachelys silvatica). Hamdaryad, 34, 166–168, 2010.
[5] Burch, J.B. & Pearce, T.A. Chapter 9: Terrestrial gastropods. In: *Soil Biology Guide*, (D.L. Dindal, eds), pp 201-309. John Wiley and Sons, New York, 1990.
[6] T. Čejka, and L. Hamerlik, ''Land snails as indicators of soil humidity in Danubian woodland (SW Slovakia)''. *Polish Journal of Ecology*, 57: 741–747, 2009.
[7] Clark, J.A. & May, R.M. Taxonomic bias in Conservation Research. *Science*, 297: 191- 192, 2002.
[8] Solem, A. A world model for land snail diversity and abundance. In: Worldwide snails: Biogeographical Studies on Non-Marine Mollusca (Solem, A. & van Bruggen, A.C., eds).. E.J. Brill/Dr W. Backhuys, Leiden, 289pp, 1984.
[9] F. Naggs, & D. Raheem, ''Sri Lankan snail diversity: faunal origins and future prospects. *Records of the Western Australia Museum''*, Supplement No. 68: 11–29, 2005.
[10] C.P. Wade, , P.B. Mordan & F.Naggs, ''Evolutionary relationships among the Pulmonate land snails and slugs''. *Biological Journal of the Linnaean Society*, 87: 593–610, 2006.
[11] Labaune, C., L'invasion de la région Méditerrannéenne française par l'escargot *Xeropicta derbentina*: mécanismes, conséquences écologiques et agronomiques. PhD thesis, Université d'Aix-Marseille III, 310 p, 2001.
[12] Leemans, R. and Cramer, W. *The IIASA Database for Mean Monthly Values of Temperature, Preciptiation and Cloudiness on a Global Terrestrial Grid*. Laxenburg: International Institute of Applied Systems Analyses, 254 p, 1991.
[13] M. Pfenninger and A. Bahl, ''Influence of habitat size on the viability of spatially structured populations of the land snail *Trochoidea geyeri''. Verh. Ges. Öko.*, 27: 469–473, 1997.
[14] P. Bouchet, ''Extinction and preservation of species in the tropical world: What future for Molluscs?'' *American Conchologist*, 20: 20–24, 1992.
[15] I.J. Killeen & M.B. Seddon, ''Molluscan Biodiversity and Conservation''. *Journal of Conchology Special Publication*, 3: 172p, 2004.
[16] P. Solymos & Z. Feher, ''Conservation prioritization using land snail distribution data in Hungary''. *Conservation Biology*, 19: 1084–1094, 2005.
[17] Aravind N.A., Rajashekhar K.P., & Madhyastha N.A., ''A review of ecological studies on patterns and processes of distribution of land snails of the Western Ghats, India. *Proceeding of World Congress of Malacology*, 222 pp, 2010.
[18] S.Sen, G. Ravikanth& N.A. Aravind, ''Land snails (Mollusca: Gastropoda) of India: status, threats and conservation strategies''. *Journal of Threatened Taxa*, 4(11): 3029–3037, 2012.
[19] G.C. Stevens, ''The latitudinal gradient in geographical range: how so many species coexist in the tropics''. *Am. Nat.*, 133: 240–256, 1989.
[20] I. Wäreborn, ''Changes in the land mollusc fauna and soil chemistry in an inland district in southern Sweden''. *Ecography* 15(1): 62-69, 1992.

[21] B. Baur & A. Baur, ''Climatic warming due to thermal radiation from an urban area as possible cause for the local extinction of a land snail''. *Journal of Applied Ecology*, 30: 333-340, 1993.

[22] C. Moritz, K.S. Richardson, S. Ferrier, G.B. Monteith& J. Stanisic, ''Biogeographical concordance and efficiency of taxon indicators for establishing conservation priority in a tropical rainforest biota''. *Proceedings of the Royal Society of London B.*, 268: 1875–1881, 2001.

[23] P.Tattersfield, C. M. Warui, M. B. Seddon & J. W. Kiringe, ''Land-snail faunas of afromontane forests of Mount Kenya, Kenya: ecology, diversity and distribution patterns''. Journal of Biogeography, 28, 7, 843 – 861, 2001.

[24] R. H. Cowie, ''Decline and homogenization of Pacific faunas: the land snails of American Samoa''. Biological conservation 99; 207-222, 2001.

[25] M.Pfenninger, A. Eppenstein & F. Magnin, ''Evidence for ecological speciation in the sister species *Candidula unifasciata* (Poiret 1801) and *C. rugosiuscula* (Michaud 1831) (Helicellinae, Gastropoda)''. *Biol. J. Linn. Soc.*, 79: 611–628, 2003a.

[26] M. Pfenninger & D. Posada, ''Phylogeographic history of the land snail *Candidula unifasciata* (Poiret 1801) (Helicellinae, Stylommatophora): fragmentation, corridor migration and secondary contact''. *Evolution*, 56: 1776–1788. 2002.

[27] M. Pfenninger, D. Posada & F. Magnin, ''Phylogeography of the land snail *Trochoidea geyeri* (Soós 1926) (Helicellinae, Stylommatophora): response to Pleistocene climatic changes. *BMC Evol. Biol.*, 3: 8., 72-95, 2003b.

[28] J. Pither, ''Climate tolerance and interspecific variation in geographic range size''. *Proc. R. Soc. Lond. B*, 270: 475–481, 2003.

[29] Pilbry, H.A., A review of the land mollusks of the Belgian Congo chiefly based on the collections of the American Museum Congo Expedition, 1909–1915. Bulletin of the American Museum of Natural History, 40, 1–370, 1919.

[30] Adam W., Etudes sur les Mollusques de l'Afrique centrale et des régions voisines. I. Vertiginidae et Valloniidae. In : *Volume jubilaire*, Vol. 2 (Victor Van Straelen, directeur de l'Institut Royal des Sciences Naturelles de Belgique: 1925–1954), pp. 725–817. Hayez, Bruxelles, 1954.

[31] Venmans, L.A.W.C., Notes on Molluscs from the Belgian Congo. I. Genus Streptostele. *Revue de Zoologie et de Botanique Africaines*, 60 : 31–48, 1959.

[32] Van Bruggen, A.C. & Van Goethem, J.L. Dr William Adam's iconography of Central and West African Gulella species (Gastropoda Pulmonata: Streptaxidae). Part 1: nominal taxa. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Biologie*, 67 : 5–30, 1997.

[33] Van Bruggen, A.C. & Van Goethem, J.L. Dr William Adam's iconography of Central and West African Gulella species (Gastropoda Pulmonata: Streptaxidae). Part 3: nine new species from the D.R. Congo. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique Biologie*, 69: 31–45, 1999.

[34] Van Bruggen, A.C. & Van Goethem, J.L. Prolegomena for a checklist of the terrestrial molluscs of the Upemba National Park, Katanga, D.R. Congo. *Bulletin de l'Institut royal des Sciences Naturelles de Belgique, Biologie*, 71 : 151–168, 2001.

[35] W.F. Ponder, ''Conservation Status, Threats and Habitat requirements of Australian Terrestrial and Freshwater Mollusca''. *Memoirs of Museum of Victoria* 56*:* 421–430, 1997.

[36] Herbert D.G. , Molluscan conservation in South Africa: Diversity, issues and priorities, pp. 61–76. In: Killeen, I.J., M.B. Seddon & A.M. Holmes (eds.). Molluscan Conservation: A Strategy for the 21st Century. *Journal of Conchology Special Publication 2.* Dorchester (UnitedKingdom): Conchological Society of Great Britain and Ireland, Dorset Press, 1998.

[37] P.B. Budha, ''Nepalese malacology trails behind "catch up". *Himalayan Journal of Sciences* 3: 9–10, 2005.

[38] C. Régnier, B. fontaine & P. Bouchet, ''Not Knowing, Not Recording, Not Listing: Numerous Unnoticed Mollusk Extinctions''. *Conservation Biology* 23: 1214–1221, 2009.

[39] K. Bahizire, K. Ndegeyi, C. Batumike, M. Bagalwa, & B. Baluku, ''A Preliminary Survey and distribution of Land snails of Katana region, Southern Kivu, Democratic Republic of Congo''. International Journal of Innovation and Scientific Research, 9, 212-224, 2014.

[40] M. Bagalwa & B. Baluku, ''Distribution des mollusques hôtes intermédiaires des schistosomoses humains à Katana, Sud – Kivu, Est du Zaïre''. *Médecine Tropicale* 57: 369 – 372, 1997.

[41] L. Cahen & J. Lepresonne, The Precambrian of the Congo, Rwanda and Burundi. In: *Rankama K (ed) The Precambrian*. Pp 143 – 290. Interscience Publishers, New York. 1967.

[42] Verhaeghe M., *Inventaire des gisements calcaires, dolomies et travertins du Kivu, du Rwanda et du Burundi*. Département Géologie et Mines du Burundi, 95pp, 1964.

[43] K.P. Hotopp, ''New land snail (Gastropoda: Pulmonata) distribution records for New York state''. *Proceedings of the academy of natural sciences of Philadelphia*, 159: 25-30, 2010.

[44] M. J. Bishop, ''Approaches to the quantitative description of terrestrial mollusc populations and habitats''. Proceedings from the Fifth European Malacological Congress. *Malacologia* 16(1): 61-66, 1977.

[45] K.C. Emberton, T.A. Pearce & R. Randalana, ''Quantitatively sampling land-snail species richness in Madagascan rainforests''. *Malacologia*, 38: 203–212, 1996.

[46] J.C. Nekola & P.S. White, The distance decay of similarity in biogeography and ecology. *Journal of Biogeography*, 26: 867–878, 1999.
[47] R.A.D. Cameron & B.M. Pokryszko, ''Estimating the species richness and composition of land mollusc communities: problems, consequences and practical advice''. *Journal of Conchology*, 38: 529–547, 2005.
[48] Burch, J.B. & van Devender, A.S. Identification of eastern North American land snails. The Prosobranchia, Opisthobranchia and Pulmonata (Actophila). *Museum of Zoology and Department of Ecology and Evolutionary Biology*. USA, 290 p, 1980.
[49] R.A.D. Cameron, B. Eversham, & N. Jackson, ''A field key to the slugs of the British Isles''. *Field Studies* 5: 807-824, 1983.
[50] Thomas, A. K., Mc Donnell, R. J., Paine T. D., and Harwood, J.D., A Field Guide to the Slugs of Kentucky. University of Kentucky, Lexington, Kentucky 40546 SR-103, 36 p, 2010.
[51] Dash M.C., *Fundamentals of ecology,* School of life science, Sambalpur University, Jyoti vihar, Orissa, Tata McGraw-Hill Publishing Company Limited, New Delhi, 203-204 pp, 1995,
[52] New, M., Hulme, M. & Jones, P., Representing twentieth-century space-time climate variability. Part I: development of a 1961-1990 mean monthly terrestrial climatology. *J. Clim.* 12, 829-857, 1999.
[53] New, M., Hulme, M and Jones, P., Representing twentieth-century space-time climate variability. Part II: development of a 1901-1996 monthly grids of terrestrial surface climatology. *J. Clim.* 13, 2217-2238, 2000.
[54] E. Lacoursière, G. Vaillancourt, & R. Couture, ''Relation entre les plantes aquatiques et les Gastéropodes (Mollusca: Gastropoda) dans la région de la centrale nucléaire de Gentilly I (Quèbec)''. Can. J. Zool. 53: 1868-1874, 1975.
[55] B. Vincent, N. Lafontaine & P. Caron, ''Facteurs influençant la structure des groupements de macroinvertébrés benthiques et phytophiles dans la zone littorale du Saint-Laurent (Québec)''. Hydrobiologia, 97: 63-73, 1982.
[56] M. Strzelec & A. Królczyk, ''Factors affecting snail (Gastropoda) community structure in the upper course of the Warta river (Poland)''. Biologia, Bratislava, 59(2): 159-163, 2004.
[57] Rundell R.J., The Land Snails of Belau: Survey of the 16 States. Committee on Evolutionary Biology, 1025 East 57th Street, University of Chicago, Chicago, IL 60637, USA and Department of Zoology, Field Museum, 1400 South Lake Shore Drive, Chicago, IL 60605, USA; 21p, 2005.
[58] Okafor F. C., The varied roles of snails (Gastropod Molluscs) in the dynamics of human existence. Thesis, University of Nigeria. 153p, 2009.
[59] C. E G. Tutin & M. Fernandez, ''Relationships between en minimum temperature and fruit production in some tropical forest trees in Gabon''. Journal of Tropical Ecology, 9: 241- 248, 1993.
[60] G. R. Karimi, M. Derakhshanfar, & H. Paykari, ''Population density, trematodal infection and ecology of *Lymnaea* snails in Shadegan'', Iran. Arch. Razi Inc., 58: 125-129, 2004.
[61] G. A. El-Kady, A. Shoukry, L. A. Reda, & Y. S. El-Badri, ''Survey and population dynamics of freshwater snails in newly settled areas of the Sinai Peninsula''. Egyptian Journal of Biology, (2): 42-48, 2000.
[62] A.J. DE Winter & E. Gittenberger, ''The land snail fauna of a square kilometer patch of rainforest in southwestern Cameroon: high species richness, low abundance and seasonal fluctuations''. Malacologia, 40: 231–250, 1998.
[63] Evans J.G., *Land snails in archaeology*. Seminar Press, London, 197 p, 1972.

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EVALUATION OF THE MAIN ENVIRONMENTAL PROBLEMSAND THE IMPACT OF CLIMATE CHANGE

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ABSTRACT: Our objective is to assess the environmental issue based on the percentages of the main biophysical and ecological phenomena in question released by the group of French researchers. Among the main environmental problems are particularly climate change, air pollution, scarcity of water, deforestation, pollution of water, waste management, biodiversity loss, population growth, population movements, deterioration of soil ecosystem-equilibrium, chemical Pollution, Urbanization, thinning of the ozone layer, energy, consumption, new diseases, degradation of natural resources etc...
The study we noted that climate change is at the top of the main environmental problems of a percentage of 51%, the scarcity of fresh water by 29%, deforestation 28%, biodiversity loss 23% , waste management 20%, urban 23% and decrease in ozone 15%...
And last comes the increased sea level Therefore one might conclude that climate change is closely correlated with urban policies in industrial energy and transportation.
In a context dominated by the struggle against the emission of greenhouse gases, problems of air quality should not be underestimated and policies relating to climate protection must be taken into account.

KEYWORDS: Environmental Management, Climate Change, Kyoto Protocol, ISO 14001.

1 INTRODUCTION

This introduction summarizes the major IPCC (International Panel on Climate Change) results reported in the second assessment report approved in 1995. Some results are established with a high level of confidence: radioactive equilibrium which determines the temperature of any planet implies that the Earth's temperature must increase with increased atmospheric concentration of gases absorbing infrared emissions; the atmospheric content of carbon dioxide, methane and other infrared absorbing gases is observed as continuously increasing. Recent observations show that the surface temperature mean value, but more significantly its variations with geographical location and altitude follow the predictions of model. Climatic palaeo records show a significant correlation between variations in the carbon dioxide concentration and temperature. As the large climatic cycles are associated with a change in the Earth's orbit parameters, this correlation should be interpreted as evidence of positive feedback: the carbon dioxide concentration should be further increased by the temperature enhancement caused by an initial anthropogenic CO_2, increase [1].

The impact of climate change is reflected in many areas: climate, ecosystems, energy, food and santé. Countries party to the United Nations Framework Convention on Climate Change have set a target to contain the rise in temperatures to less than 2°C compared to pre-industrial era. To achieve this goal global emission must be halved by 2050 compared to 1990. Collectively reduce their emissions by at least 5% over the period 2008-2014 compared to 1990.The objective is

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differentiated by country. The emissions considered include six anthropogenic Greenhouses gasses (GHG): CO_2, CH_4, N_2O, HFC, PFCs, SF_6 [2].

To enter into force, the Kyoto Protocol aimed at reducing greenhouse gas emissions must quorum of 55 states representing at least 55% of Annex B emissions in 1990.

This threshold has been reached after the ratification of Russia, to the Protocol to be formally launched in 2005. In order to facilitate the achievement of the commitments of developed countries, three so-called flexible mechanisms established by the Kyoto Protocol. However an international market for carbon quotas. Each country receives as many Assigned Amount Units (AAUs) as its GHG emissions target set by the Protocol.

2 MATERIAL AND METHODS

2.1 COUNTRIES THAT HAVE SIGNED AND RATIFIED THE KYOTO PROTOCOL

Participation in the Kyoto Protocol (Figure1), green indicates countries that have signed and ratified the treaty (dark green, countries in Annexes I and II); in orange-brown not wanting ratify it; gray without position; red ratified, but intends to retire.

In 2011, 191 states have signed and ratified the Kyoto Protocol to the United Nations Framework Convention on Climate Change. This ratification includes three parts extras:

- Niue and the Cook Islands are counted separately. Well as States independent, they have reached an agreement in free association with New Zealand.
- In addition to these Member States, the European Union is counted as part of the protocol.
- Each industrial site must annually publish a report of its CO_2 emissions, which must be less than or equal to the quotas allocated to them
- To date 191 countries have ratified the treaty signed on 11 December 1997 in Kyoto. Is it, however, respected?

Figure 1: Participation of 191 states to the Kyoto Protocol

2.2 GHG EMISSIONS BY MAJOR EMITTER IN 2010 (MTCO2-EQ)

the easiest and most common way to compare countries emissions is to add up all the fossil fuels burned in every nation, by central, cars, industries or buildings and convert them into CO_2.from this point of view, china is the largest emitter in the world with 7 billion tons of CO_2, followed by the us (5.4 billion), India and Russia (Figure 2).

France is the 17th class with 350 million tons. Note that other types of emissions are not included.

If deforestation, responsible for a quarter of global emissions, had been taken in account, for example, Brazil and Indonesia hoist up the list.

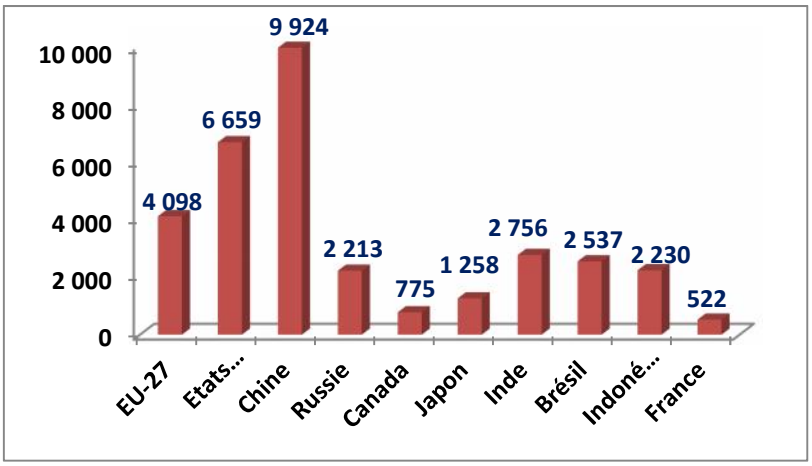

Figure 2: European Commission (2013) and MEDDE (2013)

2.3 KEY ENVIRONMENTAL PHENOMENA

The percentages of key biophysical and ecological processes disclosed by the French researcher group. SCOPE survey 2000 is indicated following figure 3. Graphical representation of the main environmental problems.

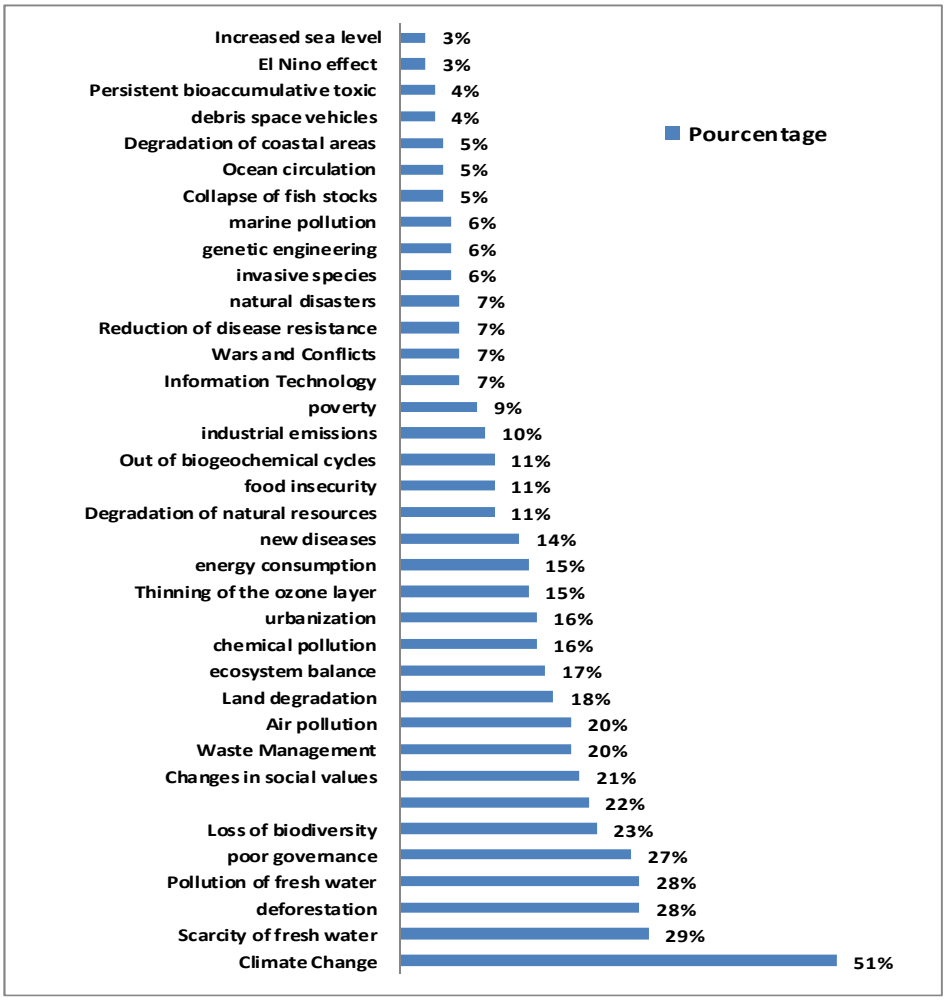

Figure 3: Percentages of key environmental issues

3 RESULTATS AND DISCUSSION

3.1 DESCRIPTIVE STATISTICS

Table 1 shows the descriptive analysis of the main environmental problems.

Table 1. descriptive analysis

Variable	Observations	Minimum	Maximum	Mean	Standard-deviation
Pourcentage %	**35**	**3**	**51**	**0,144**	**0,101**

Climate change will reach a peak of 51% (figure 3). This increase could be explained by the chemical composition of the ambient air that is a result of natural processes and these can also issue "polluting" substances such as sulfur dioxide and fine particles (volcanism, ocean biological activity and sea spray, desert dust, etc...) nitrogen oxides (soil biological activity, production during storms, etc.), hydrocarbons (emissions by vegetation, oceans, etc.), ozone (air intake from the stratosphere and photochemical reactions between nitrogen oxides and hydrocarbons of natural origin) [3].

Forests cover 28% of the surface area emerged, the phenomenon of deforestation is closely linked to that of the loss of biodiversity, which reached 23% in ecosystems, species and intra-specific variability. The disappearance of forests and filling of wetlands that naturally absorb water contribute to the formation of system disaster-causing landslides and flooding during intense rainfall events Nicaragua, Devastated by Hurricane Mitch in November 1998. However, one could say that there is a strong correlation between developing countries and deforestation caused by industrialization, population growth and expansion of agricultural activities, as well as the trade of forest products 22% [4].

Global energy demand is still strong growth of 15%. Two aspects are particularly important: fuel and electricity. The transport fuels are subject to strong demand, both in industrialized countries than in developing countries [5,6]. There has little hope of mass substitution of short or medium term fossil fuels in this field. Proposed alternatives are still very limited.

Waste management is 20%, since the publication of Decree No. 2002-540 of 18 apri12002 (RFL 362, apri1 2004, page 51).

The laboratories are in 1'obligation sort their hazardous waste according to certain criteria, including calculate the concentration of product (s) dangerous (danger threshold) of chemical waste, whether it is mandatory to evacuate and to restate a provider or if it is possible to evacuate in the common network water treatment [7].

The thinning of the ozone layer has reached 15% due to problems CFC (chlorofluorocarbons) to the extent that they affect the air conditioning and refrigeration industry. The past, the present and the future will be studied from the perspective of the regulations and industry standards for cleanliness of refrigerants.

Ozone also contributes to the greenhouse effect and, together with the particles, one of the priorities of CAFE (Clean Air For Europe) in the preservation of air quality in Europe, it is harmful to human health but also to the vegetation [8,9].

Two ad hoc committees of the Air Conditioning and Refrigeration Institute (ARI) were formed in January 1987: one to deal with the regulation of CFCs and the other to handle the acceptable level of contaminants in refrigerants. This communication will summarize the work of the Second Committee [10].

The reduction of infectious diseases has reached 7%, climatic factors (temperature, wind, humidity) and changes play a major role in the epidemiology of infectious maladies, especially vector-borne and water. Regarding respiratory infections, the role of the cold, evident in popular belief, remains controversial: winter peak is multifactorial but exposure to cold causes vasoconstriction of the nasal mucous membranes and upper airways, which reduces local defenses and allows latent viral infections to become patent. Preventing hand transmission remains paramount [9].

The elevation of sea level was 3%, which is explained by the gradual melting of the ice, the sea level will continue to grow for centuries after stabilization of the average temperature. The models calculated for 2100 have an elevation of 20 to 90 cm, due largely to the thermal expansion of the sea water. In 2500, the elevation could reach 3 to 4 m [11].

3.2 GLOBAL ISSUES: ENVIRONMENTAL PROTECTION

Further to oil crises of the twentieth century, the Brundtland Report and the Kyoto Protocol formalize the questions facing the challenges to the environment and future generations.

Considerable effort and sustained scientific research can only move back the limits of conventional reserves [12, 13, 14, 15]:

- Renewable energy sources appear to meet the expectations independence from fossil fuels, low production of greenhouse gases.
- Anaerobic digestion generates interest either for digestate, organic matter degraded anaerobically by bacteria, or biogas. This natural process leads to the formation of two products:
- Renewable energy: biogas (predominantly methane) that can be recovered in the form of heat and power (co-generation) and only heat, fuel or biomethane injected into the natural gas grid after purification.
- A fertilizer: the digestate from the undigested material as fertilizer for agricultural land.

The biogas enables the production of electricity but also the production of thermal energy, or both.

Methane (CH_4) which is produced from anaerobic digestion represents 55-85% of the volume of biogas. It is usable as an energy source, and 1 m^3 of methane (or 8570 kcal) is the equivalent of a liter of oil.

This treatment method provides for our territory local and ecological waste management, development of energy independence of the territories to maintain and create jobs which contribute to the identity and image of our territory.

4 CONCLUSION

The environmental context is marked by the issue of climate change 51%, it is also necessary to ensure the risk of toxic pollutant emissions that can produce certain technologies or practices (agrofuels), wood heating) booming because of their strengths in releases of greenhouse gases.

However, there is a strong correlation between the main environmental problems, environmental management certification according to the standard must be adopted ISO.14001 for many businesses to preserve biodiversity, assessing the vulnerability of natural ecosystems and their ability to adapt to major global concern. A ist waste sorting, it is necessary to minimize the spread and accumulation of products harmful to the environment. We must take responsibility to professional practices and go collect information from competent persons.

Furthermore, although the quality of air in cities is generally better than it was 10 or 20 years, , Urbanization and the growth of automobile traffic and certain industrial activities still cause locally or episodically high exposure situations to air pollutants.

It is also necessary be vigilant vis-à-vis risk, for example, to changes in certain activities (chemical industry, agriculture, air traffic ...) likely to lead to new pollutants or risks of high exposure to certain pollutants traces. In addition, the degradation of air quality can cover areas and populations already affected by other nuisances (soil pollution, noise pollution, slums, etc.) aggravating environmental inequalities.

TO REMEMBER

• There are primary pollutants (pollutants emitted directly into the air) and secondary pollutants (pollutants chemically formed in the air).
• The air pollution in enclosed spaces is becoming increasingly important.
• Air pollution is down overall, by improving techniques and processes in many sectors (industry, automobiles, etc.) but vigilance is required vis-à-vis risks still observed, and those related to new compounds.
• There are national and European regulations setting ambient concentrations do not exceed for various pollutants.
• The main pollutants are sulfur dioxide, nitrogen oxides, particulates, heavy metals, hydrocarbons and volatile organic compounds, polycyclic aromatic hydrocarbons, carbon monoxide, ammonia, ozone and photochemical pollutants.
• Associative structures assess compliance with these regulations.
• The law on air and the rational use of energy provides a right of access to data on air quality (compliance with the protocol Kiyo and **ISO 14001**.

REFERENCES

[1] B. Tissot, Rev. IFP, 48 (2) (1993) 91–103.

[2] http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm-fr.pdf.

[3] GIEC Bilan 2007 des changements climatiques, rapport de synthèse. Contribution des groupes de travail I, II et III au quatrième rapport d'évaluation du groupe d'experts intergouvernemental sur l'évolution du climat [équipe de rédaction principale, Pachaur, R.K. et Reisinger, A. (publie´ sous la direction de)] GIEC, Genève, Suisse, 2007,103 p.

[4] G. Martin-Herran. Deforestation and foreign transfers: a differential games approach. Montpellier: Faculté des sciences économiques, 2002, 22 p.

[5] J. M. Charpin., B. Dessus., R. Pellat. Étude économique prospective de l'énergie nucléaire. Rapport au Premier ministre La Documentation Française, Paris (2000).

[6] Conseil mondial de l'énergie Perspectives énergétiques mondiales 2020–2050, Houston (septembre 1998).

[7] F. Roussille. Gestion des déchets dans un laboratoire de biologie médicale Immuno-analyse & Biologie Spécialisée, V(25), Issues 5–6, October–December 2010, P. 276-280.

[8] K.R. Briffa., P.D. Jones, F.H. Schweingruber. OsbornInfluence of volcanic eruptions on Northern Hemisphere summer temperature, over the past 600 years, Nature 1998, 393,450–455. ences.

[9] http://www.nancy.inra.fr/la_science_et_vous/dossiers_scientifiques/rechauffement_climatique_et_forets_francaises/ modelisation_des_aires_-

[10] Society for Heating, Refrigeration & Air Conditioning Engineers American Moisture and Other Contaminant Control in Refrigeration Systems ASHRAE Handbook Systems (106th Edn) ASHRAE, Atlanta,1984, pp. 28.1–28.10 Ch 28.

[11] B. Djahida., D.M. Malika. Reconstitution de données climatiques pour l'Algeérie du Nord : application des réseaux neuronaux C. R. Geoscience ; 2010, 342, 815–822.

[12] Académie des sciences, CADAS, Rapport commun n°8, La recherche scientifique et technique dans le domaine de l'énergie, 1997.

[13] B.Tissot, D. H. Welte, The role of geochemistry in exploration risk evaluation and decision making, in: 12th World Petroleum Congress, Houston, Vol. 2, John Wiley and Sons Ltd, Chichester,1987, pp. 99–112.

[14] B.Tissot , Pétrole, gaz, environnement : Quelle approche de la R & D en exploration–production pour la fin du siècle ?, Rev. IFP 1993, 48 (2) 91–103.

[15] B. Tissot , L. Montadert , V. Richard , Recent changes and future directions in R&D for Exploration–Production, Am. Assoc. Petrol. Geol. Int. Conf. Nice, septembre 1995.

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Change in an organization; Success Steps and approaches for a Company

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ABSTRACT: Change and decision making is a common term in organizations and businesses. Decisions are affective in placing the organization ahead of the pack and also enables it perform successfully. Change is inevitable in any field or process in life. We have to undergo changes but the question is; what significance does the change have on the overall performance of the organization? What are the requirements for the changes in terms of resources? Changes are made by managers to increase their performance in the market which increases their market share in their existing markets and exploit the emerging markets effectively.

KEYWORDS: Decision Making, Problem identification, Limitation factors, Development alternatives, Decision implementation.

1 INTRODUCTION

Change is a strategic decision that a company undertakes to overcome the challenges posed by the ever changing environment. The change made should be done appropriately as it has impacts on the whole business. Both the customers and employees of the company making the change will feel the effect of the change. The change should be fair both to the company and its customers. Change does not happen independently but instead it affects the whole system around it and all the people involved in one way or the other.

2 DECISION MAKING

Decision making process has steps that it must undergo for successful implementation and impact to the intended business operation. The stages include; identifying the problem, identifying the limiting factors, developing potential alternatives, analyzing the alternatives, selecting the best alternative, implementing the decision and establishing a control and evaluation system.

3 IDENTIFYING THE PROBLEM

At this step, they addressed the stakeholders' needs and wants, the project constraints, budgetary limits, time and the stakeholders' performance requirements. Client value system can be important during this step of identifying the problems affecting the company. The client value system assists in the identification of the issues and is also useful in finding solutions to the problem (John Kelly and Steven Male, 2003). The organization can analyze the returns it get from its operations, the cost incurred, the morale of the employees, the employees turnover, etc. to identify the problems.

4 IDENTIFYING LIMITING FACTORS

In order to reach the most effective decision, managers must have access to necessary resources such as information, time, personnel, equipment, etc. the limiting factors wi help in formulating a solution to the problem that the organization faces. The limiting factors that ed to the issues the company faces is also identified. For smooth running of any business there must be available resources to fund the operations the company undertakes. The manager and his group should utilize the available time, information, resources and time to arrive at a solution. Effective problem solving requires examination of the challenge and the solution should be sustainable.

5 DEVELOPING POTENTIAL ALTERNATIVES

Brainstorming has basis on the information gathered and the issues that identify during this phase. Brainstorming is considered the most effective method as it encompasses creativeness. Steve Male and his fellow authors describe brainstorming as the creative phase where the team formulates suggestion according the functions identified earlier during the information phase. They further explain that the technique used during this phase should be consistent, and no variation should be allowed during the process. The function of this step, developing potential alternatives, is to analyze the validity of the alternatives in accordance to the customers and come up with a common idea on the modifications necessary for the hierarchy developed in the previous phase.

6 ANALYZING THE DEVELOPED ALTERNATIVES

The alternatives identified during the innovation phase were evaluated to determine their fusibility and then analyze the most appropriate alternative to looking for any further adjustments the alternative needed. Arithmetic weighting is the, most effective method through which alternatives can be developed and help them through the decision-making. Arithmetic weighting was the best method through which they could have identified and help them through the decision-making. Arithmetic weighing involves giving scores to various operations an organization undertakes as well as the developed alternatives.

7 SELECTING THE BEST ALTERNATIVE

This step finalizes the solutions proposed and prepares a report on the solutions arrived at by the members who participated in the decision making process. It is where the outcome of a workshop process is identified and agreed upon by the participants. The summary should include the risks identified and the method of their mitigation. The improved alternatives/options of design and organizational structure of the subject company, effective client value system and action plan without forgetting the development of the implementation plan is provided (Jürgen Hesselbach&Christoph Herrmann, 2011).

8 IMPLEMENTING THE DECISION

The main objective of the implementation phase is to ensure that the plans are fully implemented during the development as well as during the operation when the construction is complete. The report that generate after the workshop considers as the integral part of driving towards a successful implementation of the proposals. According to Save International, assigning of tasks is essential for the plan, for the implementation of the proposals of the workshop. It also involves assigning of responsibilities to individuals to ensure that the proposed decisions are effectively implemented as agreed by all the members (Otto Max Schaefer, 2002). Establishing a control and evaluation system, the final step, ensure that the implemented decisions have a positive impact on the operations of the business. It measures the performance of the business after the implementation of the decisions to determine whether the decision was worth or not.

9 CONCLUSION

The workshop proposals should be in a position to improve the value of the components of the subject project or business within the financial constraints of the project. Decision making is all about value enhancement as well as cost reduction. Decision making is the endless process that business can undertake anytime during its lifetime. Decisions are made due to the ever changing business environment and the business has to find ways of overcoming this challenge. The developed and implemented alternative during the process of decision making should be able to provide a long lasting

solution to risk management and value management for the services and products that an organization provides its customers. Decision making involves various techniques that are tailored towards delivering the objectives of the subject organization. All the stages of Decision making are important as they equally contribute to the success of the process.

REFERENCES

[1] Otto Max Schaefer (2002), Performance Measures in Value Management: A Model Based Approach to Explain the CVA and EVA Measures, Erich Schmidt Verlag GmbH & Co KG.

[2] S. Male, J. Kelly, M. Gronqvist& D. Graham (2007), International Journal O Project Management, Managing Value as a Management Style for Projects, Elsevier.

[3] S. Male, J. Kelly, M. Gronqvist& D. Graham, (2006), The Value Management Benchmark: Research Results of an International Benchmarking Study, Value Solutions Ltd.

[4] S. T. Green & A. M. M Lui (2007), Theory and practice in value management, Taylor and Francis, 1-11.

[5] Sham Dayal (2008), Earned Value Management Using Microsoft Office Project: A Guide for Managing Any Size Project Effectively, J. Ross Publishing.

[6] Jürgen Hesselbach&Christoph Herrmann (2011), Functional Thinking for Value Creation: Proceedings of the 3rd CIRP International Conference on Industrial Product Service Systems, TechnischeUniversitätBraunschweig, Braunschweig, Germany, Springer Science & Business Media.

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Group Dynamics; its' Effect and Impact to a Company

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ABSTRACT: Decision making in businesses is effective in propelling towards achieving its short term and long term objectives. There are a number of techniques used in decision making but the most commonly used which most businesses use is group dynamics. Group dynamics is a characteristic of any group that is useful in achieving the objectives of the group; providing solution to towards the objectives of the subject company.

KEYWORDS: Group, Factors, Group Dynamics, Team Formation, Team Development.

1 INTRODUCTION

A group can be described as individuals who have gathered to discuss and meet a certain objective. In every group there are always different behavioral and attitudinal characteristics as they participants are of different mindset and experiences. This describes group dynamics. Group dynamics can be defined as the effective roles and characteristics of a group on a group member or on the whole group. When effectively guided group dynamics can be very efficient in boosting the business's operations, revenue and the overall performance of the company.

Group dynamics are effective in most groups whether formal or informal. Group dynamics is used in the study of the behavior of a business. The purpose of group discussions is to provide solutions to issues affecting a business and prevents it from meeting certain goals or may be interfering with the whole operation of the business. Groups are usually problem centered. Group characteristics in terms of behavior and attitude play an important role in arriving at the relevant decision (s) for the good of the company. Good decision can only be arrived at when the group processes properly managed.

2 FACTORS AFFECTING EFFECTIVENESS OF GROUP DYNAMICS

Group dynamics can lose its effectiveness due to poor leadership. A group leader ensures that the meetings conducted are not dominated by majority members at the expense of the minority. The minority members also have an important role during decision making as they act as representative of different part of a business. According to RK Sahu, a leader must involve all the members into action. Leadership also inspires the participants of a group, a leader must be able to motivate the participants of a workshop and ensure that the issue that is discussed is attended to and the solutions generated.

Another factor that hinders effective leadership is excessive difference to leadership. Most of the workshop participants who not want to oppose the stand of the leader and therefore they may not give suggestions that contradict the leadership. The workshop process, therefore, would not be effective in addressing the problem a company is facing. Some individuals may not participate in the process of finding solution to the problem while others may be of negative significance to the ideas that others propose. The group that has more free riders can never reach to an inclusive solution that covers all the risks and value issues that a company faces. For effectiveness any workshop group should ensure that all the participants contribute to the discussion.

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The above challenges can be addressed when the eadership is effective in guiding the workshop process and can be able to include a the participants during the discussion. The eadership shoud ensure that order is maintained. RK Sahu argues that a good eadership is the most crucia necessity that any workshop shoud never lack. The good leader creates an environment for all the participants to know one another and appreciates their ideas. The eader can assign some participants roles and responsibilities so that they can guide the process of aligning the business or company's operations to the objectives and mission of the company. Responsibilities also help in defining the objectives of the group during the workshop. An effective group provides a platform that favors the participation of all the attendants of the workshop process.

3 TEAM FORMATION AND DEVELOPMENT

There stages a group passes through during the process of finding solution to the probem a company faces. Timothy M. Franz describes the Tuckman's theory of group development as the most effective technique. He explains the five groups of development; there are five stages of group development, forming, storming, norming, performing and adjourning. The first step involves introduction of the group members where they get to know one another. New members get the opportunity to acclimatize with the existing group members and environment. During this first stage, the group members define their tasks and objective as well as identifying the challenges is likely to face. In most cases you will find the group members focused on their behavior instead of the whole group behavior.

The second stage, storming, genera involves identifying the conflicting issues among the members and the company they are discussing. This stage is characterized with unpleasant arguments and increased group conflict. The group at this stage may be divided on the issues to be discussed as some may be overlapping their roles. The differences that the members experience during this stage are resolved during the third stage, norming. The members start to understand one another and learn the weaknesses and strengths of the ideas that are tabled by different members. They are therefore able to appreciate the contributions and ideas of others participants.

Performing is the fourth stage and it is characterized by the good communication among the participants of the groups due to the improved understanding of one another. The group can therefore be able to solve the confecting issues that affects the subject company and ensure that the solutions arrived at are sustainable. Adjourning is the final stage which aims at making the group intact. This stage is focused at productivity and effectiveness of the company's activities. At this stage the group should be in a position to provide a conclusive solution to put an end to the problem that a company faces. Since that group attendance is multidisciplinary, the solution arrived at covers all the areas of the issue affecting the company are addressed.

4 CONCLUSION

Group dynamics is considered the most important property in finding the most effective solution to the issues a company faces. The process a group engages in is purposely for enhancing the performance of the company in their market and addressing the needs of the customers. The groups function is provide ways of addressing the customer needs with the existing resources the company has. Leadership of the group affects the processes the group undertakes during addressing the issues affecting the subject company.

REFERENCES

[1] RK sahu, group dynamics & team building, Excel Books India
[2] Daniel King, Scott Lawley (2013), Organizational Behaviour, Oxford University Press.
[3] Donelson Forsyth (2009), Group Dynamics, Cengage Learning.
[4] Timothy M. Franz (2012), Group Dynamics and Team Interventions: Understanding and Improving Team Performance, John Wiley & Sons.

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Investigating and Problem Solving in Business Establishment

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ABSTRACT: Problems are unexpected outcomes in any business establishment and they cannot be avoided. They only thing that businesses can do about it is identifying the problem, identifying the root causes and developing a sustainable solution. Sustainability of the solutions ensures that the problem or related problem is well managed. It also ensures that the problem is identified early before causing problems to business operations. In this paper, the process of investigating and solving a problem is discussed.

KEYWORDS: Problem defining, Analysis, Diagnosis, Innovation, Evaluation, Risk, Implementation.

1 INTRODUCTION

Business operations can be hindered or have reduced efficiency and profitability when there is a problem. Identification of problem that affects a business at any point is important. This enabled them to come up with creative problem solving exploration, bringing their ideas together to come with the best value alternative (Steven Male, 1998). Consequently, the resulting solution will be able to harmonize the different views of the various stakeholders of the business. The business will, therefore, be able to deliver to their clients wants and needs effectively. The process of value management should be able to: all objectives of the stakeholders; rank objectives according to priorities; identify ways of achieving objectives through brainstorming; identify valuable alternatives and provide recommendations for the most effective solution for the issues affecting the business (S. Male, J. Kelly, M. Gronqvist & D. Graham, 2006).

Problem solving is a procedural process that defining the problem, analysis and diagnosis, innovation, evacuation, risk and risk management, implementing and developing a monitoring system.

2 DEFINING THE PROBLEM

Allocate enough time to the process and activities involved in knowing what the problem really is and the part or department of the business that is affected. There are some managers who make a mistake of jumping the developing to a solution to problem they don't really know. The solution may be working but will short term. Such cases can result to even magnifying the problem. Identification of the problem enables the business to establish the cause of the problem and subsequently finding the most effective solution.

3 ANALYSIS AND DIAGNOSIS

The analysis and diagnosis phase focuses on the root cause of the problem and what favored the occurrence of the problem (J. Aken, H. Berends & H. van der Bij, 2011). When the cause of the problem is identified, the most appropriate solution make be easily achieved. When the causes are not identified the solution that will be developed won't be effective to solve the problem. The effect of the issues being investigated is identified. Additionally, the vulnerability of the business is

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identified. There are some factors within the business organization that may have in one way or the other facilitated the problem. These factors are identified as they will help a great deal during development of a solution.

4 INNOVATION

This process involves brainstorming alternative solutions. Steve Male considers a group to be the most effective method of understanding the problem and the root causes and develop solutions towards the analyzed problem. The group assigned the task of finding the solution will discuss within themselves various solutions. During this step, any idea raised by the group members is useful. The innovation phase is allocated enough time for a good number of ideas that may lead to solutions to be raised. The time will depend on the type and magnitude of the problem being investigated. Steve Male suggests that brainstorming as the creative phase where the group formulates suggestions in regard to the analysis of the problem identified. The solutions suggested by the group members should be able to balance the resources of the business with their objectives.

5 EVALUATION OF THE SOLUTION

This step invoves analysis of the suggestion developed in the previous phase and identifies the best for solving the problem in question. It involves evaluating the alternatives base on feasibility, economical value, client suitability and function suitability. Feasibility of the solutions describes how easy they can be applied in solving the problem. The easily implemented solution is selected as it requires less capital, time and other resources to implement them. In terms of economical value, the solution that best fits within the budget of the business is selected; otherwise implementing the solution will be a problem itself. Steven Blais (2011) argues that the solution should not have negative impact on other operations of the business and must be sustainable to avoid related future problems. The group can assign the alternatives scores in order to come up with a suitable solution. This technique is referred to as arithmetic weighing. Objective hierarchy is another criterion that can be employed to arrive at the solution but it may not be effective as they only provide answers to the value factors of the problem.

6 ASSESSING THE RISKS ASSOCIATED WITH THE SELECTED SOLUTION

The developed solution may pose the business to risks in the future. Michael F Dallas (2008) defines risks the unavoidable outcome that can either be of negative or positive impact to the operations of the business. The group should predict any possible risks that the business may experience during and after the implementation of the selected solution. Michael F Dallas (2008) further explains that the impacts and chances of the predicted risks should be estimated. This enables in the development of a risk management plan. The plan should be sustainable in order to update and manage risks throughout the life of the business.

7 IMPLEMENTATION OF THE EVALUATED SOLUTION

Before the onset of implementation, a plan is developed showing how the arrived solution will be implemented and at what time. During development of the plan, individuals are assigned responsibilities for efficient implementation. Implementation process involves elimination of the root cause of the problem. A monitoring system that indicates the progress of the solution in counteracting the problem is developed and included in the plan. In case the solution is not effective in managing the problem, the group will have to go back to the innovation phase to brainstorm the identified problem.

8 CONCLUSION

The process of identifying problem and coming up with solution is a procedural process that requires a group to discuss various suggestions. Group dynamics is effective at raising suggestion and evaluating the best alternative. The group dynamics helps in solving the problem from various angles. The generated solution may lead to risks and other problems if not analyzed properly. The solution should be developed with consideration of feasibility, economic value, significance, function, the business customers and sustainability.

REFERENCES

[1] Anthony Manley (2009), The Elements of Private Investigation: An Introduction to the Law, Techniques, and Procedures, CRC Press.
[2] Joan van Aken, Hans Berends & Hans van der Bij (2012), Problem Solving in Organizations: A Methodological Handbook for Business and Management Students, Cambridge University Press.
[3] M. Gronquvist, S. Male & John Kelly (2006), THE FUNCTION PRIORITY MATRIX: Meeting the Function of Function Analysis
[4] Michael F Dallas (2008), Value and Risk Management: A Guide to Best Practice, John Wiley & Sons.
[5] Robert J. Thierauf (2001), Effective Business Intelligence Systems, Greenwood Publishing Group.
[6] Steven Blais (2001), Business Analysis: Best Practices for Success, John Wiley & Sons, 70.
[7] Steven Male & John Kelly (2004), A RE- APPRAISAL OF VALUE METHODOLOGIES IN CONSTRUCTION, University of Leeds.
[8] Steven Male (1998), The Value Management Benchmark: A good practice framework for clients and practitioners, Volume 2, Thomas Telford

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Business Leadership and Risk Management

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ABSTRACT: Leadership as we know it has changed, with deeper engagement necessary for the engagement of employees. Autocratic power exercised by leaders has diminished in the knowledge economy, where employees hold the knowledge capital of the organisation, engaging at a deeper level helps in leadership. Leadership by directing is gone, and this has been replaced by leadership by engagement. The leadership styles that are most popular – transactional and transformational are discussed, and it is observed that the latter style is more effective in the post-modern era. As leaders are decision makers, the efficacy of making decisions that are suitable or beneficial to most of the followers is viewed as a success criterion. Therefore, leaders must develop a plan to reduce information asymmetry within organisations and develop a consultative and participative system of generating opinions when making decisions. Such approaches help the leader in mitigating the risks involved in analysing diverse ideas and also by taking people into confidence of the constraints that are there in the decision to be made.

KEYWORDS: Leadership, Risk, Morden theory, Transformational, Participatory.

1 INTRODUCTION

We live in the Post Modern Era, dominated by the themes of pluralism, non-objectivity, cynicism and community oriented interpretation of the environment (Green, 2007). In this era, the traditional organisation is at risk. Every employee is a potential cynic and interprets the environment based on his sentiments and perceptions and understands that there are multiple perspectives on every situation. In this state, it is important for leaders to adopt a deeper meaning of leadership, over the simplistic explanations.

Leadership is crucial to organisational effectiveness, as leadership efficacy affects team success depends on knowledge sharing and facilitation (Zaccaro, 2003). The key determinants of leadership in today's context are encouraging participation in a common goal, delineation of personal goals over group objectives and engaging collaboration (Kavanagh & Ashkanasy, 2006). Such an approach calls for defining leadership:

2 LEADERSHIP AND RISK – A THEORY PERSPECTIVE

"The ability to influence a group toward the achievement of goals" (Robbins 2003, p.314) is the most pervasive and simple definition of leadership in general terms. Leadership is behaviour by individuals which shows purpose, indicates direction and meanings to the collective actions of a group of people (Hellriegel & Slocum, 1996, p.445; Rutter, 1995, p.27; Gill et al 2006; House, 1995, p. 415). The leader has to be able to unite the efforts of the members to achieve the set objectives. Therefore, leadership can enhance the effectiveness of groups and ultimately positively impact organisational effectiveness (Wang et al. 2005).

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Modern theories of leadership focus on desisting from the use of force and engaging with followers and influencing them to draw their best potential in a group environment (Wang et al. 2005). According to Wang et al. (2005), influencing individuals involves more than just giving directions, but deep engagement at the perceptual and emotional levels of other individuals. There are different styles of leadership as postulated by postulated by theorists, but the most pervasive style comparisons across literature have been with respect to the transactive and transformational styles (Meyer & Botha, 2000).

A transactional leader governs through giving specific tasks and a system of rewards and punishments. When assigned a task, and if the individual completes the task, he is rewarded and is he does not, he is not rewarded. Such a leadership style makes employees task oriented and lead to enhanced productivity. Also, as the leader simplifies the objectives into simple tasks that are compartmentalised and workable at the individual level, the level of coordination needed between team members is low (Meyer & Botha, 2000).

In contrast, the transformational leader, leads to his charisma or inspiration and sets examples at a personal level to draw the best out of his team by influencing the emotions (Cable & Judge, 2003). Due to the post-modern themes dominating the culture today, the transformational leadership style is considered to be the most appropriate as it can help address the issue of appealing to the higher emotions and ideals of individuals. A leadership style that realises and tries to draw out the inner capabilities of the employee is crucial for success now. There is intellectual motivation through transformational leadership and when in this state of mind, there is empowerment and sensitivity on the part of the leader, the employee can realise his or her full potential (Bass & Avolio, 1990).

In this author's opinion, there can be no single correct style of leading people. Leaders have to play multiple roles. While a transformational leader can appeal to the emotional side of employees and stimulate intellectual motivation, a transactional leader keeps his employees motivated by material considerations. As employees work for the remuneration as the basis of employment, leaders must also focus on the material aspects of rewards and awards. Therefore, the leader has to be able to perform multiple roles in an organisational context to be successful.

Every leader has to make decisions, and such decisions affect the fortunes of every member of the group or the organisation depending on the scale and context of the decision. Therefore, a leader is a risk taker. How well a leader assesses the risks involved and how well the decisions adopt the risk levels to execution will determine the payoffs of every member of the group and the effectiveness of the leader (Ertac & Gurdal, 2012). The risks associated with the leadership decision is bound to generate criticism from subordinates as it may be deviating from their interests or what needed to be done in their perceptions.

It must also be observed that the information available to the leader may not be adequate to make the best decision possible and the leader may have to assume some information or make an optimal decision with the available information. This can create criticism as the information asymmetry as we go down organisational levels increases, and subordinates may not have the information available to the leader (Ertac et al. 2013). Therefore, how the leader mitigates the risk of the decision, and the mitigation of criticism or wrong perception among subordinates is necessary.

The risk of misperception of the risky decision and the decision can be in part eliminated by the transparency of the leader in disclosing as much information as possible for the consideration. In other words, reducing information symmetry that helps employees understand the situational constraints in the decision help reduce the risk of backlash among employees (Ertac et al. 2013)?

It also needs to be noted that participatory decision making can also help in mitigating risks associated, by incorporating the views of the people who might be affected by the decision (Ertac et al. 2013). In many circumstances, a leader may be able to take such feedback and in some circumstances may not be able to. The participatory decision-making process must be enabled by the organisational culture which allows leaders to use such a mechanism is important. In an autocratic culture, such a process for decision making may not be possible. But wherever this is employed, the risks associated with the decision are mitigated, and the decision making for the leader is simplified.

3 CONCLUSION

A leader is a bearer of risk, on behalf of others. He not only has to direct people and monitor inputs, but also makes decisions in the course of conducting business. The efficacy of the leadership is decided by the engagement levels of the employees that inspire them to contribute and behave above their personal agendas. As discussed, leadership efficacy decides the effectiveness of the organisation.

REFERENCES

[1] Bass, B.M. & Avolio, B.J. (1993) 'Transformational leadership and organisational culture', *Public Administration Quarterly*, 17(1), pp.112-121.

[2] Cable, M. Daniel & Judge A. Timothy (2003 'Managers' upward influence tactic strategies: the role of manager personality & supervisor leadership style', *Journal of Organisational Behaviour*, 24(2003), pp.197-214.

[3] Ertac, S., & Gurdal, M. Y. (2012) 'Deciding to decide: Gender, leadership and risk-taking in groups', *Journal of Economic Behaviour & Organization*, *83*(1), pp.24-30.

[4] Ertac, S. & Gurda, Y. (2013) 'Preference Communication and Leadership in Group Decision-Making', *Koç University-TUSIAD Economic Research Forum Working Papers*. No. 1324. Koç University-TUSIAD Economic Research Forum, 2013.

[5] Green, D. (2007) 'Leading a postmodern workforce', *Academy of Strategic Management Journal*, 6(1), pp.15-26

[6] Gill A, Flaschner AB, Shachar M. (2006), 'Mitigating stress and burnout by implementing transformational-leadership', *International Journal of Contemporary Hospitality Management*, 18(2006), pp.1-16.

[7] House, R.J. (1995) 'Leadership in the twenty-first century", in Howard, A. (Ed.), *The Changing Nature of Work*, Jossey-Bass, San Francisco, CA, pp. 411-50.

[8] Hellriegel, D. & Slocum, J. (1996) *'Management'*, 7th Ed. Cincinnati: South- Western College Publishing.

[9] Kavanagh, M. & Ashkanasy, K. (2007) 'The impact of leadership and change management strategy on organisational culture and individual acceptance of change during a merger', *British Journal of Management*, 17(S1), pp.81-103.

[10] Meyer, M. & Botha, E. (2000) *'Organization Development and Transformation in South Africa'*, Durban: Butterworths.

[11] Robbins, P.S. (2003) '*Organisational Behaviour*', 9th Ed. Sg: Prentice-Hall.

[12] Rutter, G. (1995) 'Leadership: directing people for their genuine long-term good', *Human Resource Management*, 10(2), pp.27-28.

[13] Wang, H., Law, K.S., Hackett, R.D., Wang, D. & Chen, Z.X. (2005) 'Leader-member exchange as a mediator of the relationship between transformational leadership and followers' performance and organizational citizenship behaviour', *Academy of Management Journal*, 48 (2005), pp. 420-32.

[14] Zaccaro, S.J. (2003) *'The Nature of Executive Leadership'*, Washington, D.C.: American Psychological Association.

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Entrepreneurship; Business Innovation and Enterprise Development

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ABSTRACT: Entrepreneurs are often confused with business owners. Entrepreneurs create new businesses through new ideas and create new business models. Entrepreneurs are innovators of the market. The theories behind finding the crucial element in entrepreneurship have been discussed, and we can say that the Misesian school of thought that postulates that the entrepreneur is defined by taking a risk and overcoming such risk. An entrepreneurial opportunity has to undergo the motivation assessment and the knowledge assessment to understand economic, personal and knowledge objectives can be met through the venture. Entrepreneurs make decisions based on incomplete information and. Therefore, there is a possibility of risk involved in all such decisions. The knowledge of the entrepreneur and heuristics developed through experience help the entrepreneur. While entrepreneurs are core domain experts, they have to be good managers to develop an organisation. Therefore, it is suggested that entrepreneurs adopt modern manpower approaches to engaging with employees and to ensure that the employees are trained and motivated to perform better.

KEYWORDS: Entrepreneur, Entrepreneurship, Enterprise, Venture, Knowledge.

1 ENTREPRENEURSHIP AND ENTERPRISE DEVELOPMENT: AN INTRODUCTION

Entrepreneurs identify business avenues where none exists in the market to create a new demand-supply chain or to create a new market (Knight, 2000). Therefore, an entrepreneur is not simply a new business entrant in the market, but the creator of wealth, jobs and opportunities in the market. He affects many factors, in the economy, society and the lives of many people. This also implies that every individual who starts a new business is not an entrepreneur, but merely a businessman.

The classical school of entrepreneurship developed in Austria argues that an entrepreneur is an identifier of opportunities, irrespective of the success of the venture or the profits (Kirzner, 1997). The Misesian school of thought calls the entrepreneur as a bearer of risk, and therefore a successful entrepreneur bears this risk successfully (Klein, 1999). Entrepreneurial activity is encouraged by the society and the government because it can generate new wealth, prosperity and fresh jobs, which directly results in the development as well as growth of the regional and national economy and contributes to social prosperity. Therefore, in the author's opinion, the defining factor in an entrepreneurial venture is how well risk is assessed and factored into the idea to result in maximum exploitation of an opportunity, under the existing constraints (Andersson, 2005; Sarasvathy et al. 1998). The element of taking risk in a sensible manner is a key ingredient in entrepreneurship.

An entrepreneurial venture is composed of two parts – risk taking and economic calculation (Klein, 1999). While the former sets the context for understanding the opportunity, the latter extrapolates the gains that can be derived from taking a risk (Klein, 1999). The personal motivation of the entrepreneur also plays a part in the setting the desire for exploiting an opportunity, as one entrepreneur may be focused towards a high profit, high investment option, another may be trying to start a social venture for the benefit of a community where the priority may be gain of the community gains and not personal

profits. Therefore, the entrepreneur has to put his idea through two assessments – the motivation assessment and knowledge assessment (Figure 1). While the former analyses whether the idea will be what was envisioned as an ideal investment, the latter analyses whether the individual has the right knowledge or the means to develop such knowledge to exploit the opportunity (McMullen & Dean, 2006). If the motivational desirability and the knowledge feasibility assessment of entrepreneurial venture are satisfactory, an entrepreneur may gain the first mover advantage as shown in Figure 1 below.

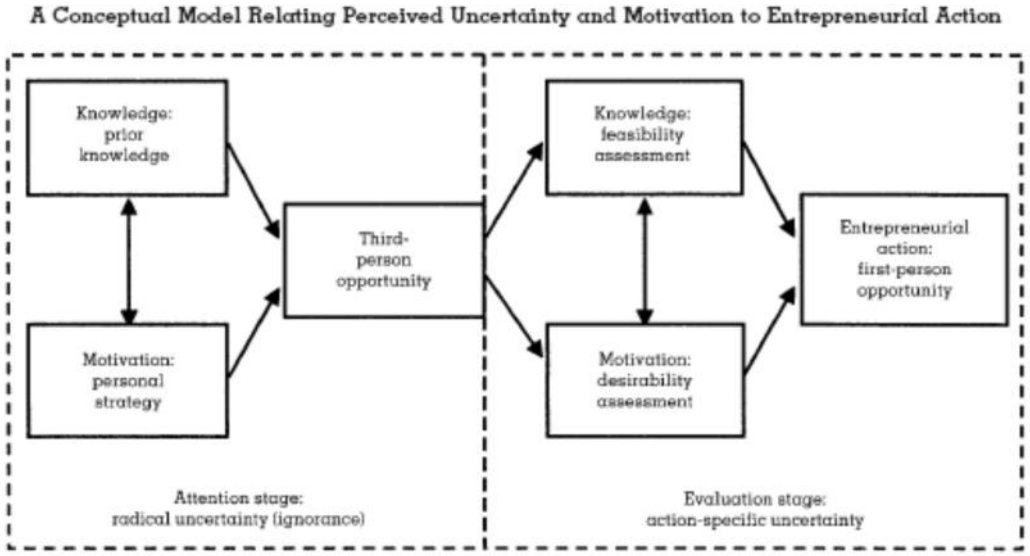

Figure 1 Source: McMullen & Dean, 2006

An entrepreneur has to make sound decisions, and many decisions may have to be made without complete information being available. We need to admit that an entrepreneurial venture is undertaken with considerable risk in the first place and at the beginning stages, there is considerable risk in every decision made; therefore, the entrepreneur has to make decisions that are as far as possible close to the optimal solution (Busenitz & Alvarez, 2001). The experience and knowledge of the entrepreneur play a vital role in ensuring that the decisions are oriented correctly. An entrepreneur has to be able to develop thumb rules or heuristics based on his experience and knowledge to arrive at decisions quickly. These heuristics help the entrepreneur arrive at the best optimal solutions. The capability of the entrepreneur to take risks and cover those risks with optimal decisions creates an effective and successful entrepreneurial business venture. It needs to be noted that the emphasis is on finding the optimal solution and not the right solution. Therefore, it is implied that the entrepreneur is still taking risk with an optimal solution too. The knowledge of the entrepreneur and the tools employed play a crucial role in the success of the venture. The right opportunity will be wasted through wrong decisions made with incomplete knowledge and the wrong tools.

2 ENTREPRENEURS: WHO ARE THEY?

Entrepreneurs are often innovators and inventors who have core domain knowledge in the business they are entering. While, they will form the technological nucleus of the venture for quite some time, the ability of the entrepreneur to manage the resources and manpower in his control are crucial. In other words, an entrepreneur has to build an organisation and its manpower to create a growing and successful business that is scalable, adaptive and vibrant. In this context, it needs to be noted that we live in a knowledge economy, where the resource, perhaps the most valuable resource, for any organisation lies in the cognitive capabilities of its employees (Foss, 2001; Gibb, 1997). Sometimes, it may seem that employees hold most of the knowledge that is needed as input for running a business. There is more bargaining power of employees now than ever before, and there is a breakdown in authority as we have known it in traditional business concerns (Foss, 2001). Managerial capability is equally important as technological superiority.

Large organisation engage with employees for leveraging their knowledge in the form of incentives, stock options, diverse exposure and engaged culture and promising career growth potential. These measures are intended to ensure that knowledge developed within the organisation remains with the organisation as much as possible. Entrepreneurs have to adopt a similar mindset, where they will have to reward employees with incentives and design innovative pay packages to ensure that the knowledge of the firm is not lost due to attrition (Foss, 2001).

Entrepreneurial ventures are often accused of being one-man shows, where the founders tend to drown out the talented employees and may not be able to provide stable and challenging work environment (Merrilees et al. 2011). How entrepreneurs apply their authority should change for positive organisational development through engagement and participative management. When an employee is trained ad capable of doing the job, then it is pointless to monitor him. At this stage, regular checks on progress and behavioural monitoring are enough. Only when it is too costly to train an employee and if the entrepreneur has the knowledge should the entrepreneur engage himself with operational responsibilities (Foss, 2001).

3 CONCLUSION

While entrepreneurs are the risk takers and the domain experts when they start a business, there is anteed for entrepreneurs to attain managerial excellence for developing an organisation. Building an organisation takes more than just risk taking, and entrepreneurs need to plan for the growth of the organisation by wielding authority wisely and developing the human resources. He has to build competence through the employees. While the core competence may be the original idea by the entrepreneur, a continuous supply of innovative ideas and projects will be needed to sustain initial breakthroughs, and this will be possible only through motivated and committed employees.

REFERENCES

[1] Andersson, D.E. (2005) 'The Spatial Nature of Entrepreneurship', *the Quarterly Journal of Austrian Economics*, 8(2), pp. 21-34.

[2] Merrilees, B., Rundle-Thiele, S., & Lye, A. (2011) 'Marketing capabilities: Antecedents and implications for B2B SME performance', *Industrial Marketing Management*, *40*(3), pp.368-375.

[3] McMullen, S.J. & Dean, A.S. 'Entrepreneurial action and the role of uncertainty in the theory of the Entrepreneur', *Academy of Management Review,* 31(1), pp.132-152.

[4] Knight, G. (2000) 'Entrepreneurship & marketing strategy: the SME under globalisation', *Journal of International Marketing*, 8(2), pp.12-32.

[5] Kirzner, M.I. (1997) 'Entrepreneurial discovery and the competitive market process: an Austrian approach', *Journal of Economic Literature*, 35(1), pp.60-85.

[6] Klein, G.P. (1999) 'Entrepreneurship & Corporate Governance', *The Quarterly Journal of Austrian Economics*, 2(2), pp.19-42.

[7] Alvarez, A. & Busenitz, W. (2001) 'The entrepreneurship of resource-based theory', *Journal of Management,* 27(1), pp. 755-775

[8] Foss, J.N. (2001) 'Misesian Ownership & Coasian Authority in Hayekian Settings: The Case of the Knowledge Economy', *The Quarterly Journal of Austrian Economics*, 4(4), pp.3-24

[9] Gibb, A.A. (1997) 'Small firms' training & competitiveness: building upon the small organisation as a learning organisation', *International Small Business Journal*, 15, pp.13-29.

[10] Sarasvathy D.K., Herbert, A. Simon & Lave, L. (1998) 'Perceiving and managing business risks: differences between entrepreneurs and bankers', *Journal of Economic Behaviour and Organization,* 33(1), pp. 207-225

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OPTIMISATION GENETIQUE DE LA TRANSFORMATION D'*OCIMUM BASILICUM* PAR *AGROBACTERIUM RHIZOGENES*

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ABSTRACT: Literature reports that roots are source of important compounds possessing pharmaceutical properties. So, we have oriented our work toward the transgenic root establishment of *O. basilicum* obtained from *Agrobacterium rhizogenes,* a natural bacterium of the soil responsible for the formation of the "hairy root". This genetic transformation was achieved from the leaves and segments of stems allowed to initiate of abundant roots, displaying the typical characteristics of the hairy root syndrome, as a rapid growth on solid and in liquid media without hormones. The root initiation seems to arise from the target cells near to the inner and outer phloem after mother plant infection**.** A bacterial inoculation at the central nervure level of the leaves led to an efficient and original protocol of transformation. Indeed numerous transgenic root clones, from *Ocimum* explants, could be obtained.
Finally, the transformed state of the roots was confirmed by molecular analysis showing the obvious integration of the genes *rol* of *A. rhizogenes* responsible of the "hairy root" phenotype.

KEYWORDS: *Ocimum basilicum,* genetic transformation, *Agrobacterium rhizogenes,* hairy root, secondary metabolites.

RESUME: Les racines sont d'importantes sources de composés d'intérêt pharmaceutique surtout lorsqu'ils sont produits dans les cellules de ces organes. Ainsi, avons-nous orienté nos travaux vers la transformation génétique d'*O.basilicum, via* la bactérie naturelle du sol, *Agrobacterium rhizogenes,* responsable de la formation de ces hairy root. La transformation génétique réalisée à partir de feuilles et de segments de tiges a permis le développement d'abondantes racines, au phénotype caractéristique du « hairy root », sur milieu solide et en milieu liquide. La formation de telles racines prend naissance à partir de cellules cibles, voisines des tubes criblés de l'explant infecté. L'inoculation bactérienne au niveau de la nervure centrale des feuilles est très efficace et constitue un protocole tout à fait original. Cette transformation conduit à des pourcentages élevés de racines et nettement plus rapide.
Enfin, l'état transformé des racines est vérifié par des analyses moléculaires confirmant que les clones ont intégré certains gènes *rol* d'*A. rhizogenes* responsables de l'induction du phénotype « hairy root ».

MOTS-CLEFS: *Ocimum basilicum*, transformation génétique, *Agrobacterium rhizogenes*, hairy root, métabolites secondaires.

1 INTRODUCTION

Ocimum basilicum L., est une plante médicinale qui appartient à la famille des Lamiaceae et répandue en zone tropicale humide. *O.basilicum* dont toutes les parties sont utilisées en thérapie traditionnelle pour traiter un grand nombre de maladies comme des infections respiratoires, la diarrhée, les maux de tête, la fièvre, les maux d'yeux et les infections cutanées. L'extrait de la plante possède des activités antimicrobiennes [1] ; des activités antibactériennes [2] antifungiques [3] ; antipaludéennes [4] et anti-protozoaires [5]. Elle est utilisée comme vermifuge en raison de ces propriétés

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antihelminthiques. Cette plante est également utilisée contre la dysenterie et les maux de dents. La décoction des feuilles est recommandée dans les affections de l'estomac et aussi comme fébrifuge. Enfin, cette décoction agit sur les vers intestinaux, quel que soit leur stade de développement. Le jus des feuilles écrasées dans un peu d'eau est prescrit en instillations nasales ou auriculaires lors de céphalées, d'otites et de sinusites. Une préparation associant les fleurs, les feuilles et fruits avec de l'huile est recommandée dans certaines affections rhumatismales. Par ailleurs, cette plante est utilisée contre les ulcères, les tumeurs et également utiliser pour fortifier le système nerveux. Les cendres des racines servent à soigner certaines dermatoses. En plus, *O. basilicum* possède aussi des propriétés insecticides dues à la présence d'huiles essentielles. Traditionnellement elle est utilisée pour éloigner les termites et les fourmis à cause de son odeur qu'elle dégage. Les composés actifs extraits sont présents sous forme de molécules aromatiques volatiles issues d'une huile extraite des feuilles et sont composés essentiellement de thymol (32-65%) et d'eugénols [6]. Elle contient également des anthocyanes, des terpènes et des lactones [7]. Cette transformation nous permet d'amplifier la production de métabolites secondaires par la plante ce qui permettrait aux malades de se soigner à moindre coût.

2 MATERIEL ET METHODES

MATÉRIEL VÉGÉTAL

Des plants d'*Ocimum basilicum* cultivés dans le phytotron du laboratoire de Biologie moléculaire et Biochimie végétale (Faculté des Sciences Pharmaceutiques – Université François Rabelais – Tours) ont été utilisés. Ces plants sont issus du Laboratoire de Physiologie et de Biotechnologie Végétales (Faculté des Sciences- Université de Lomé). Des segments de tige et des feuilles entières ont été utilisés pour les expériences de transformation génétique.

SOUCHE D'AGROBACTERIUM RHIZOGENES

La transformation génétique est réalisée avec la souche sauvage 15834 d'*Agrobacterium rhizogenes*. Les agrobactéries sont entretenues sur le milieu solide YEM (Yeast Extrait-Manitol) pendant un mois à 4°C. Avant de réaliser l'infection des explants, elles sont subcultivées sur le même milieu solide pendant 48 heures à une température de 27°C.

METHODES

DESINFECTION DES EXPLANTS

Les fragments de tiges et les feuilles prélevés sur des plants cultivés au phytotron sont débarrassés de tous les microorganismes susceptibles de contaminer le milieu de culture. Avant de procéder à la désinfection de ces explants, les extrémités des fragments de tiges et du pétiole des feuilles sont obturées avec de la cire en surfusion. Les opérations de désinfection s'effectuent par trempage des explants dans différentes solutions sous agitation, suivant le protocole présenté dans le *tableau 1* ci-dessous.

***Tableau 1*: Méthode de désinfection des explants d'O.basilicum**

Opérations	Produits utilisés	Durée
Lavage après obturation	Eau savonneuse	2 minutes
Rinçage	Eau du robinet	2 minutes
Trempage	Ethanol 70% (v/v)	1 minute
Rinçage	Eau stérile	1 minute
Trempage	Hypochlorite de calcium 7% (v/v)	5 minutes
Rinçage (x 3)	Eau stérile	2 minutes/rinçage

Toutes les solutions de désinfection renferment une goutte de Tween 80 stérile, un agent mouillant, qui assure un meilleur contact entre la surface des explants et les produits chimiques utilisés. Les explants sont séchés après rinçage, à l'aide de papier absorbant stérile. Les opérations de désinfection s'effectuent sous une hotte à flux laminaire vertical.

INFECTION DES EXPLANTS PAR UNE SOUCHE SAUVAGE D'*AGROBACTERIUM RHIZOGENES*

L'infection des explants est réalisée à l'aide d'une culture d'*A.rhizogenes* « 15834 » âgées de 48 heures. Ainsi, on prélève avec la pointe d'une lame stérile de scalpel, une petite colonie bactérienne que l'on introduit dans une blessure effectuée au scalpel au niveau de la nervure principale d'une feuille ou le long d'un segment de tige. Pour des explants constitués de tiges feuillées de vitroplants, l'infection se pratique à l'aide d'une aiguille stérile. Les explants témoins sont blessés mais non infectés. Ensuite les échantillons sont placés dans des boîtes de Pétri (90 mm de diamètre) sur le milieu de [8] ou milieu MS solide supplémenté de 30g.L^{-1} de saccharose et de vitamines B5. Le pH du milieu de culture est ajusté à 5,7 avant autoclavage à 121 °C pendant 20 minutes.

Les co-cultures sont effectuées pendant 48 heures à 28°C. Les explants sont ensuite transférés sur le même milieu minéral et vitaminé de base, dilué au demi et additionné de 1g.L^{-1} de céfotaxime pour pallier toute récurrence bactérienne ultérieure. Toutes les cultures sont ensuite stockées dans une pièce à 24 ± 1°C avec une photopériode de 12h.

Selon le type d'expérience, en moyenne une trentaine d'explants sont utilisés pour l'étude.

ISOLEMENT DES CLONES DE « HAIRY ROOT »

De courtes racines apparaissent au site de blessure, puis sont excisées et mises en culture sur un milieu solide de composition identique au précédent. Les clones qui présentent une bonne croissance sont sélectionnés pour être transférés en culture liquide.

CULTURE EN MILIEU LIQUIDE

Pour initier la culture en milieu liquide des clones sont sélectionnés à partir de segments de tige et de feuilles. Dix pointes racinaires de 2 cm environ, prélevées sur chaque clone sont mises en culture dans des Erlenmeyers de 250 mL, contenant 50 mL de milieu liquide MS additionné de vitamines B5 et de saccharose à 30 g/L. Les cultures sont maintenues à l'obscurité, à la température de 24 ± 1°C et sous agitation à 100 rpm. Après trois semaines de culture le poids de la matière fraîche de chacun des clones est déterminé.

EFFET DE DIFFERENTES CONCENTRATIONS DE SACCHAROSE SUR LA PRODUCTION DE BIOMASSE

Une expérience est réalisée à partir d'un clone sélectionné après trois passages en milieu liquide. Des racines sont introduites dans le milieu MS additionné de vitamines B5 et de saccharose à différentes concentrations : 20 ; 30 ; 40 ; 50 g/L. Les cultures sont maintenues à l'obscurité à la température de 24 ± 1°C et sous agitation à 100 rpm. Chaque condition expérimentale est répétée 3 fois. A la fin de deux semaines de cultures le poids des matières fraîche et sèche est déterminé.

EXTRACTION DE L'ADN GENOMIQUE

L'ADN génomique est extrait à partir de 400 à 500 mg de tissus végétaux. Chaque échantillon d'un clone de « hairy root » est congélé à – 85 °C est broyé dans l'azote liquide. Cette extraction est réalisée à l'aide du kit « Dneasy Plant Minikit » de Qiagen® selon les instructions du fabricant.

La concentration de l'échantillon est déterminée à partir d'une solution obtenue après dilution de 12 µl d'eluat d'ADN dans 288 µL d'eau milliQ® stérile, par mesures de l'absorbance qui sont faites au spectrophotomètre à 260 et 280 nm (1 unité d'absorbance correspond à 50 µg/mL d'ADN). Le rapport des absorbances 260/280 renseigne sur la pureté de l'ADN extrait.

AMPLIFICATION PAR PCR

La PCR, ou réaction de polymérisation en chaîne, est une méthode qui permet l'amplification en chaîne de fragments d'ADN dont on connaît, en partie, la séquence nucléotidique indispensable pour la détermination des amorces. Cette réaction d'amplification comprend une étape de pré-dénaturation de l'ADN à 94°C pendant 2 minutes, puis 35-40 cycles PCR suivis d'une étape d'élongation finale de 7 minutes à 72°C.

Chaque réaction PCR comprend : X µL d'ADN, 0,5 µL de chaque amorce (10 µM), 0,5 µL de dNTP (10mM), 0,25 µL de Taq polymérase, 2,5 mL de Tampon buffer 10x, 1,5 mL de $MgCl_2$ (25mM) pour un volume final de 25 µL. Les réactions d'amplification sont effectuées dans un thermocycleur (iCycler™, Bio-Rad®) programmé pour 40 cyles PCR.

Les amorces utilisées sont spécifiques des gènes *rol* A, *rol* B, *rol* C et du gène *vir* D *(tableau2)*

Tableau 2: Séquences des amorces oligonucléotidiques utilisées au cours des expériences de PCR

Gène	*Amorce 1 (sens)*	*Amorce 2 (antisens)*	*Taille du fragment ADN amplifié*
rol A	CAGAATGGAATTAGCCGGACTA	TTAATCCCGTAGGTTTGTTTCG	307pb
Rol B	ATGGATCCCAAATTGCTATTCC	GTTTACTGCAGCAGGCTTCATG	762pb
Rol C	ATGGCTGAAGACGACCTGTGT	GCCGATTGCAAACTTGCACTC	539pb
Rol D	ATGTCGCAAGGCAGTAAGCCCA	GGAGACTTTCAGCATGGAA	437pb

ANALYSE ÉLECTROPHORÉTIQUE DES ADN

La détermination de la taille, de la quantité et de la pureté d'un fragment d'ADN, ainsi que la séparation de plusieurs ADN s'effectuent par électrophorèse sur gel d'agarose à 1,5 % (m/v). Le gel est préparé à l'aide d'un tampon TAE 0,5X (Tris acétate 40mM, EDTA 1mM) et contient 0,4 μg mL^{-1} de BET (bromure d'ethidium), un agent intercalant des bases de l'ADN, qui permet la visualisation des bandes attendues (0,375 g d'agarose, 25 mL de TAE 0,5X, 1 μL de BET). Les produits de PCR sont additionnés d'un tampon de charge B.O 6X (bleu orange) dont le volume représente $1/10^{ème}$ de celui des produits. La migration se déroule dans le tampon TAE 0,5X pendant 1h environ à 50 $V.cm^{-1}$. La taille de l'ADN est déterminée après comparaison avec des marqueurs de taille 100pb DNA ladder (Promega).

3 RESULTATS

FORMATION DE RACINES TRANSGENIQUES A PARTIR DE FEUILLES ET DE FRAGMENTS DE TIGE D'*OCIMUM*

DEVELOPPEMENT DES RACINES

Des feuilles bien développées et des segments de tiges d'*Ocimum basilicum* sont infectés par la souche sauvage 15834 d'*Agrobacterium rhizogenes.* Les bactéries sont cocultivées avec les explants sur le milieu solide MS à 27 °C et à l'obscurité pendant 48 heures, période de compétence des bactéries nécessaire pour transformer le génome végétal. Après ce laps de temps les explants sont transférés sur le milieu solide MS dilué de moitié et additionné de cefotaxime, puis stockés dans la chambre de culture.

Une semaine après l'inoculation, un cal blanc apparaît au site de blessure sur la nervure centrale, à partir duquel des racines se développent (*Fig.1*).

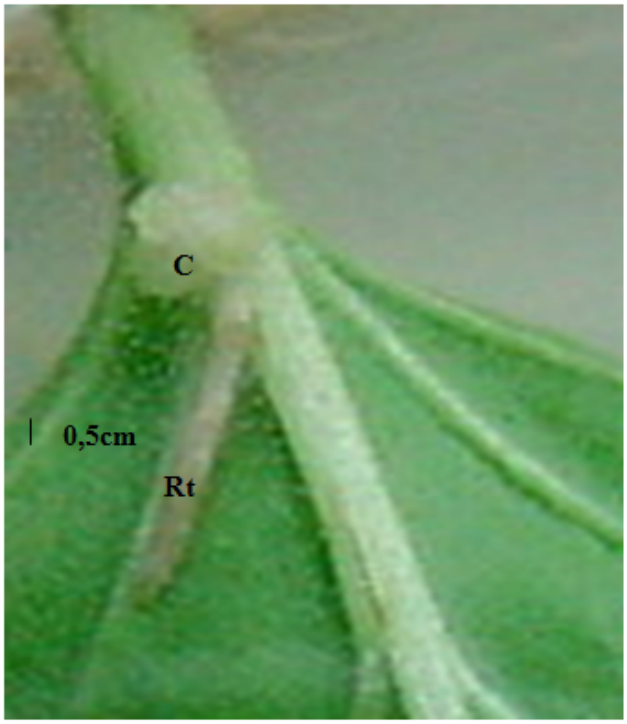

Fig. 1. Formation de racines transgéniques (Rt) à partir d'une feuille d'O. basilicum infectée par la souche sauvage 15834 d'Agrobacterium rhizogenes après production de cal (C) au site d'inoculation

Au bout de 1 à 2 semaines de culture les premières racines apparaissent au site de blessure des feuilles et présentent les caractéristiques du phénotype hairy root : absence de géotropisme et présence des ramifications latérales recouvertes de nombreux poils absorbants. Ces ramifications secondaires ou « branching » sont de plusieurs ordres*(Fig.2).* Enfin, une croissance autotrophe aux régulateurs de croissance montre le caractère transformé de ces organes.

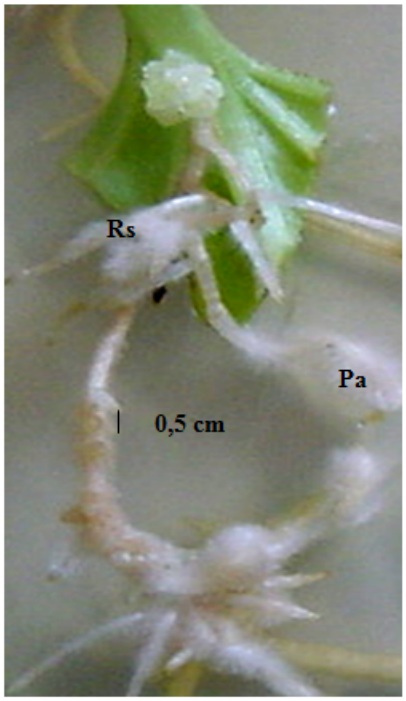

Fig. 2. Formation de racines secondaires (Rs) couvertes de poils absorbants (Pa)

Au niveau des segments de tiges, l'apparition des racines n'est pas précédée par une formation de cal au site de blessure. Ces racines présentent les mêmes caractéristiques morphologiques et physiologiques, typiques du hairy root que celles des feuilles (*Fig.3).*

Fig. 3. Développement de racines transgéniques (Rt) d'Ocimum basilicum à partir de segments de tiges. Formation des racines secondaires (Rs) et des poils absorbants (Pa)

DETERMINATION DU POURCENTAGE DE TRANSFORMATION

Dès l'apparition des racines sur les explants, nous évaluons le pourcentage de transformation des racines en tenant compte du phénotype comme il est porté au *Tableau 3* ci-dessous.

Tableau 3 : Pourcentage d'explants d'Ocimum basilicum aptes à initier des racines putativement transformées après deux semaines de culture

Jours après inoculation bactérienne	Pourcentage de transformation (%)		
	Témoins	Segments de tige traités	Feuilles traitées
7	0	62	64
14	0	85	90

-Pourcentage sur 20 explants

Les pourcentages de transformation, observés à partir de la première semaine suivant l'infection bactérienne, sont évalués à 64 % pour les feuilles et 62 % pour les segments de tiges. Ces valeurs passent dès la deuxième semaine respectivement à 90 % et 85 % pour les feuilles et les segments de tiges (Tableau 3).

Ces valeurs élevées montrent une bonne sensibilité du modèle *Ocimum basilicum* à la souche d'agrobactéries choisie.

ETABLISSEMENT DES CLONES DE « HAIRY ROOT »

DEVELOPPEMENT SUR MILIEU SOLIDE

Lorsque les racines, toujours connectées au site de blessure de l'explant, atteignent une longueur de 0,5 à 1 cm, elles sont excisées et transférées individuellement dans une boîte de Pétri contenant le milieu solide MS additionné de 30 g/L de saccharose, de vitamines B5 et de 1 g /L de cefotaxime, pour l'établissement de clones de « hairy root ». Chaque racine est induite spécifiquement par une bactérie, par conséquent, chacune des racines initiées au site de blessure d'un même explant conduit à des clones de « hairy root » différents. En effet, chacun de ces clones est le produit de l'expression des gènes bactériens intégrés dans le génome d'une cellule-hôte. Il faut rappeler que dans le cas des souches dites hypervirulentes, le transfert de l'ADN-TR et de l'ADN-TL est découplé et que, d'autre part, le transfert de chacun de ces segments d'ADN-T peut-être lui-même incomplet.

Quatre semaines après la mise en culture, les clones de racines en se développant présentent des caractéristiques très marquées du phénotype « hairy root ». Leur croissance est rapide sur milieu MS privé de régulateurs de croissance. De plus,

ces racines produisent de nombreuses ramifications ou « branching d'ordre 1, 2, 3 » caractérisées par une absence totale de géotropisme *(Figs. 4 a, b).*

La culture en milieu liquide de ces clones est possible après une production suffisante de biomasse de « hairy root » sur milieu solide.

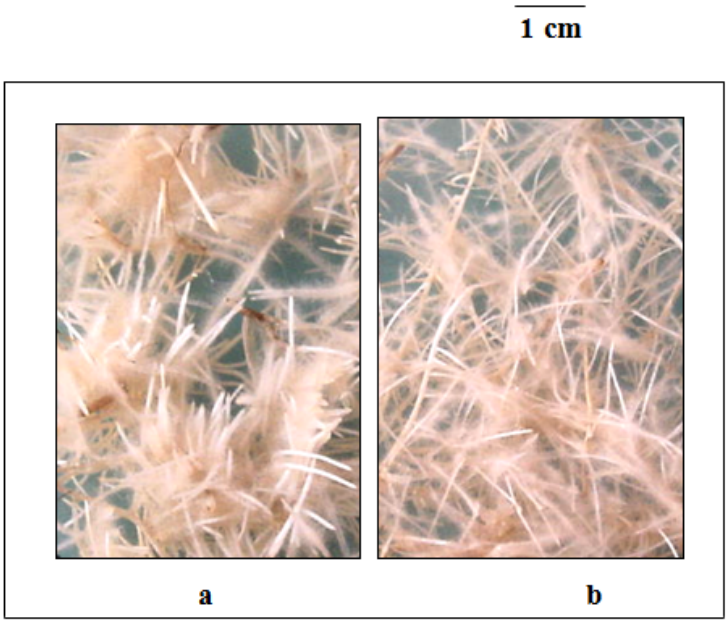

Fig. 4. Après quatre semaines de culture, développement de racines transgéniques d'Ocimum basilicum; à partir d'explants de feuilles (a) et de segments de tiges (b) sur milieu solide

DEVELOPPEMENT EN MILIEU LIQUIDE

Dix pointes de racines de 2 cm, prélevées à partir de chaque clone provenant de la culture en milieu solide sont introduites dans 50 mL de milieu liquide MS additionné de vitamines B5. Ainsi, plusieurs clones sont sélectionnés sur milieu solide, les clones 1, 2X, 7 provenant de segments de tiges et les clones 3, 3C, et 6 originaires de feuilles. La culture en milieu liquide agité conduit généralement à une croissance rapide et à une production de biomasse importante. Après dix jours, les clones présentent de nombreuses ramifications qui s'entremêlent en se développant. Quatre semaines plus tard, le poids de matière fraîche produite par chacun des clones, est compris entre 17,15 et 23,06 g. La biomasse des clones 1, 3C et 7 est légèrement supérieure à celle des autres clones (Figures. 5 a, b, c) et le poids de matière sèche par ces clones est respectivement de 0,65 ; 0,73 et 0,64 g. Nous pouvons conclure, au vu des présents résultats, que le transfert des racines *d'Ocimum* du milieu solide en milieu liquide est donc possible. Ce transfert constitue généralement une étape critique à franchir avant de parvenir à l'établissement du « hairy root » en culture liquide. Le milieu liquide MS utilisé est, semble-t-il, favorable à la culture du « hairy root » d'*O.basilicum,* car il génère une croissance rapide des racines.

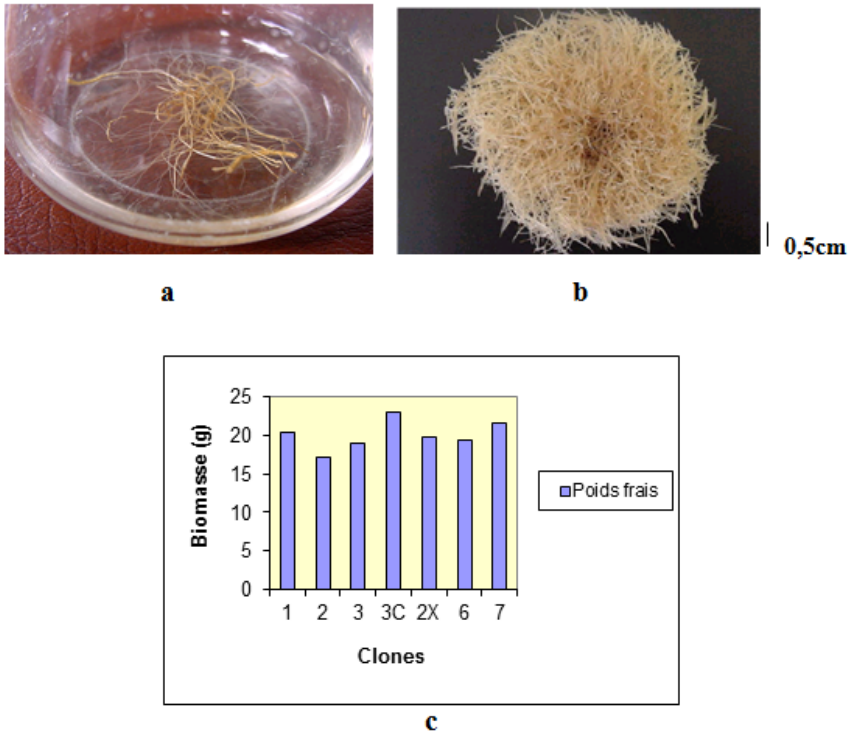

Fig. 5. (a) Croissance de racines transgéniques d'O. basilicum en milieu liquide MS. (b) Racines transgéniques très ramifiées après dix jours de culture en milieu liquide. (c) Biomasse de sept clones de racines après quatre semaines de culture en milieu liquide

EFFET DU SACCHAROSE A DIFFERENTES CONCENTRATIONS SUR LA BIOMASSE

Les racines présentant un phénotype « hairy root » sont capables de croître sans apport exogène de phytohormones dans le milieu, mais demeurent cependant hétérotrophes au carbone, en raison de l'absence de l'assimilation chlorophyllienne. Il faut donc ajouter des glucides au milieu de culture. La concentration optimale en saccharose ou autres glucides pour la croissance de chaque espèce de « hairy root » reste à déterminer.

Trois subcultures, chacune d'une durée de 10 à15 jours, sont nécessaires comme laps de temps de passage pour établir des clones de « hairy root » en milieu liquide, mais également pour tester l'efficacité d'un nutriment dans un milieu donné. Dans la présente expérimentation, l'effet du saccharose est vérifié à partir du clone 1 choisi parmi l'ensemble de clones cultivés en vue de leur établissement. Différentes concentrations en saccharose (20, 30, 40, 50 g/L) sont additionnées au milieu de culture de ce clone, afin de déterminer la concentration conduisant à une production optimale de biomasse.

Après dix jours de culture, la biomasse des racines du clone1, cultivé en présence de différentes teneurs en saccharose, augmente proportionnellement avec la concentration de ce glucide pour atteindre une valeur maximale à 40 g/L. Au-delà de ce seuil, elle diminue. Les analyses statistiques révèlent une différence significative entre l'effet des concentrations en saccharose et la biomasse des racines du clone 1. Le test de Newman-Keuls réalisé au seuil de 5 % classe le saccharose à 40 g/L comme étant la concentration qui donne les meilleures moyennes. En proportion, on observe une production plus importante de matière sèche toujours à cette concentration comme l'indiquent les résultats portés au *Tableau 4.*

Tableau 4 : Effet du saccharose sur la production de biomasse du clone 1 après 10 jours de culture en milieu liquide MS. Comparaison des moyennes entre lignes d'après le test de Newman-Keuls au seuil de 5 %

Biomasse (gr)	Saccharose ($g.L^{-1}$)			
	20	**30**	**40**	**50**
MF	2.67b ± 0.55	5.15ab ± 0.6	7.29a ± 0.55	6.04ab ± 0.2
MS	0.15b ± 0.03	0.31ab ± 0.04	0.49a ± 0.04	0.40a ± 0.02
MS/MF	0.056	0.060	0.067	0.066

Moyenne ± se sur 5 répétitions

ANALYSES MOLECULAIRES DES RACINES TRANSFORMEES

DETERMINATION DE LA CONCENTRATION EN ADN TOTAL DES EXTRAITS

Pour vérifier l'intégration des gènes *rol* dans le génome végétal et confirmer la transformation génétique des racines, l'ADN total de clones de « hairy root » d'*O. basilicum* est extrait de cellules à l'aide d'un kit (*Dneasy Plant Minikit – Qiagen – Allemagne*). Ainsi la concentration en ADN total est détermnée à partir d'échantillons de « hairy root » correspondant aux clones 1, 2X, 3C, 3, 6, 7, choisis parmi les plus performants quant à leur croissance. La concentration d'ADN total pour chacun des clones varie de 15 à 85 $\mu g.mL^{-1}$ (ou 15 à 85 ng μL^{-1}) et le degré de pureté est compris entre 0.6 et 2.0 (*Tableau 5*).

Tableau 5 : Concentration en ADN total des échantillons de « Hairy root »

Clones	[ADN] ($\mu g.ml^{-1}$)	Degré de pureté
1	67.5	1.4
2X	48.75	1.6
3C	15	2.0
3	85	1.3
6	28.75	0.6
7	26.75	0.6

ABSENCE DE CONTAMINATION BACTERIENNE DANS LES RACINES TRANSGENIQUES

L'absence d'agrobactéries à l'intérieur des cellules de « hairy root » d'*Ocimum basilicum*, est vérifiée par une réaction PCR des ADN extraits de racines en présence d'amorces du gène *vir*-D1. Sachant que les gènes de virulence ne sont jamais transférés dans le génome des cellules, les bactéries de souche sauvage 15834 sont utilisées comme un témoin positif. Il en résulte qu'un seul fragment d'ADN de 437 pb correspondant au gène *vir D1*est amplifié uniquement à partir de l'échantillon bactérien *(Fig. 6).*

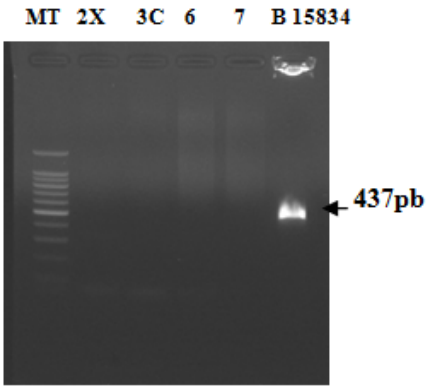

Fig. 6. Analyse des produits PCR obtenus en présence d'amorces spécifiques de gènes vir D, des ADN extraits des bactéries d'A rhizogenes (15834), et d'échantillons des racines transformées des clones (2X, 3C, 6, 7) après electrophorèse sur gel d'agarose MT: marqueur de taille 100 pb (Promega)

VERIFICATION DE L'INTEGRATION DES GENES *ROL* DANS LE « HAIRY ROOT » D'*OCIMUM BASILICUM*

L'intégration des gènes *rol* dans les cellules de racines transformées des clones d'*Ocimum basilicum* est confirmée par analyses PCR en utilisant les amorces correspondant aux séquences des gènes *rol* A, B et C. Ainsi, l'électrophorégramme montre des bandes attendues de 307 pb correspondant au gène *rol* A observées à partir des extraits d'ADN des clones 2X, 3C et 6 étudiés. Une bande similaire est amplifiée à partir de l'ADN bactérien d'*A. rhizogenes* 15834 prise comme témoin positif. Celle-ci est absente sur ce gel dans les extraits du clone 7 *(Fig.7).*

Concernant le gène *rol* B, l'ADN extrait des racines montre une amplification des séquences de ce gène. Des bandes très nettes de 762 pb, sont observées à partir des extraits d'ADN des racines appartenant à trois clones. L'ADN extrait du clone 7 conduit à une très faible amplification d'une bande de 762 pb peu perceptible sur la figure *(Fig.8).*

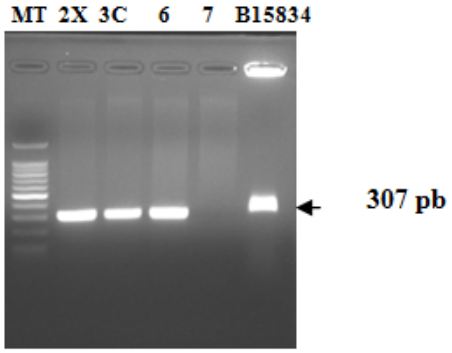

Fig. 7. Analyse des produits PCR obtenus en présence d'amorces spécifiques de gènes rol A, des ADN extraits des bactéries d'A rhizogenes (15834), et d'échantillons des racines transformées des clones (2X, 3C, 6, 7) après electrophorèse sur gel d'agarose MT: marqueur de taille 100 pb (Promega)

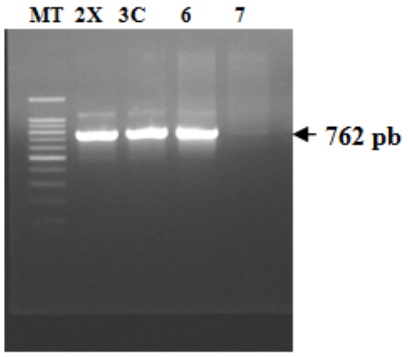

Fig. 8. Analyse des produits PCR obtenus en présence d'amorces spécifiques de gènes rol B, des ADN extraits d'échantillons des racines transformées des clones (2X, 3C, 6, 7) après electrophorèse sur gel d'agarose MT: marqueur de taille 100 pb (Promega)

L'intégration du gène *rol* C est vérifiée également par PCR en utilisant les amorces spécifiques de ce gène. Comme précédemment la souche d'*A. rhizogenes* sert de témoin positif. On observe uniquement la présence d'une bande de 539 pb à partir des extraits des racines du clone 2X. Aucune amplification correspondant à ce gène n'apparaît pour les extraits des autres clones. La même bande est amplifiée à partir de l'ADN de la bactérie d'*A. rhizogenes* 15834 (Fig. 9).

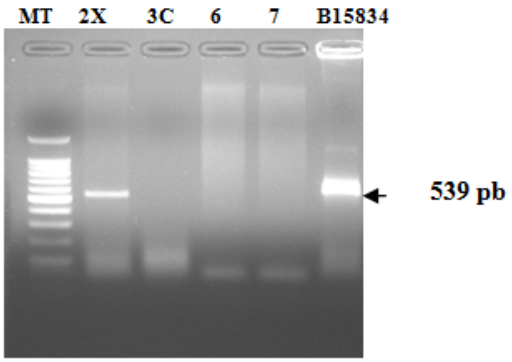

Fig. 9. Analyse des produits PCR obtenus en présence d'amorces spécifiques de gènes rolC, des ADN extraits des bactéries d'A rhizogenes (15834), et d'échantillons des racines transformées des clones (2X, 3C, 6, 7) après electrophorèse sur gel d'agarose MT: marqueur de taille 100 pb (Promega)

La transformation génétique est donc démontrée par l'intégration totale ou partielle des gènes *rol* A, B et C dans les racines des différents clones de « hairy root » d'*O. basilicum* étudiés.

4 DISCUSSION

La transformation génétique d'*O. basilicum,* après infection par les bactéries d'*A. rhizogenes* de la souche 15834, est possible à partir des deux types d'explants étudiés. Dès la première semaine après inoculation, la formation des racines adventives est directement obtenue à partir des cellules-cibles de l'explant infecté. Quelques semaines après la mise en culture de fragments de racines isolées sur le milieu solide, des clones se développent rapidement et présentent toutes des caractéristiques du phénotype « hairy root » : croissance sans régulateurs, absence de géotropisme, nombreuses ramifications et présence de poils absorbants. Le protocole préconisant l'inoculation bactérienne au niveau de la nervure centrale est efficace car les bactéries peuvent atteindre rapidement les cellules cibles. Malgré cette action très virulente sur les cellules-cibles des explants d'*Ocimum basilicum*, la souche d'*Agrobacterium rhizogenes* 15834, ne semble pas présenter la même efficacité sur les cellules-cibles d'*Ocimum gratissimum.* Cette inefficacité pourrait en partie résulter des propriétés antimicrobiennnes et antivirales de la plante comme il a été rapporté par certains auteurs ([9] et [10]). Cependant, les deux explants d'*O. basilicum* conduisent néanmoins à des pourcentages élevés de transformation, en effet 90 % de feuilles et 80 % de tiges développent des racines deux semaines environ après l'infection.

La littérature montre que l'efficacité de « l'agroinfection » dépend du choix de l'espèce végétale, du génotype de la plante et de la souche bactérienne testée. En présence de la souche A4 d'*A.rhizogenes* et de disques foliaires, des pourcentages de transformation élevés chez *Nicotiana tabacum* (98%) et beaucoup plus faible chez *Datura metel* (34%) ont été rapportés [11]. Des pourcentages plus ou moins importants ont été obtenus pour certains génotypes de peuplier [12].

Le transfert des clones de racines d'*Ocimum basilicum* en milieu liquide MS agité conduit à une croissance rapide et à une production importante de biomasse. Après quatre semaines, le poids de matière sèche est respectivement de 0,65 ; 0,73 et 0,64 g pour les clones 1, 3C et 7. Nos résultats rejoignent ceux de [13] qui ont montré dans des conditions expérimentales similaires, que la biomasse maximum des racines en milieu liquide WPM était de 0,70 g après six semaines de culture. Ces auteurs ont utilisé comme explants de départ des vitroplants obtenus après germination *in vitro* d'*O .basilicum*.

Les cultures de « hairy root », capables d'assurer leur croissance sans apport de régulateurs de croissance n'en demeurent pas moins hétérotrophes au carbone. Une croissance optimale des racines d'*O .basilicum* est observée chez le clone 1, en présence d'une concentration de 40 g/L de saccharose. D'après [13], d'une manière générale, les concentrations nécessaires à ce disaccharide pour assurer une bonne croissance des racines varient de 20 à 30 g/L . L'apport de glucides n'a pas que pour but d'optimaliser la croissance des tissus, il peut également orienter l'organogénèse [14].

Les analyses moléculaires confirment par intégration génomique des gènes *rol* A, B, et C, l'état transformé des clones d'*O.basilicum*. Bien que l'intégration de ces gènes soit démontrée seulement pour le clone 2X, le gène *rol* A est obligatoirement intégré dans le génome de tous nos clones sélectionnés, comme l'indique la présence de la bande de 762 pb, (gène *rol B*) détectée dans ces quatre clones. Par contre, l'absence du gène *rol* C peut être consécutive à un transfert incomplet de l'ADN-T dans le génome de la cellule végétale.

L'absence de ce gène chez trois des quatre clones ne remet pas en cause la formation et le bon développement d'un « hairy root ». En effet, il a été démontré que le transfert et l'expression d'un gène *rol* A ou C, est capable de développer un « hairy root » chez certaines espèces végétales comme *Populus tremula* [15]. Néanmoins, chez certaines espèces, la transformation est plus délicate et l'action du gène *rol* B plus prépondérante. [16] et [17] ont souligné le rôle morphogène de ce gène et son implication majeure dans la formation de méristèmes racinaires. Quant aux gènes *rol* A et *rol* C, travaillant en synergie avec le gène *rol* B, ils sont connus pour promouvoir la croissance des racines et sont massivement exprimés lors de l'élongation de ces organes [18]. L'intégration des gènes *rol* A et B est donc suffisante pour induire la rhizogénèse à partir des cellules transformées d'*O.basilicum*, du moins à partir des génotypes utilisés dans le présent travail.

5 CONCLUSION

Cette étude nous a permis d'obtenir la transformation rapide et efficace des racines d'*O. basilicum,* source de production de métabolites secondaires par la plante ce qui constitue un palliatif pour les soins thérapeutiques et permettrait aussi aux malades de se soigner à moindre coût.

REFERENCES

[1] Adebolu TT, Oladimeji S A, 2005, Antimicrobial activity of leaf extracts of *Ocimum gratissimum* on selected diarrhoea causing bacteria in southwestern Nigeria. Afr J. of Biotechnol Vol. 4 (7), pp. 682-684.

[2] Altamura M. M., Capitani F., Gazza L., Capone I., Costantino P. 1994 : The plant oncogene *rol*B stimulates the formation of flower and root meristemoids in tobacco thin cell layers. New Phytol 126: 283-293

[3] Ayisi N., K., Nyadedzor C. 2003 : Comparative *in vitro* effects of AZT and extracts of *Ocimum gratissimum, Ficus polita, Clausena anisata, alchornea cordifolia* and *Elaeophorbia drupifera* against HIV-1 and HIV-2 infections. Antiviral Research 58 (3): 25-33

[4] Di Cola A., Costantino P., Spano L. 1996 : Cell commitment and *rol*B gene expression in the induction of root differentiation. Plant Cell Tiss. Org. Cult. 46: 203-209

[5] Dubey N.K., Tiwari T.N., Mandin D., Andriamboavonjy H., Chaumont J-P. 2000 : Antifungal properties of *Ocimum gratissimum* essential oil (ethyl cinnamate chemotype). Fitoterapia 71 : 567-569

[6] Ezekwesili CN, Obiora KA, Ugwu OP, (2004). Evaluation of Anti-Diarrhoeal Property of Crude Aqueous Extract of *Ocimum gratissimum* L. (Labiatae) In Rats. Biokemistri 16(2):122-131.

[7] Holetz1 FB, Nakamura TU, Filho BPD, Cortez DAG, Díaz JAM,

[8] Ijaduola G, Anyiwo I, Thomas C,(1980) *Ocimum gratissimum* and blood coagulation. J. of research in Ethinomedian 1:19 – 21.

[9] Jasik J. B., Caricato G. and Mantell S. 1997: Characterisation of morphology and root formation in the model woody perennial shrub *Solanum aviculare* Forst. Expressing *rol*ABC genes of *Agrobacterium rhizogenes*. Plant Sci. 124: 57-68

[10] Kyung-Hwan Han, Gordon M.P., Strauss S.H. 1997: High-frequency transformation of cottonwoods (genus populus) by *Agrobacterium rhizogenes.* Can. J. For. Res. 27: 464-470

[11] Lemos JA, Passos X S, Fernandes OFL, Paula JR, Ferri PH, Souza LKH, Lemos AA, Silva MRR, (2005). Antifungal activity from *Ocimum gratissimum* L. toward Cryptococcus neoformans, Mem Inst Oswaldo Cruz, Rio de Janeiro, Vol. 100(1): 55-58.

[12] Margara J. et Piollat M.-T. 1985 : Evolution de l'aptitude à l'organogénèse *in vitro* à partir des feuilles de *Saintpaulia ionantha* au cours des cultures successives. C. R. Acad. Sc. Paris, t. 301, Série III, no 5 :265-268

[13] Moyano E., Fornalé S., Palazon J., Cusido R.M., Bonfill M., Morales C. et Pinol M. T. 1999 : Effect of *Agrobacterium rhizogenes* T-DNA on alkaloid production in Solanaceae plants. Phytochemistry 52 : 1287-1292

[14] Murashige T, Skoog F, (1962). A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiol. Plant. 15, 473-497

[15] Nakamura CV, Nakamura TU, Bando E, Melo AFN, Cortez DAG, Filho BPD. (1999) Antibacterial Activity of *Ocimum gratissimum* L. Essential Oil, Mem Inst Oswaldo Cruz, Rio de Janeiro, Vol. 94(5): 675-678.

[16] Nilson O., Moritz T., Sandberg B., Olsson O. 1996: Expression of the *Agrobacterium rhizogenes rol*C gene in a Deciduous Forest tree alters growth and development and leads to stem fasciation. Plant Physiol 112: 493-502

[17] Pino JA, Rosado A, Fuestes V, (1996) Composition of the essential oils from the leaves and lowers of *Ocimum gratissimum* L. grown in Cuba. J. of Essential Oil Res. 8:139 – 141

[18] Tada H., Ikeda Y., Omoto T., Shimomura K., Ishimaru K. 1996: Rosmarinic acid and related phenolics in adventitious root cultures of *Ocimum basilicum* L., Plant tissue Culture latters 13 (1): 69-74

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Improvement in the Wear Resistance and Mechanical Properties of Carburized Mild Steel by varying Carburization Temperature and constant Tempering Temperature

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ABSTRACT: The various mechanical and wear properties of alloys and metals are investigated by acknowledging the heat treatment and various carburization processes. In this investigation, the mechanical and wear properties of mild steel carburized were studied at different ranges of temperature i.e. 800, 870 and 940 degree Celsius. The aim of the present study was to analyze the effect of carburization temperatures at different scales and conditions on mechanical and wear properties of carburized mild steel. The above different temperatures were tempered at 500 degree Celsius for half an hour and then subjected for different tests such as hardness test, tensile stress test, abrasive wear test and toughness test. The results after experimental work showed that mechanical and wear properties are improved and these properties increase with increase in the carburization temperature. It was analyzed from experimental calculations through proper investigations that the toughness property decreased with the increase in the carburization temperature. So, 940 degree Celsius is best suited for mechanical and wear properties of mild steel because it gives highest tensile strength, hardness and wear resistance. It can be concluded from the experimental results of the present study that hardness, tensile strength and wear resistance of the mild steels can be improved by a simple heat treatment of solid carburizing process.

KEYWORDS: Carburization, tempering temperature, soak time, tensile stress, hardness test.

1 BACKGROUND

Carburization is a case hardening process with a simple heat treatment of simple mild steel in the presence of carbon monoxide or charcoal as a carbon bearing material in an operating temperature of 815 degree Celsius (1500 degree F) to 1090 degree Celsius (2000 degree F). In carburization with process of diffusion, the addition of carbon is coated to the surface of low carbon steel to make the outer surface hard followed by quenching process after cooling the steel. In this way phase transformation takes place from austenite to martensite to form a single phase body-cantered tetragonal iron with carbon dissolved in it. Whereas, the inner core part of steel remains soft and tough with high martensite phase.

Patidar et al [14] studied the carburized mild steel at 950 degree Celsius with soaking time of 2 h and then tempered with different temperature range of 200, 250, and 300 degree Celsius for different soaking time of 1 h, 1.5 h, and 2 h. After this, the carburized and tempered mild steel are subjected for various kind of test such as abrasive wear test at different load like 75 N, 200 N, 375 N, and mechanical properties test like hardness, and tensile. Finally it was analyzed that wear resistance and mechanical properties increased with increase in tempering temperature.

Singh et al. [15] studied three heat treatment processes namely quenching, carburizing, and tempering. The carburized mild steel at 860 degree Celsius and different soaking time 2 h, 2h 30 m, and 3 h and then it is tempered at constant tempering temperature of 200 degree Celsius and constant soaking time of 60 min. After this the carburized and tempered mild steel are subjected for various kind of test such as abrasive wear test at different load like 75 N, 200 N, 375 N, and hardness test, and tensile test, Finally it was concluded that as wear rate increases, hardness increases for different soaking time of 2 h, 3 h, and 2 h 30 m. Also tensile strength increases with increasing the soaking time from 2 h to 3 h.

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D.A. Fadare et al. [7] studied the effect of heat treatment (annealing, normalizing, hardening, tempering) on the microstructure and some selected mechanical properties of NST 37-2 steel like tensile yield strength, ultimate tensile strength, young's modulus, percentage reduction, percentage elongation, toughness, and hardness. The sample carburized mild steel are heat treated at 910 degree Celsius for annealing with holding time of 90 min, normalizing with holding time of 90 min, hardening process with holding time of 40 min and then it is tempered at 450 degree Celsius with holding time of 90 min. finally it was concluded that mechanical properties of NST 37-2 can be changed and improved by various heat treatment process.

Emamian [4] studied the effect of solid carburization on mechanical and tribological properties of powder metallurgy parts. The test specimens made from industry were carburized in a powder pack for about 2 to 5 h at a temperature of about 850 to 950 degree Celsius. The effects of austenitization and quenching are investigated on some specimens and concluded that wear resistance can be increased with moderate toughness.

O.I. Sekunowo et al. [13] studied the wear characteristics of carburized mild steel at different carburization temperature of 750, 800, 850, 900, and 950 degree Celsius and then it is tempered at temperature of 500 degree Celsius with soaking time of 30 min. After this the carburized and tempered mild steel are subjected for various kind of test such as hardness, wear, and flexural properties. Finally it was analyzed that carburization can be used to enhance the wear resistance of mild steel comparable to that achievable through conventional hardening process.

Amit Vishal et al. [2] studied the effect of thermal treatments on the performance of H13 tool steel. In this Cryogenic treatment process was used to improve the mechanical properties and wear resistance of tool steel. At quenching temperature of 1050 degree Celsius the specimens are subjected to heat treatment process and then it is quenched in cold water where again it is subjected to deep cryogenic treatment at 196 degree Celsius for 24 hrs followed by double tempering at 550 degree Celsius. Finally it was concluded that the value of hardness increases after quenching and tempering process via heat treated as compared to simple heat treated process. But toughness and wear resistance have higher value in heat treated and cryogenically treated specimen as compare to the specimen which was only heat treated.

Solid carburizing process is suited for slow cooling from the carburization temperature. It is provided for a wide variety of furnaces because the process produces its own contained environment. The operating temperature range of pack carburizing process is from 815 to 955 degree Celsius (1500 to 1750 degree F). Moreover, in this research case depth for the surface of low carbon steel have not been used. Improvement in the wear resistance and mechanical properties of carburized mild steel by varying carburization temperature and constant tempering temperature was investigated. Finally the optimized condition was introduced.

2 MATERIAL AND METHODS

Mild steels of the required dimensions were purchased from the local market and the test specimens were prepared from it. The mild steel composition by (wt %) is given as follows C-0.16, Si-0.03, Mn-0.32, S-0.05, P-0.2, Ni- 0.01, Cu-0.01, Cr-0.01 and Fe. The air dried coal powdered sample was collected from Agarwal coal limited, Chennai which was ground to pass through 70 mess British standard test sieve by the following methods of moisture, volatile, ash, and fixed carbon determination. After the selection and preparation of coal, the different test specimen samples made up of mild steel for mechanical and wear properties testing were subjected to solid carburization treatment. The temperature range for carburization of mild steel samples was 800, 870, and 940 degree Celsius with a constant soak time of 2 hours. After soaking period of time, it was quenched in water and then mild steel gets carburized which gives hardening effect. The carburized mild steel samples are kept in the muffle furnace as shown in Figure (1).

After carburization process, the phase stage of steel is often harder than needed and too brittle for most practical uses. Severe internal stresses are also set up during the rapid cooling from the hardening temperature. To relieve the internal stresses and reduce brittleness, we tempered the steel after it was hardened. So in this tempering process the carburized steel samples were heated at the temperature of 500^0C for duration of 0.5 hours and then cooling was done in the still air. The carburized and tempered mild steel specimens were then subjected to various kind of mechanical and wear tests such as abrasive wear test, hardness test, tensile test and toughness test.

Fig. 1 Muffle furnace for carburization of mild steel samples

2.1 ABRASIVE WEAR TEST

The material considered for this experiment was carburized mild steel samples which were carburized under different temperature range of 800, 870 and 940^{0}C with dimensions 4.0 cm x 2.5 cm x 1 cm. The test was conducted on a machine called Pin on disc machine as shown in Figure (2).

Fig. 2 Pin on disc machine for abrasive wear testing

In this experiment, the test was conducted with the following parameters:

(1) Load (2) Speed (3) Time

In the present experimental work, speed and time were kept constant while the load was varied from 14.7N to 49N. Parameters that remained constant throughout all the experiments are given below in Table 1.

Table 1. Parameters of experimental work

RPM	300
Time	5 minute
Type of abrasive paper	Emery, 80 grade size

For each of the sample, test was conducted for 3 times and the average of all the samples was taken as the observed values in each case. After each test only the mass loss of the specimen was considered as the wear. The wear rate of each sample was calculated from the weight loss, the amount of wear was determined by weighing the specimen before and after

the test using precision electronic weighing machine. Since the mass loss was measured so it was converted to volume loss using the density of the specimen. Hence wear volume, wear rate and wear resistance were calculated as:

2.1.1 WEAR VOLUME

Wear volume = weight loss / density

Density of specimen = 7.86 g /cm^3

2.1.2 WEAR RATE

Wear rate = wear volume / sliding distance(s)

Sliding distance (s) can be calculated as,

Sliding distance (s) = V x time

= ($2\pi RN/ 60$) x time

where, R = radius of abrasive wheel(6.90cm)

N = R.P.M (300)

π = 3.14 (constant)

Time = 5 minute (300sec)

2.1.3 WEAR RESISTANCE

Wear resistance = 1 / wear rate

2.2 HARDNESS TEST

This method consisted of indenting the test material with a diamond cone or hardened steel ball indenter. The indenter was forced into the test material under a preliminary minor load *F0* usually 150 kg. In present experimental work, Rockwell hardness was measured on carburized and tempered mild steel samples which were carburized under different temperature range of 800, 870 and 940^{0}C. For each of the sample, test was conducted for 3 times and the average of all the samples was taken as the observed values in each case.

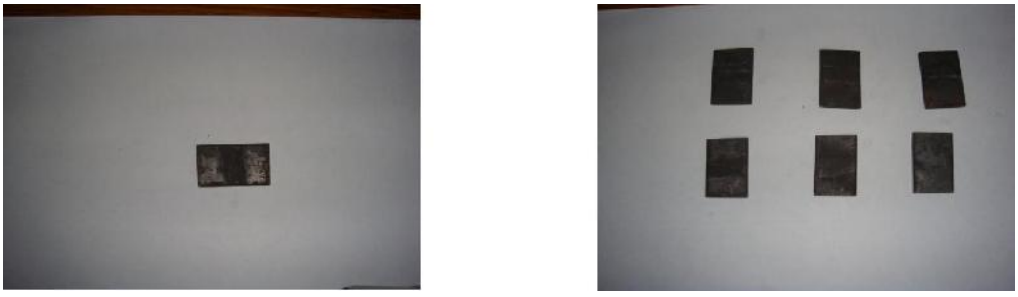

Fig. 3 Specimen for abrasive wear and hardness test

2.3 TENSILE TEST

In the present experiment, the tensile test was carried out on carburized and tempered mild steel samples which were treated under different temperature range of 800, 870 and 940^{0}C and performed in Instron 1195 machine.

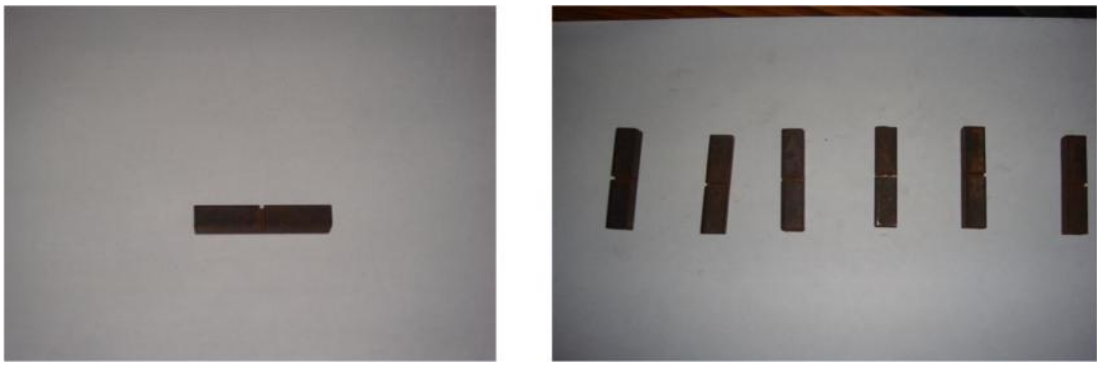

Fig. 4 Specimen for tensile strength test

2.4 TOUGHNESS TEST

This test was also conducted for three different samples carburized under the three different temperatures of 800, 870 and 940^0C.

Fig. 5 Specimen for toughness test

3 RESULTS AND DISCUSSION

The different kind of mild steel samples were carburized under different condition and temperature and tempered under the different condition and constant temperature and then tested for various kinds of test like abrasive wear test, tensile strength test, toughness test and hardness test. The abrasive wear test results for different load (i.e.14.7 N, 29.4 N and 49 N) are recorded in Table 3-5, the Rockwell hardness test result at 150 kg load is recorded in Table 6. Similarly the toughness test and tensile strength test results are recorded in Table 7 and 8, respectively.

3.1 RESULTS OF PROXIMATE ANALYSIS OF COAL FROM AGARWAL COAL LIMITED, CHENNAI

The results of proximate analysis of coal are shown in Table 2. This analysis was performed to find out the moisture percentage (wt %), volatile matter, ash and carbon content in the given coal sample. From the analysis, we found limited content 29% of carbon, 3% of moisture, 32% of volatile matter and 36% of ash.

3.2 RESULTS OF ABRASIVE WEAR TEST: ABRASION CHARACTERISTICS OF CARBURIZED MILD STEELS

From the experimental results of abrasive wear test (Table 3-5), the following regularities were found:

1. The weight loss during abrasion was highest for uncarburized simple mild steel and was lowest for the mild steel carburized at temperature of 940^0C.
2. As comparing the case of carburized mild steel only, the weight loss during abrasion was highest for the mild steel carburized at temperature of 800^0C and lowest at temperature of 940^0C, that may be because of comparatively low carbon content at lower carburization temperature. So it was concluded that as the carburization temperature increases, the weight loss during abrasion decreases. This conclusion is also shown graphically in the Fig.6.

3. The three different loads of 14.7 N, 29.4 N and 49 N was conducted on abrasion test and obtained from the test that the weight loss during the abrasion was highest for the load of 49 N and lowest for 14.7 N. Hence it was concluded from the test that as the load increases, the weight loss during abrasion also increases as shown graphically in Fig.6.

4 The wear resistance was highest for the mild steel carburized at the temperature of 940^0C and it is lowest for the uncarburized mild steel. Also when considering only carburized mild steels, the wear resistance was highest for the mild steel carburized at the temperature of 940^0C and lowest at 800^0C. Hence the abrasion results explained that the wear resistance is directly proportional to the carburization temperature i.e. as the carburization temperature increases the wear resistance increases as shown graphically in Fig.7.

5 The net result is that the mild steel carburized at temperature of 940^0C gives the best results, as it has the highest wear resistance, lowest weight loss due to abrasion and lowest wear rate.

3.3 EFFECT OF CARBURIZATION TEMPERATURE ON HARDNESS OF CARBURIZED MILD STEELS

From the results, we found that as temperature increases hardness also increases. The hardness was found to be highest for the mild steel carburized at temperature of 940^0C and was lowest for the mild steel carburized at temperature of 800^0C (Table 6 and Fig. 8).

3.4 EFFECT OF CARBURIZATION TEMPERATURE ON TOUGHNESS OF CARBURIZED MILD STEELS

The toughness properties of mild steels are highly influenced by the carburization process. Table 7 shows the toughness results of carburized and uncarburized mild steels where it was observed that the toughness values of uncarburized mild steels were higher than that of carburized mild steels and toughness values decrease with the increase in carburization temperature.

3.5 EFFECT OF CARBURIZATION TEMPERATURE ON TENSILE STRENGTH OF CARBURIZED MILD STEELS

The effect of carburization temperature on tensile strength of carburized mild steels is shown in Table 8 and it is also represented graphically in Fig.10. The results showed that the carburization process greatly improve the tensile strength of mild steels. This concluded that with the increase in the carburization temperature, the tensile strength increases linearly. When the carburization temperature of 800, 870 and 940^0C were compared, the tensile strength was found to be highest for the mild steel carburized at 940^0C, and lowest for 800^0C. So it was concluded that mild steel carburized at 940^0C give the best results and it can be preferred.

Table 2. Proximate analysis of coal from Agarwal coal limited

Coal	Proximate analysis (Wt %)			
	Moisture	Volatile matter	Ash	Fixed carbon
Agarwal coal limited	3	32	36	29

Table 3. Abrasive wear test for carburized mild steel, at load 14.7 N

Carburization Condition		Tempering condition		Weight loss, g	Wear volume, cm^3x10^{-2}	Sliding distance (s)	Wear rate, cm^2x10^{-7}	Wear resistance, $cm^{-2}x10^7$
Temp (^{0}C)	Soak Time (hrs)	Temp (^{0}C)	Soak time (hrs)					
Sample Mild Steel		_	_	0.2	2.54	680.657	3.73	0.267
800^0C	2	500^0C	0.5	0.13	1.65	680.657	2.42	0.411
870^0C	2	500^0C	0.5	0.118	1.50	680.657	2.20	0.453
940^0C	2	500^0C	0.5	0.107	1.36	680.657	2.00	0.499

Table 4. Abrasive wear test for carburized mild steel, at load 29.4 N

Carburization Condition		Tempering Condition		Weight loss, g	Wear volume, cm^3x10^{-2}	Sliding distance (s)	Wear rate, cm^2x10^{-7}	Wear resistance, $cm^{-2}x10^7$
Temp (^{0}C)	Soak Time (hrs)	Temp (^{0}C)	Soak time (hrs)					
Sample Mild Steel	-	-	-	0.25	3.18	680.657	4.67	0.213
800^{0}C	2	500^{0}C	0.5	0.15	1.90	680.657	2.80	0.356
870^{0}C	2	500^{0}C	0.5	0.135	1.71	680.657	2.52	0.396
940^{0}C	2	500^{0}C	0.5	0.12	1.52	680.657	2.24	0.445

Table 5. Abrasive wear test for carburized mild steel, at load 49 N

Carburization Condition		Tempering Condition		Weight loss, g	Wear volume, cm^3x10^{-2}	Sliding distance (s)	Wear rate, cm^2x10^{-7}	Wear resistance, $cm^{-2}x10^7$
Temp (^{0}C)	Soak Time (hrs)	Temp (^{0}C)	Soak time (hrs)					
Sample Mild Steel	_	_	_	0.3	3.81	680.657	5.60	0.178
800^{0}C	2	500^{0}C	0.5	0.185	2.353	680.657	3.45	0.289
870^{0}C	2	500^{0}C	0.5	0.165	2.09	680.657	3.08	0.324
940^{0}C	2	500^{0}C	0.5	0.145	1.84	680.657	2.71	0.368

Table 6. Rockwell hardness of carburized mild steel at load 150 kg

Carburization condition		Tempering condition		Hardness (R_c)
Temp (^{0}C)	Soak time(Hrs)	Temp(^{0}C)	Soak time (Hrs)	
Simple mild Steel	-	-	-	50
800^{0}C	2	500^{0}C	0.5	52
870^{0}C	2	500^{0}C	0.5	54
940^{0}C	2	500^{0}C	0.5	55

Table 7. Toughness test of carburized mild steel

Carburization Condition		Tempering Condition		Toughness, Joule(Nm)
Temp (^{0}C)	Soak Time (hrs)	Temp (^{0}C)	Soak time (hrs)	
Simple mild Steel	_	_	_	54
800^{0}C	2	500^{0}C	0.5	36
870^{0}C	2	500^{0}C	0.5	34
940^{0}C	2	500^{0}C	0.5	31

Table 8. Tensile strength of carburized mild steel

Carburization condition		Tempering condition		Tensile Strength (MPa)
Temp (^{0}C)	Soak Time (hrs)	Temp(^{0}C)	Soak time (hrs)	
Simple mild Steel	_	_	_	441
800^{0}C	2	500^{0}C	0.5	1870
870^{0}C	2	500^{0}C	0.5	1920
940^{0}C	2	500^{0}C	0.5	1950

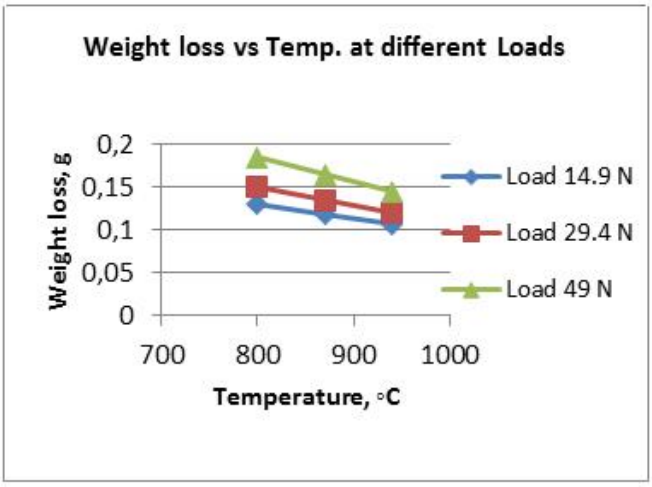

Fig. 6. Comparison of weight loss due to abrasion vs carburization temperature for three different loads of 14.7 N, 29.4 N and 49 N

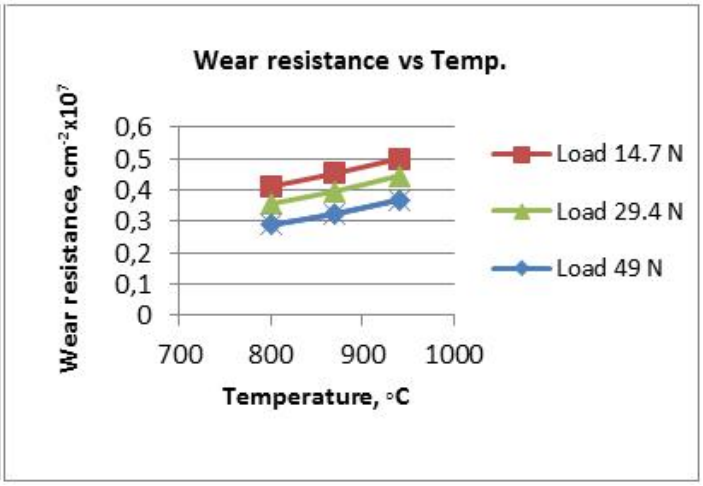

Fig. 7. Comparison of wear resistance vs carburization Temperature for three loads of 14.7 N, 29.4 N and 49 N

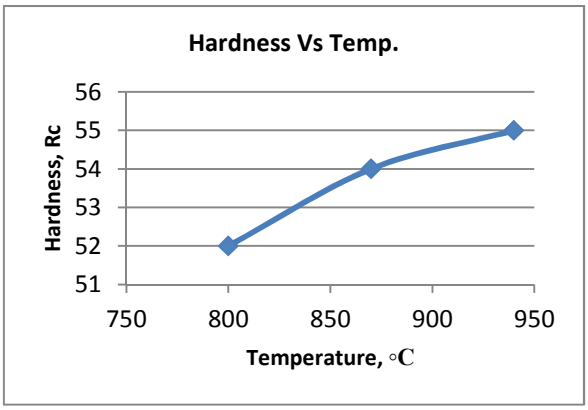

Fig. 1. Fig. 8. Variation of hardness with the carburization temperature

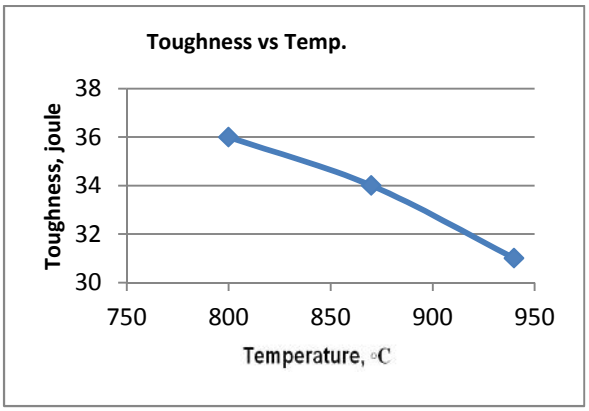

Fig. 2. Fig. 9. Variation of toughness with carburization temperature

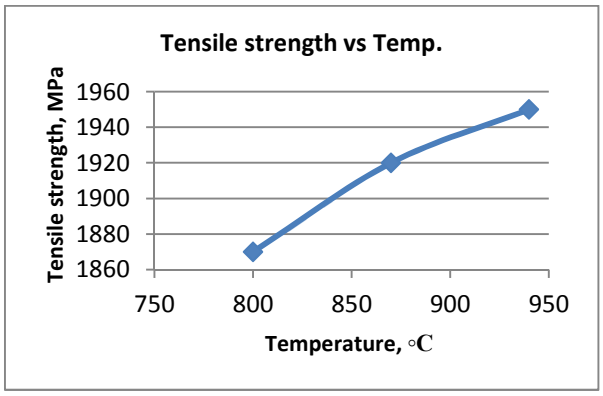

Fig. 10. Variation of tensile strength with carburization temperature

4 CONCLUSIONS

1. The mechanical and wear resistance properties of sample carburized mild steel sare increased by varying carburizing temperature from 800 to 940 degree Celsius.
2. The mechanical property of toughness decrease by increasing the carburizing temperature.
3. Hardness, wear resistance and tensile strength increases with increase in the carburization temperature.
4. Weight loss due to abrasion, wear volume, wear rate and toughness decrease with increase in the carburization temperature.
5. The wear resistance is increased due to small amount of increase in the hardness and at the same time there is loss in weight of the sample steel due to abrasion and wear rate.
6. From the range of carburizing temperatures, 940 degree Celsius gave the best result for higher hardness, higher tensile strength and higher wear resistance with low weight loss and less wear rate for carburized mild steel.

REFERENCES

[1] A. Clark, “Comparison of Austempering and Quench and Tempering Processes for carburized automotive steels”, SAE international journals, pp. 109 – 115, 2013.
[2] A. Vishal, R. Davis, “Effect of thermal treatments on the performance of H13 tool steel”, volume 3, pp. 170 – 173, 2014.
[3] A. Akdemir, R. Kus and M. Simsir “Impact toughness and microstructure of continuous steel wire – reinforced cast iron composite”, Material science and Engineering, pp. 119-125, 2009.
[4] A. Emamian, “Study on wear resistance, Hardness, and impact behaviour of Carburized Fe-Based Powder Metallurgy parts for automotive applications”, Materials Sciences and Applications, pp. 519 – 522, 2012.
[5] P. Baldissera and C. Delprete, “Effect of deep cryogenic treatment on static mechanical properties of 18NiCrMo5 carburized steel”, Material and design, 30, pp. 1435 – 1440, 2009.

[6] O. Celik , "High temperature abrasive wear behavior of an as-cast ductile iron, wear", 258; Second International Conference on Erosive and Abrasive Wear, pp. 189 – 193, 2005.
[7] D. A. Fadare, T. G. Fadara and O. Y. Akanbi, "Effect of heat treatment on mechanical properties and microstructure of NST 37-2 Steel", Journal of Minerals & Materials Characterization & Engineering, pp. 299 – 308, 2011.
[8] F. O. Aramide, S. A. Ibitoye, I. O. Oladele and J. O. Borode, "Effects of carburization time and temperature on the mechanical properties of carburized mild steel, using activated carbon as carburizer", material research journals, pp. 290 – 305, 2009.
[9] A. Gulyaev , Physical Metallurgy, 5th Edn. , Mir publishers, Moscow, pp – 173, 1980.
[10] H. Elizanty, "Effect of carburization on hardness and wear properties of the mild steel samples", International Journal of Innovation and Applied Studie, pp. 120 – 127, 2014.
[11] M. Izciler and M. Tabur "Abrasive wear behavior of different case depth gas carburized AISI gear steel", Wear, 220, pp. 90 – 98, 2006.
[12] O.I. Sekunowo, O.I. Nwagu, "Wear Characteristics of carburized mild steel", International journal of scientific & Technology research volume 3, pp. 87 – 93, 2014.
[13] S. Patidar, A. Jain, and D. Singh, "Effect of tempering temperature and applied load on various wear environment of carburized mild steel", IOSR Journal of Mechanical and Civil Engineering, pp. 62 – 69, 2012.
[14] S. Singh, D. Singh, K. Sachan and A. Arya, "Effects of soaking time and applied load on Wear Behaviour of Carburized mild steel", IOSR Journal of Engineering (IOSRJEN), pp. 10 – 19, 2013.

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Adsorption of Deltamethrin using Aluminosilicate Synthesized from Wheat straws: A Greener Approach

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ABSTRACT: Aluminosilicate (zeolites) were prepared from wheat straws. Physicochemical properties of zeolites were characterized by scanning electron microscopy (SEM) along with energy dispersive X-ray spectroscopy (EDX). The examinations showed that the synthesized product was crystalline in nature and size obtain was 5µm. Adsorption characteristics of the pesticide deltamethrin was studied in aqueous solution through Ultra Fine Liquid Chromatography (UFLC). The adsorption results show that the modified zeolite was better as compare to unmodified zeolites.

KEYWORDS: Adsorption, Deltamethrin, Zeolite, CTAB.

1 INTRODUCTION

In the last few decades water pollution by organic and inorganic chemical pollutants has become a major public concern (Oketola & Fagbemigun. 2013). Pesticides are considered the most hazardous organic pollutants encountered in wastewater effluents (Koner et al., 2012) due to their high stability and toxicity, usage in huge quantities, and wide applications for many purposes, particularly the production of massive quantities of crops. Pesticides are a diverse group or concoction of chemical compounds, biological agents, antimicrobials, disinfectants that are deliberately applied for selective management and reduction of pests including insects, plant pathogens, weeds, birds, nematodes, and microbes that destructively affect the production, processing, storage, transport, marketing of food or spread of diseases (Corsini et al., 2008; Corsini et al., 2013). Pesticides belonging to Organochlorine, carbamate, pyrethroid and herbicide groups are mostly used for the control of pest and weeds due to its cost effectiveness and easy availability. Deltamethrin is a one of synthetic pyrethroid that destroys insects on contact and through digestion (Hasan et al., 2013). It is used for many agricultural crops and home pest control throughout the year, and consequently is widespread in the environment. Moreover, it is non-degradable during storage and it is stable when exposed to atmospheric oxygen and sunlight. Acute and chronic effects on the human body include convulsions leading to muscle fibrillation and paralysis, diarrhea, dermatitis, headache, peripheral vascular collapse, vomiting, hypotension, prenatal damage, shock, and death due to respiratory failure.

Different methods have been studied for the elimination of pesticides, metals, dyes and other pollutants from the aqueous solutions such as photo catalytic degradation (Aungpradit et al., 2007), biological oxidation (Dehghani et al., 2014), nano filtration (Ahmed et al., 2008), ozonation (Maldonado et al., 2006) and adsorption (Mon et al., 2009; Ayar et al., 2008). But all these techniques except adsorption require capital cost to establish exclusive instruments for the check and balance before and after installation of these high technology processes, prerequisite of power and also production of noxious sludge or by-products for disposal. Adsorption on a solid surface is most important and useful method for removal of pesticides due to its effectiveness at low contaminant concentration, selectivity, and regenerability and cost efficiency pesticides (Sergiane et al., 2010). Activated carbon is primarily used solid adsorbents because its removal efficiency is very high and used on a wide scale due to its pore size and surface area and wide range of contaminants are elimination (Salman et al., 2012). But it is considered an expensive adsorbent due to the use of raw materials which are costly and valuable natural resources such as

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coal. Therefore zeolite is used as adsorbent because several agricultural waste products are used as raw material for its synthesis, like sugarcane baggase (Purnomo, 2013) and rice husk (Tan et al., 2011).

The present study was designed on the green route synthesis of Si-Al Zeolites by utilizing the waste of crops towards sustainable development. Wheat straw was used as silica natural precursor. Whereas, aluminum foil (spent) is accepted as alumina source.

2 METHODOLOGY

2.1 PREPARATION OF WHEAT STRAW ASH (WSA)

The wheat straws obtain from local market was treated with 3M hydrochloric acid (HCl) for 6 hours for preliminary removing all impurities. The treated wheat straws were washed thoroughly with distilled water, dried at 100 ^{0}C and pyrolyzed at 600 ^{0}C for 6 hours in furnace. The white ash obtain was used as silica source.

2.2 PREPARATION SEED GEL AND FEED STOCK GEL

The procedure for the synthesis of Zeolites follows the layout of (Tan et al., 2011), and is briefly described below:

A Teflon beaker containing a magnetic stirrer was used for the seed gel preparation. Sodium hydroxide pellets was dissolved in distill water to make clear solution, add WSA as silica source and heated under vigorous stirring to obtain a homogenous mixture represented as mixture A. In another beaker made sodium hydroxide solution and add spent aluminum foil and stir to made sodium aluminate solution as mixture B. Both mixture A and B were mixed together and aged for 24hours at room temperature in the teflon bottle and used as seed gel. The silicate (mixture A) and aluminate (mixture B) solutions were mixed together in the Teflon beaker, subsequently stirred for 2hrs with the purpose of making it completely homogenized. This combined solution

was used as the feed stock gel. Both the gels were mixed together and stir for 5hrs and aged for one day for the crystallization. After this the obtain crystals were decanted and thoroughly washed with distill water for several times and obtain the zeolite coded as WSZ. The whole process was represented in Figure 1. The obtain zeolite was modified by using cationic surfactant, cetyltrimethylammonium bromide (CTAB), to enhance the surface characteristics of the materials. A known mass of the zeolite was vigorously stirred with 0.5 molar aqueous solution of CTAB filtered and oven dried. The dried modified zeolite was coded WSZ_m.

2.3 CHARACTERIZATION

The energy dispersive X-ray spectroscopy (EDS) analyser (Hitachi X-650 scanning electron microanalyser) that was coupled to the SEM was used to identify the chemical composition of a specific area of a sample and to observe the size and shape of crystals in the zeolitic material synthesised.. Before analysis, the samples were dried, ground to a fine powder, spread on a carbon tape mounted on an aluminium stub and coated with graphite to make them conductive.

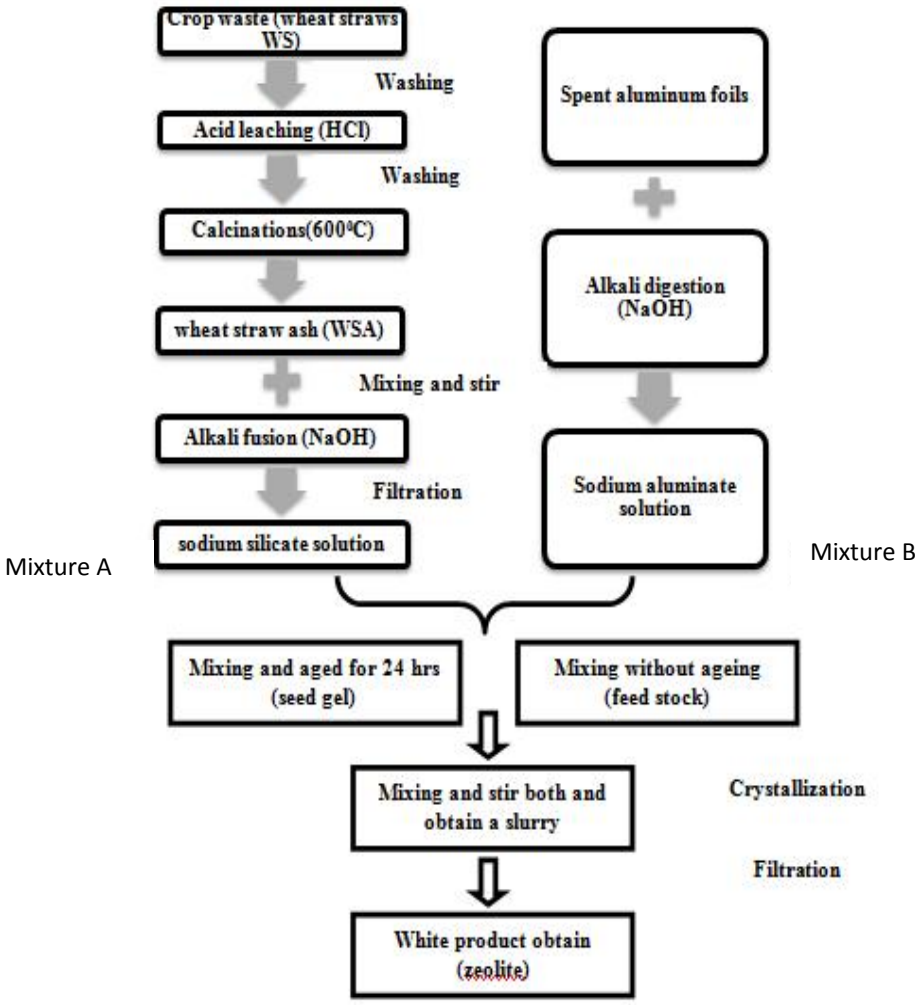

Figure.1. Flow diagram of zeolite synthesis

2.4 ULTRA FINE LIQUID CHROMATOGRAPHY (UFLC) ANALYSIS

The synthesized zeolites were subjected to analyze the pesticide adsorption by Ultra Fine Liquid Chromatography (UFLC). The adsorption process follows the layout of (Uddin et al., 2013). The pesticide were determined on Ultra Fine Liquid Chromatography (LC-2010, Schimadzu) equipped with UV detector and Reverse phase HS-C18 column (250mm 4.6mm).

2.4.1 STANDARD SOLUTION AND MOBILE PHASE

Standard solution (1 mg/L) of pesticide (deltamethrin) was injected (10-µL) using micro syringe into the column, followed by elution with a solvent mixture of acetonitrile (ACN) and water (H_2O) in 65:35 ratios at 0.5mL/minute. The calibration curve was constructed with three working standards of known strengths. UV wavelength selected for deltamethrin was 254nm.

2.4.2 EXTRACTION

Pesticide was extracted from water by liquid-liquid extraction. If pesticide was not present in the water than was spiked with desire pesticide concentration. To remove the pesticide from the water we have to use the solvent whose polarity is close to the target compound so, n-hexane along with water was taken into separatory funnel and shaking for 5 minutes. Two distinct layers were formed. The hexane extract was separated and collected in evaporating flasks. Same process was repeated two times and combines all the extracted hexane in flask. Water present in the extract was removed by treating it with anhydrous sodium sulfate and the organic solvent from water free extract was evaporated in a rotary evaporator to a small volume (Approx. 1 mL) and appends acetonitrile to make 10mL of the aliquot and transferred to a glass-Stoppard test tube for UFLC analysis.

3 RESULT AND DISCUSSION

The present investigation is centered on the green route synthesis of Zeolites (aluminosilicates) and further enhancement of surface area of the synthesized materials through modification with cationic surfactant. The application is also envisaged for the adsorptive removal of pesticide.

3.1 EDX AND SEM ANALYSIS

The zeolites synthesized using green approach was characterized for its physio-chemical properties. Figure 2 shows the elemental composition of raw and synthesized zeoites determined on Energy dispersive X-ray Spectrometer. It can be seen that aluminium, oxygen, silica and sodium are the major elements identified in the zeolites while carbon was present in the modified product which confirm the successful incorporation of surfactant. Figure 3 represents the micrographs of the zeoites. The addition of surfactant to zeolites significantly impacts the morphological characteristics. It is evident (see Figure 3 (b)) that more uniform distribution of particles with crystalline geometry appears on addition of CTAB.

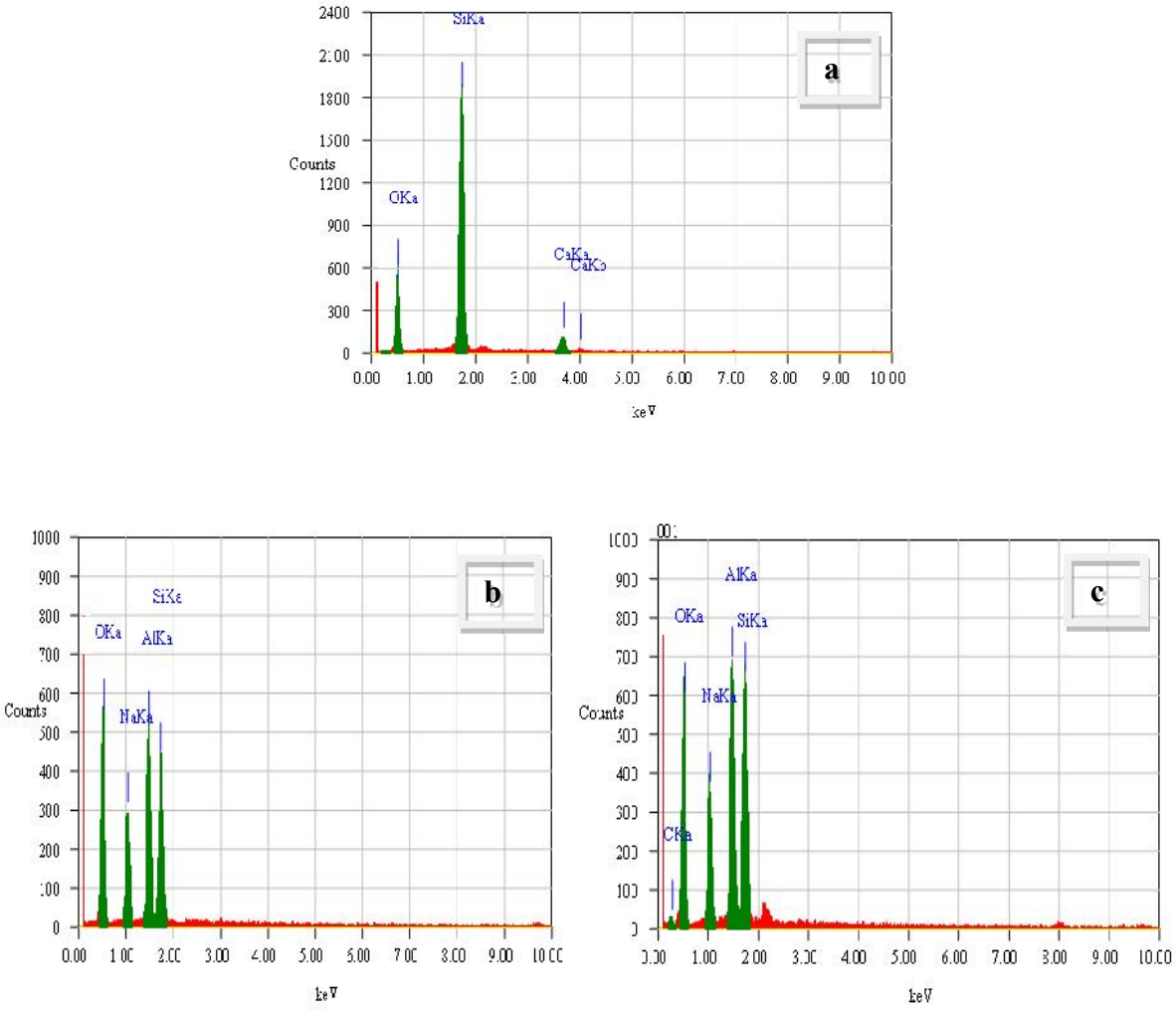

Figure.2. EDX analysis of (a) Wheat ash (b) WSZ and (c) WSZ_m

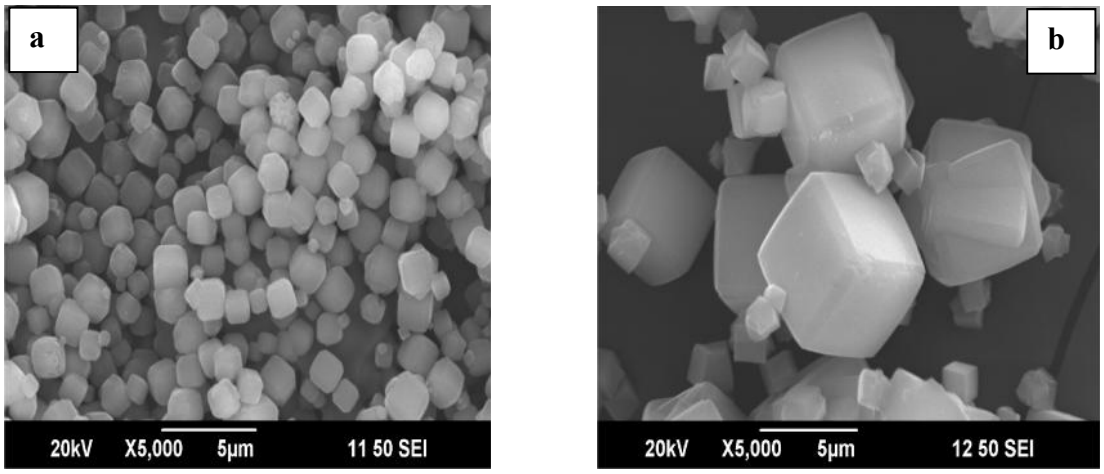

Figure.3. SEM images of (a) WSZ and (b) WSZ_m

3.2 UFLC ANALYSIS

The synthesized zeolites were applied as adsorbents to determine efficiency for the removal of pesticides and estimated on Ultra Fine Liquid Chromatography (UFLC).

The stock solution of the standard pesticides was 1 mg/L. From this we prepared three working standard solutions for the calibration with 0.03, 0.06 and 0.09 mg/L concentrations by adding the proper amount of stock standard solution and making dilutions with solvent. Calibration curves of the pesticides are shown in Figure 4.

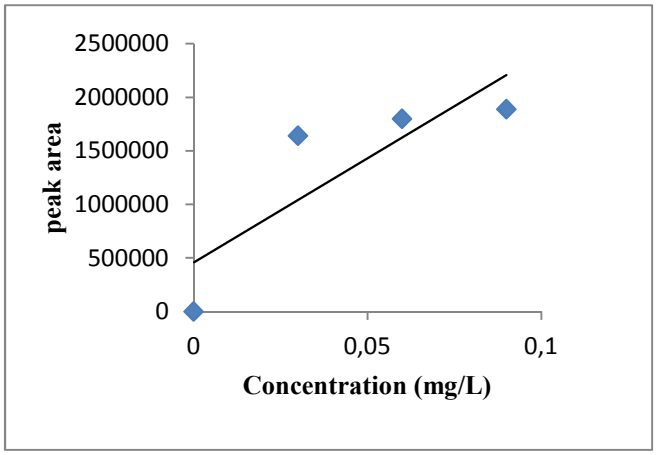

Figure.4. Calibration curve for Deltamethrin

The constant concentration of pesticide was adsorbed on a known mass of synthesized adsorbent (zeolite). The mixture was stirred for 30 minutes, filtered and an aliquot (10 µL) of filtrate was injected on UFLC. The retention time of pesticide was determined from standard calibration curve which was 4.8 minutes for deltamethrin.

Quantitative analysis was done by Limit of quantification (LOQ) and Limit of detection (LOD). LOQ was defined as the lowest concentration of the analyte that could be compute with adequate exactitude and accuracy. The Limit of detection (LOD) was defined as the lowest concentration of the analyte in a sample that could be detected but not necessarily measured. The LOQ and LOD were assessed as signal-noise ratios (S/N) of 10: 1 and 3 : 1, correspondingly, and were attained by evaluating un-spiked samples (Falqui-Cao et al., 2001). In the present investigation, LOD and LOQ results are summarized in Table 1.

Table.1. Quantitative analysis (Limit of detection and Limit of quantification) of pesticide

Compounds	Deltamethrin
LOD	1.16655E-07
LOQ	3.535E-07

The synthesized adsorbents were applied to determine their efficiency for the removal of the pesticide. The known concentration of pesticides along with the constant mass of the adsorbent was taken in a flask and shaken for 30 minutes. After that the solution was filtered and analyze by UFLC.

Figure 5 shows the pesticide peak area before and after the application of adsorption process and it illustrates that after adsorption there was a definite reduction in the peak area which explain that zeolite were good adsorption capacity towards the deltamethrin. And it is concluded that modified zeolite from crop waste (WSZ_m) was more efficient than unmodified zeolite (WSZ). The adsorption trends of synthesized adsorbents were as follow:

WSZ_m>WSZ

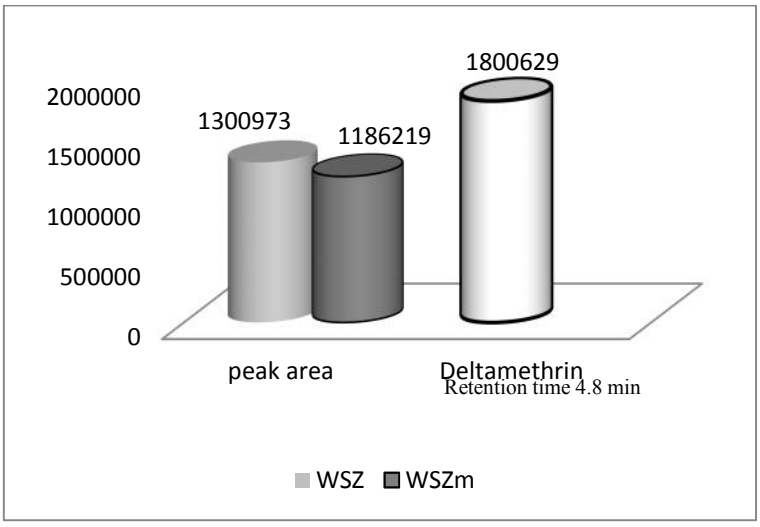

Figure.5. Peak area of Deltamethrin with and without use of adsorbents

4 CONCLUSION

Zeolites were synthesized using greener approach by utilizing the waste of wheat straws and spent aluminum foil as silica and alumina source respectively towards sustainable development. Zeolite was synthesized by hydrothermal process and later on modified by cationic surfactant cetyltrimethyl ammonium bromide (CTAB). The synthesized zeolites were characterized to study the physio-chemical properties using different standardized techniques of SEM along with EDX for identification of surface morphology and elemental composition of the obtain product. All these confirm the synthesis of the Zeolite from waste. The synthesized materials are also subjected as adsorbents for the removal of pesticide (deltamethrin) and it was concluded that zeolites has better adsorption capacity for deltamethrin. While modified Zeolite from crop waste (WSZ_m) was more efficient than unmodified Zeolite (WSZ).

REFERENCES

[1] Ahmad, S., Zia-Ul-Haq, M., Imran, M., Iqbal, S., Iqbal, J., & Ahmad, M. (2008). Determination of residual contents of pesticides in rice (Oryza sativa L.) crop from different regions of Pakistan. *Pakistan Journal of Botany*, 40(3), 1253-1257.

[2] Aungpradit, T., Sutthivaiyakit, P., Martens, D., Sutthivaiyakit, S., & Kettrup, A.A.F. (2007). Photocatalytic degradation of triazophos in aqueous titanium dioxide suspension: identification of intermediates and degradation pathways. *Journal of Hazardous Material,* 146, 204-213.

[3] Ayar, N., Bilgin, B., & Atun, G. (2008). Kinetics and equilibrium studies of the herbicide 2, 4-dichlorophenoxyacetic acid adsorption on bituminous shale. *Journal of Chemical Engineering*, 138(239), 48-26.

[4] Corsini, E., Liesivuori, J., Vergieva, T., Van Loveren, H., & Colosio, C. (2008). Effects of pesticide exposure on the human immune system. *Human & experimental toxicology*, *27*(9), 671-680.

[5] Corsini, E., Sokooti, M., Galli, C. L., Moretto, A., & Colosio, C. (2013). Pesticide induced immunotoxicity in humans: a comprehensive review of the existing evidence. *Toxicology*, *307*, 123-135.

[6] Dehghani, M., Nasseri, S., & Karamimanesh, M. (2014). Removal of 2, 4-Dichlorophenolyxacetic acid (2, 4-D) herbicide in the aqueous phase using modified granular activated carbon. *Journal of Environmental Health Science and Engineering*, *12*(28).

[7] Dehghani, M., Nasseri, S., & Zamanian, Z. (2013). Biodegradation of alachlor in liquid and soil cultures under variable carbon and nitrogen sources by bacterial consortium isolated from corn field soil. Iran J Environ Health Sci Eng, 10(1), 21.

[8] Falqui-Cao, C., Wang, Z., Urruty, L., Pommier, J. J., & Montury, M. (2001). Focused microwave assistance for extracting some pesticide residues from strawberries into water before their determination by SPME/HPLC/DAD. Journal of agricultural and food chemistry, 49(11), 5092-5097.

[9] Hassan, A. F., Youssef, A. M., & Priecel, P. (2013). Removal of deltamethrin insecticide over highly porous activated carbon prepared from pistachio nutshells. *Carbon letters*, *14*(4), 234-242.

[10] Maldonado, M.I., Malato, S., Perez-Estrada, L.A., Gernjak, W., Oller, I., Domenech, X., & Peral, J. (2006). Partial degradation of five pesticides and an industrial pollutant by ozonation in a pilot-plant scale reactor. *Journal of Hazardous Material,* 138 (2), 363-369.

[11] Mon, E.E., Hirata, T., Kawamoto, K., Hiradate, S., Komatsu, T., Moldrup, P., 2009. Adsorption of 2,4-Dichlorophenoxyacetic Acid onto Volcanic Ash Soils: Effects of pH and Soil Organic Matter. *Matter Environment Asia,*1,1-9.

[12] Oketola, A.A., & Fagbemigun, K.T. (2013). Determination of Nonylphenol, Octylphenol and Bisphenol-A in Water and Sediments of Two Major Rivers in Lagos, Nigeria. *Journal of Environmental Protection*, 4(7A), 38-45.

[13] Purnomo, C. W. (2013). Utilization of bagasse fly ash for carbon–zeolite composite preparation. *Journal of Porous Materials*, *20*(5), 1305-1313.

[14] Salman, J. M., & Al-Saad, K. A. (2012). Adsorption of 2,4-Di- chlorophenoxyacetic Acid onto Date Seeds Activated Carbon Equilibrium, Kinetic and Thermodynamic Studies. *International Journal of Chemical Sciences*, 10(2), 677-690.

[15] Sergiane, S.C., Demoliner, A., Fabiane, P.C., Marcelo, G.M.D., Ednei, G.P. (2010). Pesticide residue determination in groundwater using solid-phase extraction and high-performance liquid chromatography with diode array detector and liquid chromatography-tandem mass spectrometry. *Journal of Brazilian Chemical Society*, 21(4), 642–650.

[16] Tan, W. C., Yap, S. Y., Matsumoto, A., Othman, R., & Yeoh, F. Y. (2011). Synthesis and characterization of zeolites NaA and NaY from rice husk ash. *Adsorption*, *17*(5), 863-868.

[17] Uddin, M. A., Saha, M., Chowdhury, M. A. Z., & Rahman, M. A. (2013). Pesticide Residues In Some Selected Pond Water Samples Of Meherpur Region Of Bangladesh. *Journal of the Asiatic Society of Bangladesh, Science*, *39*(1), 77-82.

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MARKET CENTRES AND REGIONAL DEVELOPMENT PATTERN OF PURBA MEDINIPUR IN WEST BENGAL

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ABSTRACT: Study of market centres as well as market economic functions in regional planning and development has been found very important in the assessment of the pattern of development of any region. This has attracted attention of the planners all over the world. The market related functions or activities with the level of concentration of services and facilities will help identification the development status of the region. This study attempts to examine the existing pattern of market economic development vis-à-vis development potential in different blocks of Purba Medinipur district of West Bengal. It has been observed that the functional and spatial organizations are interrelated phenomena which influence the economic and social life of the people. Through a systematic study spatial relationships among the existing market activities are observed and it has been noticed that there is a definite pattern of dispersal or concentration of activities in space. On the basis of the above understanding study has been conducted on the potential services of markets and related economic functions of Purba Medinipur district as an areal unit.

KEYWORDS: Market centre, economic development, spatial relationship, potential services.

1 INTRODUCTION

The study of the market economic function in regional planning has got immense and identification of services necessary for economic development of any region of the world. The market related functions or activities with the level of concentration of services and facilities will help to identity the development status of the region. The present study is looking towards the existing pattern of market economic development vis-à-vis development potential in different blocks, the priority areas of planning are concerned in development of backward blocks. The functional and spatial organizations are interrelated phenomenon which influences the economic and social life of the people. The functional activities as explained by Philbrick[(1)] that "the word functional is used because the different yet associated purpose of functions of human establishments compose in the aggregate the different functional patterns of human activity, which make generalization about society possible in the context of areal distribution. The word organization is used because human activity is inter-dependent and inter-connected in area. People is establishments through their actions interconnecting them with other people in other establishments create larger area units of human organizations, than the establishments in which the focus their lives". In spatial relationships among the existing market activities are observed, it will be noticed that there is a definite pattern of dispersal or concentration of activities in space.

2 STUDY AREA

Purba Medinipur, the southernmost district of the Burdwan Division, extending over area of 4,151.64 square kilometers, is situated between the parallels of 21º36´35´´ N and 22º57´10´´N latitudes and meridians of 86º33´50´´E and 88º12´40´´E longitudes. The present analysis has been depends mainly on field work from where maximums data related to make functions or trade activities and collected. It is worth mention here that most of relevant geographical and historical

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information regarding the functional activities of 58 (fifty eight) identified market centers and related aspects of marketing geography was conducted using the finalized questionnaire for each market centers.

3 OBJECTIVES OF THE STUDY

On the basis of the theoretical frame the particular objective of the analysis is

i. To study the potential services of markets and related economic function of Purba Medinipur district as area unit;

ii. To correlate the market development with regional development of the various sub regions of the study region;

iii. The expression of market potential of the district helps the process of economic regionalization and identifies the status of economic development of the region.

4 RESEARCH METHODOLOGY

The important aspect of the present study is to identify the block level status of economic development in relation to market functions of Purba Medinipur district. The market function of any geographical area is related with number of other factors like agricultural, industrial and other tertiary products. So, the level of aggregation of various variables are composed at the block level where basic statistical information are mostly available in the present structure of statistical organizations in district level set up. For measurement of the inter-block disparity related with marketing functions, the following methods have been logically selected for the present study.

a) Blockwise level of development (based on UNDP index)

b) Level of composite market function development (based on average development index of UNDP and average market potential).

5 BLOCKWISE LEVEL OF DEVELOPMENT

This method is based on UNDP (United Nations Development Programme) index of development analysis. Here, the variables selected for the analysis is related directly or indirectly with the marketing functions.

The blockwise selected variable are:

i) Irrigated area (hector)

ii) Number of agricultural labour

iii) Food grain production ('000 metric ton)

iv) Road length (Km)

v) Population served per bank

vi) Small savings ('000 Rs)

vii) Co-operative working capital ('000 Rs)

UNDP index of development used here as:

$$Index = \frac{value\ of\ individual\ block - minimum\ value\ of\ the\ block}{maximum\ value\ of\ the\ block - minimum\ value\ of\ the\ block}$$

The calculated values of the entire variable are shown in the *appendix – I* the sum of the computed values of the development index are divide by the number of variables for different blocks are given in table-2 along with the different classes of occurrence. Here the standard deviation grouping technique is applied to derive different development classes such as from very high to very low.

Table 1. Identified permanent markets with no of shops and employee of Purba Medinipur, 2010

Sl. No	Markets	Total Shops	Total employee	Sl. No	Markets	Total Shops	Total employee
1	Nimtouri	271	631	30	Balughata	104	142
2	Radhamoni	312	591	31	Amarshi	173	312
3	Srirampur	122	185	32	Manglamaro	162	274
4	Dimari	123	248	33	Potashpur	209	347
5	Nonakuri	328	580	34	Bhagawanpur	191	320
6	Mecheda	588	1274	35	Bhimeswari	187	311
7	Panskura Station Bazar	444	949	36	Kudi	112	183
8	Panskura Puratan Bazar	329	583	37	Balighai	117	193
9	Kolaghat	333	634	38	Paniparul	348	491
10	Deulia	134	221	39	Henria	298	647
11	Siddha	117	193	40	Kalagachia	124	206
12	Moyna	151	242	41	Khejuri	209	375
13	Gosafat	186	292	42	Janka	154	238
14	Nandakumar	376	872	43	Boga	135	214
15	Babattarhat	106	169	44	Bhupatinagar	157	257
16	Khanchi	193	380	45	Madhakhali	158	252
17	Chandipur	391	677	46	Bajkul	253	441
18	Narghat	180	305	47	Ramnagar	652	1066
19	Mahisadal	387	682	48	Deulihat	329	473
20	Geonkhali	170	282	49	Mirgoda	129	206
21	Kapaserya	129	218	50	Balisai	323	469
22	Nandigram	335	711	51	Kalindi	115	177
23	Amdabad	110	161	52	Pichaboni	113	177
24	Reyapara	139	232	53	Depal	138	232
25	Hanschara	104	162	54	Satmaile	155	261
26	Sutahata	216	349	55	Rasulpur	148	245
27	Chaitanyapur	302	606	56	Marishda	107	162
28	Kukrahati	148	244	57	Nachinda	163	266
29	Brajalalchak	295	627	58	Kalinagar	137	213

Source: Primary data collected from field survey.

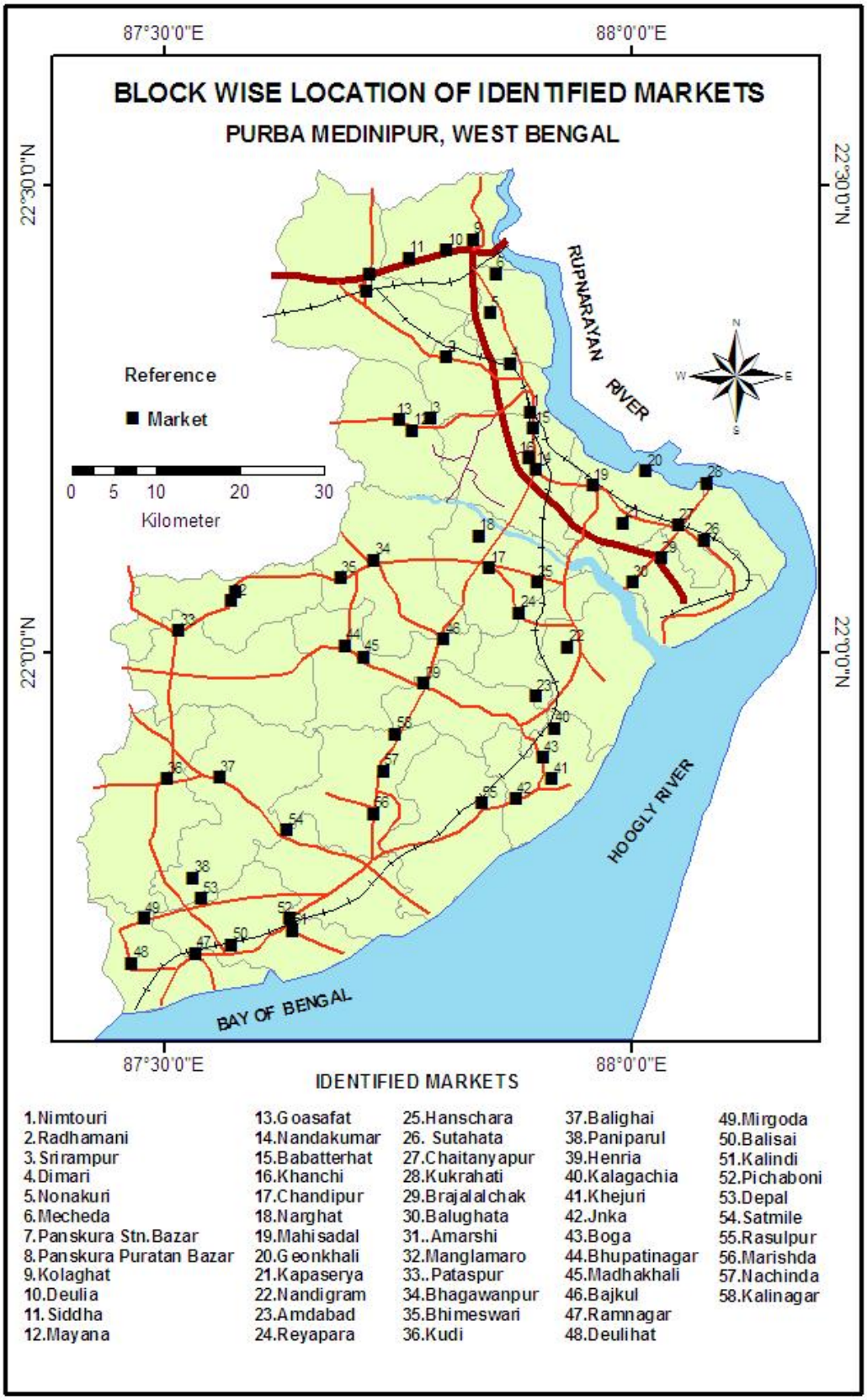
87°30'0"E
88°0'0"E
BLOCK WISE LOCATION OF IDENTIFIED MARKETS
PURBA MEDINIPUR, WEST BENGAL
22°30'0"N
22°0'0"N
RUPNARAYAN RIVER
HOOGLY RIVER
BAY OF BENGAL
Reference
Market
0 5 10 20 30
Kilometer
N
S
E
W
IDENTIFIED MARKETS
1.Nimtouri
2.Radhamani
3. Srirampur
4.Dimari
5.Nonakuri
6.Mecheda
7.Panskura Stn.Bazar
8.Panskura Puratan Bazar
9.Kolaghat
10.Deulia
11. Siddha
12.Mayana
13.Goasafat
14.Nandakumar
15.Babatterhat
16.Khanchi
17.Chandipur
18.Narghat
19.Mahisadal
20.Geonkhali
21.Kapaserya
22.Nandigram
23.Amdabad
24.Reyapara
25.Hanschara
26. Sutahata
27.Chaitanyapur
28.Kukrahati
29.Brajalalchak
30.Balughata
31..Amarshi
32.Manglamaro
33..Pataspur
34.Bhagawanpur
35.Bhimeswari
36.Kudi
37.Balighai
38.Paniparul
39.Henria
40.Kalagachia
41.Khejuri
42.Jnka
43.Boga
44.Bhupatinagar
45.Madhakhali
46.Bajkul
47.Ramnagar
48.Deulihat
49.Mirgoda
50.Balisai
51.Kalindi
52.Pichaboni
53.Depal
54.Satmile
55.Rasulpur
56.Marishda
57.Nachinda
58.Kalinagar

Figure – 1

Table – 2.Blockwise level of development related to marketing
(Based on UNDP index of development)

Sl. No	Average Index Class	Level of Development	No. of blocks	Name of the Block	No of markets	% of markets
1	0.0275 - 0.1484	Very Low	7	Nandigram-II, Haldia, Khejuri-I, Khejuri-II, Ramnagar-I, Ramnagar-II, Contai-II	17	29.31
2	0.1484 - 0.2693	Low	7	Sahid Matangini, Chandipur, Nandigram-I, Sutahata, Egra-II, Contai-III Bhagawanpur-II,	17	29.31
3	0.2693 - 0.3902	Moderate	7	Nandakumar, Mahisadal, Potashpur-I, Potashpur-II, Bhagawanpur-I, Egra-I, Contai-I	13	22.41
4	0.3902 - 0.5111	High	3	Tamluk, Panskura-II, Moyna	9	15.52
5	0.5111 - 0.6320	Very High	1	Panskura-I	2	3.45
Mean =0.2693						
Standard deviation = 0.1210						

From the table-2, it is clear that Panskura – I block shows a very high level of development in relation to market related variables. In this block the number of agricultural labour, food grain production and irrigated area is higher than other blocks of the district. All these criteria related with both permanent and periodic markets because the maximum number of the markets of the district are agro-based which helps to develop economic functions in the block. The other three blocks like Tamluk, Panskura – II and Mayna belongs to high level of development due to its higher road density, banking service and food grain production. Road length and financial support plays a vital role in the development of market functions. Near about 50 percent of blocks shows a low to very low development index value which includes Nandigram – I & II, Ramnagar – I & II, Chandipur, Bhagawanpur – I, Contai – II & III, Khejuri – I & II, Sutahata, Sahid Matangini and Egra – II. All these blocks have low food grain production, financial support and road length which influence the lower level of development related with marketing functions. Rest of the seven blocks like Nandakumar, Mahisadal, Potashpur – I & II, Bhagawanpur – I, Egra – I and Contai – I accounts for moderate development rate. In these seven blocks though the food grain production is high but the financial support and co-operative system are in an underdeveloped condition which causes the moderate levels of development.

The pattern of development related to market function of the district shows a peculiar type. Only four blocks with 18.97 percent of market under study area reflects very high to high level of development where are 58.62 percent of permanent market belongs to 34 blocks shows very low to low level of market development value. There are 22.41 percent markets located within seven blocks belongs to moderate level of development. The variables related with market functions of the district are given in the above table reflects that the permanent markets of the district is not up to a remarkable stages of the development which can influence the whole economic development pattern of the study region.

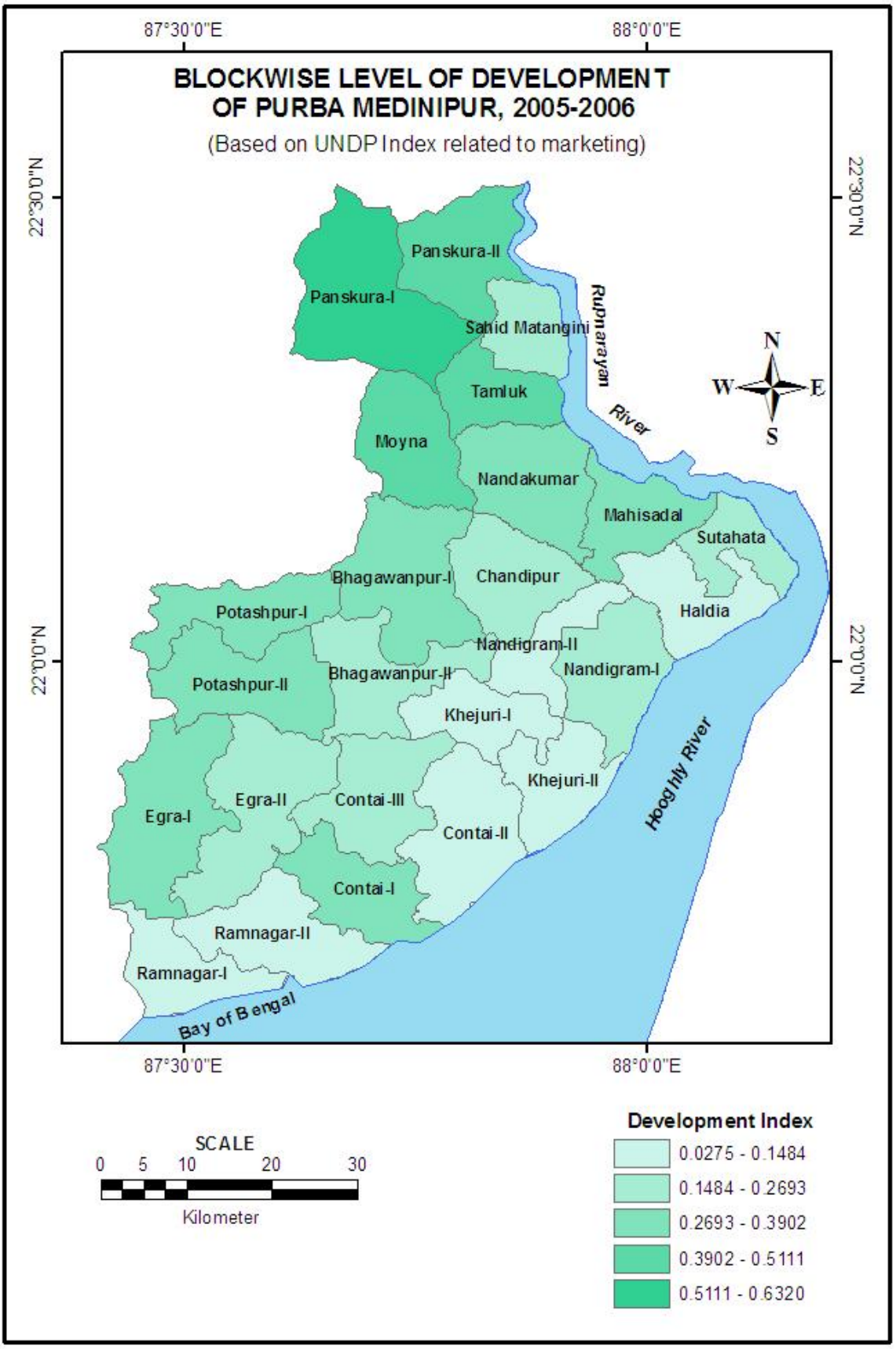
BLOCKWISE LEVEL OF DEVELOPMENT
OF PURBA MEDINIPUR, 2005-2006
(Based on UNDP Index related to marketing)
87°30'0"E
88°0'0"E
22°30'0"N
22°0'0"N
Panskura-II
Panskura-I
Sahid Matangini
Rupnarayan River
Tamluk
Moyna
Nandakumar
Mahisadal
Sutahata
Haldia
Bhagawanpur-I
Chandipur
Potashpur-I
Nandigram-II
Nandigram-I
Potashpur-II
Bhagawanpur-II
Khejuri-I
Khejuri-II
Hoogly River
Egra-I
Egra-II
Contai-III
Contai-II
Contai-I
Ramnagar-II
Ramnagar-I
Bay of Bengal
N
W
E
S
SCALE
0 5 10 20 30
Kilometer
Development Index
0.0275 - 0.1484
0.1484 - 0.2693
0.2693 - 0.3902
0.3902 - 0.5111
0.5111 - 0.6320

Figure – 2

6 LEVEL OF COMPOSITE MARKET FUNCTION DEVELOPMENT

This is an important method which is used to analyze the development aspect of the market economic function of any region. This method is directly related to the market potential value with the development index calculated by UNDP method of analysis. For working out the composite market functional development index two major components are used i.e. blockwise UNDP index and sum of market potential value. Multiplving both the blockwise information we can get the result which gives the idea about market development aspect the study region. The UNDP method of development index has been already calculated earlier and the blockwise average market potential value also computed by using the formula below:

$$Vi = \sum_{j=1}^{n} \frac{mj}{dij}$$

Where,

V_i = the total marketing potential of i^{th} market centre;
mj = mass (market worker) of the market centre 'j'
d_{ij} = distance between two market 'i' & 'j'

The level of composite market function development can be calculated by using the formula below:

$$FDI = \Sigma\ (abmp \times abdi)$$

Where,

FDI = functional development index related to marketing

abmp = average blockwise market potential

abdi = average blockwise development index (as per UNDP)

Table – 4. Level of Composite market function development
(Based on average development index of UNDP and average market potential)

Sl. No.	Functional development index	Level of development	No of blocks	Name of the blocks	No of markets	% of markets
1	Above 4000	Very High	2	Panskura – I, Sahid Matangini.	04	6.90
2	3000 – 4000	High	3	Nandakumar, Ramnagar-I, Tamluk.	10	17.24
3	2000 – 3000	Moderate	2	Nandigram-I, Chandipur.	3	5.17
4	1000 -2000	Low	3	Mahisadal ,Panskura – II, Egra-II,	8	13.79
5	Below 1000	Very Low	15	Egra-I, Sutahata, Haldia, Khejuri-I Khejuri-II, Potashpur-I, Potashpur-II, Bhagawanpur-II ,Bhagawanpur-I , Moyna, Ramnagar-II, Contai-I, Contai-II, Contai-III, Nandigram-II	33	56.90
Total			25		58	100

The functional development classes has been grouped on the basis of the difference from mean and the standard deviation value and the class vary from very low to very high level of development. Like other previous indexes the functional development index shows some similar pattern of growth. Here one advantages of this method is market potential and market employees are used as the important variable. Therefore, the computed result is much more reliable than previous two methods. The table no -4 shows that near about 17.24 percent markets of the study region influence the development of 3 blocks in market economic function. Here again Panskura – I block belongs to very high level of development group and Ramnagar – I belongs to high group. In reality, within these two groups the important 3 higher order permanent markets are located, i.e., Panskura in Panskura – I, Mecheda in Sahid Matangini and Ramnagar in Ramnagar – I block. Tamluk, Nandigram and Chandipur block belongs to low developed class which occupied 12.07 percent of markets of the district. Except Tamluk, Nandigram and Chandipur has the low market potential value but Tamluk urban market influences surrounding markets of

the block. Rest 41 markets of 18 blocks accounts for 70.69 percent of markets of the study region which are belong to very low level of development group. The markets of these blocks are purely local product based and subsistence in nature. So, the market participation is low which cause the low market potentials of the district and the consequence is the very low level of functional development pattern.

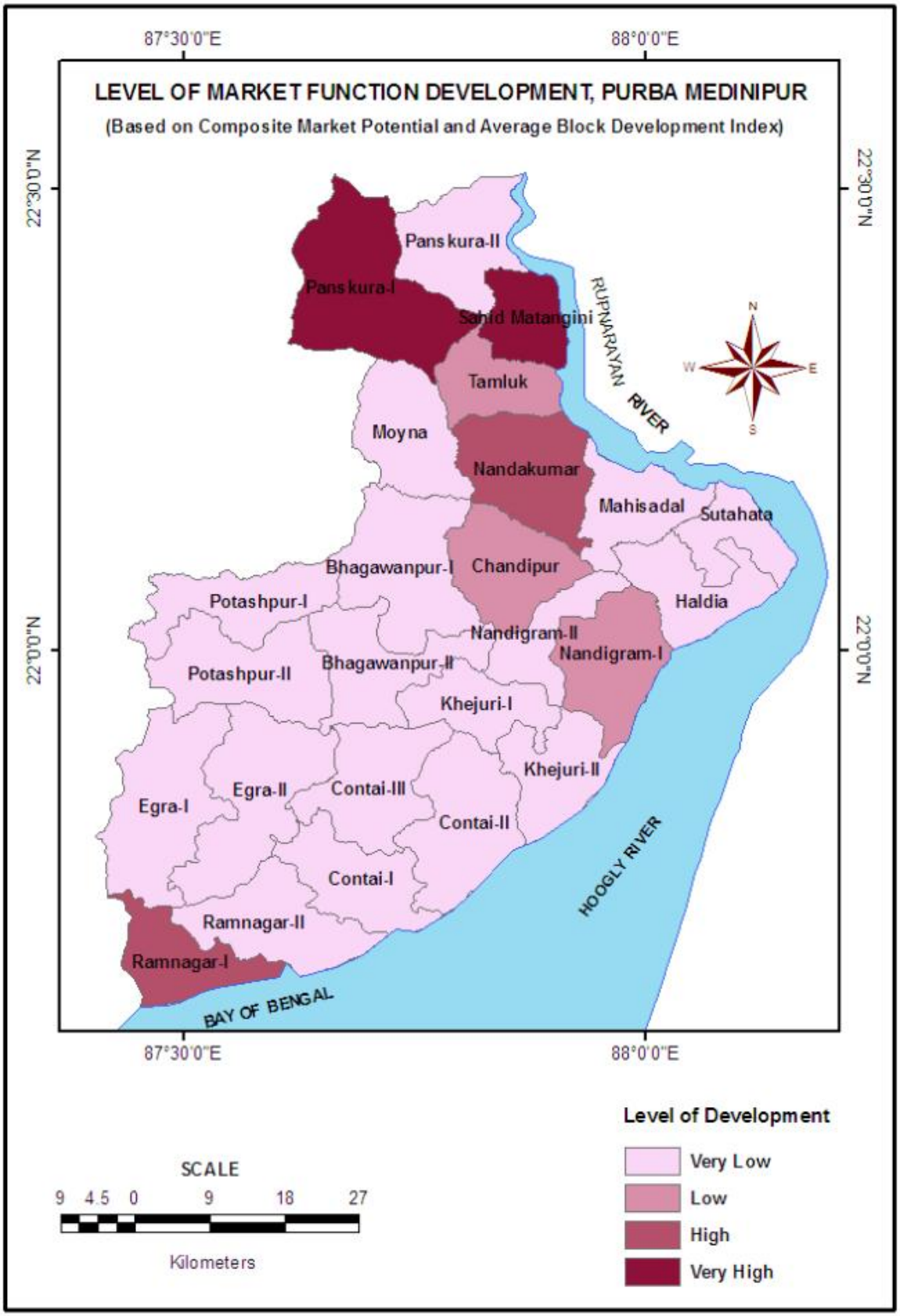
LEVEL OF MARKET FUNCTION DEVELOPMENT, PURBA MEDINIPUR
(Based on Composite Market Potential and Average Block Development Index)
87°30'0"E
88°0'0"E
22°30'0"N
22°0'0"N
Panskura-II
Panskura-I
Sahid Matangini
Tamluk
Moyna
Nandakumar
Mahisadal
Sutahata
Haldia
Chandipur
Bhagawanpur-I
Potashpur-I
Nandigram-II
Nandigram-I
Bhagawanpur-II
Potashpur-II
Khejuri-I
Khejuri-II
Egra-I
Egra-II
Contai-III
Contai-II
Contai-I
Ramnagar-II
Ramnagar-I
RUPNARAYAN RIVER
HOOGLY RIVER
BAY OF BENGAL
N
S
E
W
SCALE
9 4.5 0 9 18 27
Kilometers
Level of Development
Very Low
Low
High
Very High

Figure - 3

7 CONCLUDING REMARKS

All the detail calculation has been shown in appendix 1, 2 and 3. The computed composite development value are grouped on the basis of mean and standard deviation and the 25 blocks are divided into five level of development zone varies from very low to very high. There are only two blocks, i.e. Panskura – I and Sahid Matangini belongs to high to very high levels of development group where only four markets are located which share 6.90 percent of permanent market under study of Purba Medinipur district. There are 17 blocks with 39 permanent markets shows a very low to low level of development which is more than 67 percent of permanent markets. It reflects that the market development related variables are not the dominant factors rather less influential items. The rural economic growth, demand and behavioral aspects of the people played a vital role in the development of markets. More than 25 percent of markets located at Nandakumar, Tamluk, and Potashpur – I & II, Panskura and Moyna block are moderately developed because of their nearness to the urban centres like Tamluk, Panskura and Haldia which influence the economic development process of these blocks.

REFERENCES

[1] Philbrick A.K., (1957), "Principles of Area Functional Organization in Regional Human Geography", *Economic Geography, Vol.33. P.300.*

[2] Dasgupta, B. (1971), "Socio – Economic Classification of Indian District – A Statistical Approach", *Economic and Political Weekly, August, 14. 1971.*

[3] Pal, M.N. (1975), "Regional Disparities in the levels of Development in India", *Indian Journal of Regional Science, Vol.II, No.1, 1975, PP. 12-35.*

APPENDIX 1. **BLOCKWISE LEVEL OF DEVELOPMENT OF PURBA MEDINIPUR, 2010(BASED ON UNDP INDEX OF DEVELOPMENT)**

Sl. No	*Block*	*Irrigated area (hec)*	*Index*	*Agricultural labour*	*Index*	*Food grains production ('000mt)*	*Index*	*Road length (km)*	*Index*	*Population served/bank*	*Index*	*Small savings ('000 Rs)*	*Index*	*Co-operative working capital ('000 Rs)*	*Index*	*Total Index Value*	*Average Index Value*
1	Tamluk	8680	0.43	18601	0.43	33.629	0.27	466	0.30	41000	0.65	82531	0.23	3184844	1.01	3.31	0.47
2	Sahid Matangini	5900	0.23	17202	0.36	29.03	0.22	279	0.14	20000	0.03	168779	0.55	61506	0.01	1.54	0.22
3	Panskura - I	16790	1.00	30086	1.00	101.931	1.00	680	0.48	31000	0.35	88608	0.26	83659	0.02	4.11	0.59
4	Panskura - II	8566	0.42	17399	0.37	48.129	0.43	651	0.45	29000	0.29	292550	1.00	45846	0.01	2.97	0.42
5	Moyna	10058	0.52	26483	0.82	52.574	0.47	353	0.20	25000	0.18	177555	0.58	66104	0.01	2.79	0.40
6	Nandakumar	8770	0.43	23347	0.82	48.763	0.43	452	0.28	29000	0.29	132779	0.42	46601	0.01	2.53	0.36
7	Chandipur	5250	0.18	17995	0.40	19.447	0.12	586	0.40	27000	0.24	76691	0.21	34825	0.00	1.55	0.22
8	Mahishadal	7560	0.35	22858	0.64	43.471	0.38	699	0.50	30000	0.32	87759	0.25	73769	0.02	2.45	0.35
9	Nandigram-I	2900	0.02	19791	0.49	29.977	0.23	339	0.19	25000	0.18	66044	0.17	21128	0.00	1.28	0.18
10	Nandigram-II	3470	0.06	12932	0.15	7.978	0.00	595	0.41	26000	0.21	48188	0.11	21724	0.00	0.92	0.13
11	Sutahata	5090	0.17	11679	0.08	14.846	0.07	181	0.05	53000	1.00	51282	0.12	429121	0.13	1.63	0.23
12	Haldia	3450	0.06	10017	0.00	11.461	0.04	136	0.02	27000	0.24	184865	0.61	115830	0.03	0.98	0.14
13	Potashpur-I	14110	0.81	14782	0.24	42.361	0.37	801	0.58	30000	0.32	87741	0.25	117972	0.03	2.60	0.37
14	Potashpur-II	13310	0.75	16266	0.31	57.469	0.53	118	0.00	25000	0.18	44963	0.10	92130	0.02	1.89	0.27
15	Bhagawanpur-I	9500	0.48	24964	0.74	33.355	0.27	573	0.39	25000	0.18	50815	0.12	60609	0.01	2.19	0.31
16	Egra-I	13230	0.75	14748	0.24	54.135	0.49	418	0.26	24000	0.15	48763	0.11	23139	0.00	1.99	0.28
17	Egra-II	10450	0.55	16489	0.32	15.466	0.08	518	0.34	26000	0.21	111646	0.34	132720	0.04	1.88	0.27
18	Khejuri-I	2830	0.01	14670	0.23	17.87	0.11	512	0.34	19000	0.00	84654	0.24	178578	0.05	0.98	0.14
19	Khejuri-II	2650	0.00	11961	0.10	11.108	0.03	683	0.48	29000	0.29	18714	0.00	204385	0.06	0.96	0.14
20	Bhagawanpur-II	8560	0.42	20309	0.51	44.537	0.39	726	0.52	21000	0.06	55428	0.13	148656	0.04	2.07	0.30
21	Ramnagar-I	7520	0.34	13946	0.20	13.037	0.05	201	0.07	21000	0.06	38292	0.07	236888	0.07	0.86	0.12
22	Ramnagar-II	5410	0.20	16319	0.31	18.468	0.11	353	0.20	23000	0.12	35753	0.06	101652	0.03	1.03	0.15
23	Contai-I	3460	0.06	11654	0.08	13.007	0.05	367	0.21	25000	0.18	89544	0.26	3460332	1.09	1.93	0.28
24	Contai-II	3060	0.03	16934	0.34	11.778	0.04	336	0.19	26000	0.21	30036	0.04	187525	0.05	0.90	0.13
25	Contai-III	6190	0.25	13833	0.19	13.96	0.06	1290	1.00	23000	0.12	45560	0.10	182744	0.05	1.77	0.25
																Mean	*0.2693*
																SD	*0.1210*

***APPENDIX – 2.* SHOWING MARKET COMPOSITE FUNCTION**

Sl. No	Block	Markets	Composite function(cf) (Based on WKD Davies centrality index *)	Market Population(p)	(cf*P)
1	Tamluk	1.Nimtouri	19.005	631	11992.307
		2.Radhamani	22.564	591	13335.108
		3.Srirampur	2.013	185	372.457
		4.Dimari	2.322	181	420.239
2	Sahid Matangini	5.Nonakuri	19.806	580	11487.375
		6.Mecheda	71.994	1274	91720.743
3	Panskura - I	7.Panskura Stn.Bazar	38.947	949	36960.751
		8.Panskura Puratan Bazar	17.311	583	10092.278
4	Panskura - II	9.Kolaghat	18.962	634	12021.902
		10.Deulia Bazar	2.594	221	573.345
		11.Siddha	2.131	193	411.356
5	Moyna	12.Mayana	3.165	242	765.993
		13.Goasafat	4.708	292	1374.665
6	Nandakumar	14.Nandakumar	33.383	872	29109.632
		15.Babatterhat	1.628	169	275.145
		16.Khanchi	7.252	380	2755.737
7	Chandipur	17.Chandipur	25.520	677	17277.111
		18.Narghat	5.943	305	1812.513
8	Mahishadal	19.Mahisadal	21.254	682	14495.515
		20.Geonkhali	5.433	282	1531.997
		21.Kapaserya	2.923	218	637.204
9	Nandigram-I	22.Nandigram	20.964	711	14905.407
10	Nandigram-II	23.Amdabad	1.561	161	251.336
		24.Reyapara	2.982	232	691.833
		25.Hanschara	1.497	162	242.574
11	Sutahata	26. Sutahata	6.438	349	2246.742
		27.Chaitanyapur	15.700	606	9514.078
		28.Kukrahati	3.552	244	866.720
12	Haldia	29.Brajalalchak	17.698	627	11096.702
		30.Balughata	1.312	142	186.259
13	Potashpur-I	31.Amarshi	5.929	312	1849.820
		32.Manglamaro	5.564	274	1524.458
14	Potashpur-II	33.Pataspur	6.614	347	2294.885
15	Bhagawanpur-I	34.Bhagawanpur	5.407	320	1730.109
		35.Bhimeswari	5.040	311	1567.555
16	Egra-I	36.Kudi	2.230	183	408.138
17	Egra-II	37.Balighai	2.032	193	392.171
		38.Paniparul	18.624	491	9144.508
18	Khejuri-I	39.Henria	16.370	647	10591.424
		40.Kalagachia	2.214	206	456.051
19	Khejuri-II	41.Khejuri	6.628	375	2485.333
		42.Janka	3.126	238	744.038
		43.Boga	2.495	214	533.976
20	Bhagawanpur-II	44.Bhupatinagar	3.706	257	952.542
		45.Madhakhali	3.613	252	910.587
		46.Bajkul	9.508	441	4193.029
21	Ramnagar-I	47.Ramnagar	70.583	1066	75241.746
		48.Deulihat	15.532	473	7346.743
		49.Mirgoda	2.418	206	498.193
22	Ramnagar-II	50.Balisai	14.288	469	6700.880
		51.Kalindi	1.766	177	312.609
		52.Pichaboni	1.744	177	308.774
		53.Depal	2.869	232	665.650
23	Contai-I	54.Satmaile	3.563	261	929.893
24	Contai-II	55.Rasulpur	3.522	254	894.537

25	Contai-III	56.Marishda	1.458	162	236.158
		57.Nachinda	4.085	266	1086.512

APPENDIX – 3. **LEVEL OF COMPOSITE MARKET FUNCTION DEVELOPMENT (BASED ON AVERAGE DEVELOPMENT INDEX OF UNDP AND AVERAGE MA**

Sl. No	Block	Average Development Index(abdi)	Avg. Blockwise Market Potential(abmp)	(abdi*abmp)	Difference from mean	Difference from SD	Level of market development
1	Tamluk	0.473	6530.028	3088.659	11727.456	10436.225	*VERY HIGH*
2	Sahid Matangini	0.220	51604.059	11349.735	9271.827	7980.596	*VERY HIGH*
3	Panskura - I	0.587	23526.515	13805.364	1801.719	510.488	*HIGH*
4	Panskura - II	0.424	4335.534	1839.711	1339.836	48.606	*HIGH*
5	Moyna	0.399	1070.329	426.662	1010.750	-280.480	*LOW*
6	Nandakumar	0.362	10713.505	3879.627	640.682	-650.548	*LOW*
7	Chandipur	0.222	9544.812	2119.176	41.268	-1249.962	*LOW*
8	Mahishadal	0.350	5554.905	1946.607	-131.301	-1422.532	*VERY LOW*
9	Nandigram-I	0.182	14905.407	2718.591	-238.198	-1529.428	*VERY LOW*
10	Nandigram-II	0.132	395.248	52.169	-800.080	-2091.310	*VERY LOW*
11	Sutahata	0.233	4209.180	980.732	-1097.176	-2388.407	*VERY LOW*
12	Haldia	0.140	5641.480	790.766	-1287.142	-2578.373	*VERY LOW*
13	Potashpur-I	0.372	1687.139	627.385	-1306.994	-2598.225	*VERY LOW*
14	Potashpur-II	0.270	2294.885	618.619	-1450.524	-2741.754	*VERY LOW*
15	Bhagawanpur-I	0.313	1648.832	516.747	-1459.289	-2750.520	*VERY LOW*
16	Egra-I	0.284	408.138	115.949	-1480.321	-2771.551	*VERY LOW*
17	Egra-II	0.268	4768.340	1277.829	-1561.162	-2852.392	*VERY LOW*
18	Khejuri-I	0.140	5523.737	770.914	-1651.246	-2942.477	*VERY LOW*
19	Khejuri-II	0.138	1254.449	172.880	-1784.962	-3076.192	*VERY LOW*
20	Bhagawanpur-II	0.296	2018.719	597.588	-1820.945	-3112.176	*VERY LOW*
21	Ramnagar-I	0.123	27695.561	3417.745	-1905.028	-3196.259	*VERY LOW*
22	Ramnagar-II	0.147	1996.978	292.947	-1908.612	-3199.842	*VERY LOW*
23	Contai-I	0.276	929.893	256.963	-1961.959	-3253.190	*VERY LOW*
24	Contai-II	0.129	894.537	115.049	-1962.860	-3254.090	*VERY LOW*
25	Contai-III	0.253	669.050	169.296	-2025.739	-3316.969	*VERY LOW*
						MEAN	*2077.908*
						SD	*3369.139*

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Amino Acids as Potential Emulsifiers in Stabilizing Oil/Water Emulsions

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ABSTRACT: The potential of some amino acids (leucine, glutamic acid, isoleucine, aspartic acid and tryptophan) as emulsifiers in stabilizing some vegetable oils/water emulsions was investigated. The vegetable oils used for the study were Palm kennel oil, Melon oil, Sesame oil, Coconut oil and Groundnut oil. This was achieved by first forming homogenised emulsions of the oil/water and the time of phase separation was monitored. The amino acids were added to the emulsions and the mixtures homogenised and the phase separation time was studied. In all cases, there was increase in phase separation time, which is an indication of increase in stability. These amino acids can be used as emulsifiers in stabilizing oil/water emulsions.

KEYWORDS: Emulsion, Emulsifier, stabilization, Droplet, Vegetable oil, amino acids.

1 INTRODUCTION

Oils form an important class of food substances as they provide energy and serve several other functions such as delivery of fat-soluble chemicals and food processing. Oils are however not soluble in water, the medium in which much of our food, cosmetics, drugs and many industrial products (pesticides, textiles, detergents/soaps etc) are prepared. As foods, oils give a greasy sticky feel when ingested orally. As a result, much of the oils used as foods drugs or cosmetics are presented in the form of emulsions as exemplified in sauces and salad dressings.

An emulsion is a mixture of two immiscible liquids. It contains tiny droplets of one liquid suspend in another. For example, an oil-in-water emulsion contains droplets of oil dispersed in water. Water and oil are immiscible as such they form two distinct layers when mixed together. Adheeb [1], defined emulsion as a heterogeneous system, consisting of at least one immiscible liquid intimately dispersed in another in form of droplets, whose diameter in general exceeds o.1µm. According to Shoko [2] emulsions are used in many fields which includes cosmetics, medicine and in foods. Such emulsions must be stable to ensure consistency, good texture and physical appeal.

Stable emulsions are produced when an emulsifier is added to the mixture of the liquids. An emulsifier consists of a water-loving hydrophilic head and an oil-loving hydrophobic tail. The hydrophilic head is directed to the aqueous phase and the hydrophobic tail to the oil phase. The emulsifier positions itself at the oil/water interface and reduces the interfacial tension hence stabilising the emulsion. Emulsifiers decrease the average size of the droplets in emulsions produced by homogenization because they reduce the interfacial tension, thereby facilitating droplet disruption. They also improve the stability of emulsions to droplet aggregation by generating repulsive forces between the droplets and/or by forming interfacial membranes around the droplets that are resistant to rupture. Emulsifiers used for some oil/water blends include lecithin, sodium/potassium salts of fatty acids, mono- and diglycerides, spans, polysorbates, polyglycol ethers, proteins and protein residues ([3], [4], [5], [6]). Satoshi [7], summarised the functions of an ideal emulsifiers to include rapid adsorption to the surface of the oil droplets formed during homogenization, lowering the interfacial tension and protecting the droplets against aggregation during emulsion processing, storage, and utilization. Vanessa [6], have also demonstrated the use of proteins and protein residues in the stabilization of edible oil/water emulsions.

Emulsifiers have the ability to interact with other food ingredients. In this way, various functionalities can be obtained, for example interaction with proteins or carbohydrates. The emulsifier may be an aerating agent, starch complexing agent and/or crystallisation inhibitor. For example, fat molecules do not mix well with water and so form globs inside the digestive

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tract. Emulsification of the fat breaks the fat droplets into smaller units, thus exposing their surfaces for rapid actions by digestives enzymes (e.g. lipase). These enzymes break up the fat molecules to much smaller fragments that can easily be absorbed by the lining of the intestines. The function of the emulsifying agents is similar to that of detergents used in washing.

Food emulsifiers are molecules, which contain a non-polar unit e.g., aliphatic, alicyclic, or aromatic hydrocarbons; and one or more polar units which contained heteroatoms such as oxygen, nitrogen, and sulfur. The polar functionality makes the emulsifier anionic, cationic, amphoteric, or nonionic. Amino acids like alanine, phenylalanine, leucine and isoleucine are surfactants that contain nonpolar aliphatic and aromatic side chains. While, arginine, lysine and tryptophane, contain amino groups, which promote cationic character to the protein and as such are known as cationic surfactants. Aspartic and glutamic acids possess side chains with carboxyl groups, which contribute to their anionic character hence they are known as anionic surfactants.

The use of proteins and their residues in stabilization of edible emulsion is significant as such emulsions constitute an important part of our diet. A first line of approach in this study is to examine how amino acids, the building blocks of proteins, affect the stability of the oil-water interface.

2 MATERIALS AND METHODS

The amino acids; leucine, glutamic acid, isoleucine, aspartic acid and tryptophan and the vegetable oils; Palm kennel oil (PKO), Melon oil (MLO), Sesame oil (SSO), Coconut oil (CNO) and Groundnut oil (GNO) were commercially obtained.

2.1 DETERMINATION OF FLOW RATE

A two liter capacity beaker was filled with distilled water at room temperature. 10mL of distilled water was transferred to the un-graduated arm of an Ostwald Viscometer. The Viscometer was suspended into the beaker with the aid of a retort stand and left for about twenty minutes. The water was then pumped by exerting pressure through the un-graduated arm to a level above the upper calibration mark in the graduate arm of viscometer, and then released. The time taken for the meniscus to drop from the upper mark; above the bulb to the lower mark below the bulb in the graduated arm of the Ostwald Viscometer was recorded, five replicate determinations were made in each case. The procedure was repeated using each of the oil samples.

2.2 DETERMINATION OF DENSITY OF THE OIL SAMPLES

A 25mL density bottle was weighed and filled with water and reweighed, the result was recorded. The experiment was repeated using the vegetable oils. The densities of the water and the oil samples were calculated using the mathematical expression density = mass/volume.

From the measured flow times and the densities, the relative viscosities of the vegetable oils were calculated using the mathematical expression. $\frac{\eta_o}{\eta_w} = \frac{t_o \rho_o}{t_w \rho_w}$

Where η_o = viscosity of oil
η_w = viscosity of water
t_o = flow time of oil
t_w = flow time of water
ρ_o = density of oil
ρ_w = density of water

2.3 DETERMINATION OF THE STABILITY OF HOMOGENISED OIL/WATER MIXTURE

Exactly 1.0mL of oil sample and 9.0mL of distilled water was transferred into a clean dry conical flask and stirred vigorously using a magnetic stirrer for one minutes. The homogenised mixture was quickly transferred into a 25mL measuring cylinder and timing started immediately. The time taken for the oil to clearly separate from water was recorded. Five replicate determinations were made in each case. The experiment was repeated using oil volume fractions from 0.2 to 0.9.

2.4 DETERMINATION OF THE EFFECTS OF AMINO ACID ON THE PHASE SEPARATION OF THE OIL/WATER MIXTURE AT ROOM TEMPERATURE

Oil/water volume ratio of 1:9 was transferred into seven different test tubes labeled from A to G. 0.009g, 0.046g, 0.920g, 0.138g, 0.184g, 0.230g and 0.276g of amino acid samples, corresponding to 1%, 5%, 10%, 15%, 20%, 25% and 30% on the weight of the oil respectively, were transferred into the seven test tubes. The oil/water/amino acid mixtures were stirred vigorously using a magnetic stirrer for five minutes and allowed to stand. The time taken for clear phase separation was recorded. The conductivities of the sample solutions were also measured. Replicate determinations were conducted and the average calculated.

3 RESULTS AND DISCUSSION

The results of density, Table 1.0, indicate that all the vegetable oils were less dense than water. This implies that a mixture of the oils and water will lead to creaming of the oil droplets. Creaming velocity is dependent on density difference between the liquids [8]. The larger the density difference, the faster the creaming velocity. From the result, melon oil with a lower density will cream faster than the rest of the oils. On the other hand groundnut oil with the highest density will have a slower creaming velocity.

Table 1. Density and relative viscosity of the vegetable oils

	Density (g/ml)	**Relative Viscosity (pas)**
Palm kernel Oil (PKO)	0.93	3.129
Melon Oil (MLO)	0.91	2.865
Sesame Oil (SSO)	0.96	2.866
Coconut Oil (CNO)	0.94	2.711
Groundnut Oil GNO	0.96	2.863
Water	1.04	-

Table 2. Variation in stability of vegetable oils with different oil/water volume ratio

Oil/water Volume (mL)	Time for Oil/water Phase Separation (Minutes)				
	Palm karnel oil (PKO)	Melon Oil (MLO)	Sesame oil (SSO)	Coconut oil (CNO)	Groundnut Oil (GNO)
1.9	3.99	2.22	4.49	2.43	1.52
2.8	5.81	4.23	6.30	4.53	3.49
3.7	7.35	6.30	7.97	6.40	5.30
4.6	10.00	9.00	9.84	8.41	7.67
5.5	11.50	10.14	12.00	11.50	8.99
6.4	13.62	12.31	14.05	12.62	10.58
7.3	15.83	14.00	15.99	14.51	12.05
8.2	17.51	16.10	16.95	15.99	13.50

Table 3. Variation in stability and conductivity of vegetable oils with different percentages of leucine

Oil/water Volume (mL)	Mass of Leucine	Time for Oil/water phase Separation (Minutes)					Conductivity (mScm)				
		PKO	MLO	SSO	CNO	GNO	PKO	MLO	SSO	CNO	GNO
1:9	1%	11.27	10.46	09.45	07.61	05.61	0.039	0.047	0.035	0.036	0.048
1:9	5%	13.31	12.38	10.36	09.68	06.59	0.035	0.041	0.032	0.034	0.046
1:9	10%	15.28	14.58	12.44	11.49	08.61	0.026	0.039	0.029	0.029	0.035
1:9	15%	17.50	18.42	16.51	14.38	10.64	0.025	0.036	0.026	0.028	0.033
1:9	20%	20.40	21.62	20.33	16.21	12.38	0.023	0.022	0.024	0.025	0.022
1:9	25%	24.62	23.62	23.57	21.55	14.46	0.019	0.020	0.016	0.023	0.021
1:9	30%	27.68	25.50	26.62	23.42	16.41	0.015	0.017	0.014	0.020	0.020

Table 4. Variation in stability and conductivity of vegetable oils with different percentages of glutamic

Oil/water Volume (mL)	Mass of glutamic	Time for Oil/water phase Separation (Minutes)					Conductivity (mScm)				
		PKO	MLO	SSO	CNO	GNO	PKO	MLO	SSO	CNO	GNO
1:9	1%	05.20	07.30	06.57	05.55	04.95	0.0352	0.0435	0.0421	0.0395	0.0334
1:9	5%	07.10	10.03	09.48	07.32	07.87	0.0334	0.0410	0.0415	0.0375	0.0317
1:9	10%	09.55	13.17	12.17	10.05	10.56	0.0299	0.0391	0.0384	0.0330	0.0278
1:9	15%	12.68	17.48	16.38	13.19	11.86	0.0258	0.0372	0.0360	0.0301	0.0249
1:9	20%	15.88	22.58	20.49	17.50	13.46	0.0245	0.0334	0.0320	0.0282	0.0247
1:9	25%	18.98	26.60	24.50	22.60	16.78	0.0242	0.0300	0.0290	0.0255	0.0245
1:9	30%	22.60	31.80	30.62	26.62	20.55	0.0242	0.0250	0.0249	0.0248	0.0242

Table 5. Variation in stability and conductivity of vegetable oils with different percentages of isoleucine

Oil/water Volume (mL)	Mass of Isoleucine	Time for Oil/water phase Separation (Minutes)					Conductivity (mScm)				
		PKO	MLO	SSO	CNO	GNO	PKO	MLO	SSO	CNO	GNO
1:9	1%	5.00	4.38	3.59	3.35	4.0	0.046	0.032	0.032	0.037	0.020
1:9	5%	5.58	4.58	4.50	4.45	4.03	0.043	0.041	0.041	0.060	0.018
1:9	10%	6.59	5.52	5.00	6.00	5.00	0.041	0.037	0.037	0.032	0.012
1:9	15%	8.47	6.47	5.59	7.58	5.59	0.039	0.030	0.030	0.010	0.011
1:9	20%	12.32	8.58	7.56	8.59	8.22	0.038	0.022	0.022	0.008	0.009
1:9	25%	15.00	11.58	9.47	9.58	9.34	0.027	0.018	0.018	0.006	0.007
1:9	30%	15.58	12.80	10.59	30.32	10.53	0.027	0.011	0.011	0.004	0.005

Table 6. Variation in stability and conductivity of vegetable oils with different percentages of Aspartic acid

Oil/water Volume (mL)	Mass of Aspartic acid	Time for Oil/water phase Separation (Minutes)					Conductivity (mScm)				
		Palm karnel oil	Melon Oil	Sesame oil	Coconut oil	Groundnut Oil	Palm karnel oil	Melon Oil	Sesame oil	Coconut oil	Groundnut Oil
1:9	1%	10.58	6.50	11.14	4.10	11.10	0.055	0.039	0.025	0.041	0.042
1:9	5%	20.14	6.52	14.48	4.14	12.12	0.032	0.039	0.023	0.031	0.041
1:9	10%	40.18	7.10	15.12	6.16	13.20	0.021	0.029	0.014	0.030	0.040
1:9	15%	50.20	7.50	18.20	10.15	15.21	0.025	0.021	0.013	0.020	0.031
1:9	20%	70.30	8.14	20.22	10.18	17.48	0.021	0.005	0.010	0.011	0.031
1:9	25%	80.80	10.15	22.54	10.48	18.50	0.011	0.003	0.010	0.010	0.021
1:9	30%	90.50	10.55	29.40	10.42	20.51	0.010	0.001	0.001	0.001	0.001

Table 7. Variation in stability and conductivity of vegetable oils with different percentages of Tryptophan

Oil/water Volume (mL)	Mass of Tryptophan	Time for Oil/water phase Separation (Minutes)					Conductivity (mScm)				
		Palm karnel oil	Melon Oil	Sesame oil	Coconut oil	Groundnut Oil	Palm karnel oil	Melon Oil	Sesame oil	Coconut oil	Groundnut Oil
1:9	1%	5.00	4.38	3.59	3.35	4.00	0.046	0.052	0.032	0.037	0.020
1:9	5%	5.58	4.58	4.50	4.45	4.03	0.043	0.041	0.027	0.036	0.018
1:9	10%	6.59	5.52	5.00	6.00	5.00	0.041	0.0037	0.018	0.032	0.012
1:9	15%	8.47	6.47	5.59	7.58	5.47	0.039	0.030	0.016	0.010	0.011
1:9	20%	12.32	8.58	7.56	8.59	8.22	0.038	0.022	0.012	0.008	0.009
1:9	25%	15.00	11.58	9.47	9.58	9.34	0.027	0.018	0.009	0.006	0.007
1:9	30%	15.58	12.80	10.59	10.32	10.53	0.018	0.011	0.005	0.004	0.005

The viscosity of a liquid is its resistance to flow due to strong intermolecular forces of attraction existing with the liquid [9]. Viscosity is directly proportional to density. The results (Table 1.0) indicate viscosity of the vegetable oil to range between 2.711pas to 3.129pas. The viscosity of emulsion is dependent on the droplets concentration, size, shear rate and the electrostatic repulsion between droplets [10]. Therefore, if the concentration of the oil droplet is increased, the viscosity will also increase, since droplets become closely packed together such that their movement is restricted. Generally, the vegetable oils used are more viscous than water as such, increased in volume fractions of the oils increases viscosity and hence increase in stability of the systems.

Table 2.0 indicates the volume ratio of oil/water at difference intervals with the time taken for the two phases to be separated. At a lower fraction of the oil, the time of phase separation for the highly viscous oils was very short e.g. groundnut oil and melon oil. This implies that at lower fraction of the oil, the oil/water emulsion is very unstable and cream easily, increasing the volume fraction of the oil with a corresponding decrease in the continuous phase fraction (water) increases the stability of the emulsion. This can be observed by the increase in phase separation time.

Table 3.0 shows result of stability of the emulsion formed by the various vegetable oils on addition of the amino acids at different percentages. There is significant increase in phase separation time even at the least percentage of the amino acid added. This is an indication of increase in stability.

The phase separation time for groundnut oil on addition of leucine was lower than observed for the other vegetable oils. This is due to the high viscosity of groundnut oil when compared to the other vegetable oils. Generally, increasing the percentages of amino acids increases time of phase separation hence increase stability of the emulsion (Table 4.0- 7.0).

The conductivity of the emulsion was observed to decrease as the percentage of amino acid was increased. This is because the amino acids which are amphiphilic substances reduce the interfacial tension of the oil and water thereby enhancing the formation of more stable interfaces which disrupt the free movement of ions in solution and hence lower the conductivity.

4 CONCLUSION

The results of the study show an increase in phase separation time when the amino acids were added to the emulsions, this is an indication of increase in stability of the emulsions. This implies that amino acids can be used as emulsifiers in oil/water emulsions.

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REFERENCES

[1] Adheeb Usaid A.S., Premkumar, J and Rangganathan T.V (2014). Emulsion and it's Applications in Food Processing - A Review. *International Journal of Engineering Research and Applications.* 4(4): 241-248

[2] Shoko Y. Junichi K., Tatsuru T., Fuminori H., Aritomo Y., Hideki S., and Masahiko A. (2001). Emulsifying Potency of New Amino Acid-Type Surfactant (II): Stable Water-in-Oil (W/O) Emulsions Containing 85 wt% Inner Water Phase, *Chem. Pharm. Bull.* 49(10): 1331-1335.

[3] Chow M.C and Ho, C. C (1996). Properties of Palm oil-in-water Emulsions: Effect of Mixed Emulsifiers. *The Amer. Oil Chemists Society,*73 (1) 47-53

[4] Krenmena Nikovska (2012). Study of the Olive oil-in-water Emulsions with Protein Emulsifiers. *Emir. J. of Food and Agriculture* 21(1)17-24

[5] Hasenhuettl, G.L. (2008). Synthesis and Commercial Preparation of Food Emulsifiers. *Food Emulsions and their Applications, Hasenthuettl, G.L and Hartel R.W. ed. Springer, pp11-38.*

[6] Vanessa, C., Roberto A. Amelia, F. (2008). Emulsifying Properties of Proteins *Bol. Soc. Quím. Méx.*, 2(2), 80-89*01003*

[7] Satoshi Ogawa, Eric A. Decker, and Julian McClements (2003). Influence of Environmental Conditions on the Stability of Oil in Water Emulsions Containing Droplets Stabilized by Lecithin-Chitosan Membranes, *Biopolymers and Colloids Research Laboratory, Department of Food Science, University of Massachusetts, Amherst, Massachusetts 01003*

[8] Pandurangan M. K., Murugesan S. and Gajivaradhan P. (2014). Physico-chemical Properties of Groundnut oil and their Blends with Other Vegetable Oils, *Journal of Chemical and Pharmaceutical Research*, 6(8):60-66 Allaoua Achouri, Youness Zamani & Joyce Irene Boye (2012). Stability and Physical Properties of Emulsions Prepared with and without Soy Proteins, Journal of Food Research,1(1):254-267; doi:10.5539/jfr.v1n1p254

[9] Allaoua Achouri, Youness Zamani & Joyce Irene Boye (2012). Stability and Physical Properties of Emulsions Prepared with and without Soy Proteins, Journal of Food Research,1(1):254-267; doi:10.5539/jfr.v1n1p254

[10] Roman Pichot (2010). *Stability and Characterisation of Emulsions in the presence of Colloidal Particles and Surfactants,* A thesis submitted to The University of Birmingham for the degree of Doctor of Philosophy, Department of Chemical Engineering School of Engineering The University of Birmingham November 2010.

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Progressive Survey on Primary School girls' Education from 2009 to 2014: Case study of Ntambuka Collectivity

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ABSTRACT: This study was conducted on Idjwi Territory within the southern part of the Island covering Ntambuka Collectivity. It aimed, on the one hand, at studying the rate of schooled girls extending from 2009 to 2014 in primary schools. On the other hand, it sought to determine the declining causes of schooled girls and then to forward a proportion of remedial suggestions in order to increase the number of schoolgirls in that part of the island. On the basis of our genuine investigation, we have come up the following findings: the number of girls decreased systematically as they moved from one class into another. Moreover, the causes of this dwindle of schooled girls are basically due to teachers' immorality, precocious marriages, parents' retrograde culture and poverty, and negligence on behalf of the school girls themselves.

KEYWORDS: schooling, education, dwindle, schoolgirl, promotion, progress.

1 INTRODUCTION

1.1 PROBLEM STATEMENT

Obviously, education plays a crucial role in the progress and the development of any nation. Accordingly, its action is perceptible for the orientation of the future, the promotion of the population welfare, and social, economic and political transformations and so on. Furthermore, measures have been taken to give right to each person, in particular the universal declaration of the human rights of December 10, 1948. From this General Assembly of the United Nations , it has been stipulated that" every person has right to education" and this disposition has been reminded in 1989 as regards the convention about the child's rights.

Despite decades of engagement in favour of a qualitative teaching for every child, and in spite of the renewal of these actions, we still have around 121 millions of children that are deprived of this right in the world (Koffi Annan 2004:1), in particular the girls (UNICEF2004:1); which is a serious hindrance for the future of children and**,** therefore, a real challenge to address.

To implement the concept " right to teaching ", most countries of the world instituted an obligatory and free primary education so that every citizen has the basic education which can enable him/her to read, to write, to count and to communicate easily and fairly. In the same range of thought, the UNESCO organized several conferences worldwide after World War II in Latin America, in Asia in the State Arabs, in Europe, in North America and finally in Africa. The situation of the DR Congo is not spared from this.

According to a UNICEF report (2004:7), around 4,400,000 children in school age, among whom 2,500,000 girls are outside of the school structures in the Democratic Republic of the Congo. The rate of schooling is of 48.6% for the girls against 51.7% for the boys; for 100 girls aged of 6 years, only 16 are registered in the first year of primary school. In several regions, the girls run more risks to be deprived of the primary and secondary education than the boys.

Our particular attention has been focused on Ntambuka Collectivity within Idjwi-Island as it occurs in the current survey. Furthermore, we decided to choose such a place because it is more accessible to us and we are Muny'Idjwi native where the

research was carried out. In fact, most pupils in the schools of this collectivity are boys. The number of girls is lower than that of boys, and such a situation is perceptible in all the neighboring schools in that part of the island.

Nowadays, with the UNICEF and its slogan" all girls to school ", we have noticed that there is an enormous and increasing schooling of the girls in primary schools.

1.2 RESEARCH QUESTIONS

Despite the good declarations of the UNICEF, the decrease of the number of girls in the education system does not give any hope for the best future. As such, this situation attracted our curiosity through the following questions:

- Has the number of the schooled girls increased or decreased from 2009 to 2014 in primary schools within Ntambuka Collectivity?
- What are the reasons that could influence the increase or the decline of their number?
- What could be the solutions to the problematic decline of the number of schooled girls?

1.3 HYPOTHESES/ASSUMPTIONS

To answer the above questions, we resorted to three hypotheses:

- The number of the schooled girls in primary schools within Ntambuka Collectivity has gradually decreased from 2009 to 2014.
- The reasons for the decreasing number of schooled girls would be the poverty of the parents, the precocious marriages, the immorality of the teachers, the retrograde customs….
- The main exit strategies would be the entire involvement and commitment of girls in studies and the avoidance of premature marriages. Also, parents should treat girls and boys as equal human beings who have the same rights and the same opportunities. Similarly, parents should root out from their minds the beliefs according to which the education of girls is a waste of time and financial resources.

1.4 SPECIFIC STUDY OBJECTIVES

This paper specifically aims at:

- Studying the progressive rate about the schooling of girls from 2009 to 2014 in the primary schools of Ntambuka Collectivity;
- Determining the reasons of the school dwindle of schoolgirls;
- Suggesting a few possible solutions for the rise of the level of girls' education in this part of the island.

Our survey focuses on the primary schools of Ntambuka Collectivity and deals with the progress of girls' education in primary schools from 2009 to 2014.

Our survey extends on three axes which make up the scope of our study: Mugote, Nyakalengwa and Mpene groupings.

It also looks into the following insights:

- The theoretical considerations where we succinctly define the key concepts and the theory in connection to the topic;
- The methodological approach through which we talk about the target population, and the techniques of data collection, analysis and treatment;
- Finally, the presentation, analysis and interpretation of the findings.

1.5 THEORETICAL FRAMEWORK

Hereafter, we present the definition of our key concepts of the survey as well as its theoretical setting. The key concepts are: education, schooling, school dwindle, a promoted, the abandonment.

- **Education**

Etymologically, the word 'education' is derived from the Latin ***ēducātiō*** ("A breeding, a bringing up, a rearing) from ***ēdūcō*** ("I educate, I train") which is related to the homonym ***ēdūcō*** ("I lead forth, I take out; I raise up, I erect") from ***ē-*** ("from, out of") and ***dūcō*** *("I lead, I conduct").*

In its broadest, general sense, education is the means through which the aims and habits of a group of people live on from one generation to the next. Generally, it occurs through any experience that has a formative effect on the way one thinks, feels, or acts. In its narrow, technical sense, education is the formal process by which society deliberately transmits its accumulated knowledge, skills, customs and values from one generation to another, e.g., instruction in schools.

A right to education has been created and recognized by some jurisdictions: Since 1952, Article 2 of the first Protocol to the **European Convention on Human Rights** obliges all signatory parties to guarantee the right to education. At the global level, the **United Nations' International Covenant on Economic, Social and Cultural Rights** of 1966 guarantees this right under its Article 13.

Furthermore, Irina Bokova (2015:2) states that:

''Education is a right that transforms lives when it is accessible to all, relevant and underpinned by core shared values. Because quality education is the most influential force for alleviating poverty, improving health and livelihoods, increasing prosperity and shaping more inclusive, sustainable and peaceful societies, it is in everyone's interest to ensure that it is at the centre of the post-2015 development agenda.''

In the same range of ideas, UNESCO (2014:4): *''reaffirms a humanistic and holistic vision as a fundamental human right and essential to personal and socio-economic development. The objective of such education must be envisaged in a broad lifelong learning perspective that aims at enabling and empowering people to realize their rights to education, fulfill their personal expectations for a decent life and work, and contribute to the achievement of their societies' socio-economic development objectives. In addition to the acquisition of basic knowledge and cognitive skills, the content of learning must promote problem solving and creative thinking; understanding and respect for human rights; inclusion and equity; cultural diversity; it must also foster a desire and capacity for lifelong learning and learning to live together, all of which are essential to the betterment of the world and the realization of peace, responsible citizenship and sustainable development.''*

- **Schooling**

Schooling is, according to Larousse (2008:387), an action of schooling, or attending a school.

Being about the education, the encyclopedic and illustrated Larousse (1979:1972) defines schooling like a set of the courses of study followed in the schools. As far as we are concerned, the schooling of the girls comes back to the action of schooling the girls.

- **School dwindle**

The term "school dwindle" is used in the sense of a loss of schooling for the ongoing education. Indeed, in a school system that does not advocate the automatic passage of a lower class to the upper class, the dwindle appears by the fact that all pupils who start a cycle of teaching do not reach the level of instruction required or all do not finish it in the prescribed minimal length.

or the UNESCO (1988:16), the school dwindle is a combination of two phenomena which are the surrender and the increase that influence a difference between the initial number and those arrived to the terms of the cycle. Thus, we can take into consideration the fact that the dwindle is made up of both pupils who take the enrolment at the beginning of one school year but who surrender during the same year for various motives and those that repeat the classes. It is the reduction of the school number during one year or a cycle of study.

- **A promoted**

According to the Larousse Dictionary (2008: 340), a promoted is any person who receives a promotion, the one that, after having succeeded in different tests throughout the school year, is judged like someone that must go in the upper class.

- **The abandonment**

According to the UNESCO, the abandonment is considered like a school desertion, the fact of giving up a given teaching. The abandonment can be of social, economic, educational or administrative type.

2 WORKING METHODOLOGY

To collect the necessary data for our survey, we resorted to the documentary technique. As for the treatment of data, we used the indication of percentage in terms of the schooling rate, the promotion rate and the dwindle. Accordingly, in this point, we want to specify our research methods and our techniques for target population sampling, data collection, data

analysis and result interpretation. We will also outline the challenges we faced during our research and the means that allowed us to overcome those challenges and then find our way out.

2.1 TARGET POPULATION OF THE SURVEY

The target population of our survey is made up of all girls who enrolled in standard one in some primary schools within Ntambuka Collectivity for the school year 2009-2010 and who were in standard six at the beginning of the school year 2013-2014. To better identify our population, we present the table below:

Table 1. The population of primary school girls within Ntambuka Collectivity that enrolled in primary 1 for 2009-2014 school year

N°	Name of school	Number of enrolled students	N°	Name of school	Number of enrolled students
01	Buhagwa	22	26	Musheke	19
02	Rambo	14	27	Bushake	25
03	Muhumba	16	28	Sayuni	31
04	Mazina	28	29	Muhyahya	20
05	Kirutu	38	30	Chasi II	21
06	Buhanga	32	31	Lubuye	14
07	Boza	40	32	Bushatiro	13
08	Kashofu	84	33	Lwamarhulo	34
09	Bihembe	55	34	Kisunzu	12
10	Rambo	58	35	Bubinga	18
11	Bulundi	32	36	Momvu	20
12	Malinde	19	37	Lushindi	19
14	Bushake	26	39	Kabugo	31
15	Mulamba	30	40	Rwankuba	19
16	Kilala	32	41	Ruminika	26
17	Nyamusiru	24	42	Nyamizi	10
18	Buhoro II	14	43	Kihumba	25
19	Bunyama	13	44	Gorho	15
20	Kananyama	11	45	Eureka	24
21	Furaha	20	46	Mazigiro	21
22	Bwina	30	47	Maendeleo	12
23	Mubale	20	48	Ntambuka	21
24	Kibati	19	49	Byamo	11
25	La Confiance	14	50	Nyakalengwa	20
	TOTAL				**1231**

Source: Quarterly report of Idjwi Sub-Division consulted on June 20, 2014

The results in the above table clearly show that 1231 girls enrolled in first year in the 50 schools within Ntambuka Collectivity for the 2009-2010 school year.

2.2 TECHNIQUE OF DATA COLLECTION

To access the data, we resorted to two basic techniques: the documentary technique and interview technique.

According to Grawitz and Pinto (1967:19), the documentary technique is the one that requires the consultation of both official and private documents. The researcher does not exercise any control on the way whose documents have been established but he must rather select those that pertain to his research. Furthermore, it allows the researcher not only to exploit the information of people as a source in order to actually elaborate the problem statement, formulate his hypothesis better, and choose the techniques of treatment of the data well, but also to facilitate the interpretation of available findings.

Thus, we consulted honours lists of all primary schools in the Ntambuka Collectivity from 2009 to 2014 in order to study the evolution of the girls' education. The consultation of the so-called honors lists allowed us to appropriate the number of the schooled girls enrolled in all the first years and their progression until primary six (without being interested in the repeaters), until the obtaining of their primary leaving certificates witnessing the end of primary studies.

Mucchielli (1976:22) holds that the technique of interview permits to get some information on a topic with the help of the questions. It is a useful method as a means of data collection permitting the verification of hypotheses. The principles of this technique are identical to those of the direct method.

Besides, the range of the interview can be limited by the inability of the topic to provide some information. It is then advised to resort to other means in order to complete the missing pieces of information. Among these means, we have the technique of the questionnaire thanks to which one puts a set of questions to respondents representing a given population. The distortions of the memories come to limit the use of the interviews also since they hinder the interviewee in providing his thorough and exact past pieces of information.

2.3 DATA ANALYSIS AND DATA TREATMENT TECHNIQUE

The analysis of data is an important stage that allows the researcher to interpret his results or findings, to check if the objectives assigned to research at the outset are reached, and to draw applicable as well as pertinent findings interconnecting to his starting hypotheses.

According to Mwenego (2007: 24), the treatment of data is a set of the operations by which the information is gathered, confronted and canalized in order to get a systematic representation of the results. The statistical data that have been collected thanks to the documentary technique have been represented in a diagram and have been treated by means of an indication of percentage in order to master the evolution of the education of girls in the Ntambuka Collectivity.

3 DATA PRESENTATION AND INTERPRETATION OF THE FINDINGS

Our preoccupation here is to know the evolution of girls' primary school education in the Ntambuka Collectivity from 2009 t0 2014.

3.1 DATA PRESENTATION

We find it worth mentioning and reminding that our target population covers a set of 50 primary school girls in the Ntambuka Collectivity who got enrolled in the first primary year for the 2009-2014 school years. Their number is presented in the table below. Indeed, one will keep in mind that a promoted is the one who has passed in the upper class, i.e. the one that, after having succeeded in the different tests by the end of a school year, is judged capable of being in the upper class.

Thus, the rate of promotion for the year of **x** survey and the school year **a** corresponds to the number of new pupils of the year of survey **x+1** during the school year **a+1** expressed in proportion of the total number of the year of **x** survey during the school year **a**. Hence the formula:

$$P_a^x = \frac{E_a^x - E_{a+1}^{x+1}}{E_a^x} x100$$ **or** $$P_a^x = \frac{P}{1} x100$$ where P= Rate of promotion ; P= Number of promoted, E= Number of pupils of a given school year.

Table 2. Synoptical table of the results from 2009 to 2014

RATE / YEAR	Registered	Passed	%	Gave up	%	Repeated	%	Dwindle / Loss	%
2009-2010	1231	701	56.6	360	29.2	170	13.8	530	43.1
2010-2011	701	512	73.1	108	15.4	81	11.5	189	26.9
2011-2012	512	392	76.6	70	13.7	50	9.8	120	23.4
2012-2013	392	282	71.9	58	14.8	52	13.3	110	28.1
2013-2014	282	199	70.6	47	16.6	36	12.8	83	29.4

Source: Our investigations

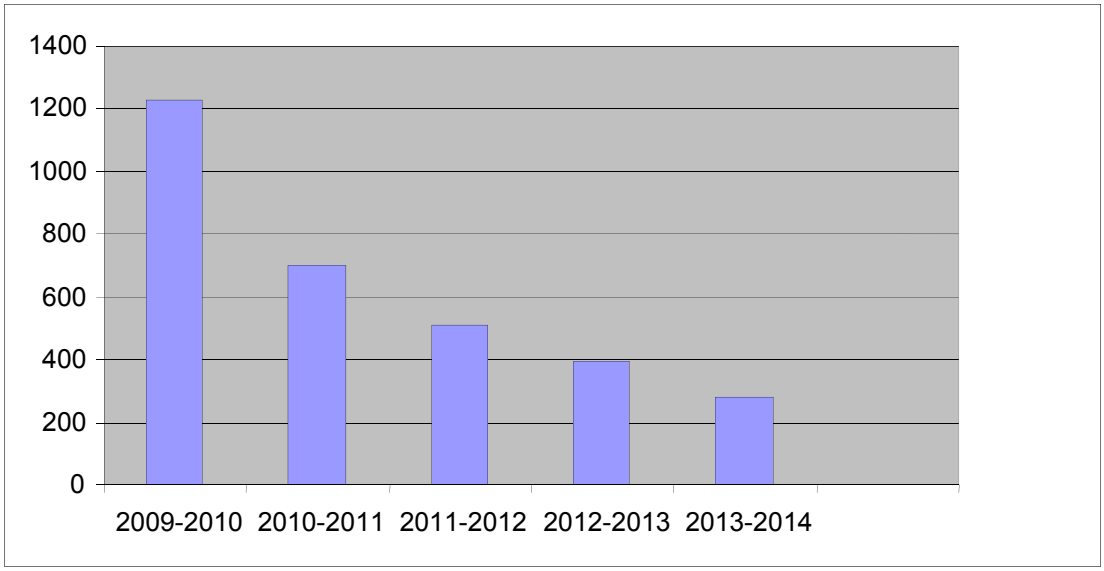
Note: The rate of dwindle is the combination of two phenomena including abandonment and repetition which influence the difference between the initial number and those who reached the end of the cycle.

3.2 DATA INTERPRETATION

Our data show that in first primary year, the number of girls within Ntambuka Collectivity schools rose to 1231. But, the more they passed classes, the more their number decreased sensibly because for a number of 1231 girls registered in first years, only 701 were promoted either 56.9% with for a number of forsaking of 360 girls, and of 170 repeaters, that is to say, a rate of dwindle of 43.1%. Similarly, for the school year 2009-2010, only 512 girls were promoted, either 41.6%, of the total number, 108 girls had surrendered while 81 girls repeated the class, either a dwindle rate of 58.4%.

Similarly, for other years, for 1231 pupils who had enrolled in 1st year, only 199 girls got their primary school leaving certificates to end up primary studies, either 16.2%, and 1032 girls did not reach there, either a rate of dwindle of 83.8%. Moreover, our two hypotheses of departure according to which the number of the schooled girls within Ntambuka Collectivity primary schools would evolve negatively from 2009 to 2014 and the numbers of girls that begin the first primary years would not reach at the end of the primary cycle are confirmed.

Hereafter, is the graphic representation of this evolution as of the number of girls from 2009 to 2014.



The above diagram in columns shows that the number decreased sensibly since the recruiting year 2009 until 2014; either a decrease of 83.8%.

After the analysis and interpretation of the results of the data collected by the documentary technique, we also start the analysis and the interpretation of the data collected by questionnaire of investigation.

Our questionnaire of investigation embodies two types of questions: the first tried to clear the reasons of abandonment on one hand and failure of the girls on the other hand. Furthermore, hand, the second types of questions lists down some remedial solutions susceptible to fight against the school dwindle of girls. These two questions were administered to the 50 headmasters of the primary schools which formed our population of survey.

The tables present the findings of every question oriented first of all toward the reasons of the school failures of girls (n°3 below) and then toward the solutions to take into account so that to fight against the dwindle of girls n°4.

Table n°3: Causes of abandonment and school failure of girls

Theme 1: What are the causes of abandonment and school failures of girls?

N°	Investigation answers	Number	%
01	Parents' poverty	18	36
02	Precocious marriages	10	20
03	Disinterestedness of the parents (retrograde customs)	6	12
04	Immorality of teachers or other people (like street people)	12	24
05	Schoolgirls' negligence	4	8
	Total	**50**	**100**

Source: Our investigations of August5, 2014

It is evident from this table that the reasons of the abandonment and failure of the girls in primary schools within Ntambuka Collectivity are the poverty of the parents, either 36%, the precocious marriages, either 20%, the disinterestedness of the parents (retrograde custom), either 12%, the immorality of the teachers, either 24% and the carelessness of the girls, either 8%.

These results allow us to confirm our second hypothesis according to which the reasons of the school dwindle of the girls would be the poverty of the parents, the precocious marriages; the retrograde customs of the parents and the immorality of the teachers…

As for the solutions, the table below allows us to analyze the data of the second question that concerns the solutions to undertake in order to fight against the school dwindle of girls.

Table n°4: Solutions to undertake in order to fight against the school dwindle of girls

Theme 2: What are the solutions to undertake in order to fight against that calamity?

N°	Answers	Yes	%	Non	%
01	To pay teachers fairly	46	92%	4	8%
02	To punish the people who would constitute the obstacle	41	82%	9	18%
03	To make the primary studies free of charge	50	100%	0	0%
04	To banish customary prejudices	42	84%	8	16%
05	To avoid courting school girls	38	76%	12	24%
06	To get school girls to be committed to studies	32	64%	18	36%
07	To lead the campaigns of sensitization	35	70%	15	30%
08	To balance the girls' domestic work	31	62%	19	38%

Source: Our investigations of August 8, 2014

From the above table, we can deduce that in order to fight against this calamity of school dwindle of the girls, 92% of them investigated, advanced the idea to really remunerate the teachers while applying the agreements of" Mbudi ". ''There is no other alternative that will be able to definitely solve and root out this problem of schooling of children,'' they said. Accordingly, the government should actively get involved in searching for an adequate solution seriously. Otherwise, the level of the children will always suffer. Those who agree with punishment of people who constitute the obstacle to the schooling of the girls reach 82%; while 100% ask that the primary education be of free of charge. 84% would ask that the customary prejudices are to be banished, 76% would wish that the teachers avoid wooing their school girls, 70% would wish that the campaigns of sensitization were organized in favor of the schooling of girls.

4 CONCLUSION AND SUGGESTIONS

Our survey entitled " Progressive survey on primary schoolgirls' education from 2009 to 2014: Case study of Ntambuka Collectivity'' dealt with three relative questions as regards the progress of the number of schooled girls: The schooled girls from 2009 to 2014 in the primary schools within Ntambuka Collectivity, the reasons of the dwindle and the solutions to undertake in order to fight against the school dwindle of the girls.

Two hypotheses have been anticipatively advanced in order to check these preoccupations including the fact that:

- The number of the schooled girls in the primary schools within Ntambuka Collectivity evolves negatively from 2009 to 2014.
- The number of girls who start the first primary years within Ntambuka Collectivity does not reach the end of their primary cycle.

We have come up with the following findings / results:

- In first primary year, the number of girls in the primary schools of Ntambuka collectivity rose to 1231 girls in 2009-2010. But the more they went in upper classes, the more their number decreased sensibly because for a number of 1231 registered girls in first years, only 701 were promoted, either 56.6%, and 530 girls, either 43.3%, were not able to finish the primary cycle.
- For the school year 2009-2010, only 512 were promoted, either 73.1%, of the total number with a rate of dwindle of 189 girls, either 26.9. It is the same way for other years, this is to say, for 1231 pupils who had taken the enrollment in 1st year, only 199 got their primary leaving certificates to end up primary studies in 2013-2014, either 16.2%, and 1032 girls, either 83.8%, did not reach there. Our first starting hypothesis according to which: the number of the schooled girls in primary schools within Ntambuka Collectivity would evolve negatively from 2009 to 2014 is thus confirmed.

As for the school dwindle of the girls, our investigation confirmed that it is especially due to poverty of the parents (36%), to the immorality of the teachers (24%), to the precocious marriages (20%), to the parents' retrograde customs (12%) and to the carelessness of the girls themselves (8%). We confirm our second hypothesis according to which the reasons of the school dwindle of the girls would be the poverty of the parents, the precocious marriages; the customs retrograde of the parents and the immorality of the teachers…

These results incite us to formulate a few suggestions and the following recommendations:

- **To the Government of DR Congo:**
- To reduce the school expenses for the girls;
- To foresee severe punishments for any person who would constitute an obstacle to the schooling of girls;
- To lead campaigns of sensitization on the family planning;
- To supply girls regularly with school supplies so that they can feel highly encouraged;

- **To the teachers:**
- To provide good pieces of advice to the girls;
- To avoid courting any pupil girls.

- **To the parents:**
- To banish the customary prejudices according to which the girls are trained for the domestic and rustic works;
- To balance the works of the girls to allow them to take the studies seriously;
- To sensitize their children girls on the advantage of schooling.

- **To the girls:**
- To study with endeavor and commitment;
- To avoid the precocious marriages.

Our expectation through this survey that reaches its end is to get the schooling of girls improved within the area we carried out our research. Non exploited strategies can lead to the same results. The researchers have a big challenge to address as regards the issue and the development of Ntambuka Collectivity in particular and Idjwi Territory as well as DRC and Africa in general.

REFERENCES

[1] Adam C. at alii. 2012 . *Progress and Obstacles to Girls' Education in Africa.* Plan WARO
[2] Bulimpanga B. M. 2009. *Déperdition scolaire des filles par cohorte à l'école secondaire dans la collectivité chefferie-Rubenga*, TFE inédit.
[3] Dubois C.et al.1979. *Larousse encyclopédique illustré.* Paris Librairie Larousse.
[4] Grawitz, M et Pinto R.1967. *Méthode des sciences sociales*.Paris, Dalloz,
[5] Larousse .2008. *Dictionnaire français*. Paris, Larousse.
[6] *MacMillan English Dictionary for Advanced Learners*: Second edition 2007

[7] Malala N D.2004. *Psychopédagogie*, cours inédit, UNILAI.
[8] Mundenga, D.2003. *Didactique générale*. Cours inédit, ISP/Bukavu
[9] Mwenengo.J.P. 2005.La scolarisation des filles à l'école secondaire dans la commune de Bagira.
[10] Mucchielli R.1976. *Questionnaire de l'enquête psychologique*, Paris, EST.
[11] UNESCO.1974. *Le droit de l'éducation*, Paris, 16e MC p.1
[12] UNESCO. 2011. *EFA Global Monitoring Report 2013/4.*
[13] UNESCO. 2000. *l'Afrique pour l'Afrique vers une éducation de qualité pour tous*, Paris, UNESCO,
[14] UNICEF. 2004. *Résumé officiel, in situation des enfants dans le monde*, New York UNICEF,
[15] UNICEF. 2005. *L'enfance en péril, in situation des enfants dans le monde*, New York UNICEF,
[16] UNICEF. 2006. *Exclus et invisibles, in situation des enfants dans le monde*, New York UNICEF,
[17] United Nations General Assembly. Ref. A/67/941. 2013. *Progress of the Open Working Group of the General Assembly on Sustainable Development Goals.http//www.un.org/ga/search/view doc asp/symbol=A/67/941&Lang€*

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Communautés des Algues Epilithiques des cours d'eau de la région de Lwiro, Est de la RD Congo

[Epilithic Algae Communities of water streams in Lwiro region, Eastern DR Congo]

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ABSTRACT: An inventory of the epilithic algae has been taken during 12 months (from January up to December 2012) according to a monthly sampling per site in the 12 streams of Lwiro region: Birunga, Gaho, Kaboneke, Kabindi, Kahenu, Kanakalwiro, Kalengo, Kamirihembe, Lwiro, Mahyuza, Tchoga and Tchongoloka. The epilithic algae has been scraped from 25 cm^2 of upper part of the stones. The collected sample has been put in a test tube containing 50 ml of 4% formalin. After a thorough mixture of this sample, 1ml subsample has been taken for epilithic algae identification thanks to optical microscope. The results that we got throughout this study show that these watercourses are very rich in epilithic algae with a total of 64 identified species divided into 5 classes, namely Bacillariophyceae (45.3%), Chlorophyceae (21.9%), Cyanophyceae (15.6%), Desmidiaceae (10.9%) and Euglenophyceae (6.3%). The epilithic algae of Tchongoloka is the most diversified with 20 species and that of Kabindi is the less diversified with 11 species only. The high number of individual of algae is enregitred in Tchongoloka (264 individuals) and low number in Kalengo (235 individuals). The variations of species number correspond also with the variations of density, 660 individuals/cm^2 for Tchongoloka and 542.5 individuals/cm^2 for Mahyuza.

KEYWORDS: Inventory, Epilithic algae, Diversity, Streams, Lwiro region.

RESUME: Un inventaire des algues épilithiques a été réalisé durant 12 mois (de Janvier à Décembre 2012) avec un prélèvement par mois dans 12 cours d'eau de la région de Lwiro. Ces cours d'eau sont : Birunga, Gaho, Kaboneke, Kabindi, Kahenu, Kanakalwiro, Kalengo, Kamirihembe, Lwiro, Mahyuza, Tchoga et Tchongoloka. Les algues épilithiques ont été récoltés par grattage sur la partie supérieure du caillou ramassé sur une surface de 25 cm^2. L'échantillon récolté a été mis dans un tube à essai contenant 50 ml de formol à 4%. Après l'homogénéisation de l'échantillon, 1 ml de sous échantillon a été retiré pour l'identification des algues épilithiques à l'aide du microscope optique. Les résultats obtenus au cours de cette étude montrent que ces cours d'eau sont très riches en algues épilithiques avec un total de 64 espèces identifiées renfermant 3171 individus et reparties en 5 classes qui sont les Bacillariophycées (45,3%), les Chlorophycées (21,9%), les Cyanophycées (15,6%), les Desmidiacées (10,9%) et les Euglénophycées (6,3%). Les algues épilithiques de Tchongoloka est le plus diversifié avec 20 espèces et celui de Kabindi est le moins diversifié avec 11 espèces seulement. Le grand nombre d'individus d'algues est enregistré dans Tchongoloka (264 individus) et le petit nombre dans Kalengo (235 individus). Les variations de nombre d'espèces correspondent aux variations de la densité, soit 660 individus/cm^2 pour Tchongoloka et 542,5 individus/cm^2 pour Mahyuza.

MOTS-CLEFS: Inventaire, Algues épilithiques, Diversité, Cours d'eaux, Région de Lwiro.

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1 INTRODUCTION

La région de Lwiro est traversée par plusieurs cours d'eau indispensables à la vie de très nombreuses espèces végétales et animales, y compris l'homme. Les communautés des algues épilithiques de ceux-ci n'ont jamais fait l'objet d'une étude détaillée et systématique. Dans leurs recherches, Bisimwa et al. [1] se sont principalement limités aux diatomées des rivières Lwiro et Kabindi. Cependant, des travaux de recherches antérieures menées dans tous les continents révèlent que certains groupes d'algues épilithiques ont été abondamment employés dans l'étude de la qualité des eaux lotiques [2-7]. De plus, les algues épilithiques constituent un support nutritif de la macrofaune aquatique [1,8,9].

Les cours d'eau de la région de Lwiro sont présentement sujets de la pollution à cause des déchets d'origine agricole et domestique qui y sont jetés continuellement par la population environnante [1]. La connaissance des communautés des algues épilithiques de ces cours d'eau est importante pour permettre à apprécier la qualité des eaux et de mener la surveillance de l'état environnemental des écosystèmes aquatiques de cette région.

Le présent travail vise ainsi à combler cette lacune en inventoriant les espèces algales benthiques qui colonisent les cours d'eau de la région de Lwiro. A l'échelle écosystémique, les communautés des algues épilithiques de ces cours d'eau nécessite des efforts de recherche en vue de définir sa diversité qui maintient l'équilibre environnemental des écosystèmes aquatiques de la côte occidentale du lac Kivu et permet alors d'estimer la qualité des eaux. Cet article présente donc les résultats préliminaires obtenus dans lesdits cours d'eau.

2 MATÉRIEL ET MÉTHODES

2.1 MILIEU D'ÉTUDE

Les 12 cours d'eau dans lesquels cette étude a été menée font tous partie des affluents de bassin versant de Kalehe du lac Kivu, à l'Est de la RD Congo (figure 1). Il s'agit des rivières: Lwiro, Kabindi, Tchongoloka, Birunga, Gaho, Kaboneke, Kahenu, Kalengo, Kanakalwiro, Tchoga, Kamirihembe et Mahyuza. Les eaux de ces cours d'eau sont beaucoup utilisées par la population environnante comme l'eau de boisson, pour la cuisson des aliments et la vaisselle, et pour la fabrication des boissons locales. On y fait également la baignade, la lessive et même l'abreuvement des animaux.

La région de Lwiro (28°45' - 28°85' de longitude Est et 2°15' - 2°30' de latitude Sud) est située dans la partie occidentale du lac Kivu, au versant oriental du mont Kahuzi, entre 1465 m et 2200 m d'altitude et à 45 Km au Nord de la ville de Bukavu [1]. Cette région de 141 Km^2 de superficie, au sol volcanique [1], 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, et même dans les vallées. Cette région est favorable à l'agriculture et à l'élevage notamment du petit bétail. Son climat tropical d'altitude est caractérisé par une température annuelle moyenne de 20,5° C et une pluviosité de 121,5 mm par an [10]. Il permet de distinguer deux saisons à savoir: la saison sèche (de juin à août) et la saison pluvieuse (de septembre à mai).

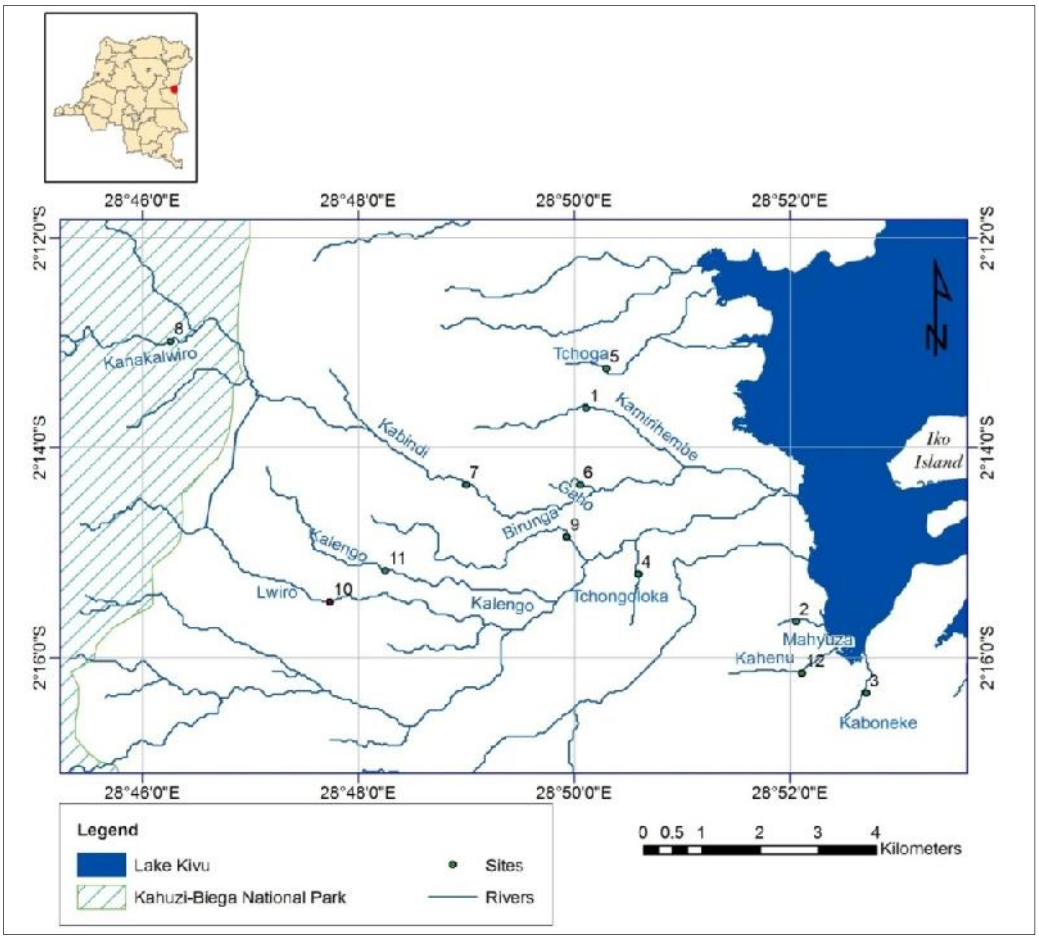

Figure 1. Localisation des cours d'eaux échantillonnés. 1-Kamirihembe, 2-Mahyuza, 3-Kaboneke, 4-Tchongoloka, 5-Tchoga, 6-Gaho, 7-Kabindi, 8-Kanakalwiro, 9-Birunga, 10-Lwiro, 11-Kalengo, 12-Kahenu

2.2 MÉTHODOLOGIE

De janvier à décembre 2012, l'échantillonnage a été réalisé avec un prélèvement, par mois, dans chaque site. Un seul site a été choisi sur chaque cours d'eau et le choix des sites, sur les différents cours d'eau, a été dicté par la pratique de plusieurs activités humaines dans le milieu, en l'occurrence l'agriculture.

Les algues épilithiques ont été prélevées, en faciès lotique, sur une surface de 25 cm^2 sur chaque pierre ramassée dans le cours d'eau à l'aide une petite brosse. L'échantillon, une fois recueilli, a été mis dans un tube à essai contenant 50 ml de formol à 4%. Seulement, après l'homogénéisation de l'échantillon, 1ml de la suspension algale a été retiré pour l'identification [11]; [1,8]. Chaque fois une goutte de ce sous échantillon (1 ml) était déposée entre la lame et la lamelle. La préparation ainsi obtenue a été examinée au microscope optique (Olympus CHD 6H0136, objectif 400x). Tout individu rencontré était identifié et comptabilisé [2,11,12] et cela pour chaque préparation.

L'identification des algues épilithiques a été faite à l'aide des clés de détermination de [13-15]. La densité absolue (individu/cm^2) des algues épilithiques s'évaluait par rapport au nombre total des préparations observées au microscope et le nombre d'individu identifiés pour chaque site. La diversité spécifique était calculée par l'indice H' de Shannon-Weaver complétée par l'indice J' de diversité relative ou l'équitabilité [16]. L'abondance numérique moyenne des algues épilithiques dans les différents sites a été calculée à l'aide du logiciel Statlab version 2.1.

3 RÉSULTATS

3.1 LISTE ET ABONDANCE MOYENNE DES ESPÈCES IDENTIFIÉES

Les communautés des algues épilithiques des cours d'eau de la région de Lwiro sont présentées dans le tableau 1. Il y ressort que, qualitativement, ils sont représentés par 5 classes à savoir : les Bacillariophycées, les Chlorophycées, les Cyanophycées, les Desmidiacées et les Euglénophycées dont l'ensemble totalise 64 espèces et renferme 3171 individus. On peut y constater alors leur présence et leur abondance numérique moyenne dans les différents cours d'eau varie d'une espèce à une autre.

3.2 NOMBRE D'ESPECES ET D'INDIVIDUS DES ALGUES EPILITHIQUES EN FONCTION DES CLASSES D'ALGUES

Le nombre d'espèces des algues épilithiques varie d'une classe à une autre avec un maximum de 29 espèces, soit 45,3 % du total pour les Bacillariophycées, et un minimum de 4 espèces, soit 6,3 % du total, pour les Euglénophycées. Les Bacillariophycées et les Chlorophycées constituent la quasi-totalité de la communauté algale, soit 43 espèces. Ce qui correspond à 67,2 % de la richesse spécifique totale. On constante de même que le nombre d'individus varie d'une classe à une autre avec un maximum de 1294 individus correspondant à 40,8 % chez les Bacillariophycées et un minimum de 294 individus qui correspondent à 9,3 % chez les Euglénophycées (tableau 2). Donc, le nombre d'espèces et celui d'individus varient dans les même sens.

Tableau 1. Abondances moyennes et variations des densités moyennes et des indices de diversité des algues épilithiques des cours d`eau de la région de Lwiro

Taxons	Stations											
	Birunga	Gaho	Kaboneke	Kabindi	Kahenu	Kalengo	Kanakalwiro	Kamirihembe	Lwiro	Mahyuza	Tchoga	Tchongoloka
Bacillariophycées												
Achnanthes lanceolata (De Bréb) Grün	2,9		9,9		13,0						11,4	
Cymbella lanceolata Van Heurck	9,5				13,6		13,3					
C. prostata Berkel					12,5				22,6		10,9	11,5
C. sinuata Greg		15,2										
C. tumida (De Bréb) Van Heurck								22,8	19,8			
Denticula tenuis Kütz			9,3									
Denticula sp.			11,7							12,7		
Diatoma hiemale (Lyng) Heib		13,1				18,6	21,8			12,6		
D. vulgare Bory	12,4			10,5			14,2	9,1				
Eunotia polydentula Brun					12,7			11,6				
E. tenella (Grün) Hust								13,0	17,0	27,0		
Eunotia sp.											14,6	
Frustulia rhomboides (Ehr) Cleve				23,5			21,8					20,3
F. vulgaris (Thw) De Toni					27,3		16,9					
Gomphonema angustatum (Kütz) Rabenh				24,2				25,8				6,8
Gyrosigma attenuatum (Kütz) Cleve											11,7	
Melosira varians Agar				20,4						20,0		
Navicula cocconeiformis Greg					4,9							16,5
N. cryptocephale Kütz	22,1											
N. gracilis Ehr	4,7										18,7	1,4
N. viridula Kütz		7,4				11,6					8,7	
Nitzshia acicularis Smith	16,3							34,6				
N. filiformis Hust								9,1				13,6
N. linearis Smith			21,3						26,6			8,8
Pinnularia brebissonii Cleve		17,9	39,8			25,1				28,3		7,7
Surirella biseriata De Bréb		10,1				14,5						17,4
Surirella sp.		13,4		20,4		18,4						

Tabellaria flocculosa Kütz	22,1	18,1				17,1						
Tabellaria sp.		5,8				8,7				21,4		
Chlorophycées												
Cladophora aeragrophila Raben					32,6	22,1			24,2			
Cladophora sp.	13,5	15,3										
Chlorella vulgaris Beyer			24,2					11,7				10,2
Chlorella sp.						9,6	18,3					9,3
Chaetophora sp.	15,4										23,3	9,5
Crucigenia cuneiformis Brun					23,4			32,6		27,5		
C. rectangularis (Braun) Gay							9,6					
Kirchneriella lunaris (Kirch) Möbius			14,5									
Mougeotia planctonica Virieux	12,5	11,4		30,7					11,8			
Mougeotia sp.						18,3						
Penium jenneri Ralfs							22,2			13,5		
Penium sp.		19,3									20,4	
Rhizoclonium riparian Harvey			33,3	34,3				11,7				
Sorastrum americanum (Bohlin) Schmid	17,6										21,3	
Cyanophycées												
Anabaena circinalis Raben	8,3	16,5									23,3	
Aphanocapsa delicatissima West	6,7							13,1		16,9		18,3
A. stagnina (Sprengel) Braun				36,0							13,6	
Coelosphaerium kutzingianum Nageli		13,5							21,7	21,1		
C. nagelianum Unger					19,8		11,2				13,1	
Merismopedia glauca Nageli			14,2						23,7			8,3
Merismopedia sp.					29,2			15,9	14,6			
Oscillatoria geminata Meneg						18,3	27,1					
Oscillatoria sp.						13,7						
O. tenuis Agar			20.8				9.7					8,4
Desmidiacées												
Closterium abruptum West	13,5	16,6									13,4	
C. aciculare West		10,8		27,6			13,6					10,2
Cosmarium australe (Racib) Lütk				13,4	12,7	10,5	7,9					20,0
Gonatozygon aculeatum Schmid			15,1					16,6	20,4			
Micrasterias cunningtonii West			18,9		19,3	4,8						19,8
Spirotaenia condensata De Bréb	17,5							12,4	13,6		15,6	
Staurastrum dickiei Ralfs		11,6				5,7	15,5			12,0		
Euglénophycées												
Euglena acus Ehr.	24,1						17,4		19,6			
Leponicilis ovum (Ehr) Lemmer	4,8	21,0	7,0					10,0				17,8
Phacus longicauda Ehr				5,0	10,3	9,4				4,0	16,0	
Trachelomonas ovalis Von Daday	26,1				12,7	8,6	12,6		7,4			28,2
Densité (individu/cm^2)	625	592.5	600	615	610	587.5	632.5	625	607.5	542.5	590	660
Indice H' de Shannon Weaver	3,93	3,98	3,35	3,25	3,62	3,90	3,86	3,67	3,46	3,42	3,82	4,13
Indice J' de Diversité relative	0,95	0,98	0,91	0,95	0,96	0,96	0,97	0,95	0,94	0,96	0,99	0,96

Tableau 2. Nombre des espèces et des individus des algues épilithiques en fonction des classes d`algues des cours d`eau de la région de Lwiro

	Espèces		Individus	
Classes d`algues	Effectif	Pourcentage	Effectif	Pourcentage
Bacillariophycées	29	45,3%	1294	40,8%
Chlorophycées	14	21,9%	685	21,6%
Cyanophycées	10	15,6%	485	15,3%
Desmidiacées	7	10,9%	413	13,0%
Euglénophycées	4	6,3%	294	9,3%
Total	64	100%	3171	100%

3.3 DISTRIBUTION DES ESPECES DANS LES CLASSES D'ALGUE EN FONCTION DES COURS D'EAU

Le nombre le plus élevé des espèces est enregistré dans Tchongoloka (20 espèces) suivi de Birunga (18 espèces). Le moins élevé est celui de Kabindi (11 espèces). La distribution de ces espèces dans les différentes classes d'algues inventoriées varie aussi d'un cours d'eau à une autre ; avec, pour la classe des Bacillariophycées, un maximum de 9 espèces dans Tchongoloka et un minimum de 4 espèces dans Lwiro (tableau 3). Pour les Chlorophycées, le maximum (4 espèces) est observé dans Birunga et le minimum (2 espèces) dans Kabindi, Kahenu, Lwiro et Mahyuza. Pour les Cyanophycées, le maximum (3 espèces) et le minimum (1 espèce) sont respectivement signalés dans Kanakalwiro, Lwiro, Tchoga et Tchongoloka et dans Kabindi. Pour les Desmidiacées, le maximum (3 espèces) est enregistré dans Gaho, Kalengo, Kanakalwiro et Tchongoloka et le minimum (1 espèce) dans Mahyuza. Enfin, pour les Euglénophycées, le maximum (3 espèces) dans Birunga et le minimum (1 espèce) dans Gaho, Kaboneke, Kabindi, Kamirihembe, Mahyuza et Tchoga.

3.4 REPARTITION DES INDIVIDUS DANS LES CLASSES D'ALGUES EN FONCTION DES COURS D'EAU

Le plus grand nombre d'individus est observé dans Tchongoloka (264 individus) suivi de Lwiro amont (256 individus) et le plus petit nombre est celui de Mahyuza (217 individus). En fonction de cours d'eau, la répartition des individus par classe d'algues est inéquitable non seulement dans les différentes classes des communautés d'algues épilithiques mais aussi dans les différents cours d'eau prospectés (tableau 4). Les Bacillariophycées sont les plus dénombrées dans Kamirihembe (126 individus) et les moins dans Kahenu (84 individus). Les Chlorophycées sont les plus inventoriées dans Kaboneke (72 individus) alors que les moins inventoriées sont dans le Tchongoloka (29 individus). Les Cyanophycées sont les plus enregistrées dans Lwiro (60 individus) et les moins dans Birunga (15 individus). Les Desmidiacées sont les plus dénombrées dans Tchongoloka (50 individus) et les moins dans Mahyuza (12 individus). Les Euglénophycées sont les plus observées dans Birunga (55 individus) et les moins dans Mahyuza (4 individus).

3.5 DENSITE MOYENNES ET INDICES DE DIVERSITES DU PERIPHYTON EPILITHIQUE

Les densités moyennes des algues en fonction des cours d'eau et les indices de diversités des algues épilithiques sont présentées dans le tableau 1. On y constate que la densité moyenne la plus élevé est celle de Tchongoloka (660 individus/cm^2) suivie de celle de Kanakalwiro (632.5 individus/cm^2). La moins élevée est celle de Mahyuza (542,5 individus/cm^2). Selon l'indice H' de Shannon-Weaver, la diversité spécifique la plus élevée est enregistrée dans Tchongoloka (4,13) suivie de celle de Gaho (3,98) et la moins élevée est celle de Kabindi (3,25). Quant à la diversité relative J', la plus élevée est signalée dans Tchoga (0,99) suivie de celle de Gaho et Lwiro (0,98) et la moins élevée (0,91) est celle de Kaboneke. Donc, les densités moyennes et les indices de diversité n'évoluent pas dans le même sens.

4 DISCUSSION

Au cours de cette étude les résultats obtenus montrent que les cours d'eau de la région de Lwiro renferment du périphyton épilithique, celui-ci est composé de 64 espèces d'algues identifiées dans l'ensemble des sites prospectés (13 sites). Les Bacillariophycées, totalisant 29 espèces et 1294 individus, représentent 45,3% de la richesse spécifique totale et 40,8% de l'effectif global. Vu le nombre d'espèces et d'individus que renferme la classe des Bacillariophycées par rapport à d'autres classes (tableau 2), cela montre qu'elles s'adaptent bien dans ces différents cours d'eau. Elles sont, en effet, dominées qualitativement par les *Cymbella*, *Navicula* et *Nitzshia* et quantitativement par les *Pinnularia brebissonii* Cleve, *Gomphonema angustatum* Rabenh, *Diatoma hiemale* (Lyng) Heib, *Cymbella prostata* Berkel et *Tabellaria flocculosa* Kütz. Ces espèces, selon Symoens, et A. Werff [17] et Maillard [18], sont à large répartition écologique.

Les Chlorophycées sont représentées par 685 individus soit 21,6 % du total des communautés des algues épilithiques. Les 14 espèces constituent 21,9 % de la richesse spécifique. Qualitativement ce groupe est représenté par les genres *Cladophora, Chlorella*, *Crucigenia, Mougeotia* et *Penium* et quantitativement par les espèces *Cladophora aeragrophila* Raben*, Crucigenia cuneiformis* Brun*, Mougeotia planctonica* Virieux*, Penium sp* et *Rhizoclonium riparian* Harvey. Les Cyanophycées comportent 485 individus soit 15,3% du total du peuplement du périphyton. Les 10 espèces représentent 15,6% de la richesse spécifique. Les Cyanophycées qualitativement sont plus dominées par le genre *Oscillatoria* alors que les espèces *Aphanocapsa stagnina* (Spreng) Braun *et Merismopedia sp* ont dominées quantitativement ces genres.

Tableau 3. Distribution des espèces par classes d'algues en fonction des cours d`eau de la région de Lwiro

Classes d'algues	Stations											
	Birunga	Gaho	Kaboneke	Kabindi	Kahenu	Kalengo	Kanakalwiro	Kamirihembe	Lwiro	Mahyuza	Tchoga	Tchongoloka
Bacillariophycées	7 38,9%	8 47,0%	5 38,4%	5 45,4%	6 42,8%	7 41,2%	5 31,2%	7 46,6%	4 30,7%	6 50,0%	6 40,0%	9 45,0%
Chlorophycées	4 22,2%	3 17,6%	3 23,1%	2 18,2%	2 14,3%	3 17,6%	3 18,7%	3 20,0%	2 15,4%	2 16,6%	3 20,0%	3 15,0%
Cyanophycées	2 11,1%	2 11,7%	2 15,4%	1 9,1%	2 14,3%	2 11,7%	3 18,7%	2 13,3%	3 23,1%	2 16,6%	3 20,0%	3 15,0%
Desmidiacées	2 11,1%	3 17,6%	2 15,4%	2 18,2%	2 14,3%	3 17,6%	3 18,7%	2 13,3%	2 15,4%	1 8,3%	2 13,3%	3 15,0%
Euglénophycées	3 16,6%	1 5,9%	1 7,7%	1 9,1%	2 14,3%	2 11,7%	2 12,5%	1 6,6%	2 15,4%	1 8,3%	1 6,6%	2 10,0%
Total	18 100%	17 100%	13 100%	11 100%	14 100%	17 100%	16 100%	15 100%	13 100%	12 100%	15 100%	20 100%

Tableau 4. Répartition des individus par classes d`algues en fonction des cours d`eau de la région de Lwiro

Classes d'algues	Stations											
	Birunga	Gaho	Kaboneke	Kabindi	Kahenu	Kalengo	Kanakalwiro	Kamirihembe	Lwiro	Mahyuza	Tchoga	Tchongoloka
Bacillariophycées	90 36,0%	101 42,6%	92 38,3%	99 40,2%	84 34,4%	114 48,5%	88 34,8%	126 50,4%	86 35,4%	122 56,2%	76 32,3%	104 39,4%
Chlorophycées	59 23,6%	46 19,4%	72 30,0%	65 26,4%	56 22,9%	50 21,3%	50 19,7%	56 22,4%	36 14,8%	41 18,9%	65 27,6%	29 11,0%
Cyanophycées	15 6,0%	30 12,6%	35 14,6%	36 14,6%	49 20,1%	32 13,6%	48 19,0%	29 11,6%	60 24,7%	38 17,5%	50 21,2%	35 13,2%
Desmidiacées	31 12,4%	39 16,4%	34 14,2%	41 16,6%	32 13,1%	21 8,9%	37 14,6%	29 11,6%	34 14,0%	12 5,5%	29 12,3%	50 18,9%
Euglénophycées	55 22,0%	21 8,9%	7 2,9%	5 2,0%	23 9,4%	18 7,6%	30 11,8%	10 4,0%	27 11,1%	4 1,8%	16 6,8%	46 17,4%
TOTAL	250 100%	237 100%	240 100%	246 100%	244 100%	235 100%	253 100%	250 100%	243 100%	217 100%	236 100%	264 100%

En ce qui concerne les Desmidiacées et les Euglénophycées, elles sont généralement peu abondantes dans les cours d'eau de la région de Lwiro. Elles totalisent dans l'ensemble 707 individus, soit environ 22,3% du total de la flore algale benthique identifiée. Les Desmidiacées sont représentées qualitativement par le genre *Closterium* et quantitativement par

les espèces *Gonatozygon aculeatum* Schmid*, Micrasterias cunningtonii* West, *Cosmarium australe* (Racib.) Lütk et *Closterium aciculare* West tandis que les *Euglénophycées* sont quantitativement dominées par les *Trachelomonas ovalis* Von Daday*, Euglena acus* Ehr et *Leponiclis ovum* (Ehr) Lemmer. Selon Maillard [18], ces espèces sont cosmopolites.

5 CONCLUSION

Cette étude est une indication sur la diversité des communautés des algues épilithiques des cours d'eau de la région de Lwiro. Ces données ci-dessous, qualifiées de préliminaires, présentées dans ce travail, constituent l'amorce d'une étude algale benthique de cours d'eau de la région. Ce travail a ainsi le mérite d'avoir suscité davantage l'intérêt pour l'exploration scientifique de ce vaste écosystème aquatique encore insuffisamment étudié.

RÉFÉRENCES

[1] M.A. Bisimwa, B. Baluku et M.F. Ngera, "Estimation de la qualité des eaux des rivières Lwiro et Kabindi (Est de la RD Congo) à l'aide d'indice diatomique," *Cahier du CERUKI, Numéro Spécial CRSN-Lwiro*, 62-73, 2009.

[2] M. Coste, *Les diatomées indicatrices de la qualité de l'eau: une collaboration avec les agences de l'eau,* 2003. [Online] Available : http://WWW.cemagref.fr/Information. (April 12, 2012)

[3] J.P. Descy, "Les communautés algales de la Haute Meuse Belge et la qualité de ses eaux: un bilan à l'Automne 1981," *Bull. Soc. Roy. Bot. Bel.* 116: 31-50, 1983.

[4] J.P. Descy, "Utilisation des algues benthiques comme indicateurs biologiques de la qualité des eaux courantes," *Lejeunia, nouv. Ser*., 62-66, 1980.

[5] J.P. Descy, "La végétation algale benthique de la Meuse Belge et ses relations avec la pollution des eaux," *Lejeunia, nouv. Ser*., 60-62, 1973.

[6] V. Sládeček and A. Sladeckova, "Determination of periphyton production by means of glass slides method," *Hydrobiologia*, 23. 1/2: 125-158, 1963.

[7] V. Sládeček, and A. Sladeckova, "Periphyton as indicator of the reservoir water quality. II. Pseudoperiphyton," *Ergn. Limnol.,* 9: 177-191, 1977.

[8] M.A. Bisimwa, M.F. Ngera, K. Bisimwa, M. Bagalwa and N. Mushayuma, "A Preliminary Checklist of Epilithic Algae of Kahuzi-Biega National Park, Democratic Republic of the Congo," *Greener Journal of Biological Science*, Vol. 3 (8), 282-291, 2013.

[9] M. Menioui, "Etude faunistique et écologique des peuplements infralittoraux superficiels des côtes rocheuses du Maroc. I. Peuplement à Padina pavonica," *Arq. Mus. Bocage*. Vol. II, 14, 287-300, 1993.

[10] T. Tete, N. Balezi, M.M. Wimba, et M. Zagabe, "Considération sur les perturbations climatiques: précautions et adaptations agricoles dans les régions de Mulungu et de Lwiro au Sud-Kivu," *Annales de l'UEA.* Vol. 1, 1-21, 2006.

[11] A.C. Chindah, I.C. Aduabobo, A.B. Salomon and A. Amadia, "The epibentic algal community of the Bonny estuary, Niger Delta, Nigeria," *Acta Hydrobiol*, 35/4, 307 – 320, 1993.

[12] B. Fawzi, M. Chlailda, S. Oubrmaim, M. Loudiki, B. Sabour, et A. Bouzidi, "Application de certains indices diatomiques à un cours d'eau Marocain: Oued Hassar," *Rev. Sci. Eau* 14/1, 73-89, 2001.

[13] M. Ricard, *Atlas du phytoplancton marin. Vol.2. Diatomophycées*. Ed. CNRS, Paris, 297p, 1987.

[14] H. Germain, *Flore des diatomées. Eaux douces et saumâtres*. Boudée et Cie, Paris, 443p, 1981.

[15] R. Patrick, and C.W. Reimer, *The diatoms of the United States.* Monograph of the Academy of Natural Sciences of Philadelphia, 13 (2), 213p, 1975.

[16] J.L. Wilhm, and T.C. Dorris, Biological parameters for water quality criteria. Bioscience, 18: 477-491, 1968.

[17] J.-J. Symoens, et A. Werff, "Les Diatomées des chutes de la Tshopo (Kisangani–Zaïre)," *Bull. Jard. Bot. Nat. Bel*., 62, 349-354, 1993.

[18] R. Maillard, "Contribution à la connaissance des diatomées d'eau de la nouvelle–Calédonie (Océanie)," *Cah. ORSTOM., Séc. Hydrobiol.,* Vol. XII, n°2, 143-172, 1978.

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Assemblages des Algues Epibenthiques des cours d'eau du Parc National de Kahuzi-Biega (Est de la DR Congo)

[Epibenthic Algal Assemblages of Kahuzi-Biega National Park Streams (East of DR Congo)]

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ABSTRACT: This paper is a report on epibenthic algae identified in water samples recovered from Kahuzi-Biega National Park streams. The samples were collected during dry season (July-August 2007) from 10 streams. Altogether, some 170 species with 9,872 individuals have been identified, belonging to 6 algal groups containing 61 genera. Bacillariophyceae with 3,550 individuals (61 species, 20 genera) formed the most abundant group followed by Cyanophyceae with 2,551 individuals (47 species, 12 genera) and Chlorophyceae with 1,685 individuals (30 species, 15 genera). This algal community is very diversified and balanced (Shannon-Weiner index varied between 4.44-4.67, Species Diversity between 15.81-13.31 and Equitability between 0.97-0.99). The higher number of species (114 species, 55 genera) was recorded at station MV and the lesser number (91 species, 51 genera) at station MG.

KEYWORDS: Benthic algae, Species richness, Composition, Kahuzi-Biega National Park, DR Congo.

RESUME: Cet article un rapport sur les algues épibenthiques identifiées des échantillons d'eau des cours d'eau du Parc National de Kahuzi-Biega. Les échantillons ont été prélevés pendant la saison sèche (Juillet-Août 2007) à partir de 10 cours d'eau. Au total, quelque 170 espèces avec 9.872 individus ont été identifiées, appartenant à 6 groupes d'algues renfermant 61 genres. Les Bacillariophycées avec 3.550 individus (61 espèces, 20 genres) ont formés le groupe le plus abondant suivis par les Cyanophycées avec 2.551 individus (47 espèces, 12 genres) et le Chlorophycées avec 1.685 individus (30 espèces, 15 genres). Cette communauté d'algues est très diversifié et équilibré (indice de Shannon-Weiner a varié entre 4,44 à 4,67, la diversité des espèces entre 15,81 à 13,31 et l'équitabilité entre 0,97-0,99). Le nombre le plus élevé d'espèces (114 espèces, 55 genres) a été enregistré à la station MV et le plus petit nombre (91 espèces, 51 genres) à la station MG.

KEYWORDS: Algue benthique, Richesse Spécifique, Composition, Parc National de Kahuzi-Biega, RD Congo.

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1 INTRODUCTION

The Kahuzi-Biega National Park (PNKB) coast is undergoing rapid environmental changes due to the increase in human population density in this area. Extremely high metropolitan growth rates in sensitive environments form a severe threat for terrestrial and aquatic ecosystems. For the past two decades in PNKB, human activities have increasingly threatened the stability of the aquatic ecosystem, thereby devastating its flora and fauna [1]. It is of particular interest because of its unique biodiversity contains, 44 species of larger mammals (including 10 primate species) have been reported from the highland region, 56 species (14 primate species) from the lowland region [2]. The highland region is characterised by bamboo forest (*Arudinaria alpine*) (37%), primary mountain forest (28%) in the west and northern parts of the Park, secondary mountain forest (20%) in the eastern part, *Cyperus latifolius* swamp (7%) and vegetation (8%), as described by Goodall [3] and Murnyak [4].

Biological surveys of stream communities have long been used to assess the impacts of human activities on receiving waters [5-8]. Stream biological integrity reveals itself in the condition, abundance, and diversity of its biota. These data may be used to assess stream condition relative to biological condition of an unimpaired stream. However, water quality assessments using biological criteria are less common than those based on stream chemistry or toxicology. A change in the physicochemical aspect of a water body brings about a corresponding change in the relative composition and abundance of the organisms in that water. Biomonitoring is the systematic use of living organisms or their responses to determine the quality of the environment [9]. Our objective is to investigate and provide information on the characteristic species and abundance of the epibenthic algal composition of PNKB streams.

The benthic algae are good bioindicators [10], since assemblages composition quickly responds to environmental changes due to their relatively short life spans and rapid immigration rates [11]. They can be also applied in general aquatic bioassessment, which uses species richness, composition and abundance to assess human impacts on aquatic environments and global biodiversity changes [7]. Habitat destruction and eutrophication threaten many epibenthic algae species with extinction. The most threatened species are these, which occur only in restricted habitats, and are usually found in low numbers. Species richness is related to environmental conditions, habitat heterogeneity [12], depends on the sample size [13] and survey intensity.

2 MATERIALS AND METHODS

2.1 STUDY AREA

The PNKB, having an area of 600,000 ha [1,14], is situated in Eastern DR Congo in the Albertine Rift region. It is located within latitudes 1° 36'S and 2°37'S and longitudes 27°33'E and 28°46E (figure 1). The PNKB spans two areas of different altitudes, low altitude located in the Congo basin near Itebero-Utu and high altitude located on the western border of the Congolese basin in the north-west of Bukavu. Because of its varied topography, the average temperature in the high altitude is around 18^{o}C, but it varies in the corridor between 19 and 22^{o}C. The average annual rainfall is about 1619.12 mm with a maximum of 1989.01 mm and a minimum of 1249.23 mm. The average global radiation is strong; it is about 421.8 calories/cm^{3} per month. The average relative humidity is also high, 83% with a maximum of 84% and a minimum of 82% [1,15].

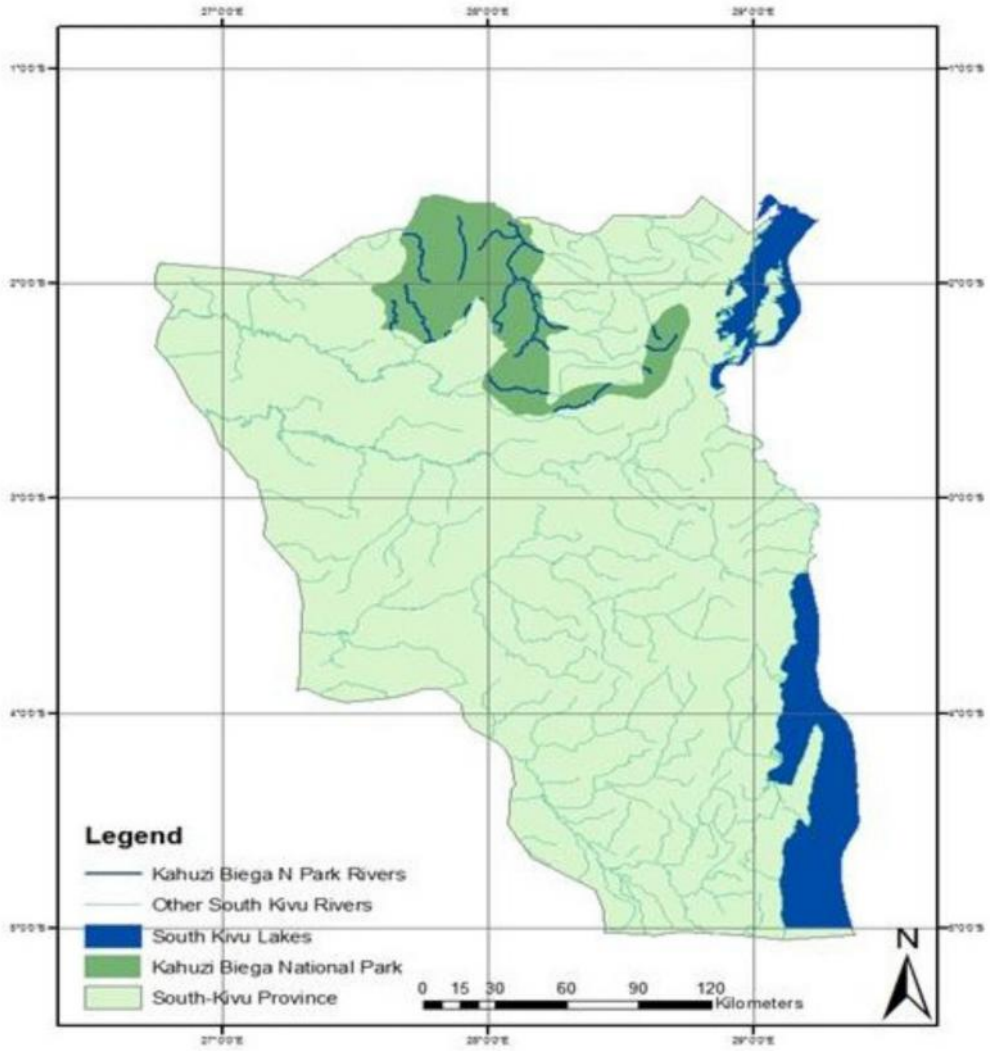

Figure 1. Geographical situation maps of PNKB

2.2 SAMPLE COLLECTIONS AND ANALYSES

Data used in our analyses were compiled by Bisimwa et al. [1] surveys of PNKB streams conducted from July to August 2009. Epibenthic algae were sampled from 10 streams (Bwangizi, Chumba, Chanderema, Chitori, Cinhya, Langa, Mirembo, Mugaba, Mushuva et Nabugobugo) (figure 2) situated between 1900 and 2400 m asl. The streams, draining into the southeastern side of PNKB, are small second or third order systems no more than 3 m wide and less than 1 m deep. The station was always under canopy (>50% canopy cover), while at stations MG, CY and CR were almost open with little direct shading during the day. Small pebbles, sand and clay dominated the substrate at all sampling locations. Characterization of each stream station included water chemistry variables and stream habitat/environmental variables. The methods used in, and the results of, these analyses were previously reported [1,16].

The rocks or stones were scraped clean of the epibenthic algae with a toothbrush at 25 cm^2 of upper surfaces and preserved in 100 ml of distilled water. Samples were preserved in 4% formalin *in situ*, returned to the laboratory on ice, and refrigerated until analysis. In the laboratory, samples were homogenized, thoroughly agitated, and 1 ml of subsample was collected with a pipette for biological analysis [17,18]. Every time after mixed, one drop of this subsample was put on a slide glass and analyzed with an Olympus CHD 6H0136 microscope at a magnification of 1000x [17,19,20]. Descriptive keys and illustrations of the following authors were used: [21-25]. In order to determined community structure, the Shannon-Weiner index (*H*), Species richness index (*D*) and Species Equitability (*J*) were applied [26-30].

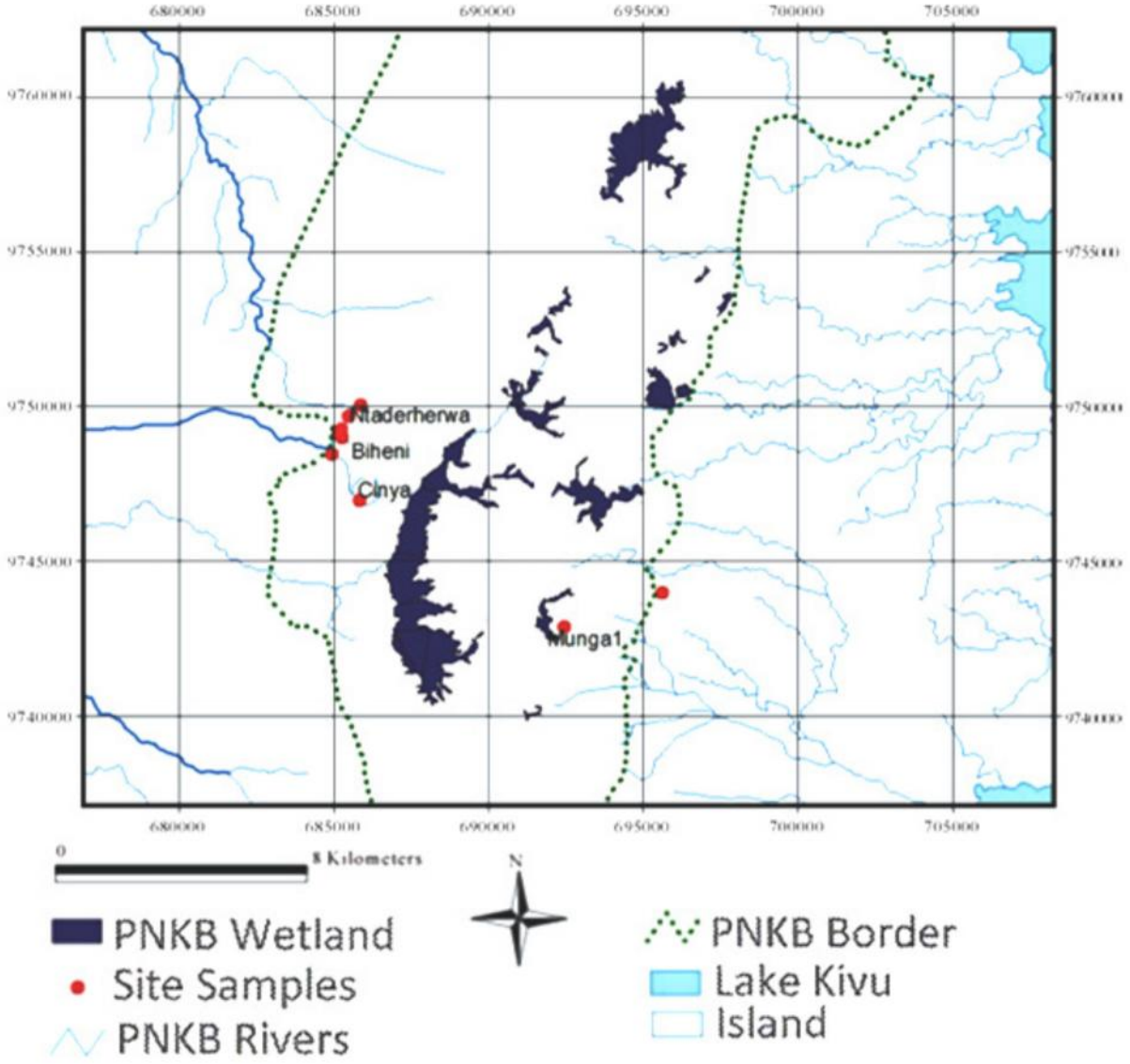

Figure 2. Locations of sampling station in PNKB

3 RESULTS

The physicochemical parameters of lakes, ponds and rivers have considerable effect on the aquatic life. These parameters determine the productivity of a water body. The results of some of chemistry parameters are summarized in table 1.

Table 1. Mean value of water chemistry sampled in PNKB streams

LG=Langa, CM=Chanderema, NG=Nabugobugo, MV=Mushuva, MB=Mirembo, MG=Mugaba, BZ=Bwangizi, CY=Cinhya, CB=Chumba, CR=Chitori. TP=Total Phosphorous, TN=Total Nitrogen, SM=Suspended Matters, DO=Dissout Oxygen

Parameters	Stations				
	LG	CM	NG	MV	MB
Temperature (ºC)	14.9 ± 0.12	14.1 ± 0.2	13.8 ± 0.1	11.3 ± 1.3	13.3 ± 0.3
pH	7.0 ± 0.1	6.1 ± 0.4	5.6 ± 0.4	7.7 ± 0.1	6.3 ± 0.2
Flow (m^3/S)	0.1 ± 0.02	0.02 ± 0.1	0.1 ± 0.04	0.1 ± 0.4	0.03 ± 0.01
Conductivity (µS/cm)	17.0 ± 3.2	54.0 ± 4.2	12.5 ± 1.2	64.0 ± 3.0	17.0 ± 2.0
Ammonium (µmol/L)	2.9 ± 1.2	3.4 ± 1.2	2.8 ± 0.1	2.4 ± 0.2	3.1 ± 0.1
Nitrite (µmol/L)	0.3 ± 0.04	0.5 ± 0.02	0.5 ± 0.01	0.4 ± 0.1	0.3 ± 0.1
Nitrate (µmol/L)	0.2 ± 0.3	0.4 ± 0.1	0.3 ± 0.1	0.3 ± 0.2	0.3 ± 0.1
TP (µmol/L)	0.1 ± 0.01	0.6 ± 0.04	0.1 ± 0.1	0.3 ± 0.02	0.1 ± 0.01
TN (µmol/L)	3.4 ± 0.1	4.3 ± 1.1	3.6 ± 0.01	2.8 ± 1.03	3.7 ± 1.02
Alkalinity (mg/L)	11.0 ± 0.1	14.0 ± 0.03	3.5 ± 0.02	13.0 ± 0.1	5.5 ± 0.5
SM (mg/L)	0.1 ± 0.4	1.0 ± 0.1	0.2 ± 0.1	1.5 ± 0.3	0.9 ± 0.1
DO (mg/L)	7.6 ± 0.2	7.6 ± 0.3	4.3 ± 0.2	6.2 ± 0.7	6.1 ± 0.4

Parameters	Stations				
	MG	BZ	CY	CB	CR
Temperature (ºC)	14.1 ± 0.2	13.8 ± 0.2	13.3 ± 0.01	14.6 ± 0.02	14.5 ± 0.02
pH	7.1 ± 0.4	6.1 ± 0.5	5.7 ± 0.4	5.6 ± 0.8	5.5 ± 1.1
Flow (m^3/S)	0.1 ± 0.04	0.8 ± 0.04	0.04 ± 0.01	0.1 ± 0.1	0.02 ± 0.1
Conductivity (µS/cm)	23.6 ± 0.3	13.0 ± 2.5	11.5 ± 0.8	13.0 ± 0.1	14.0 ± 2.4
Ammonium (µmol/L)	2.8 ± 0.03	1.7 ± 1.1	1.4 ± 0.02	1.4 ± 0.01	2.8 ± 0.1
Nitrite (µmol/L)	0.4 ± 0.04	0.8 ± 0.02	0.5 ± 0.04	0.5 ± 0.03	0.5 ± 0.1
Nitrate (µmol/L)	0.3 ± 0.03	0.3 ± 0.1	0.4 ± 0.01	0.3 ± 0.02	0.3 ± 0.1
TP (µmol/L)	0.2 ± 0.01	0.1 ± 0.01	0.3 ± 0.02	0.1 ± 0.01	0.1 ± 0.01
TN (µmol/L)	3.5 ± 0.1	2.8 ± 0.03	3.7 ± 0.1	2.2 ± 0.8	3.6 ± 0.04
Alkalinity (mg/L)	6.3 ± 0.7	6.0 ± 1.2	2.5 ± 0.5	2.0 ± 0.4	2.0 ± 0.8
SM (mg/L)	0.2 ± 0.1	0.8 ± 0.1	0.1 ± 0.03	0.1 ± 0.1	0.3 ± 0.01
DO (mg/L)	4.8 ± 2.1	5.7 ± 0.6	2.6 ± 0.2	5.7 ± 0.4	5.4 ± 0.3

During investigation, 170 species were recorded from PNKB streams. The algal species were belonging to 6 algal groups containing 61 genera (table 2). The epibenthic algal assemblages over the sampling period were dominated by Bacillariophyceae (61 species, 20 genera), Cyanophyceae (47 species, 12 genera) and Chlorophyceae (30 species, 15 genera). The rest of the assemblages were composed by Desmidiaceae (17 species, 7 genera), Euglenophyceae (10 species, 4 genera) and Dinophyceae (5 species, 2 genera) (figure 3). The greatest species number was found at station MV (114 species from 55 genera), followed by station MB (106 species from 50 genera). The algae flora of station MG was with less species number, only 91 species from 51 genera were observed (figure 4). Highest species diversity (15.81) was recorded at station MV while station MG had the lowest species diversity (13.31). The highest and lowest Shannon-Weiner index values (4.67 and 4.44) were recorded respectively at station MV and station MG. The Equitability index was highest (0.99) at stations NG, MV, BZ, CY and CB while the lowest value (0.97) was recorded at station LG.

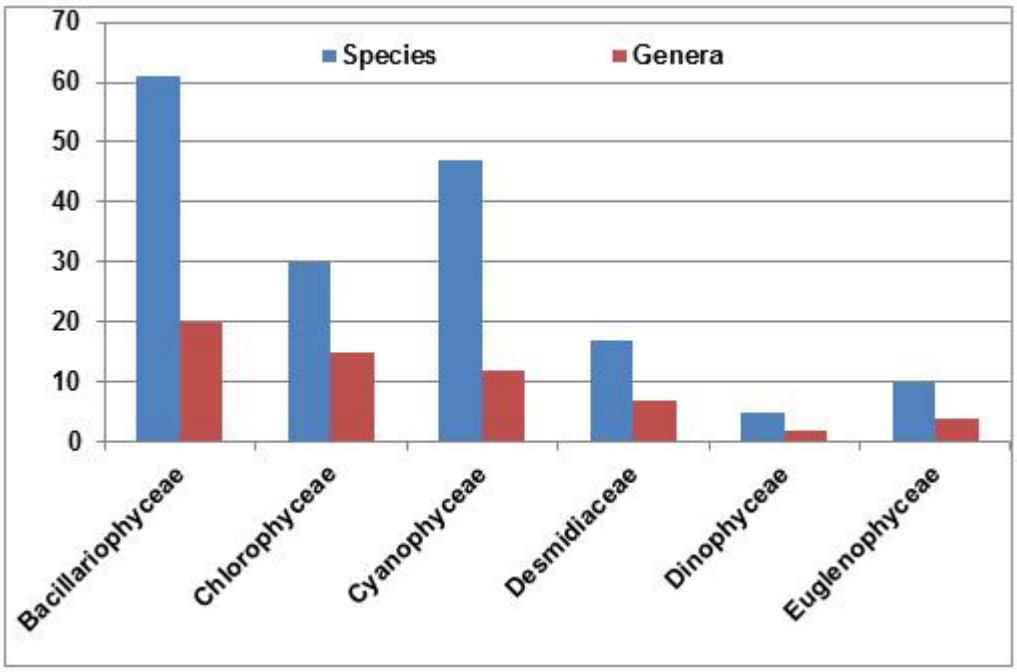

Figure 3. Distribution of epibenthic algae in different algal groups

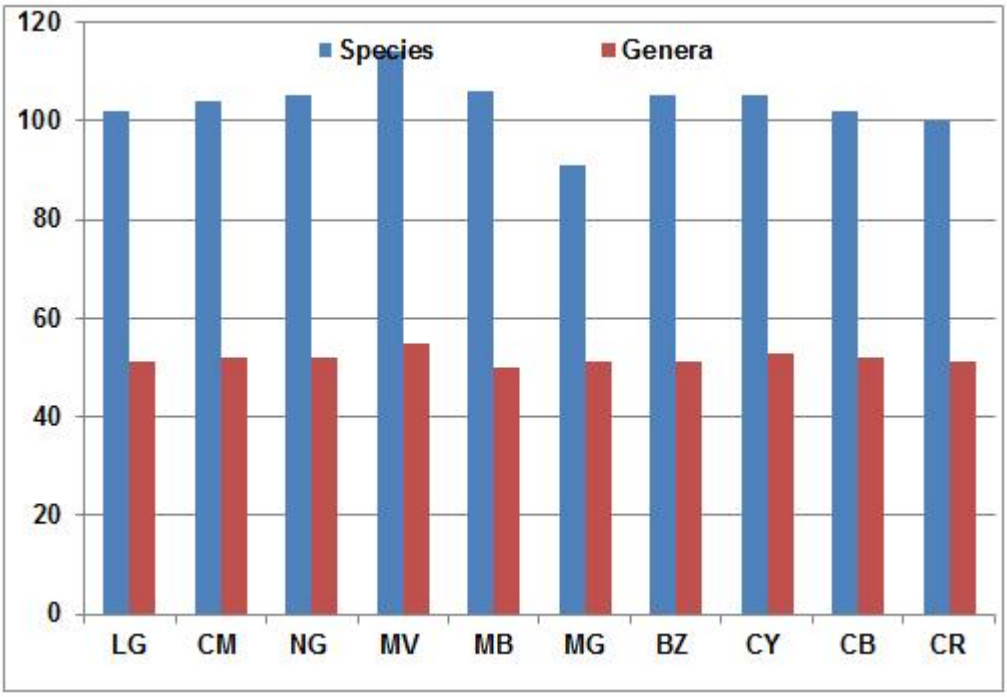

Figure 4. Variation of epibenthic algae in different streams of PNKB

Table 2: Epibenthic algae encountered during the study period in PNKB streams

LG=Langa, CM=Chanderema, NG=Nabugobugo, MV=Mushuva, MB=Mirembo, MG=Mugaba, BZ=Bwangizi, CY=Cinhya, CB=Chumba, CR=Chitori.
Grp.=Group, Com.=Community

Species	Stations										Total	% in Grp.	% in Com.
	LG	CM	NG	MV	MB	MG	BZ	CY	CB	CR			
Bacillariophyceae													
Achnanthes	11	8	0	25	16	9	5	13	10	16	113	3,2	1,1
Amphora	10	7	10	15	24	0	8	0	0	23	97	2,7	1,0
Cyclotella	0	0	8	10	34	8	18	23	10	43	154	4,3	1,6
Cymbella	33	29	28	81	41	16	30	27	18	33	336	9,5	3,4
Diatoma	0	0	22	16	13	9	7	12	7	4	90	2,5	0,9
Epithemia	10	11	0	5	0	5	18	12	18	15	94	2,6	1,0
Eunotia	19	22	20	16	10	5	21	18	18	21	170	4,8	1,7
Fragilaria	20	21	19	14	29	18	17	6	23	12	179	5,0	1,8
Frustulia	9	11	9	24	19	24	21	8	11	7	143	4,0	1,4
Gomphocymbella	0	12	13	8	16	0	0	4	15	28	96	2,7	1,0
Gomphonema	31	33	30	10	25	37	41	41	49	14	311	8,8	3,2
Gyrosigma	12	0	0	10	20	14	13	20	0	5	94	2,6	1,0
Melosira	6	30	17	11	13	9	17	17	16	23	159	4,5	1,6
Navicula	38	64	50	86	58	62	70	55	69	35	587	16,5	5,9
Nitzschia	36	38	52	36	23	41	14	27	38	33	338	9,5	3,4
Pinnularia	11	19	8	21	0	18	11	0	0	5	93	2,6	0,9
Rhopalodia	0	10	19	18	6	8	0	5	0	5	71	2,0	0,7
Surirella	13	7	22	26	16	17	14	12	5	9	141	4,0	1,4
Synedra	11	19	38	17	25	10	34	29	15	12	210	5,9	2,1
Tabellaria	0	6	8	10	5	4	9	14	14	4	74	2,1	0,7
Total	**270**	**347**	**373**	**459**	**393**	**314**	**368**	**343**	**336**	**347**	**3550**	100,0	36,0
Chlorophyceae													
Ankistrodesmus	10	11	0	5	5	13	22	7	32	9	114	6,8	1,2
Cladophora	21	18	23	15	14	11	13	8	10	14	147	8,7	1,5
Chaetophora	5	12	0	0	0	0	0	0	0	0	17	1,0	0,2
Chlorella	6	10	0	5	4	0	0	11	10	0	46	2,7	0,5
Crucigenia	25	39	31	30	22	11	31	13	25	45	272	16,1	2,8
Enteromorpha	6	9	10	0	27	10	0	18	0	9	89	5,3	0,9
Kirchneriella	10	9	0	0	0	12	18	0	5	0	54	3,2	0,5
Microspora	0	0	0	0	0	0	5	5	5	5	20	1,2	0,2
Mougeotia	9	12	18	15	16	13	7	11	14	10	125	7,4	1,3
Pediastrum	15	23	24	49	17	18	16	20	11	19	212	12,6	2,1
Penium	19	14	12	18	13	4	11	13	15	14	133	7,9	1,3
Protoccus	15	0	5	13	0	8	5	8	5	9	68	4,0	0,7
Rhizoclonium	19	15	11	19	17	10	23	10	9	26	159	9,4	1,6
Richteriella	4	11	7	9	0	0	0	10	5	10	56	3,3	0,6
Sorastrum	21	5	8	24	27	15	20	16	20	17	173	10,3	1,8
Total	**185**	**188**	**149**	**202**	**162**	**125**	**171**	**150**	**166**	**187**	**1685**	100,0	17,1
Cyanophyceae													
Anabaena	18	15	4	10	4	13	4	28	16	23	135	5,3	1,4
Anabaenopsis	0	10	17	10	0	0	0	0	0	0	37	1,5	0,4
Aphanocapsa	10	21	8	15	0	13	24	19	20	0	130	5,1	1,3
Coelosphaerium	11	18	6	28	19	4	15	17	21	12	151	5,9	1,5
Dactylococcopsis	14	9	22	21	5	10	18	0	10	0	109	4,3	1,1

Isocystis	0	0	0	0	13	6	18	0	10	0	47	1,8	0,5
Lyngbya	26	10	30	24	14	30	42	29	68	38	311	12,2	3,2
Merismopedia	29	40	35	18	17	42	0	43	31	56	311	12,2	3,2
Microcystis .	32	36	24	31	22	32	24	19	8	14	242	9,5	2,5
Oscillatoria	87	90	84	71	81	29	52	89	64	54	701	27,5	7,1
Psedanabaena	24	25	10	31	35	6	17	18	10	22	198	7,8	2,0
Synechocistis	15	16	17	17	25	5	24	24	13	23	179	7,0	1,8
Total	**266**	**290**	**257**	**276**	**235**	**190**	**238**	**286**	**271**	**242**	**2551**	100,0	25,8
Desmidiaceae													
Closterium	26	10	14	35	20	25	21	19	22	27	219	19,9	2,2
Cosmarium	16	17	8	21	20	13	6	21	18	17	157	14,3	1,6
Desmidium	10	20	20	10	20	0	10	10	20	20	140	12,7	1,4
Docidium	10	10	4	9							33	3,0	0,3
Gonatozygon	0	20	29	27	23	4	15	10	17	20	165	15,0	1,7
Micrasterias	25	9	20	20	10	15	19	20	17	13	168	15,3	1,7
Spirotaenia	0	12	10	9	0	9	10	10	0	0	60	5,5	0,6
Staurastrum	18	12	17	15	13	19	14	10	24	16	158	14,4	1,6
Total	**105**	**110**	**122**	**146**	**106**	**85**	**95**	**100**	**118**	**113**	**1100**	100,0	11,1
Dinophyceae													
Ceratium	14	18	13	18	16	12	17	19	17	15	159	52,3	1,6
Peridinum	26	19	12	28	10	0	10	9	21	10	145	47,7	1,5
Total	**40**	**37**	**25**	**46**	**26**	**12**	**27**	**28**	**38**	**25**	**304**	100,0	3,1
Euglenophyceae													
Euglena	38	36	50	31	45	21	43	32	25	51	372	54,5	3,8
Leponicilis	10	0	10	0	13	5	0	12	10	0	60	8,8	0,6
Phacus	11	13	15	9	8	14	10	16	14	12	122	17,9	1,2
Trachelomonas	20	0	10	30	10	0	10	10	28	10	128	18,8	1,3
Total	**79**	**49**	**85**	**70**	**76**	**40**	**63**	**70**	**77**	**73**	**682**	100,0	6,9
Grand Total	**945**	**1021**	**1011**	**1199**	**998**	**766**	**962**	**977**	**1006**	**987**	**9872**		100,0

Bacillariophyceae stood out due to their numerical abundance and frequency of occurrence, and together accounted for 3,550 individuals representing 36.0% of the algal community (table 2). The large number (459 individuals with 45 species) was recorded at station MV and the small number (270 individuals with 32 species) on station LG. The *Navicula* represent 16.5% of the bacillariophyceae with 9 species which *Navicula cuspidata* was the most important. The *Cymbella* and *Nitzschia* ranks second (9.5%) with respectively 6 and 5 species. Beside *N. cuspidata*, there are a number of bacillariophyceae in proportion dominant and present in all stations such as *Frustulia rhomboides*, *Gomphonema angustatum*, *Melosira nyassensis*, *Nitzschia acicularis, Nitzschia filiformis* and *Synedra pulchella*. On the other hand, *Cymbella placentula*, *Eunotia arcus*, *Navicula muticoides*, *Navicula placentula*, *Nitzschia sp.* and *Rhopalodia gibberula* were localized only at most 3 stations.

Cyanophyceae was the second most numerous group (2,551 individuals, 25.8% of the algal community), although with a smaller contribution than bacillariophyceae (table 2). The large number (290 individuals with 31 species) was collected at station CM and the small number (190 individuals with 23 species) at station MG. The *Oscillatoria* (27.5%, 15 species) dominate this class and an important species was *Oscillatoria geminata*. The *Lyngbya* and *Merismopedia* were the second genera with respectively 6 and 5 species, representing 12.2% of the stock of cyanophyceae. *Anabaena flos-aquae, Coelosphaerium nägelianum, Microcystis aeruginosa* and *Synechocistis elongatum* have dominated all stations. On the other hand, *Anabaenopsis tanganikae*, *Microcystis hansgirgiana*, *Oscillatoria limosa, Oscillatoria rubescens, Oscillatoria setigera* were limited at most 3 stations.

Chlorophyceae was the third numerous group with 1,685 individuals representing 17.1% of the epibenthic algal assemblages (table 2). The large number of chlorophyceae (202 individuals with 19 species) was recorded at stations MV. The small number (125 individuals with 15 species) was recorded at station MG. They are dominated by the genera *Crucigenia* (4 species), 16.1% of total chlorophyceae. In second place comes *Pediastrum* with 5 species and constitutes 12.6% of total chlorophyceae, the most important species was *Crucigenia cuneiformis*. Dominant species and present in all stations were

Cladophora aeragrophila, *C. cuneiformis, Mougeotia planctonica* and *Penium jenneri*. On the other hand, *Ankistrodesmus falcatus, Chaetophora sp., Enteromorpha sp., Pediastrum boryanum* and *Pediastrum clathratum* were localized only at most 3 stations.

Desmidiaceae was the fourth numerous groups accounted for 1,100 individuals representing 11.1% of the algal community. It was represented by *Closterium* which forms 19.9% of the group with 4 species and *Micrasterias* which forms 15.3% with 2 species. *Closterium aciculare* was more important species. The large number of desmidiaceae (146 individuals with 14 species) was collected at station MV and the small number (85 individuals with 9 species) at station MG. Only *Cosmarium moniliferum* is dominant and present in all stations and *Closterium abruptum* and *Closterium polystichum* were present only at most 3 stations.

Euglenophyceae (682 individuals, 6.9%) and Dinophyceae (304 individuals, 3.1%) were represented respectively by *Euglena* (54.5% with 6 species) and *Ceratium* (52.3% with 1 species). The large number of Euglenophyceae (85 individuals with 7 species) was sampled at stations LG; and the small number (40 with 5 species) at stations MG. *Euglena acus* is important species of the group. *Phacus longicauda* is the dominant species and present in all stations. Only *Euglena polymorpha* is limited to 3 stations. The large number of Dinophyceae (46 individuals with 3 species) was collected at stations MV; and the small number (12 with 1 species) at station MG. *Ceratium hirundinella* is the only dominant specie present in all stations. *Peridium inconspicuum* and *Peridinum sp.* were limited at most two stations.

4 DISCUSSION AND CONCLUSION

The results of this study showed that these epibenthic algal assemblages are much diversified and mainly composed of Bacillariophyceae followed by Cyanophyceae, Chlorophyceae, Desmidiaceae, Dinophyceae and finally Euglenophyceae. The list of species recorded in this paper was in general similar to other benthic algae composition of the tropical rivers [1,31-34]. It is possible that natural potential of habitat for colonization, presence of different ecological niches as well as nutrient quantity and quality are main factors responsible for diverse (170 species) epibenthic flora. This is in agreement with the work of Lindahi and Melin [35] showing that nitrate and phosphate stimulate the growth of algae. The highest Shannon-Weiner index value (4.67) was recorded at station MV, this consequently resulted in the highest species diversity value (15.81) recorded at station MV. This observation is in line with the earlier work reported by Bisimwa et al. [1] that the higher the value of Shannon-Weiner index (*H*) the greater the benthic algae diversity. Heterogeneous bottom habitat of station MV (muddy bed with non-decomposed fragments of water plants, sand and gravel), accompanied with high concentration of detritus and high average concentration of dissolved oxygen, probably contributes to species richness and abundance of epibenthic algae.

The development of large numbers of cosmopolitan species in PNKB streams, such as *F. rhomboides, G. angustatum, M. nyassensis, N. cuspidata, N. acicularis, N. filiformis, S. pulchella, C. aeragrophila, C. cuneiformis, M. planctonica, P. jenneri, A. flos-aquae, C. nägelianum, M. aeruginosa, O. geminate, S. elongatum, C. aciculare, C. moniliferum, C. hirundinella, E. acus* and *P. longicauda* is typical of many other tropical rivers [1,31-34]. They are characteristic of bit mineralized, acid or dystrophic water. This group has a good value indicative of the chemical composition of the waters of these rivers less polluted [1,16]. Many of these species occur also regularly in both algal associations acidoclines peat lands in temperate regions, in associations acidobiontes tropical streams [1,33]. The abundance and diversity of epibenthic algae vary according to limnological features and the trophic state of freshwater bodies [36]. Total epibenthic algae abundance may increase with increasing eutrophication. Composition and diversity of epibenthic algae provide information on the characteristics and quality of the water body [19,20,37,38].

The distribution of the epilithic algae with more dominant species in some stations may have several ecological implications. One possible alternative explanation for this phenomenon is the preference of environment by algae species, which may be associated with the physicochemical parameters and climatic factors but especially with the nutrient load of the river [19,20,37-39]. In PNKB, these nutrients come from the decomposition of plant scraps, especially leaves, falling abundantly in or near some rivers. Phosphorus and nitrate are important in the development of benthic algae. They stimulate their growth and multiplication [17]. Similarly, the distribution of bacillariophyceae species spread regardless of station, implied that the optimum conditions for its growth and reproduction is beneficial for this large group, despite variations in physicochemical parameters observed in all stations [16]. Bisimwa et al. [1] reported that there was need for other extensive ecological studies to be carried out in the PNKB streams.

REFERENCES

[1] M.A. Bisimwa, M. Ngera, K. Bisimwa, M. Bagalwa, and N. Mushayuma, "A Preliminary Checklist of Epilithic Algae of Kahuzi-Biega National Park, Democratic Republic of the Congo," *Greener Journal of Biological Science* Vol. 3 (8), 282-291, 2013.

[2] M. Mankoto, J. Yamagiwa, B. Steinhauer, N. Mwanza, T. Maruhashi, and T. Yumoto, "Conservation of Eastern Lowland Gorilla in the Kahuzi-Biega National Park, Zaïre," *University Louis Pasteur, Strasbourg*. 113-122, 1994.

[3] A.J. Goodall, "Feeding and Ranging Behaviour of a Mountain Gorilla Group (*Gorilla gorilla beringei*) in the Tshibinda-Kahuzi Region (Zaïre)," *Primate Ecology Academic Press, London*, pp. 450-479, 1977.

[4] D.F. Murnyak, "Censusing the Gorillas in Kahuzi-Biega National Park," *Biological Conservation*, Vol. 21, No. 3, pp. 163-176, 1981.

[5] B.A. Whitton and M.G. Kelly, "Use of algae and other plants for monitoring rivers," *Australian Journal of Ecology* 20:45–56, 1995.

[6] R.L. Lowe and Y. Pan, *Benthic algal communities and biological monitors*. Pages 705–739. *In* R.J. Stevenson, M. Bothwell, and R.L. Lowe. Algal ecology: freshwater benthic ecosystems. Academic Press, San Diego, California, 1996.

[7] E.F. Stoermer and J.P. Smol, "The Diatoms: Applications for the Environmental and Earth Science," *J. Phycol*. 35, 1340-1342, 1999.

[8] R.J. Stevenson and J.P. Smol, *Use of algae in environmental assessments*. *In* J.D. Wehr and R.G. Sheath (editors). Freshwater algae in North America: classification and ecology. Academic Press, San Diego, California, 2001.

[9] D.M. Rosenberg, "A National Aquatic Ecosystem Health Program for Canada: We should go against the flow," *Bull. Entomol. Soc. Can*. 30(4): 144-152, 1998.

[10] J. Prygiel, B.A. Whitton and J. Bukowska, *Use of the algae for monitoring rivers III*. Agence de l'Eau Artois-Picardie, Douai Cedex: 271 pp, 1999.

[11] S. Dixit, J.P. Smol, J.C. Kingston and D.F. Charles, "Diatoms: powerful indicators of environmental change. Environ," *Sci. Technol*., 26/1: 23-33, 1992.

[12] R.G. Wetzel, *Limnology. 2nd Ed*., Saunders College Publishing, Philadelphia, ISBN: 0-7216-9240-0, 1983.

[13] B. Kawecka, & P. Eloranta, Zarys ekologii glonów wód słodkich i środowisk lądowych. *Wydawnictwo Naukowe PWN, Warszawa*: 256p, 1994.

[14] E. Fischer, *La végétation du Parc National de Kahuzi-Biega (Sud-Kivu, Zaïre).* Gehurt Stag. 93 p, 1993.

[15] R. Kasisi, *Planification et l'application d'un développement durable comme principale stratégie de conservation des ressources dans la région du Parc National de Kahuzi-Biega*. PhD Thesis. Montreal University, 364p, 1989.

[16] M. Bagalwa, N. Zirirane, S.U. Pauls, K. Karume, M. Ngera, M. Bisimwa and N.G. Mushagalusa, "Aspects of the physico-chemical characteristics of rivers in Kahuzi-Biega National Park, Democratic Republic of Congo," *Journal of Environmental Protection*, 3, 1590-1595, 2012.

[17] A.C. Chindah, I.C. Aduabobo, A.B. Salomon and A. Amadia, "The epibenthic algal community of the Bonny estuary, Niger Delta, Nigeria," *Acta Hydrobiol*, 35/4, 307-320, 1993.

[18] C. Cocquyt, "Seasonal variations of epilithic diatom communities in the northern basin of Lake Tanganyika," *Syst. Geogr. Pl*. 69. 265-273, 1999.

[19] B. Fawzi, M. Chlaida, S. Oubraim, M. Loudiki, B. Sabour et A. Bouzidi, "Application de certains indices diatomiques à un cours d'eau Marocain: Oued Hassar," *Rev. Sci. Eaux* 14/1. 73-89, 2001.

[20] M. Coste, *Les diatomées indicatrices de la qualité de l'eau: une collaboration avec les agences de l'eau,* 2003. [Online] Available : http://WWW.cemagref.fr/Information. (April 12, 2012)

[21] L.A. Whitford and G.J. Schumacher, *A Manual of Fresh Water Algae*. Spark Press, Raleigh, N.C., pp: 324, 1973.

[22] R. Patrick and C.W. Reimer, *The diatoms of the United States*. Monograph of the Academy of Natural Sciences of Philadelphia, 13 (2), 213 p, 1975.

[23] H. Germain, *Flore des diatomées. Eaux douces et saumâtres*. Boudée et Cie, Paris, 443p, 1981.

[24] M. Ricard, *Atlas du phytoplancton marin*. Vol.2. Diatomophycées. Ed. CNRS, Paris, 297p, 1987.

[25] K. Krammer and H. Bertalot, *Bacillariophyceae*. Berlin. 482p, 2000.

[26] C.E. Shannon and W. Weiner, *The mathematical theory of communication*. University of lllinois Press, Urbans. 125p, 1963.

[27] R. Margalef, *Perspective in Ecological Theory*. University of Chicago Press. Chicago. 111p, 1970. [28] E. C. Pielou, "The measurement of diversity types of biological collections," *Journal of Theoretical Biology*, 13, 131-144, 1975.

[28] E.C. Piélou, "The measurement of diversity in different types of biological collections," *J. Theoret.Biol*., 10: 370-373, 1966.

[29] R.A. Kempton, "The structure of species abundance and measurement of diversity," *Biometrics* 35: 307-321, 1979.

[30] A.E. Ogbeibu, *Biostatistics: A practical approach to reseach and data handling*. Mindex Publishing Company limited, Benin City, Nigeria. 264p, 2005.
[31] S.K. Golama, "La flore diatomique de quelques cours d'eau de Kisangani (Zaire)," *Belg. Journ. Bot*. 124: 11-20, 1991.
[32] S.K. Golama, *Bacillariophycées, Desmidiées et Euglenophycées de la Région de Kisangani (Zaire).* Mém. Acad. Roy. Sci. Outre-Mer, Cl. Sci. Nat. Med., nouv. Ser. No 8, 23 (3), 1993.
[33] J.J. Symoens et A. van der Werff, "Les Diatomées des chutes de la Tshopo (Kisangani-Zaïre)," *Bull. Jard. Bot. Nat. Belg*. 62: 349-354, 1993.
[34] J.J. Symoens et A. van der Werff, "Diatomées de quelques cours d'eau des environs de Yangambi (Cuvette centrale zaïroise, Région du Haut-Zaïre)," *Bull. Jard. Bot. Nat. Belg*. 65: 347-357, 1996.
[35] P.E.B. Lindahi and K.E.R., Melin, "Algal arrays of Archipelago waters," *Quantitative aspects. Oikos*, 24, 171-178, 1973.
[36] E. Jappesen, J.P. Jensen and M. Sandergaeid, "Response of phytoplankton, zooplankton and fish to re-oligotrophication: an 11-year study of 23 Danish Lakes," *Aquatic Ecosystem Health and management* 5:31-43, 2002.
[37] B.J. Bellinger, C. Cocquyt and C.M. O'Reilly, "Benthic diatoms as indicators of eutrophication in tropical streams," *Hydrobiologia* 573: 75-87, 2006.
[38] M.A. Bisimwa, M.F. Ngera et Baluku, B., "Inventaire préliminaire du périphyton épilithique des cours d'eau de la région de Lwiro, Sud-Kivu, RD Congo," *Cahier du CERUKI, Numéro Spécial CRSN-Lwiro*, 74-82, 2009.
[39] L. Bennasser, M. Fekhaoui, J.-L. Bénoit-Guyod et G. Merlin, "Influence de la mare sur la qualité des eaux du Bas Sebou soumis aux rejets de la plaine du Gharb (Maroc)," *Wat. Res.* Vol. 31, No 4, 859-867, 1997.

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Synthesis of Ni based metal organic frameworks and its applications for removal of polyaromatic hydrocarbons

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ABSTRACT: Metal Organic Frameworks (MOFs) are widely employed as catalysts and semiconductors due to unique combination of crystalline and porous structure. The presence of polar and non-polar groups on organic linkers provides extra coordination sites for attachment of various metals. The topology of single and mixed organic ligands is tuned to higher surface area and increased porosity likely to serve as good adsorbents.

The present study is based on synthesis of single and mixed ligand MOFs with Nickel as precursor. Oxalic and trimesic acid, representatives of di- and tri- carboxylates provides the organic framework. The characterization of synthesized MOFs by FTIR, XRD and SEM/EDX techniques reveal average crystallite size (0.2-3nm) and Ni is incorporated to mass percentage of 9-13%. Ni-O binding is exhibited at FTIR frequency of 493-500cm^{-1}. The application of synthesized MOFs in batch experiment at varying adsorbent dose, concentration and temperature demonstrated adsorptive capacity for Polyaromatic hydrocarbons in the sequence dibenzofuran (81%) > phenanthrene (91%) > anthracene (33%). The adsorbents were also proven to be effective for removal of pollutants from industrial waste with average percent removal of 73% for incinerator ash.

The study concluded that use of synthesized MOFs as an adsorbent for removal of pollutants is most effective way for environmental remediation. These MOFs can also be applied for catalysis of toxic environmental pollutants.

KEYWORDS: Oxalic acid, Trimesic acid, Dibenzofuran, Phenanthrene, Anthracene.

1 INTRODUCTION

The continuous industrial discharge and accumulation of environmental pollutants has impacted almost every aspect of life forms and physical compartments of the environment. The toxic and persistent nature of many of the pollutants poses a threat and their removal from environmental components is even more challenging [1]. To combat these problems, the researchers are continuously urging for effective and economically viable remedial measures.

Upto now various conventional methods have been adopted for removal of environmental pollutants. Of these, adsorption offers an easy, low cost and effective alternate process. Its preference is owned by the versatility and regeneration of adsorbents. However, limited numbers of structural and porous architectures available for sorption limit the usage [2] of well established adsorbents like Activated carbon and zeolites. So, research is directed at the synthesis and development of novel adsorbents with flexible artifacts.

Metal Organic Frameworks (MOFs) represent class of hybrid material that exist as infinite crystalline lattices with metal clusters and organic linkers, and possess accessible cages, tunnels and modifiable pores [3]. These properties render MOFs as efficient adsorbents for diverse applications [4]. Further, substitution of polar or non polar groups on organic backbone [5] makes them more selective (due to enhanced hydrophilicity and hydrophobicity) for efficient removal of hazardous compounds. MOFs have been successfully explored as sorbents [6]. For this purpose, various types of MOFs have been synthesized with variations in central metal, organic linkers and incorporated active species. However, limited use of MOFs [7] has been reported in the removal of polyaromatic hydrocarbons. Poly aromatic hydrocarbons (PAH) belongs to Persistent Organic pollutants are released naturally from forest fires and volcanic eruptions but human activities have increased their amount in environment by incomplete pyrolysis of fossil fuels such as coal and other organic substances at domestic and

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industrial level. Due to their long half life PAH are considered as one of the most toxic classes of pollutants and their removal from environment is mandatory **[8].**

The present research is an attempt to synthesize novel MOFs with variation of single and mixed ligand and incorporation of Ni as metal. These MOFs were further evaluated for removal of linear, non linear and substituted polyaromatic hydrocarbon.

2 MATERIAL AND METHODS

Hydrothermal method [9] was adopted for synthesis with slight modification. A greener aspect was added by carrying out the synthesis under ambient temperature and pressure conditions. Further, novelty of mixed ligands (di- and tri-carbooxylate) synthesis of MOFs is also introduced. Oxalic acid and trimisic acid were used to provide organic framework for the incorporation of nickel metal. The synthesis method follows the general procedure as:

Each of the Carboxylic acid (2mmol) dissolved in absolute ethanol (12ml) was added separately, to aqueous Ni-salt solution (4mmol) under continuous stirring for 30 minutes. The solution was left undisturbed for nucleation in fume hood for 5 days. The resultant product was filtered, washed repeatedly with ethanol, and evaporated on rotary evaporator. The dried product was pulverized and placed in desiccator till further use. In a similar fashion, mixed ligand MOFs was synthesized by adding 1:1 mixed solution of oxalic and trimesic acids to the stirring solution of metal salt.

The synthesized materials were characterized for surface and bulk properties on standardized FTIR (FTIR 8400, Shimadzu, Japan), X-rays Diffraction (Panalytical X'Pert Pro multipurpose) and SEM/EDX (JEOL JSM-6490, Japan).

The adsorptive potential of synthesized single and mixed ligand MOFs for removal of selected PAH was evaluated in batch adsorption experiment on UV-Visible spectrophotometer (UV-1601-Schimadzu, Japan) under varying conditions. Each batch was administered with three induced PAH concentration of (0.001mg/L, 0.003mg/L, 0.005 mg/L) on each of the adsorbent dose (1mg, 5mg, 10mg) and working temperatures of 25^{o}C (room temperature), 50^{o}C, and 70^{o}C. The absorbance of Phenanthrene, Anthracene, and Dibenzofuran was recorded at 250nm, 375nm and 292nm, respectively after full spectral scan. The adsorption (percentage removal) was calculated from the constructed standard calibration curve using the formula as.

$$\%R = \frac{Ci - Ct}{Ci} \times 100$$

3 RESULTS AND DISCUSSION

The present research provides an efficient, simple and environment friendly greener method for the successful synthesis of uni-and bi-ligand organic framework centralized around Nickel. Further, the efficacy of each of the synthesized material as adsorbent under varying experimental batch conditions is determined.

3.1 CHARACTERIZATION OF SYNTHESIZED MATERIALS

The synthesized products were characterized using FTIR, XRD and SEM/EDX to identify its bonding, crystallinity, morphology and elemental composition. FTIR analysis (see Figure 1) indicated the presence of organic ligand in (NiOX) at 721cm^{-1} that may be attributed to structural vibration of C-C bond. The peak at 829cm^{-1} and 1300cm^{-1}-1370cm^{-1} is assigned to asymmetric stretching and symmetric vibration of υ(CO), respectively, in oxalic acid. The incorporation of metal (Nickel) into organic frame depicts sharp and intense asymmetric stretching modified to broad band at 1710cm^{-1}-1780cm^{-1}. This change might be representation of υ(OCO) due to metal binding [10].

FTIR spectrum (see Figure1) of Ni-trimesic acid (NiT) reveals the sharp peak of C-H in-plane and out-planes bending vibration of benzene ring [11] at 1150cm^{-1}-1250cm^{-1} and 675-900cm^{-1}. On the other hand, bi-ligand Ni-MOF (NiTOX) showed C-H in plane bending in the range 1278cm^{-1}-1107cm^{-1}, whereas, C-C stretching of benzene ring is depicted at 1404cm^{-1} - 1468cm^{-1}. In- plane bending vibration of υ(CO) is represented by two sharp peaks in the range 650cm^{-1} -750cm$^{-1.}$ Ni-O coordination bond determined at 400-500cm^{-1} represents binding of metal with organic ligand [12].

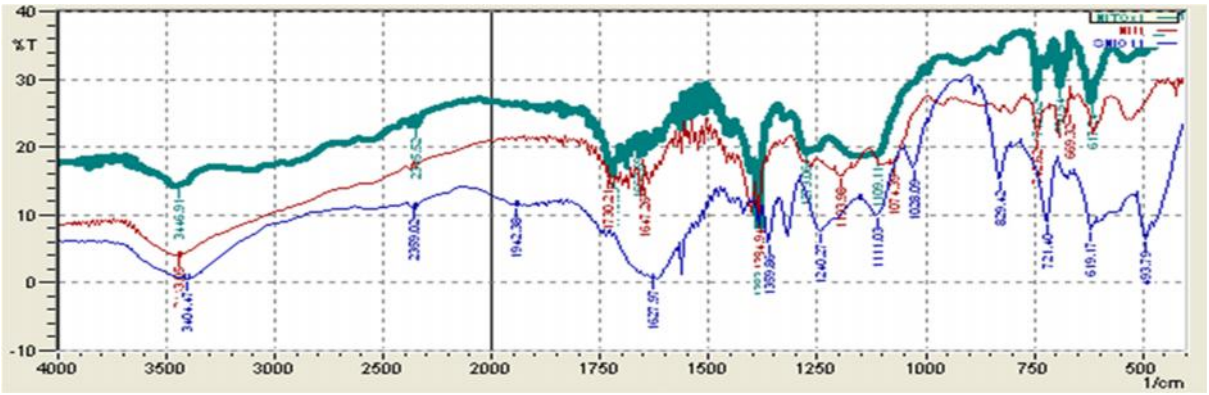

Fig. 1. FTIR Spectra of Ni based uni-and bi-ligand MOFs (a) NiOX (b) NiT (c) NiTOX

The synthesized metal-organic materials were impinged with X-rays to determine diffraction of incoming rays at definite angles by inter-spacing of layers/planes (see Figure 2). Ni doping on oxalic acid (NiOX) shows sharp and intense peaks at 18.8°, 22.5°, 23.6°, 29.4° and 30.9° with d spacing 4.7A°, 3.9A°, 3.7A°, 3.0A° and 2.8A°, respectively. Similar pattern was observed by Rios, et al., 2012. However, emergence of small peaks diffracted at 38.9° and 47.9° may indicate unreacted NiO as impurity (Haq and Haider, 2010). On the other hand, Nickel based trimesic acid (NiT) revealed important diffractions at 19.7°, 24.3°, 27.4°, 29.5°, 32.9° and 39.0°. Furthermore, diffraction due to –COOH is observed at lower angles (18.8° and 19.7°) indicating presence of two and three groups attached to aliphatic (oxalic acid) or aromatic (trimesic acid), respectively (Yang, *et al.,* 2014). The expected metal binding through carbonyl group is demonstrated at angle of 29°-31°. However, it is interesting to note that aliphatic binding diffracts with high intensity (close to 100) in comparison to aromatic groups

The composite (NiTOX) synthesized by mixing equimolar ratio of aliphatic (oxalic) and aromatic (trimesic) offers unique diffraction pattern. It exhibits metal to carbonyl linkage in the range 29°-31°. It is also noted that a new peak at 33.1° of high intensity appeared as a result of aliphatic to aromatic linkage. In addition, diffracted peaks due to free –COOH aliphatic and aromatic groups diminishes in the composite. This confirms the successful synthesis of composite having both reagents.

XRD pattern may conclude that the product is crystalline in nature. The crystalline nature of MOFs is reported in the literature [3].

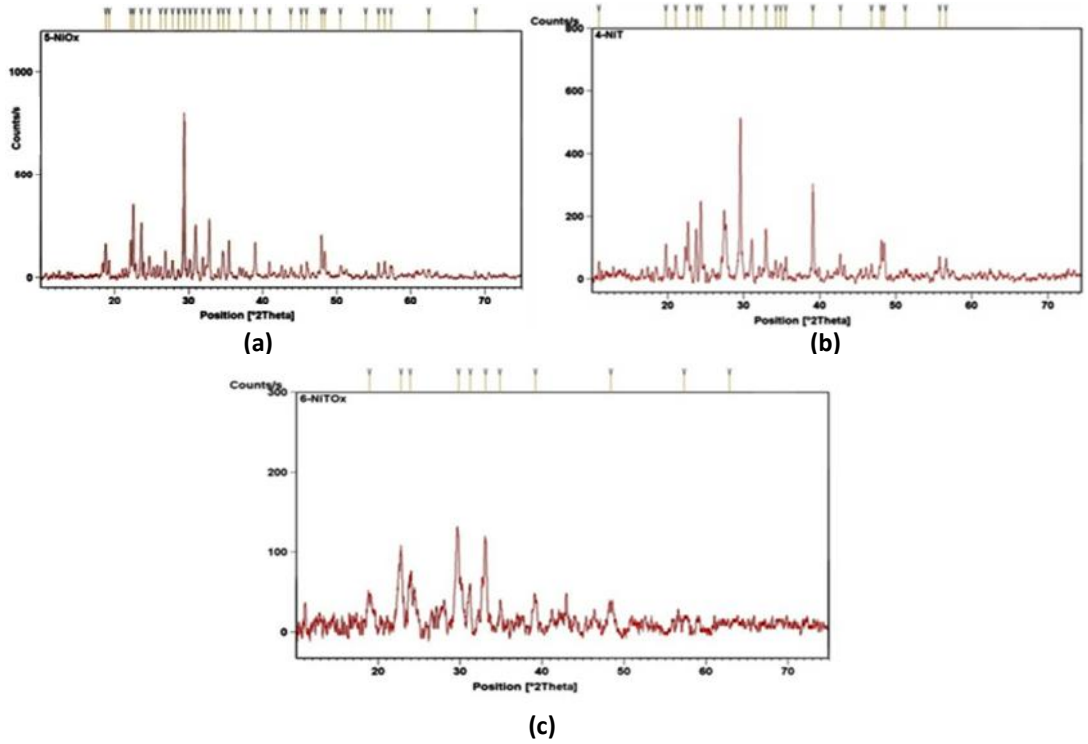

Fig. 2. XRD of synthesized Ni-based MOFs (a) NiOX (b) NiT (c) NiTOX

Each of the synthesized Metal Organic Framework was scanned under SEM for surface morphological features and assessment of average particle size. The micrographs are reproduced in Figure 3.

The basic organic framework of oxalic acid and trimesic acid complexed with Nickel shows beautifully arranged particles with well defined geometrical shapes. Agglomerates of cubic shapes stacked one above other defines NiOX, whereas, the same cubic geometry is more clearly attained by NiT particles. It might be attributed to the available three –COOH groups attached to aromatic ring for the later in comparison to two aliphatic in the earlier. It is suggested that higher is the number of binding groups, more regular geometrical arrangement is attained. Cubic geometry with tetrahedral arrangement for Ni-Oxalate is reported by [10]. The composite (NiTOX) exhibits agglomerates of cubes and pure cubic pattern, representing participation of both components. Further, conversion into the composite is verified by overwhelming appearance of new phase (showing interconnected cage like structure) widely seen in the image. The synthesis of such composite is the peculiar feature of the present research and not reported elsewhere.

The size determined by SEM for NiOX (1-5µm) is found slightly smaller than NiT (1.47-6µm) crystals. Whereas, composite NiTOX size is diversified over the range 24-840 nm. The study concludes that synthesized MOFs are mesoporous with definite crystalline geometry. Such characteristics features are also identified in the literature [14] for MOFs.

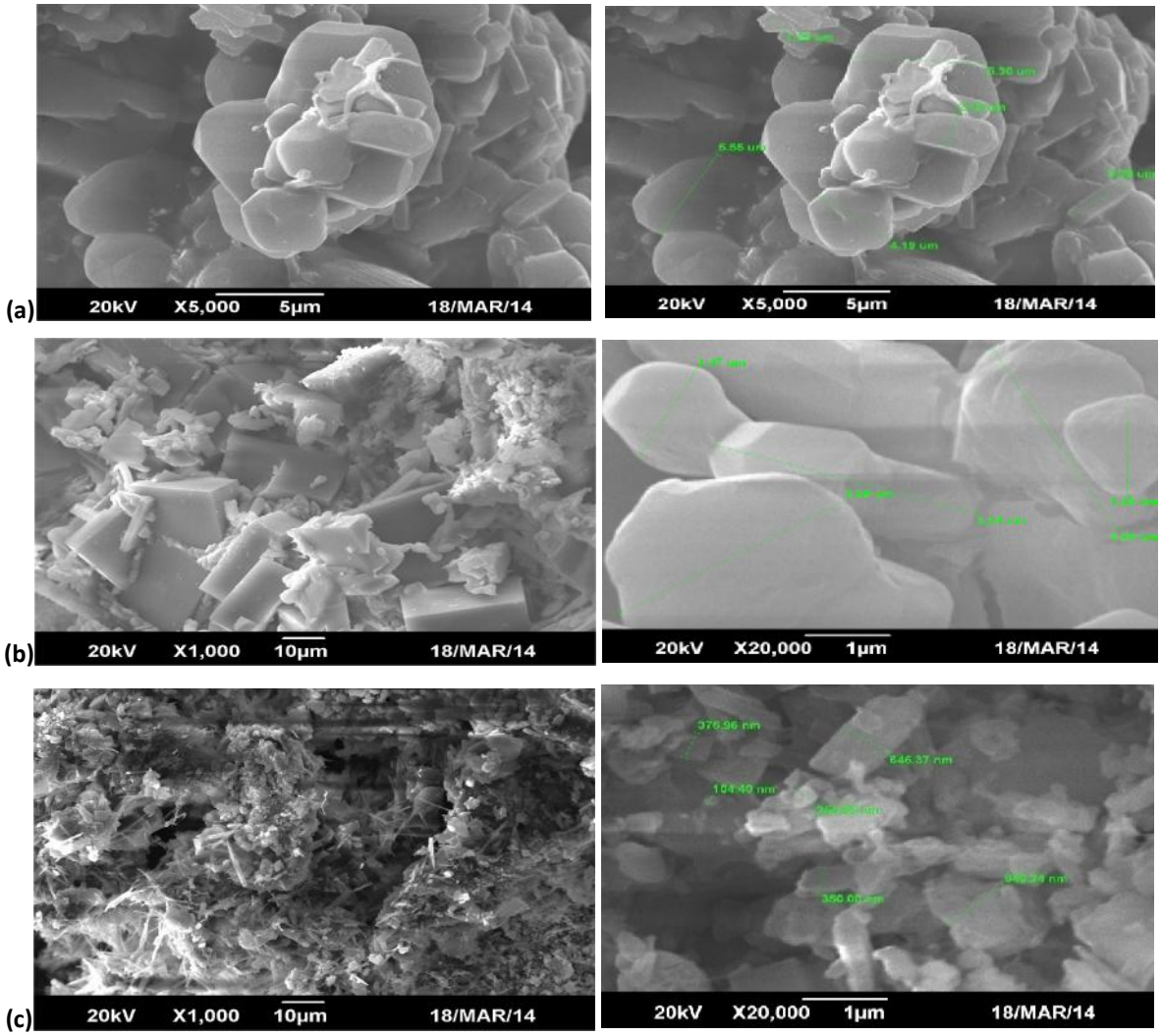

Fig. 3. SEM images of synthesized Ni-based MOFs (a) NiOX (b) NiT (c) NiTOX

The incorporation of metals into the organic framework was determined by EDX analysis. Highlights of results (given in Table 1) clearly indicates carbon and oxygen as the main constituents of each synthesized material confirming the framework (of oxalic acid and trimesic acid) is constructed mainly on these two atoms. However, variation in carbon content in NiOX and NiT can directly be related to less and more carbons in aliphatic ($C_2H_2O_4$) and aromatic ($C_9H_6O_6$), respectively. Further, carbon

to oxygen ratio in the respective two MOFs (11.4:1.3) indicates more oxygen for less carbon containing compound, supported by molecular formulae. The mixed ligand composite shows carbon to oxygen ratio as 1:2, also supported by [15].

Table 1. EDX data of Ni-based uni-and bi-ligand MOFs

Sample Code	NiOX			NiT			NiTOX		
	Atom (%)	Mass (%)	Error (%)	Atom (%)	Mass (%)	Error (%)	Atom (%)	Mass (%)	Error (%)
C	7.26	4.36	6.75	41.79	30.67	3.86	31.07	22.98	3.20
O	57.85	44.99	4.65	53.45	52.24	10.10	65.46	64.49	6.97
Ni	4.58	13.06	15.42	4.76	17.09	26.15	3.46	12.52	22.69

3.2 APPLICATION FOR REMOVAL OF PAPS

Adsorption removal experiments were conducted on phenanthrene, anthracene and dibenzofuran to study the adsorption behavior of synthesized adsorbents for removal of POPs. The results indicated better adsorption for phenanthrene and dibenzofuran than anthracene. The reason for good adsorption of phenanthrene than anthracene could be due to more hydrophilic nature of phenanthrene than anthracene which allows better interaction with hydrophilic adsorbents due to hydrogen bonding and thus adsorption is enhanced [16]. Further, the non linear structure of phenanthrene favors more adsorption in small pores than the linear anthracene. In case of dibenzofuran, adsorption is more due to presence of oxygen atom in the ring structure which makes it more electronegative and behaves as anion. This anionic behavior gives it more opportunity to adsorb on the cationic surface due to acidic nature of adsorbents [17].

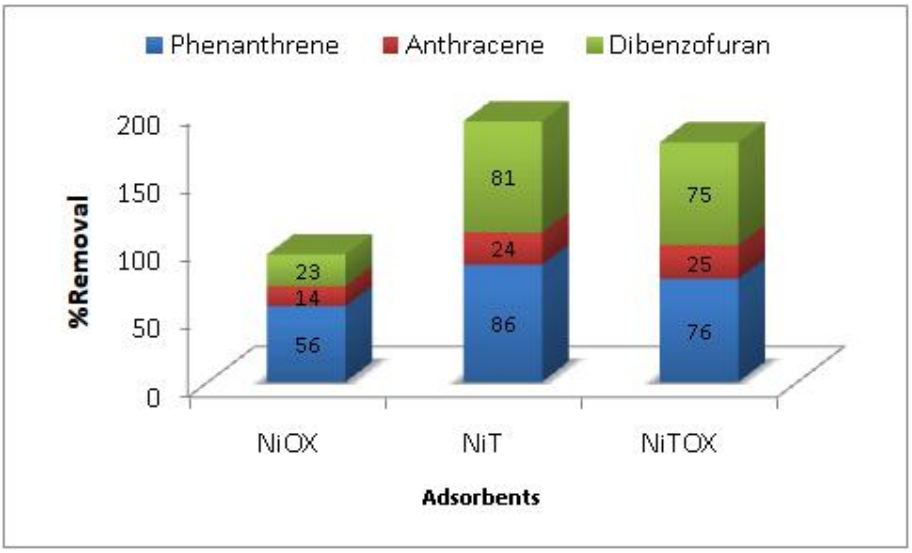

Fig. 4. Efficiency of synthesized MOFs as adsorbents for removal of PAH

3.2.1 EFFECT OF CONTACT TIME

Batch adsorption experiment was conducted to study the effect of contact time on removal efficiency of POPs (phenanthrene, anthracene and dibenzofuran). The purpose of studying contact time was to establish the equilibrium reaction time between adsorbate and adsorbent. Results are graphically presented in Figure. It is seen that the rate of phenanthrene uptake by all adsorbents was initially quite high, followed by much slower subsequent removal rate leading to equilibrium. The equilibrium attained in 10-15min which further results in desorption phenomena. The rapid approach of equilibrium could be due to presence of external adsorption sites which are easily accessible for these adsorbents [18].

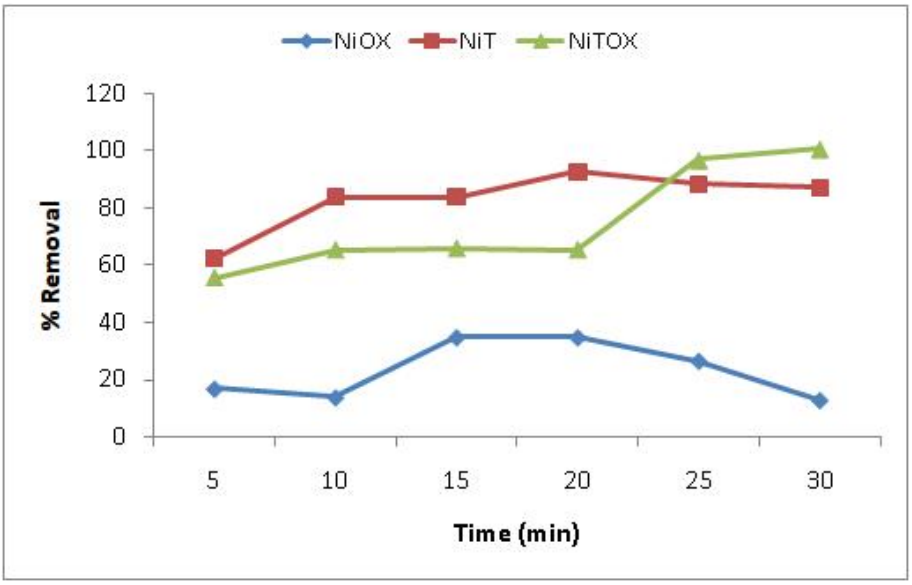

Fig. 5. Removal (in Percentage) of phenanthrene with time

3.2.2 EFFECT OF ADSORBENT DOSE

To identify the effect of adsorbent dose on adsorption behavior of Phenanthrene, batch experiments was conducted on three doses (1mg/Kg, 5mg/Kg and 10mg/Kg) with varying initial concentrations(0.001mg/L, 0.003mg/L and 0.005mg/L. The results presented in Figure 3.2.2.2 showed no specific trend. Most of the adsorbents presented decrease in adsorption with increasing dose due to aggregation of adsorbent particles.

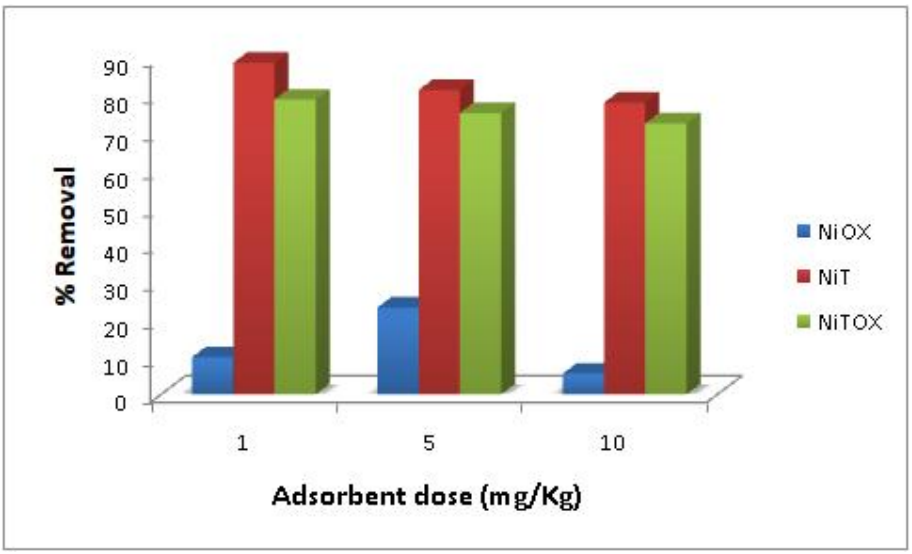

Fig. 6. Effect of adsorbent dose for removal of phenanthrene

3.2.3 EFFECT OF INITIAL CONCENTRATION

Effect of induced concentration for removal of phenanthrene was studied for induced concentrations of 0.001mg/L, 0.003mg/L and 0.005mg/L (Figure 3.2.2.3). The adsorbent NiOX and NiT presented decreased in concentration with increasing the initial concentration while NiTOX showed irregular trend.

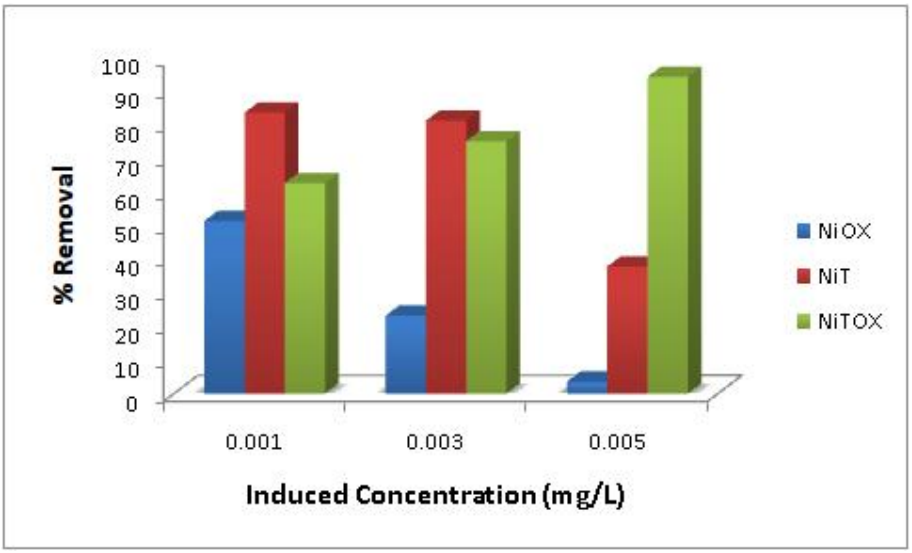

Fig. 7. Effect of induced concentration for removal of phenanthrene

3.2.4 EFFECT OF TEMPERATURE

Effect of temperature for removal of phenanthrene was studied at 25°C, 50°C and 70°C with optimum initial concentration of 0.003mg/L and adsorbent dose of 5mg/Kg. The results presented in Figure 3.2.2.4 presented the maximum adsorption at 50°C which indicates that removal of phenanthrene requires specific activation energy. This activation energy creates more reactive sites by decreasing the density and hence increases the rate of reaction. Less adsorption at 70°C may be result of increase in kinetic energy of molecules which hinders the adsorption process.

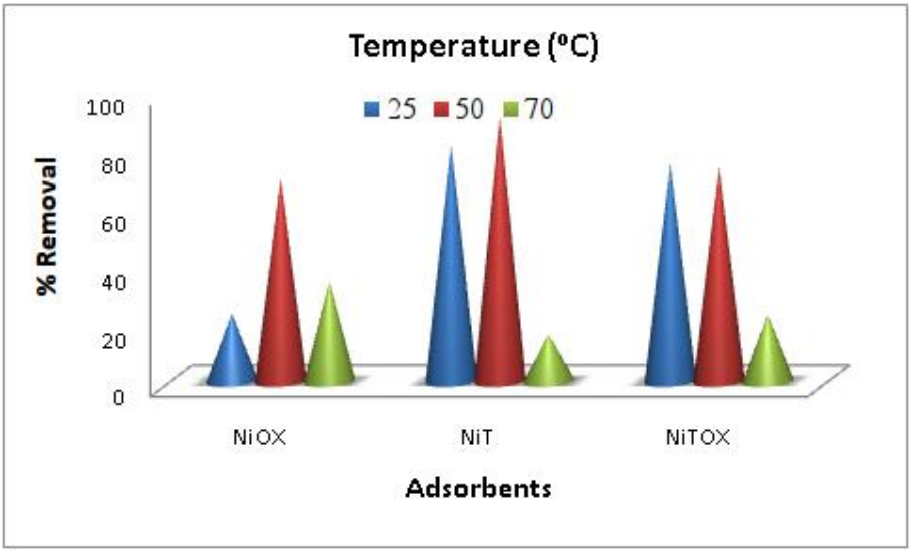

Fig. 8. Effect of temperature for removal of phenanthrene

3.2.5 REMOVAL EFFICIENCY OF DIFFERENT ADSORBENTS

Effect of different adsorbents on percent removal of phenanthrene was studied by taking the optimum concentration i.e. 0.003mg/L and adsorbent dose i.e. 5mg. The percentage removal of PAH increased in the following increasing order i.e. NiOX < NiTOX < NiT. This trend could be due to presence of more functional groups of carboxylic and phenolic in NiT and NiTOX as compared to NiOX. The results also presented no effect of type of metal present in MOFs for removal of phenanthrene.

3.2.6 ADSORPTION ISOTHERM AND KINETICS

Kinetic study of the adsorption gives an important insight to understand the mechanism of adsorption. The adsorption kinetics and isotherm models were applied on batch experiments for removal of phenanthrene. Equilibrium Isotherms are used to quantify the adsorptive capacity of three adsorbents while kinetic data is used to predict the rate at which the adsorbates are removed from the solution. Isotherm studies were conducted using three models i.e. Freundlich, Langmuir and Temkin. The isotherm studies indicated that the adsorption of all pollutants followed the Freundlich and Temkin model. In order to investigate the sorption kinetics of pollutants, first order, pseudo first order, pseudo second order and intra-particle diffusion were applied to fit the experimental data. The results indicated the pseudo second order the best fit model to explain the adsorption kinetics.

Table 2. Adsorption isotherms of PAH

Dyes	Adsorbent	Isotherm Models								
		Freundlich			Langmuir			Temkin		
		K_F	n	R^2	K_L	q_m	R^2	K_T	B_1	R^2
Phenanthrene	NiOX	-4.057	6.886	0.990	-11.96	49.18	0.993	-7.833	7.054	0.999
	NiT	-1.467	2.529	0.999	-0.783	6.422	0.967	-11.98	9.935	0.999
	NiTOX	-1.448	2.500	0.998	-0.760	6.315	0.993	-12.14	10.03	0.999
Anthracene	NiOX	-2.810	4.509	0.845	40.19	-9.032	0.910	6.757	-7.598	0.681
	NiT	1.040	-3.402	0.917	-19.59	10.49	0.882	-3.525	4.396	0.977
	NiTOX	0.537	-1.817	0.935	-3.321	2.706	0.959	-3.834	4.641	0.998
Dibenzofuran	NiOX	-1.637	2.760	0.993	-1.086	8.030	0.974	-11.37	9.585	0.999
	NiT	-1.226	2.191	0.999	-0.474	4.83	0.998	-13.85	11.07	0.997
	NiTOX	-1.365	2.383	0.998	-0.644	5.735	0.995	-12.70	10.38	0.999

Table 3. Kinetic models of PAH

Dyes	Kinetic Models						
	Adsorbent	Pseudo-2nd order			Intra-particle		
		K_2	q_e cal	R^2	A	K_{id}	R^2
Phenanthrene	NiOX	2.690	-3.813	0.966	-0.007	1.304	0.649
	NiT	0.534	0.047	0.996	-0.001	1.823	0.306
	NiTOX	0.534	-0.065	0.997	-0.001	1.832	0.139
Anthracene	NiOX	2.625	7.946	0.940	-0.003	1.099	0.031
	NiT	0.900	3.582	0.913	0.019	1.045	0.710
	NiTOX	0.853	2.269	0.905	-8E-05	1.529	0.000
Dibenzofuran	NiOX	0.772	-0.606	0.934	-0.008	1.859	0.474
	NiT	0.434	-0.353	0.971	-0.002	1.972	0.247
	NiTOX	0.479	-0.385	0.950	-0.000	1.888	0.030

REFERENCES

[1] WHO, *Health risks of persistent organic pollutants from long-range transboundary air pollution.* Copenhagen, Denmark: World Health Organization, 2003.

[2] S. Amijalayer, *Investigation of structural and dynamic properties of metal-organic frameworks,* Bochum: Ruhr Universitat, 2011.

[3] J. M. Yang, Q. Liu, and W. Y. Sun, "Shape and size control and gas adsorption of Ni (II)-doped MOF-5 nano/microcrystals", *Microporous and Mesoporous Materials*, vol. 190, pp. 26-31, 2014.

[4] A. C. McKinlay, R. E. Morris, P. Horcajada, G. Ferey, R. Gref, and P. Couvreur, "BioMOFs: metal-organic frameworks for biological and medical applications", *Angewandte Chemie International Edition,* vol. 49, no. 36, pp. 6260-6266, 2010.

[5] M. Eddaoudi, J. Kim, N. Rosi, D. Vodak, J. Wachter, M. O'Keeffe, and O. M. Yaghi, "Systematic design of pore size and functionality in isoreticular MOFs and their application in methane storage", *Science, vol.* 295, no. 5554, pp. 469-472,2002.

[6] X. Li, L. Zheng, L. Huang, O. Zheng, Z. Lin, L. Guo, B. Qiu, and G. Chen, (2013) "Adsorption removal of crystal violet from aqueous solution using a metal-organic frameworks material, copper coordination polymer with dithiooxamide", *Journal of Applied Polymer Science*, vol.129 no. 5, pp. 2857-2864, 2013.

[7] E. Haque, J. E. Lee, I. T. Jang, Y. K. Hwang, J. S. Chang, J. Jegal, and S. H. Jhung, (2010). "Adsorptive removal of methyl orange from aqueous solution with metal-organic frameworks, porous chromium-benzenedicarboxylates", *Journal of hazardous materials*, vol. 181 no.1, pp. 535-542.

[8] B. K. Lee, and V. T. Vu, "*Sources, distribution and toxicity of polycyclic aromatic hydrocarbons (PAHs) in particulate matter",* Intech, 2010.

[9] H. Wang, S. J. Liu, D. Tian, J. M. Jia, and T. L. Hu, "Temperature-Dependent Structures of Lanthanide Metal-Organic Frameworks Based on Furan-2, 5-Dicarboxylate and Oxalate", *Crystal Growth and Design,* vol. 12, no. 6, pp. 3263-3270, 2012.

[10] A. Rios-Ramos, C. Rivera-Maldonado, G. I. Garcia-Acosta, C. M. Lozano-Paulino, P. M. Fierro-Mercado, L. Fuentes-Cobas, and R. M. Roque-Malherbe, "Synthesis, structure, adsorption space and magnetic properties of Ni-oxalate porous molecular magnet", *Journal of Materials Science and Engineering A: Structural Materials: Properties, Microstructure and Processing,* vol. 2, no. 3, pp. 284-301, 2012.

[11] Y. Ge, H. Adler, A. Theertham, L. L. Kesmodel, and S. L. Tait, "Adsorption and Bonding of First Layer and Bilayer Terephthalic Acid on the Cu (100) Surface by High-Resolution Electron Energy Loss Spectroscopy", *Langmuir*, vol. 26, no. 21, pp. 16325-16329, 2010.

[12] H. Zhang, R. Xiao, M. Song, D. Shen, and J. Liu, "Hydrogen production from bio-oil by chemical looping reforming", *Journal of Thermal Analysis and Calorimetry*, vol. 115, no. 2, pp. 1921-1927, 2014.

[13] I. U. Haq, and F. Haider, "Synthesis and Characterization of Uniform Fine Particles of Nickel Compounds", *Journal of the Chinese Chemical Society*, vol. 57, no. 3A, pp. 343-347, 2010.

[14] C. Chmelik, J. Karger, M. Wiebcke, J. Caro, and J. M. Baten, "Adsorption and diffusion of alkanes in CuBTC crystals investigated using infra-red microscopy and molecular simulations", *Microporous and Mesoporous Materials*, vol. 117, no. 1, pp. 22-32, 2009.

[15] N. T. Binh, D. M. Tien, L. T. K. Giang, H. T. Khuyen, N. T. Huong, T. T. Huong, and T. D. Lam, "Study on preparation and characterization of MOF based lanthanide doped luminescent coordination polymers", *Materials Chemistry and Physics*, vol. 143, no. 3, pp. 946-951, 2014.

[16] Y. Mei, F. Wu, L. Wang, Y. Bai, W. Li, and H. Liao, "Binding characteristics of perylene, phenanthrene and anthracene to different DOM fractions from lake water", *Journal of Environmental Sciences,* vol. 21, no. 4, pp. 414-423, 2009.

[17] X. Li, Z. Li, and L. A. Luo, "Adsorption kinetics of dibenzofuran in activated carbon packed bed", *Chinese Journal of Chemical Engineering,* vol. 16, no. 2, pp. 203-208, 2008.

[18] G. Y. Jing, H. L. Duan, X. M. Sun, Z. S. Zhang, J. Xu, Y. D. Li, and D. P. Yu, "Surface effects on elastic properties of silver nanowires: contact atomic-force microscopy", Physical Review B, vol. 73, no. 23, pp. 235409, 2006.

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Effect of Ni additions on the microstructure of Zn based lead free solder alloys for high temperature applications

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ABSTRACT: The effects of nickel additions on the change in microstructure of Zn-*x*Ni lead free solder alloys were investigated. The investigation revealed that increasing Ni additions led to the increase in size of intermetallic Zn-Ni particles along with an increase in volume fraction of intermetallic particles. The microstructure also revealed the presence of the prominent delta (δ) phase in all three compositions of the solder alloy i.e. Zn-0.7 mass% Ni, Zn-1.0 mass% Ni and Zn-1.5 mass% Ni respectively. The presence of irregular shaped δ phase particles and conjoined δ phase particles were noticed in alloys with higher Ni content along with δ particles at grain boundaries. The most remarkable change occurred in the size of Zn grains, which decreased in size as Ni additions were increased. This reduction in size can be attributed to pinning effect of Zn grains by intermetallic particles.

KEYWORDS: Zn-*x*Ni lead free solder alloys, intermetallic Zn-Ni particles, delta (δ) phase, conjoined δ phase particles, pinning effect.

1 INTRODUCTION

Lead-free solders have received remarkable attention in the field of high temperature industrial applications. These applications include bonding of semiconductor devices onto substrates, step soldering technology, flip-chip connections, solder ball connections, etc [1]. There has been significant research in the field of lead-free solders but only a small degree of research specifically relate to high temperature lead-free solders [2]. High-temperature solder alloys are however, a key structural material for various industrial components and assemblies which require a high level of quality and reliability and also to be free from lead. As such, there is a need to identify the relative strengths and weaknesses of the current generation of lead-free solder alloys suitable for high-temperature applications and identify opportunities for further developments.

Solder alloy systems like Pb–Sn, Au–Sn, Au–Ge, Zn–Al, Zn–Sn, Bi–Ag and Sn–Sb alloys are high temperature solders typically designed to withstand temperatures between 150 and 200^{0}C [3]. These solders have been the subject of research on various functional properties [4-6] and reliability issues [7-9]. One of the basic criteria a high temperature solder should satisfy is having an appropriate melting range that allows ease of manufacture of soldered components. This melting range has been defined by industry as 270–350^{0}C in order to ensure efficient process control [10]. Selecting of the solder alloy for a specific job must take into consideration its melting temperature which should be higher than service temperature. At the same time, the solder alloy should possess a solidus temperature higher than 270^{0}C in order to withstand peak temperatures of second level soldering. The liquidus temperature of solder alloy should be below 350^{0}C to avoid thermal degradation of polymers commonly used in the substrate. These temperature criteria are fundamental considerations in the selection of high temperature solders. However, reasonable consideration must be given to alloys that fall outside of the temperature guidelines if properties are not adversely affected. For example, few Zn-base solders were developed for ultra-high temperature applications with the alloying elements: (4–6) mass% Al and (1– 5) mass% Cu [6]. These solders were designed to have liquidus temperatures between 382 and 402^{0}C.

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An attempt was made to develop Zn based high temperature solders by addition of Ni. As a result the system attained higher melting point than 402^{0}C. The Zn-Ni eutectic temperature is around 420^{0}C that is higher than the Zn-Al-Cu ternary system as shown in the binary phase diagram in Fig. 1. In this study the effect of varying Ni content on the change in microstructure has been studied by preparing Zn-Ni solder alloys by varying the mass% of Ni.

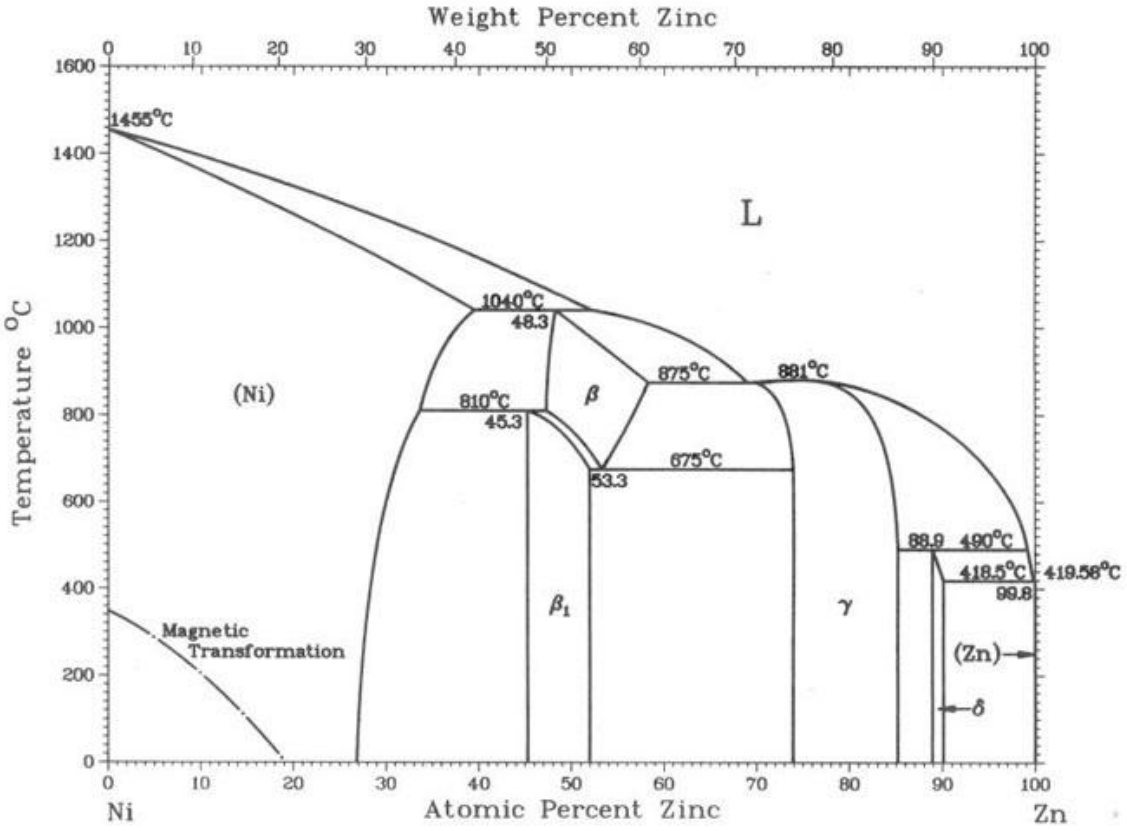

Fig. 1. Zn-Ni binary phase diagram

2 MATERIALS AND METHODS

2.1 PREPARATION OF SOLDER ALLOY

The lead free solder alloys were prepared from commercially available pure Zn and Ni powders. Three Ni compositions were used for the respective study, i.e. 0.7 mass%, 1.0 mass% and 1.5 mass% Ni for the preparation of lead free Zn-Ni solder alloys. In the primary step, Zn briquettes were placed in a graphite crucible for melting in a gas fired pit furnace. The Ni powder to be added to the molten Zn was first preheated to around 250^{0}C before addition. After preheating, required amount of Ni powder was added to the melt. The melt was homogenized by manual stirring for few minutes and was finally poured in to preheated metal mold at a pouring temperature of 530^{0}C. This process was carried out for all the desired Ni compositions. The preparation steps for casting the solder alloy is shown in Fig. 2(a) to 2(e).

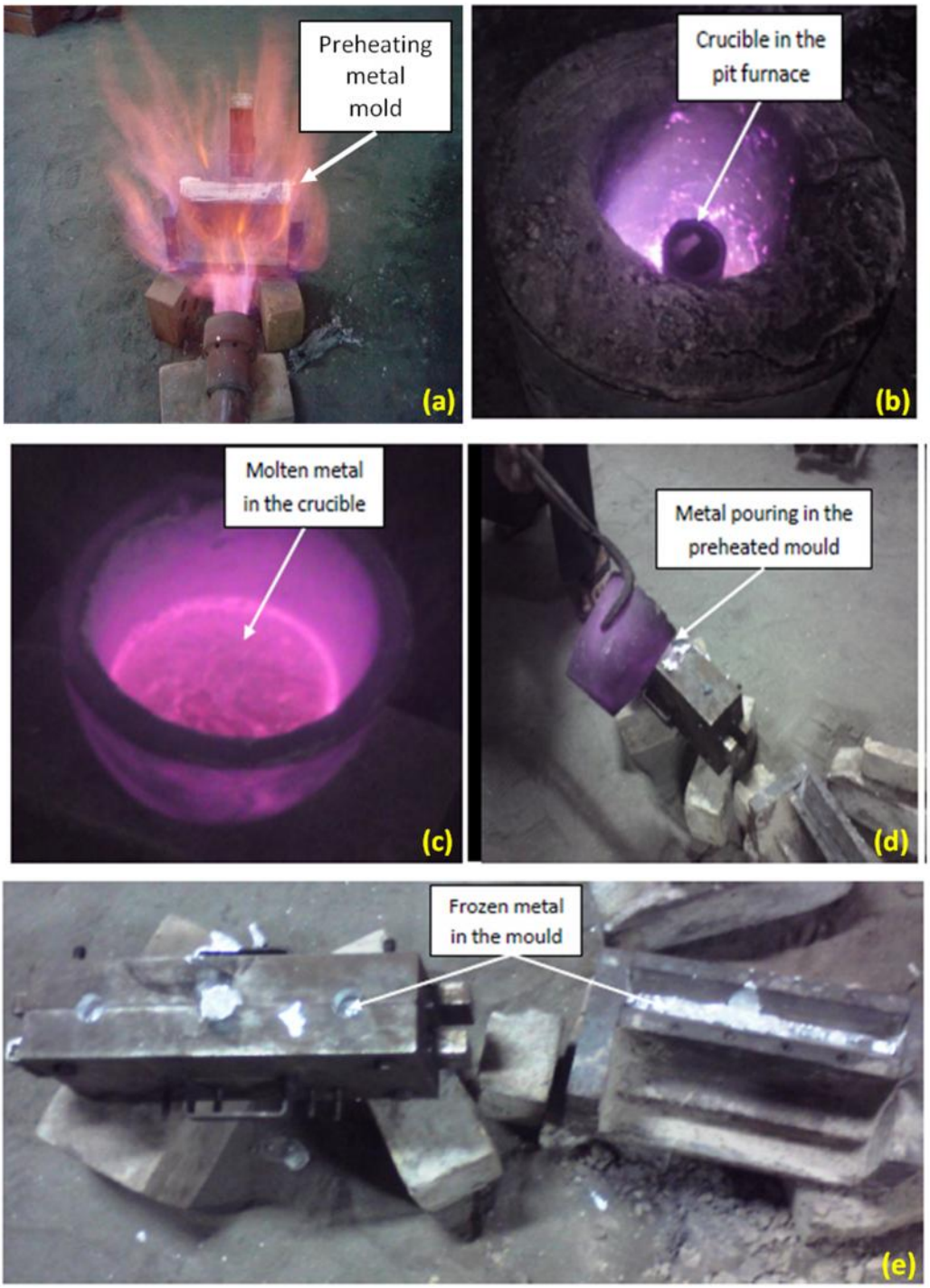

Fig. 2. Preparation of Zn-Ni Solder alloys (Casting Route)

2.2 MICROSTRUCTURAL ANALYSIS

Cylindrical samples were prepared for microstructural analysis. After progressive polishing on grit papers, samples were brought for fine polishing on a wheel where alumina powder was used as polishing media. Non-ferrous metallographic fine polishing standard technique was carried out with 0.05µm Al_2O_3 particles in order to obtain the microstructure. Then samples were cleaned with water and finally cleaned and dried in acetone. After drying the samples were etched in an etching solution containing 100 ml Ethanol (96%) and 1 to 5 ml Hydrochloric acid (32%). The samples were investigated by an optical microscope ((LEICA-MZFLIII, Italy)) and micrographs were recorded with a digital camera (OPTIKA Microscope B-600 MET).

3 RESULTS AND DISCUSSIONS

The microstructure of lead free Zn-Ni solder alloys are given in Fig. 3. The changes in microstructure with %Ni additions are readily visible with the increase in volume fraction of Zn-Ni intermetallic particles in the matrix. From Fig. 3 it is clearly evident that on increasing the mass% of Ni addition to the Zn based solders, the size of Zn-Ni intermetallic particles increases along with an increase in volume fraction of intermetallic particles. The matrix of the Zn-Ni lead free solder alloy consists of variation in the shape of intermetallic particles due to incomplete dissolution of Ni in Zn. These variations comprises a heart shaped phase known as delta (δ) phase, irregular δ shaped phase, conjoined δ phase and irregular shaped. The microstructure also shows the evidence of incomplete dissolution of Ni particles in Zn which are positioned preferentially at the grain boundaries in the form as a second phase. Due to the increase in volume fraction of intermetallic particles, there is a decrease in the size of Zn grains. This can be contributed to the pinning effect of Zn grains by the intermetallic particles/phase.

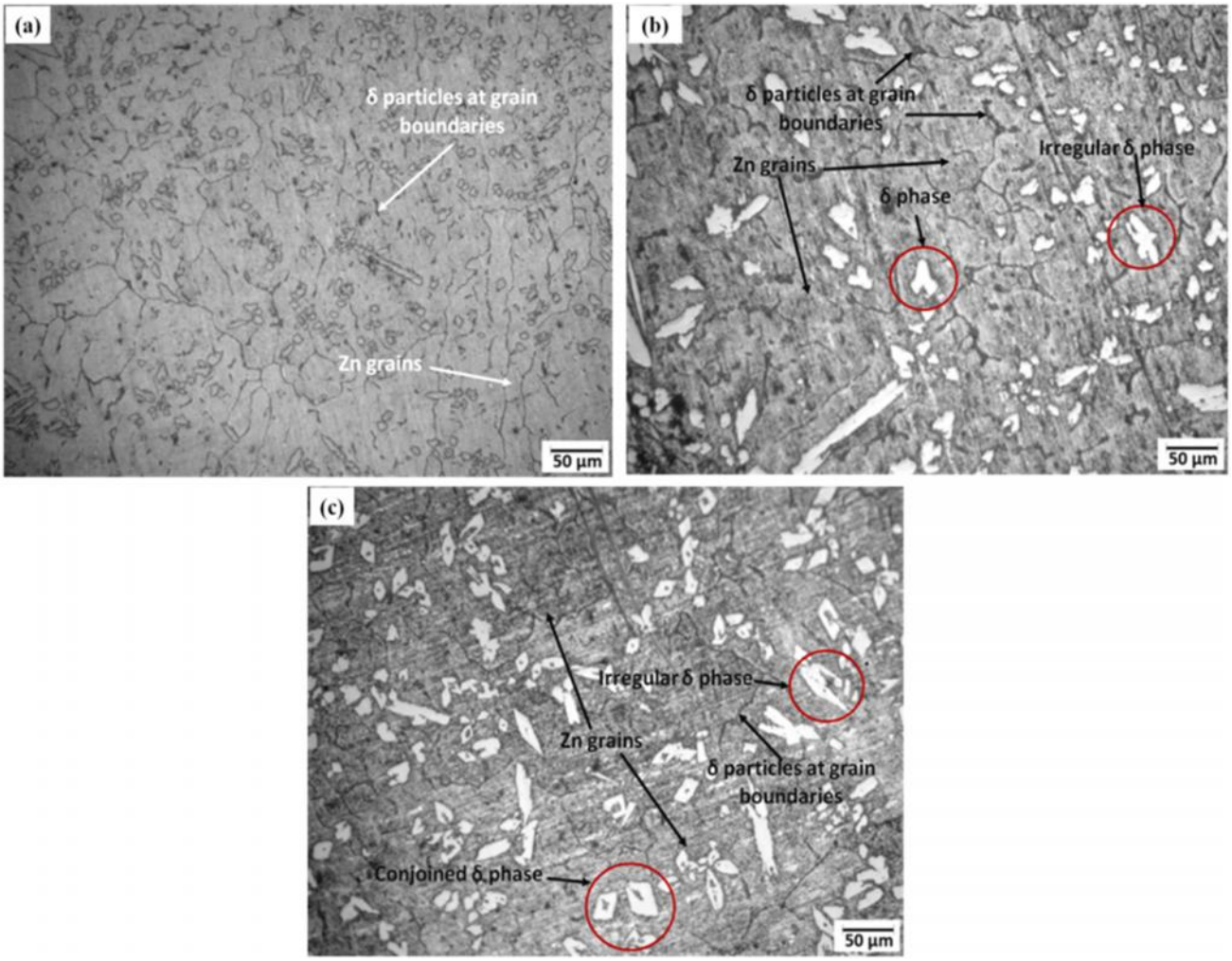

Fig. 3. Microstructures of Zn-Ni lead free solder alloy after (a) 0.7 mass% Ni addition, (b) 1.0 mass% Ni addition, (c) 1.5 mass% Ni addition [Magnification: 200X]

The microstructure of Zn-Ni free solder alloy at a higher magnification is shown in Fig. 4. The microstructure shows the presence of δ phase, conjoined δ phase/particles and intermetallic second phase at the grain boundaries. The cause of two δ phase joining head to head has yet to be studied. This type of structure is seen to increase as mass% Ni additions increase.

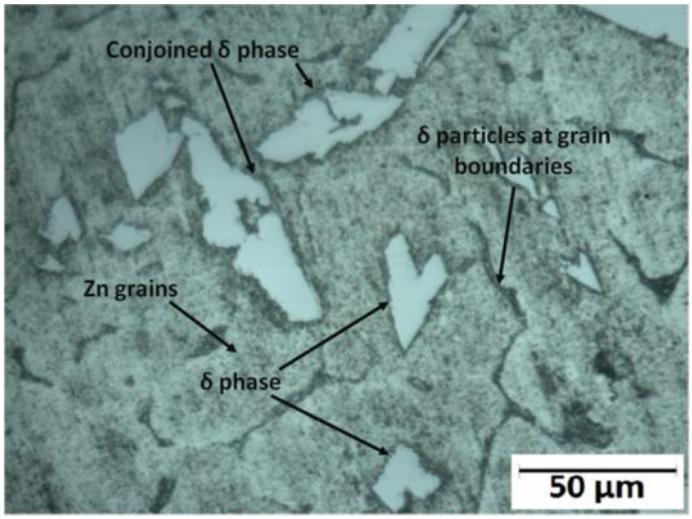

Fig. 4. Microstructure of Zn-1.5 mass% Ni lead free solder alloy [Magnification: 500X]

4 CONCLUSIONS

The change in microstructure of Zn-Ni lead free solder alloys was investigated and it was found that by increasing the mass% Ni additions the size and volume fraction of Zn-Ni intermetallic particles increased. The size of Zn grains decreased as Ni additions increased, which can be contributed to pinning effect by intermetallic particles during grain growth. The presence of intermetallic second phase particles were noticed due to incomplete dissolution of Ni in Zn.

ACKNOWLEDGMENT

The authors would like to thank the department of Materials and Metallurgical Engineering for their support and cooperation in this research.

REFERENCES

[1] Sharif, A., Gan, C. L., & Chen, Z. Transient liquid phase Ag-based solder technology for high-temperature packaging applications. Journal of Alloys and Compounds, 2014; 587: 365-368.
[2] Sharif, A., Zhang Lim, J., Made, R. I., Lau, F. L., Phua, E. J. R., Lim, J. D., Wong, C. C., Gan, C. L. & Chen, Z. (2013). Pb-Free Glass Paste: A Metallization-Free Die-Attachment Solution for High-Temperature Application on Ceramic Substrates. Journal of electronic materials, 2013; 42: 2667-2676.
[3] Guang Zeng, Stuart McDonald, Kazuhiro Nogita. *Microelectronics Reliability* 2012; 52: 1306–1322
[4] Chen SW, Chen CC, Gierlotka W, Zi AR, Chen PY, Wu HJ. "Phase equilibria of the Sn–Sb binary system". *J Electron Mater* 2008;37:992–1002.
[5] Hasan, M. M., Sharif, A., & Gafur, M. A. Microstructure and Bulk Material Properties of Zn-Al Alloys as an Exciting Replacement of Lead Based High Temperature Interconnect Materials. International Journal of Science and Advanced Technology 2014;4: 20-27.
[6] Kang N, Na HS, Kim SJ, Kang CY. "Alloy design of Zn–Al–Cu solder for ultra high temperatures". *J Alloy Compd* 2009; 467:246–50.
[7] Shengmin W, Keer LA, Vaynman S, Lawson LR. "A constitutive model for a high lead solder". *Compon Pack Technol IEEE Trans* 2002;25:23–31.
[8] Chang R, McCluskey F. "Constitutive relations of indium in extreme temperature electronic packaging based on Anand model". *J Electron Mater* 2009;38:1855–9.
[9] Lee KA, Jin YM, Sohn Yh, Namkung J, Kim M-C. "Continuous strip casting, microstructure and properties of Au–Sn soldering alloy". *Met Mater Int* 2011;17:7–14.
[10] Chidambaram V, Hattel J, Hald J. "Design of lead-free candidate alloys for high temperature soldering based on the Au–Sn system". *Mater Des* 2010;31:4638–45.

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Possibilité d'utilisation du biocarburant au Cameroun : cas du biodiesel à partir de l'huile de palme dans la zone du Moungo

[Possibility of use of biofuel in Cameroon: the case of biodiesel from palm oil in the Moungo]

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ABSTRACT: Due to gradual exhaustion of mineral oil reserves and the problems of climate change, studying the possibilities that can be offered by biofuel in improving agriculture, can constitute a useful solution. Therefore, this article falls within the framework of technologies transfer with the purpose of exploring the different possibilities by which red palm oil can substitute diesel oil as a source of energy.

Indeed, in the Moungo region of Cameroon, many palm oil extraction units are still processing palm nuts using diesel oil as a main source of energy. On the basis of the socioeconomic study held in the Moungo region of Cameroon, these palm oil extraction units are categorised according to different source of energy that is petrol, diesel oil, electricity and human energy. The mains processes through which palm nuts are being processed are described. These processes do not vary according to the sources of energy used and considering the different step involved in the process, the pressurization can be done using either manual press or motorized press. The analysis of the possibilities by which palm oil can substitute diesel oil as source of energy through comparison of cost of production according to the source of energy shows that all the extraction processes are efficient. However, expenses related to the supply of energy vary not only with the type but also with the quantity of source energy required by these presses

In term of ranking, we found that the cheapest one is electricity followed by diesel oil, petrol and human energy in that last order. Substitution of diesel oil with palm oil is cheaper for presses consuming 0.5 litre of diesel oil per ton of palm nut processed while with a press requiring 1 or 1.5 litres of diesel oil per ton of palm nut, electricity represents the most efficient energy source followed by palm oil, diesel, petrol and human energy. Palm oil as a source of energy is therefore shown to be the most efficient followed by diesel oil, petrol and human energy in none electrified areas of palm oil production.

In conclusion, our experiment suggests that it is possible to use palm oil as fuel in diesel engines. However, these engines should previously be adapted in order to avoid possible technical breakdowns. Beyond considerations of technological and economic feasibility, this study thus highlights the risk of competition between food use and energy conversation of some agricultural products, which could contribute to jeopardize food security in many contexts.

KEYWORDS: Biofuel, biodiesel, palm oil, diesel, oil extraction, Mungo, Cameroon.

RESUME: Cet article s'inscrit dans le cadre du transfert de technologie et porte sur une analyse des possibilités d'utiliser l'huile de palme rouge comme substitut énergétique au gasoil. En effet, dans la zone du Moungo au Cameroun, il se développe des petites unités d'extraction d'huile de palme utilisant le gasoil comme principale source d'énergie. Une

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typologie des unités d'extraction de l'huile de palme de la zone en fonction des sources d'énergies utilisées est réalisée. Nous décrivons ensuite les principaux procédés d'extraction d'huile utilisés dans la zone et montrons qu'ils ne varient pas en fonction des sources d'énergie et que l'étape de pressurage peut se dérouler soit avec des pressoirs manuels ou avec des pressoirs motorisés. Nous constatons que l'analyse des possibilités de substitution du gasoil par l'huile de palme à travers une comparaison des coûts de production en fonction des sources d'énergie montre que tous les types de pressurages sont efficaces, mais les dépenses liées à l'approvisionnement en sources d'énergie varient en fonction des types et des quantités de sources d'énergie requises par ces pressoirs. Ces dépenses sont relativement moindres avec l'électricité, suivie du gasoil, de l'essence et de l'énergie humaine en dernière position. L'huile de palme comme substitut énergétique au gasoil représente l'alternative énergétique la plus économique uniquement pour les pressoirs utilisant 0.5litre de gasoil par tonne de noix de palme tandis qu'avec les pressoirs utilisant 1 ou 1.5 litres de gasoil par tonne de noix de palme, l'électricité se présente comme la source d'énergie la plus efficiente. L'huile de palme serait ainsi la source la plus appropriée surtout dans les zones ne disposant pas de d'énergie électrique. Toutefois, il convient au préalable d'adapter les machines devant consommer l'huile de palme comme carburant pour éviter des éventuelles pannes techniques. Au-delà des considérations de faisabilité technologique et économique, cette étude met ainsi en lumière le risque de concurrence entre un usage alimentaire et une conversation en énergie de certaines productions agricoles, ce qui pourrait voir ce dernier usage contribuer à hypothéquer la sécurité alimentaire dans bien de contextes.

MOTS-CLEFS: Biocarburant, biodiesel, huile de palme, gasoil, extraction de l'huile, Moungo, Cameroun.

1 INTRODUCTION

L'huile de palme est un liquide gras extrait de la pulpe du fruit de palmier *Elaeis guineensis*. Cette huile présente l'intérêt d'être l'huile végétale la plus riche en bêta carotène (précurseur de la vitamine A) et entre dans la liste d'ingrédients des industries notamment les industries agroalimentaires, les industries cosmétiques et les savonneries. Elle constitue l'un des principaux ingrédients de la cuisine africaine et comme telle, elle entre dans la préparation des repas rituels lors des mariages et cérémonies funéraires en Afrique. Elle constitue la principale source d'approvisionnement en lipide pour les ménages qui n'ont pas les moyens d'acquérir de l'huile raffinée (De Theux, 2004).

Au Cameroun, la production de l'huile de palme représente une source d'emplois pour de milliers d'individus (environ 2800 petits et moyens producteurs) et garantit à son promoteur, un revenu régulier tout au long de l'année avec une moyenne d'environ 600 000 FCFA /an sur la base de 30 à 45 FCFA/régime et 350 à 450 FCFA/litre (NEPAD 2004). Dans de bonnes conditions de sol et de climat, les meilleures variétés sélectionnées donnent plus de 6 tonnes d'huile de palme et une tonne d'huile de palmiste par hectare et par an sur les plantations industrielles (Noel *et al.,* 1997). Ce potentiel explique sans doute l'engouement fort observé depuis quelques années pour la culture du palmier à huile avec la multiplication des unités de transformations artisanales et semi artisanales au Cameroun.

Au delà du regain d'intérêt aujourd'hui observé, la production nationale d'huile de palme reste déficitaire et de l'avis des experts, le Cameroun doit encore importer environ 60 000 tonnes d'huile de palme pour couvrir les besoins de sa population sachant que la demande croit d'environ 3% chaque année (CDDR SAILD, 2003). Les huiles artisanales sont fortement concurrencées sur le marché national et international par les huiles industrielles et les huiles importées. Face à l'enjeu de développement de cette filière, la vulgarisation d'une gamme de petits matériels (stérilisateurs, égrappoirs, malaxeurs, presses, défibreurs) de transformation est de plus en plus encouragée en vue de l'augmentation de la production d'huile et l'amélioration de la qualité de l'huile produite.

Or, lors de la production de l'huile de palme, ces petits matériels utilisent pour la plupart du gasoil (diesel) comme source d'énergie, ce qui occasionne d'importantes charges d'exploitation et augmente le coût de production d'un litre d'huile de palme. Dans un contexte marqué par la flambée des prix du pétrole, les changements climatiques, le développement du biocarburant, la recherche des sources d'énergies alternatives s'avère nécessaire. L'utilisation de l'huile de palme brute comme carburant (biodiesel) dans les unités d'extraction d'huile de palme artisanale est promue par certains acteurs (des ONG par exemple) et présentée comme un moteur puissant dans le développement de cette filière et une piste exploitable devant contribuer à l'amélioration des revenus des exploitants, en particulier les petits. Cette étude se veut être une contribution à cette réflexion et a pour objectif d'analyser les possibilités d'utilisation de l'huile de palme comme substitut énergétique au gasoil dans les unités traditionnelles d'extraction des huiles.

2 MATERIELS ET METHODES

L'étude a été réalisée au Cameroun et principalement dans le département du Moungo situé dans la région du Littoral. Il compte une population de 452722 habitants répartie sur une superficie de 3723 km² soit une densité de 121,6 habitants au km². Dans le cadre de cette étude, les villages suivants ont été ciblés : Souza Gare, Nkapa, Bekouma, Mbonjo et Maleke. Ces villages ont été choisis en raison de la grande diversité qu'elles présentent dans le domaine de la production artisanale de l'huile de palme. Nous faisons particulièrement allusion aux équipements de transformation, aux sources d'énergie employées et aux échelles de production.

Les données de cette étude ont été collectées aux moyens des entretiens, auprès des producteurs d'huile de palme et des extracteurs d'huile de palme, et nous avons procédé à un échantillonnage aléatoire de 37 producteurs. En effet, avec l'aide des chefs de poste agricole de la zone, nous avons identifié dans un premier temps les principaux producteurs, lesquels producteurs nous ont par la suite aidés à identifier les autres producteurs d'huile de palme artisanale. Par souci de diversité, nous avons tenu compte de la situation géographique des exploitations et la culture des enquêtés ceci dans le but d'obtenir un éventail assez large de techniques de transformation. Aussi, des enquêtes par entretien ont été réalisées auprès des responsables du PDRBA-MN (Programme de Développement Rural du Bassin Agricole du Moungo-Nkam), de la délégation départementale du MINADER pour le Moungo, du directeur technique en charge du garage à la SOCAPALM, et de certains techniciens d'agriculture de la zone.

En plus, des observations directes sur le terrain ont été faites pour compléter la collecte des données. Les données issues des sources secondaires ont été collectées à travers des recherches documentaires. La représentativité de notre échantillon a été atteinte par saturation c'est-à-dire qu'en fonction des entretiens et des questionnaires que nous avons administrés sur le terrain, nous avons décidé d'arrêter lorsque les éléments nouveaux n'apparaissaient plus au cours de l'enquête.

Les données collectées au cours des enquêtes ont porté sur : les caractéristiques des producteurs d'huile de palme ; les procédés de production d'huile de palme ; les coûts de production ; les équipements utilisés dans l'extraction d'huile de palme ; les fonctionnement des équipements ; la perception des producteurs quant à l'utilisation du biocarburant à partir de l'huile de palme ; les impacts de cette utilisation sur l'exploitation ; les limites de l'utilisation de l'huile de palme comme biocarburant, etc. Les données collectées au moyen des entretiens ont fait l'objet d'analyse thématique. Les données obtenues au moyen des questionnaires ont été analysées au moyen des logiciels EXCEL et SPSS pour obtenir des statistiques descriptives (moyenne, écart type, maximum, minimum, de fréquences).

3 RESULTATS ET DISCUSSION

3.1 TYPOLOGIE DES PRODUCTEURS D'HUILE DE PALME

3.1.1 TYPOLOGIE DES PRODUCTEURS EN FONCTION DE LA TAILLE DES PALMERAIES VILLAGEOISES

Tableau 1 : Superficie des palmeraies villageoises

Superficie des palmeraies	Effectif	Pourcentage
< 5 ha	14	48.3
[5-10 ha [	6	20.7
[10-15 ha [	2	6.9
>15 ha [	7	24.1
Total	27	100

L'observation de ce tableau montre qu'en fonction de l'étendue des palmeraies villageoises, les petits producteurs dont l'exploitation ne dépasse pas 5 ha sont majoritaires et représentent 48.3% des producteurs enquêtés. Seulement 24.1% des producteurs enquêtées ont plus de 15 ha de palmeraie, superficie pouvant aller jusqu'à 120 ha. Il faut signaler qu'en plus de cette catégorie de producteurs dotés chacun d'une palmeraie et qui représente environ 84% de la population des producteurs d'huile de palme, il existe une autre frange de cette même population qui ne possède pas de plantations. Ils représentent environ 16% de cette population. Pour produire l'huile de palme, cette seconde catégorie de producteurs doit automatiquement acheter la production des autres paysans n'ayant pas les moyens ou le temps de presser les fruits de leur propre production.

3.1.2 TYPOLOGIE DES PRODUCTEURS EN FONCTION DES SOURCES D'ÉNERGIE

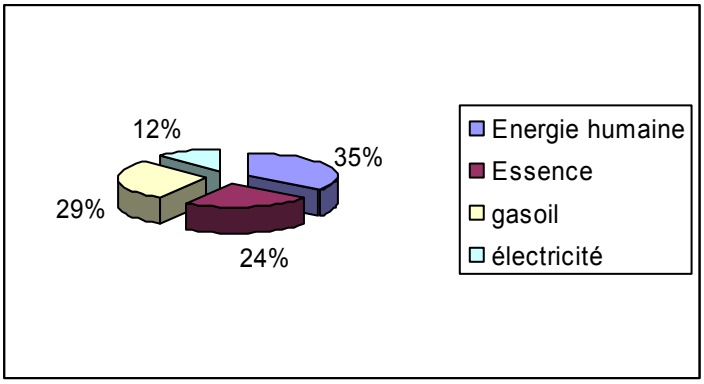

Figure 1 : Sources d'énergie employées

En fonction des sources d'énergie utilisées par les équipements d'extraction d'huile de palme, 35% des unités de transformation utilisent l'énergie humaine et 65% font recours à une source d'énergie non produite localement. L'énergie humaine constitue donc la source d'énergie la plus employée dans la zone comparativement aux trois autres que sont l'essence, le gasoil, l'électricité. Ceci peut s'expliquer par le fait que les pressoirs manuels coûtent relativement moins chers que les pressoirs motorisés. Pour ce qui est des sources d'énergie employées dans les pressoirs motorisés, on constate que le gasoil représente la source d'énergie la plus employée suivie de l'essence et l'électricité.

3.1.3 TYPOLOGIE DES PRODUCTEURS EN FONCTION DU STATUT JURIDIQUE DES UNITÉS D'EXTRACTION

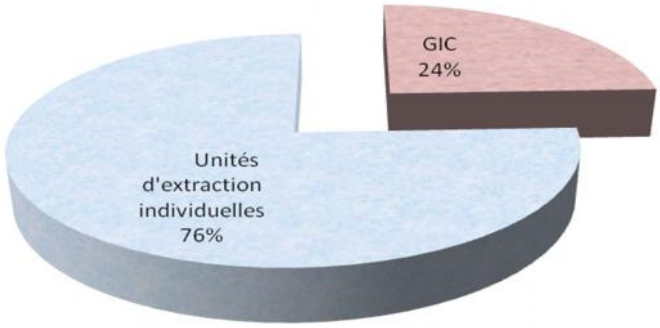

Figure 2 : Répartition des producteurs en fonction du statut juridique

Il ressort de cette figure que 24% des unités d'extraction appartiennent chacun à un Groupe d'Initiative Commune (GIC) tandis que 76 % des autres unités d'extraction relèvent plutôt d'initiatives de producteurs individuels. La législation camerounaise donne en effet la possibilité à au moins cinq individus de se constituer en GIC, entité reconnue par les autorités, ce qui permet ainsi de mener des activités en tant qu'organisation. Dans tous ces GIC, la transformation des noix s'effectue de façon rotative, un producteur utilisant les équipements à la suite d'un autre. Toutefois, une contribution sous forme d'huile est récupérée chez chaque producteur et remise au délégué du GIC pour l'entretien et la maintenance des équipements de transformation. Cette contre partie exigée à chaque producteur affilié dans les GIC est en général de 2 bidon de 22 litres d'huile de palme pour une tonne de noix pressée, ce qui représente environ 20% de la quantité d'huile de palme obtenue.

3.1.4 TYPOLOGIE DES UNITES D'EXTRACTION EN FONCTION DU MATERIEL D'EXTRACTION

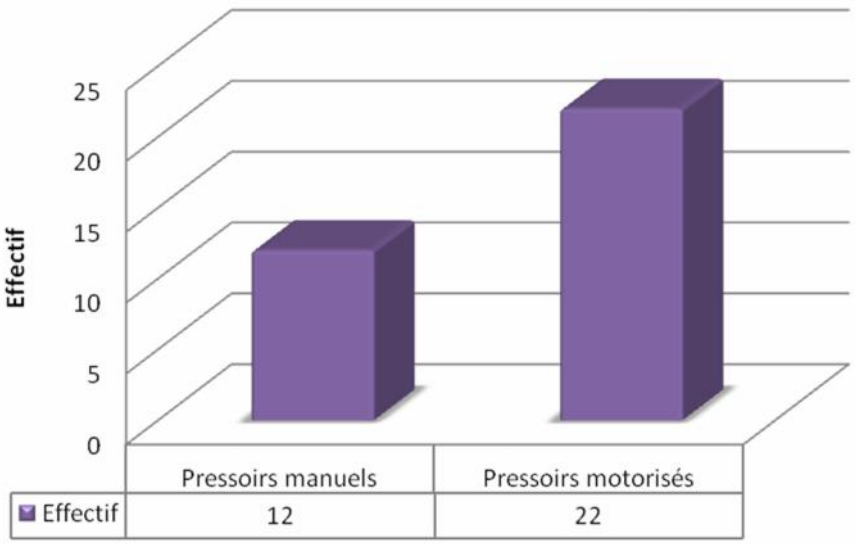

Figure 3 : Répartition des unités d'extraction en fonction du matériel d'extraction

L'observation de ce graphique montre bien qu'environ 35% des pressoirs sont de type manuel tandis que les pressoirs motorisés représentent environ 65%. Les techniques archaïques d'extraction autrefois utilisées dans le processus de production artisanale d'huile de palme disparaissent progressivement.

3.2 PERCEPTION DES PRODUCTEURS SUR LE BIOCARBURANT A PARTIR DE L'HUILE DE PALME

Les perceptions des producteurs vis-à-vis des sources d'énergie localement utilisées dans le processus d'extraction de l'huile de palme ne sont pas les mêmes. En effet, 83.8% des enquêtés pensent que l'utilisation de l'huile de palme comme carburant dans le processus d'extraction de l'huile de palme pourrait améliorer leur production tandis que 16.2% de nos enquêtés ne le pensent pas. La principale raison avancée est que non seulement l'huile de palme est toujours disponible localement mais aussi, coûte relativement moins cher que le gasoil. Ainsi, à la question de savoir si les producteurs d'huile de palme seraient disposés à adopter l'huile de palme en substitution au gasoil, 97.1% répondent par l'affirmative. Ceci soulève donc la question de savoir dans quelle mesure la substitution de l'huile de palme au gasoil serait avantageuse. Est-ce automatiquement le cas juste du fait que le litre d'huile de palme coute moins cher que celui du gasoil ?

3.3 LES ETAPES COMMUNES DU PROCESSUS D'EXTRACTION DE L'HUILE DE PALME DANS LA ZONE DU MOUNGO

Plusieurs étapes conduisent à l'obtention de l'huile de palme :

3.3.1 LA RÉCOLTE DES RÉGIMES

Elle consiste à sélectionner les régimes bien mûrs du palmier, à les couper à l'aide d'un outil tranchant tels que la faucille ou la machette et les transporter sur le lieu de l'extraction de l'huile. Cette tâche est généralement effectuée par les hommes. Apres cette récolte, les régimes doivent être transportés au lieu de l'extraction de l'huile des noix de palme. Ce transport est aussi en général effectué par les hommes.

3.3.2 FERMENTATION

Dans ce cas, on met les régimes en tas pendant 3 à 4 jours pour faciliter la séparation des fruits de la grappe.

3.3.3 L'ÉGRAPPAGE

Les noix sont séparées de la grappe à la main ou à l'aide d'une machette

3.3.4 CUISSON DES FRUITS

Les fruits sont ensuite cuits pendant au moins 4 heures

3.3.5 PRESSURAGE

Les fruits sont soumis à l'action d'une presse

3.3.6 CUISSON DE L'HUILE

A partir de l'huile brute que nous avons obtenue lors du pressurage, on ajoute de l'eau et la cuisson du mélange dure jusqu'à ce que l'huile se sépare de l'eau par décantation.

3.3.7 CLARIFICATION

L'huile qui surnage dans les bacs à cuisson est écumée à l'aide des petites cuvettes

3.3.8 MISE EN BOUTEILLE OU EMBALLAGE

L'huile ainsi obtenue est mise dans des bidons à l'aide d'un entonnoir et stockée à l'abri de la lumière (chaleur). Cette étape marque ainsi la fin du processus d'extraction de l'huile de palme destinée à l'alimentation et cette huile constitue également le biocarburant prêt à l'utilisation comme source d'énergie.

Notons ici que l'ordre et le détail des étapes du processus d'extraction ne varient pas d'une unité d'extraction à l'autre. Toutefois, l'étape N° 5 concernant le pressurage fait intervenir deux types de matériels d'extraction. En réalité, les unités d'extraction peuvent être distinguées par le type de matériel d'extraction employé à savoir les pressoirs manuels ou les pressoirs motorisés. En raison de ces différents matériels d'extraction et des sources d'énergie utilisées, les coûts d'entretien et de maintenance varient également.

3.4 COMPARAISON DES DEPENSES D'ENTRETIEN ET DE MAINTENANCE EN FONCTION DE LA SOURCE D'ENERGIE EMPLOYEE

Tableau 2 : Comparaison des dépenses d'entretien et de maintenance en fonction de la source d'énergie employée

Eléments de la maintenance préventive	Énergie humaine	Essence	Gasoil	Electricité
Dépenses pour l'achat des courroies	0	200FCFA /tonne de noix	200 FCFA /tonne de noix	200 FCFA/tonne de noix
Frais de lubrification du réducteur	0	90 FCFA /tonne de noix	90 FCFA /tonne de noix	90 FCFA/tonne de noix
Frais de lubrification du moteur	0	60 FCFA/tonne de noix	60 FCFA/tonne de noix	0
Dépenses totales liées à l'entretien et la maintenance	0	350 FCFA/tonne de noix	350 FCFA/tonne de noix	290 FCFA/tonne de noix

De ce tableau, il ressort que les dépenses liées à l'entretien et la maintenance des équipements de transformation sont relativement moindres pour les producteurs employant l'énergie humaine. Ceci peut s'expliquer par le fait que les pressoirs manuels n'exigent pas un travail de maintenance particulier en dehors du nettoyage et du contrôle de certaines pannes. Par contre en plus de ces travaux d'entretien, les producteurs employant les moteurs thermiques doivent dépenser en moyenne 350 FCFA/ tonne de noix de plus que ceux qui emploient l'énergie humaine et ceux qui emploient l'électricité doivent réserver en moyenne 290 FCFA/ tonne de noix de plus que ceux qui emploient l'énergie humaine. Ces dépenses supplémentaires sont en fait liées à la motorisation des procédés d'extraction. Toutefois, parmi les sources d'énergie employées dans les moteurs, l'électricité s'avère être la plus économique en matière de coût d'entretien et de maintenance. La principale raison est que les moteurs électriques ne requièrent pas de lubrification et de vidange comme les moteurs thermiques.

Tableau 3 : Comparaison des types de pressurage en fonction des sources d'énergie

Instruments utilisés	Pressoirs manuels	Pressoirs motorisés		
Sources d'énergie	**Énergie humaine**	**Essence**	**Gasoil**	**Électricité**
Coût unitaire de la source d'énergie	1000-1500 FCFA/personne/fût	575 FCFA/litre	526 FCFA/litre	100 FCFA/kwh
Quantité de sources d'énergie nécessaires	5000-7500 FCFA /tonne/personne	1ou1.5 litres/tonne	0.5, 1 ou1.5 litres/tonne	3 kwh/tonne
Transport de la source d'énergie jusqu'au lieu de l'extraction	0	200-1000 FCFA pour 5 à 20 litres	200-1000 FCFA pour 5 à 20 litres	0
Dépenses totales liées à l'approvisionnement en énergie	10000 - 15000 FCFA/tonne	625 ou 912.5 FCFA /tonne	313, 576 ou 839 FCFA /tonne	300 FCFA /tonne
Coûts de maintenance	0	350 FCFA/tonne	350 FCFA /tonne	290 FCFA/tonne
Coût de production	10000-15000 FCFA /tonne	975 ou 1262.5 FCFA/tonne	663, 926 ou 1189 FCFA/tonne	590 FCFA /tonne
Quantité d'huile produite	250-300 litres/tonne	250-300 litres/tonne	250-300 litres/tonne	250-300 litres/tonne
Performances horaires	5h /tonne	1h/tonne	1h /tonne	1h /tonne
Main d'œuvre nécessaire	2 au moins	0	0	0

Ce tableau montre que tous ces procédés d'extraction sont efficaces car pour une même masse de noix transformées, on obtient pratiquement la même quantité d'huile de palme (250-300 litres/tonne de noix). Cependant, lorsqu'on regarde le temps mis avec chaque procédé et le coût lié à l'approvisionnement en énergie, on constate que le pressurage manuel constitue le procédé de pressurage le plus coûteux de part la quantité de main d'œuvre nécessaire ainsi que le coût de cette main d'œuvre dans la production de l'huile de palme. Bien que les coûts d'entretien et de maintenance soient plus faibles avec le pressurage manuel, les dépenses énergétiques font de ce type de pressurage le procédé d'extraction le plus coûteux. En plus de son coût très élevé (10000 à 15000 FCFA/tonne), ce procédé exige un travail musculaire assez pénible et ses performances horaires sont médiocres car il faut consacrer en moyenne 5 heures de temps pour presser une tonne de noix de palme.

Par contre, le procédé de pressurage via les pressoirs motorisés constitue le mode de transformation le plus intéressant aussi bien du point de vue économique que du point de vue technologique. Les dépenses liées à l'utilisation des sources d'énergie (l'essence, le gasoil et l'électricité) restent moins élevées par rapport au pressurage manuel. Les dépenses liées à l'approvisionnement en énergie s'élèvent à 313 FCFA, 576 FCFA et 839 FCFA par tonne de noix respectivement pour les moteurs consommant 0.5litre, 1 litre et 1.5 litres de gasoil par tonne. Ces dépenses s'élèvent à 625 FCFA et 913 FCFA par tonne de noix respectivement pour les moteurs consommant 1 litre et 1.5 litres d'essence par heure. L'essence constitue la source d'énergie la moins coûteuse devant le diesel et l'électricité ceci en raison de son coût d'achat unitaire qui est plus élevé que celui du gasoil et de l'électricité.

Les dépenses sont relativement plus faibles avec les pressoirs motorisés employant l'électricité car le coût de production est relativement plus réduit avec ces types de pressoirs. Ainsi, l'électricité comme source d'énergie est relativement plus économique suivie du gasoil.

Concernant les autres paramètres de l'évaluation (main d'œuvre requise, durée de l'activité), on ne constate pas de différence significative tant pour les producteurs employant l'essence et le gasoil que pour ceux employant l'électricité. Par contre, le pressurage manuel requiert au minimum deux personnes lors de l'extraction et cette main d'œuvre n'est pas toujours disponible.

Avec l'estimation des coûts de production en fonction des différentes sources d'énergie utilisées, il importe maintenant de connaitre l'impact sur le coût de production de la substitution du gasoil par l'huile de palme comme biocarburant dans son processus d'extraction. Autrement dit, l'huile de palme comme source d'énergie en lieu et place du gasoil permettrait elle d'avoir un coût de production moindre?

3.5 FAISABILITE DE L'UTILISATION DU BIOCARBURANT D'HUILE DE PALME

3.5.1 RAPPEL DE LA LITTÉRATURE SUR L'UTILISATION DE L'HUILE DE PALME COMME CARBURANT

Les différentes étapes du processus de production de l'huile de palme ainsi que les sources d'énergie utilisées (énergie humaine, essence gasoil et électricité) dans la zone du Moungo ont été présentées dans les sections précédentes. Sur la base de la littérature disponible, de toutes ces sources d'énergie, seul le gasoil peut être substitué par l'huile de palme dans le processus d'extraction. La faisabilité technique de cette substitution a déjà été démontrée par plusieurs auteurs. De Theux (2004) a fait des études sur l'utilisation de l'huile de palme comme combustible dans les moteurs. Deschepper (2006) a également fait le test de fonctionnement de deux moteurs diesel, l'un alimenté à l'huile de palme et l'autre au gasoil. Au Cameroun, la Société Camerounaise de Palmeraies (SOCAPALM) et la Ferme Suisse ont déjà fait l'expérience de l'utilisation de l'huile de palme brute comme carburant dans les moteurs Diesel (Libert, sd). Dans le cadre de ce travail, nous avons trouvé important de discuter avec le directeur Technique chargé du garage à la SOCAPALM en vue d'obtenir leurs expériences depuis que ce système de production a été mis en place. Avec, le soutien de l'Organisation Non Gouvernementale Action pour un Développement Equitable Intégré et Durable (ADEID), nous avons également effectué un essai de fonctionnement du moteur diesel à l'huile de palme dans le cadre de cette recherche, ce qui a bien marché.

Nous pouvons retenir de tous ces exemples que l'huile de palme brute s'emploie bien comme carburant dans les moteurs sous réserve de quelques adaptations. A ce jour, les performances énergétiques de l'huile de palme par rapport au gasoil sont connues. On sait par exemple qu'en terme de puissance, le moteur diesel fonctionnant à l'huile de palme développe environ 90% de la puissance que ce même moteur donnerait au gasoil dans les mêmes conditions. Dans le même sens, pour une même capacité énergétique, il faut un litre d'huile de palme pour 0.9 litre de gasoil. Autrement dit, un litre d'huile de palme produit la même quantité d'énergie que 0.9 litre de gasoil produiraient dans les mêmes conditions.

Connaissant les performances énergétiques de l'huile de palme, on peut bien se demander quel pourrait être son coût de la production (processus d'extraction de l'huile de palme) si elle était employée comme source d'énergie ?

Tableau 4 : Comparaison du coût partiel de production en fonction de l'utilisation du gasoil ou bien du biodiesel à partir de l'huile de palme

Source d'énergie employée	**Diesel ou gasoil**	**Biodiesel (huile de palme)**	
Prix du litre de carburant	526 FCFA /litre	319 FCFA/litre en période de pointe	478 FCFA/litre en période de soudure
Frais de transport jusqu'au lieu de l'extraction	50 FCFA/litre	0	0
Prix de revient de la source d'énergie	576 FCFA/litre	319 FCFA /litre	478 FCFA /litre
Quantité de sources d'énergies nécessaires	0.5, 1 ou 1.5 litres/tonne de noix	0.55, 1.11 ou 1.66 litres/tonne de noix	0.55, 1.11 ou 1.66 litres/tonne de noix
Dépenses liées à l'approvisionnement en source d'énergies	313, 576 et 839 FCFA/tonne	175.45, 354.09, ou 529.54 FCFA/tonne	262.9, 530.58 ou 793.48 FCFA/tonne
Coût de maintenance	350 FCFA/tonne	350 FCFA/tonne	350 FCFA /tonne
Coût de production	663, 926 et 1189 FCFA /tonne	525.45, 704.09 et 879.54 FCFA/tonne	612.9, 880.58 et 1143.48 FCFA/tonne
Économies réalisées par rapport au gasoil		137.55, 221.91 et 309.46 FCFA/ tonne	50.1, 45.42 et 45.52 FCFA /tonne

Ce tableau montre que si l'huile de palme était employée comme combustible dans les machines dont les consommations s'élèvent à 0.5l, 1l ou 1.5 l de gasoil par tonne de noix, le producteur aurait respectivement dépensé 175.45 FCFA, 354.09 FCFA et 529.54 FCFA/tonne de noix pressée pendant les périodes de récolte des régimes de palmier à huile, et 262.9 FCFA, 530.58 FCFA et 793.48 FCFA/tonne de noix pressée pendant les périodes de soudure. Ainsi par rapport au gasoil, le producteur aurait réalisé une économie de 137.55, 221.91 et 309.46 FCFA/tonne de noix en période de pointe et, 50.1, 45.42 FCFA et 45.52 FCFA /tonne en période de rareté respectivement pour les machines consommant 0.5l, 1 et 1.5 l/tonne de

noix. L'huile de palme dans les zones de production reste donc plus économique que le gasoil aussi bien en période de production qu'en période de rareté, toutes choses étant égales par ailleurs.

Toutefois, l'utilisation de l'huile de palme comme substitut énergétique au gasoil ne se présente pas toujours comme l'alternative énergétique la plus économique devant les autres sources d'énergie localement utilisées notamment l'électricité. Les dépenses liées à l'utilisation de l'électricité (590FCFA/tonne de noix) restent relativement inférieures à l'huile de palme comme source d'énergie à l'exception des pressoirs employant 0.5 litre de gasoil par heure par tonne de noix de palme et ce en période de production d'huile de palme.

Si nous considérons maintenant les différents groupements de villages de la zone du Moungo-Sud, nous constaterons qu'en dehors de Nkapa et Souza Gare qui sont électrifiés, les groupements Bekouma, Mbonjo et Maleke ne sont pas électrifiés. Vu que l'analyse du coût partiel de production lié à l'utilisation des sources d'énergie dans le processus d'extraction de l'huile de palme montre que le gasoil est la source d'énergie la plus économique après l'électricité, dans les zones non électrifiées à l'instar de Bekouma, Mbonjo et Maleke, le gasoil représente par conséquent la source d'énergie la plus économique au producteur. Ainsi, l'autoconsommation de l'huile de palme comme substitut énergétique au gasoil dans son processus d'extraction constitue l'alternative énergétique la plus efficiente devant le gasoil, l'essence et l'énergie humaine toutes choses étant égales par ailleurs.

3.6 IMPACTS DE L'UTILISATION DU BIODIESEL COMME BIOCARBURANT SUR SA PRODUCTION

L'introduction de l'huile de palme comme biocarburant dans son processus d'extraction aura sans doute des impacts au niveau social, économique et environnemental.

Au niveau social, on peut relever entre autres :

- Une autonomie énergétique du fait que le gasoil ne sera plus importé dans les unités de production ;
- Une amélioration des capacités de production car les producteurs seront désormais à même de produire en plus de l'oléagineux alimentaire le carburant pour la production ;
- Une implication des producteurs avec un grand potentiel de création d'emplois. De nombreux services énergétiques peuvent émaner de l'emploi de l'huile de palme comme carburant dans les moteurs.

Au niveau économique, nous déduisons à l'issue de nos analyses :

- Une réduction du coût partiel de production lié à l'utilisation de l'huile de palme comme source d'énergie du fait qu'elle se présente comme l'alternative énergétique la plus économique pour les unités d'extraction devant le gasoil, l'essence et l'énergie humaine ;
- Une élévation du niveau de compétitivité des petits et moyens producteurs notamment devant les agro-industries et les huiles importées du fait qu'ils pourront désormais produire l'huile de palme en grande et à faible coût.

Au niveau environnemental, on assisterait à une réduction des polluants atmosphérique (CO2, Soufre et Résidus de cendre) comparée aux carburants pétroliers.

3.7 ÉVALUATION OBJECTIVE DE LA TECHNOLOGIE : ACCEPTABILITE ET FACTEURS PROBABLES DU REJET

L'utilisation de l'huile de palme comme carburant dans les moteurs faisant partir des technologies des énergies renouvelables, une analyse de son caractère approprié s'est avérée indispensable ceci dans le but d'anticiper les facteurs probables du rejet de cette technologie. A cet effet, nous avons utilisé la Technologie Assessment Loop (TAL) développé par Nji (1992 :34). La TAL est un instrument d'évaluation des technologies qui met l'accent sur les effets prévisibles et les effets imprévisibles d'une technologie en prenant en compte les aspects technique, socio-économiques, culturels et environnementaux.

La combinaison de tous ces facteurs révèle que cette technologie est techniquement efficiente, économiquement faisable, socialement désirée, culturellement et politiquement acceptable. Toutefois plusieurs facteurs pourraient contribuer au rejet de cette technologie :

- La complexité de la technologie ceci en raison de la diversité des kits d'adaptations qui pourraient être peu pratiques pour certains utilisateurs ;
- Aussi, l'huile de palme doit être chaque fois rendue liquide avant utilisation dans les moteurs ;
- La maintenance liée à la technologie particulièrement le système d'adaptation à mettre en place avant toute utilisation des huiles végétales comme carburants dans les moteurs à gasoil ;

- La non reconnaissance de cette technologie au niveau des assurances notamment lorsqu'on effectue des modifications sur sa voiture pour rouler à l'huile végétale ;
- L'insuffisance des quantités d'huile de palme disponibles, car elles doivent satisfaire aussi bien les besoins alimentaires que les besoins énergétiques de la population ;
- Risque de concurrence avec la sécurité alimentaire. En effet, étant un bien alimentaire rare et de plus en plus cher, l'utilisation de l'huile de palme comme biocarburant pourrait réduire les quantités disponibles pour la consommation humaine, contribuant ainsi à l'insécurité alimentaire des populations.

4 CONCLUSION

L'activité d'extraction de l'huile de palme est en expansion dans la zone du Moungo au Cameroun. Les unités d'extraction utilisent des pressoirs qui peuvent être manuels ou motorisés. L'énergie humaine, le gasoil, l'essence et l'électricité constituent les sources d'énergie employées dans la zone. L'huile de palme rouge ou jaunâtre obtenue à la fin de l'extraction peut être utilisée comme biocarburant dans tout moteur diesel sous réserve de quelques petites adaptations à apporter aux moteurs en question. L'analyse de la rentabilité de ce biocarburant montre que bien qu'il soit plus économique que le gasoil dans les zones de production, il ne se présente pas forcement comme l'alternative énergétique la plus efficiente parmi les sources d'énergies employées notamment en comparaison à l'électricité. Autrement dit, l'électricité pourrait constituer dans certaines situations la source d'énergie la plus efficiente aux producteurs. Cependant, l'électricité n'est pas toujours accessible à tous les producteurs car seulement 12% de la population des producteurs d'huile de palme l'emploient comme source d'énergie dans cette production. Aussi, les fréquentes coupures d'électricité et les multiples baisses de tension régulièrement observées traduisent clairement les limites de cette source d'énergie. Par contre, l'huile de palme comme alternative énergétique est toujours accessible aux producteurs pendant toute l'année malgré des hausses de prix en période de pénurie. Les producteurs d'huile de palme sont disposés à l'adopter comme biocarburant s'ils sont assurés de sa faisabilité technique, ce qui soulève ainsi la nécessité d'un travail de vulgarisation de cette technologie. Cette technologie impliquant l'autoconsommation de l'huile de palme comme carburant dans les moteurs serait donc plus appropriée dans les zones de production d'huile de palme, surtout que plusieurs d'entre elles n'ont pas accès à l'électricité. Cependant les mesures doivent être prises pour permettre à cette technologie de jouer un rôle capital dans le développement. La mise en place d'un cadre juridique relative à l'utilisation des huiles végétales comme carburant est indispensable. En plus, l'Etat doit jouer un rôle régulateur non négligeable dans l'introduction de cette source d'énergie dans sa palette d'énergie notamment à travers des politiques publiques incitatives visant à encourager son utilisation dans certains secteurs d'activités. Les potentiels utilisateurs doivent accorder une attention particulière aux adaptations nécessaires avant toute utilisation des huiles végétales comme carburant ainsi qu'au respect des règles de maintenance que cela implique. Ceci appelle aussi à un travail d'accompagnement de la part des technologues pour rendre ces adaptations plus aisées.

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REFERENCES

[1] Association citoyenne de défense des intérêts collectifs (ACDIC). 2007. Biocarburants : sacrifier l'alimentation pour les moteurs. Appel Citoyen. N°015. Décembre 2007.Cameroun. 5P

[2] Buerkle, Teresa. 2003. Le palmier à huile hybride prospère du Kenya. Département de l'Agriculture et de la Protection des Consommateurs. FAO. Rome

[3] Cailleux, Maryline., Lagrandré, Damien et Lhomme, Anne. 2009. Les agrocarburants : opportunités et menaces pour les populations du Sud. Actes Journée d'étude du Groupe Initiatives. Les éditions de Groupe Initiative/GRET. N° 31. 45p

[4] Deschepper Gilles. 2006. Rapport d'essais de moteurs à huile de palme : essai comparatifs de deux moteurs diesels, l'un alimenté à l'huile de palme et l'autre, au gasoil. CODEART. www.codeart.org consulté le 10-05-2009

[5] De Theux, Barthélémy. 2004. Utilisation de l'huile de palme comme combustible dans les moteurs diesel. Institut Supérieur Industriel. Electromécanique. Haute Ecole LEONARD de VINCI. Belgique. 119p.

[6] Elong, Gabriel, Joseph. 2003. Les plantations villageoises de palmier à huile de la SOCAPALM dans le Bas-Moungo (Cameroun) : un projet mal Intégré aux préoccupations des paysans. *Les Cahiers d'Outre-Mer*[En ligne], 224 | Octobre-Décembre 2003, mis en ligne le 13 février 2008.

[7] Nji, Ajaga. 1980. A Methodogoly for Technologie Assessment: A Functional-Structural Approach. Iowa State journal of research. Vol.55.No.1. pp. 1-11. Iowa State, USA.

[8] Nji, Ajaga. 1992. The Dialectic between Appropriate Technology, Public policy and Rural Development: Implications for Discovery and Innovation in the Third World. Review. Discovery and Innovation. Vol. 4. No.1. pp.33-43. Dschang University Centre. Cameroon. West Africa.

[9] Noel, Jean-Marc., Rouziere, André., Graille, Jean et Pina, M. 1997. DRUPALM : Nouveau procédé pour les huileries de palme. I. Description. *Plantations, recherche, développement Mai - Juin 1997* Département des Cultures Pérennes, Programme Palmier à Huile, CIRAD. France

[10] Ribier, D., Rouzière, A. 1995. La transformation artisanale des plantes à huile : expériences et procédés. GRET. Paris. France.

[11] Rousset, Patrick. 2008. Guide technique pour une utilisation énergétique des huiles végétales. CIRAD.

[12] Service d'Appui aux Initiatives Locales de Développement. 2003. La gestion d'une petite unité de production d'huile de palme. CDDR. Yaoundé. Cameroun.

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THE BOKO HARAM INSURGENCY IN NIGERIA: A NATIONAL SECURITY THREAT TO THE UNITED STATES

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ABSTRACT: Activities of violent non-state actors like the Boko Haram sect in Nigeria have greatly affected the national security of the United States. The methods employed by non-state actors enable some groups to be able to take on much stronger entities by waging asymmetric warfare. For instance, "The hijacking of airplanes was common in the late 1960s and early 1970s. The seizing of embassies was popular in the late 1970s and early 1980s and the blowing up of mid-flight airplanes took center stage in the late 1980s. Other tactics include hostage taking, the assassination of prominent individuals and detonating bombs in government or public buildings. These methods have changed over time, but history has also shown that various non-state actors use different tactics no matter what the time period. The 9/11 attacks showed the deadly combination of a mid-air hijacking, suicide mission, and the targeting of public/government/military buildings. More importantly, it showed how a non-state group could adapt their tactics to defeat Western security apparatuses in order to carry out a massive strike. The second factor is communications technology. Innovations like the Internet and cell phones have enabled groups to communicate quickly and effectively. Because the diffusion of these two innovations is so vast, it presents a great challenge to Western security agencies, particularly if the group is operating in a weak or failed state. This study highlights the activities of the Boko Haram insurgency group, as a Violent Non-State Actor (VNSA) and its implications for the United States national security, and proposes a solution that may reduce the activities of the group.

KEYWORDS: Hijack, violent, warfare, hostage, and security.

1 INTRODUCTION

The Northern region of Nigeria over the past decades has continued to experience a steady rise in terrorist's activities and violence instigated by the dreaded sectarian group called the Boko Haram. While some observers have traced the cause of these extremists violence to poverty, economic disparity, and socio-political differences within the Nigerian state, the complication and complexity of the situation has led many to believe that Boko Haram's violent extremism is beyond domestic agenda (Adejumo 2011; Dambazu 2007). The use of suicide attacks on civilian populations presents a pattern that is typical of international terrorists that is alien to Nigeria. Further, the groups' ability to garner support from the grassroots, especially from the rank and file of impoverished and the uneducated in northern Nigeria has become of great concern to the government of Nigeria (Egburonu 2012).

The group, Boko Haram, has laid a siege to the North East part of Nigeria and appears to be expanding its territory by the day. In addition to the mindless killings of defenseless and innocent Nigerians, members of the group also carry out wanton destruction of property so as to make people in the zone embrace their ideological views on Islamic religious code (Emezi 1997). To state the fact, the fear of Boko Haram in Northern part of Nigeria is the beginning of wisdom (Oshodi 2011). The group, whose agenda is to push for the enthronement of Sharia in favor of western education, has always sent fears down

the spines of young and old in the North Eastern states of Borno, Bauchi, Yobe, Adamawa, Gombe and Taraba. Wherever the group operates, it often leaves behind indelible marks of sad stories and scary scenes of destruction, maiming and death. In Borno, the stronghold of the group, many lives and property have been lost to guerrilla-like attacks unleashed on the residents of the ancient town of Maiduguri by the sect since it began its operations a few years ago.

How to respond to these domestic terrorists groups in Nigeria has become a major challenge to both the government and security officers. In April, 2014, the Boko Haram group captured international attention following the kidnap of about 270 school girls in the small town of Chibok, Borno State. Besides, over 5,000 people have been estimated to have died from the attacks by the group which has generated international outrage against the government for its slow approach in dealing with the situation (Dapo 2012; Egburonu 2012). Certainly, this is not the best of times for the Federal Government of Nigeria. Not with the colossal loss of human lives and kidnapping of the school girls. Given the timeline of Boko Haram since its operation to date is to say the least, wiping away thousands of lives. And with the failure of intelligence on the part of the security personnel, one then wonder how the insurgency can be curtailed.

2 BACKGROUND AND HISTORY OF THE GROUP

The Boko Haram terrorists group which means "Western education is forbidden" is a controversial Islamic extremists group whose sole aim is to Islamize the Northern part of Nigeria through the imposition of Sharia laws in all the states that make up Northern Nigeria. The group which started relatively unknown in 2001 has today, become a source of concern to both the Nigerian government and the international community, forcing the United States of America to formally designate it as a terrorists organization in November 2013 (Kirk 2014). Membership of this organization has been estimated to between 20, 000 to 40,000 members (U.S. Bureau of Counterterrorism 2014). Boko Haram has killed more than 5,000 civilians since 2009 to date, including at least over 2,000 in the first half of 2014 (Farouk 2014). Additionally, the group has abducted more than 500 women and children since 2009, including the kidnapping of 276 school girls from Chibok, Borno State of Nigeria in April 2014. Moreover, at least over half a million people have either fled their residences or displaced by the conflict perpetuated by the group forcing the government of Nigeria to declare a state of emergency in the three Northern states of Adamawa, Yobe, and Borno respectively in 2012 (Council on Foreign Relations 2014).

3 IDEOLOGY AND MOTIVATION

The terrorist group, Boko Haram was founded based on the Sunni Islamic sect championing the imposition of strict Sharia laws in the Northern part of Nigeria as influenced by the Wahhabi movement that seeks for an Islamic Nigeria state, while at the same time opposing western education (Bartolotta 2011). Observers believed that the Islamic Sharia law imposed by the Zamfara state government of Nigeria in January 2000 may have facilitated and promoted the activities of the group in Nigeria, Africa's biggest economy with a population of about 170 million (Neumann 2008). During the first few years of its operation, the group conducted its activities peacefully, making people to believe that it stood for the good of the common man in society. However, Boko Haram has repeatedly attacked schools, churches, mosques and markets. Further, state institutions such as police stations and military facilities have also remained primary targets. Following a public outcry, the Nigerian government declared a state of emergency in three states – Borno, Yobe, and Adamawa, and launched a military offensive against the group. The Nigerian military claims to be making major strides in defeating Boko Haram, but attacks from the group continue. There is scant opportunity to verify military claims or investigate some of the human-rights abuses purportedly committed by the army in the course of fighting the group.

Little is known about Boko Haram and its motivations, and information about the group's activities remains under a tight control. However, political observers have traced the root cause of the group's activities to the following: great amalgamation of Northern and Southern Nigeria by the British colonial masters in 1914, the role of ethnicity, Systemic Corruption and leadership failure, poverty, and culture of impunity (Otite 1990; Onyemaizu 2006; Ikime 1987). Since the group started its offensive, it has followed the doctrine that Western education is haram - prohibited and against the teachings of Islam. Targeting schools has become a Boko Haram trademark. This has resulted in thousands of parents across the region withdrawing their children from institutions where Western education is taught, fearing attacks. In this way, Boko Haram has succeeded in creating an environment where children are taken out of classes and schools are forced to shut down. Following the declaration of a state of emergency, the security services set out to disconnect all communication, from mobile phones to satellite phones, making it difficult to contact people to verify what is happening on the ground (Onuoh 2014). The military have, on a day-to-day basis, put out information to the public giving the impression it is succeeding in the war against Boko Haram. However, it is difficult to cross-check the military's version of events because the media have been seriously restricted from working in areas affected by the crisis (Cocks 2014).

4 THREAT ASSESSMENT FROM THE UNITED STATES

Citing several reasons which includes links to al-Qaeda in the Islamic Maghreb, al-Shabaab, al-Qaeda in AfPak, al-Qaeda in the Arabian Peninsula, Ansar al-Din, the Movement for Unity and Jihad in West Africa, and the thousands of deaths, as well as the 2013 kidnapping and execution of seven international construction workers in the Northern part of Nigeria, the United States designated Boko Haram and the Ansaru as a terrorists organization (Onu 2014). Furthermore, the killings of about 500 people by the group in Nigeria on June 3, 2014, couple with the kidnap of over 200 girls from their school in Chibok, Borno State, Nigeria this year provided an assessment of the dangers posed by the group to the Nigerian government and the international community.

Terrorism in Nigeria has revealed the current powerlessness of the West Africa regional leaders in defeating Boko Haram and other terrorists' group in the region. An assessment of the threats posed by the group to Nigeria and the world community by Henry Jackson Society showed the following:

4.1 WEAK INTERNATIONAL AND REGIONAL RESPONSE

The group Boko Haram, as a terrorist's organization remains a threat to the Nigeria government and the international community whose huge investment in the region is at stake. Boko Haram's threat is not just to Nigeria, but also to its neighbors such as Cameroon, Mail, Algeria, Niger, Chad, and Benin republic where its members are currently engaged in the attacks of innocent civilians. Even though the West Africa regional leaders have resolved to confront this terror group, their resolve has been marred by the lack of commitment from these leaders in the area of intelligence sharing, border control, and surveillance. Cameroon, for example remains a fertile ground for the recruitment and training ground for Boko Haram, while the infiltration of the Islamic Jihadists from the neighboring Niger republic pose a growing threat to innocent population and regional security.

4.2 BOKO HARAM'S TIES TO AL-QAEDA

The nexus between Boko Haram and the al-Qaeda group have been established and goes back a decade (Henry Jackson Society 2014). Boko Haram is known to be affiliated to at least six al-Qaeda groups like al-Qaeda in the Islamic Maghreb, al-Shabaab, al-Qaeda in AfPak, al-Qaeda in the Arabian Peninsula, Ansar al-Din and the Movement for Unity and Jihad in West Africa. Boko Haram's ties to al-Qaeda exist because of its affiliations to AQIM (Henry Jackson Society 2014).Also, there has been allegations that some of elements of Boko Haram have been known to have responded to the AQIM leadership in the kidnapping of foreigners in the region.

4.3 DIFFICULT MILITARY AND INTELLIGENCE SHARING

Another threat assessment of the danger posed by Boko Haram to the international community is the difficult military and intelligence sharing terrain. Because of the sheer size of the terrain to cover, coupled with the inability of the Nigeria government intelligence agency to gather adequate intelligence about the group, the use of satellites and drones by the United States government against the group is extremely difficult. Besides, by merging into the civilian population to hide their presence, the group has made it difficult for the security forces to obtain information about them. To be successful in any counter-insurgence against the group, there must be a reliable Human Intelligence network (HUMINT), which is currently lacking between the Nigeria public and the security agencies. Even with the best intelligence available, the group still thrives due to its supporters' seeming penetration of the Nigerian political and security agents (Bovard 2003).

While the Boko Haram group, as perceived by the United States and other international community is seen as less of a threat than the al-Qaeda in the Islamic Maghreb (AQIM) or al-Shabaab in Somalia, it has killed on a scale greater than both groups. This is likely to change, especially if the group launches attacks against oil facilities in the South which could raise the stakes because of the economic interests and investments involved (Conklin 2007).

5 POLICY RECOMMENDATIONS

There is no doubt that Boko Haram has posed a national security challenges to the Nigeria government. There is need for the government, with the help of other advanced nations like the United States and Great Britain to help modernize her security agencies (U.S. Department of State 2013). This will aid the government in the area of training and intelligence sharing and gathering. Further, the government must carry out some major economic and political reform that would address the economic and socio-political deprivation and the wealth inequality among the masses. Specifically, the U.S.

intelligence community should assist by playing a major role in its intelligence collection on the group using the human intelligence (HUMINT) and the signal intelligence (SIGINT) to help complement the efforts of the Nigeria security agencies. The United States intelligence could also liaise with their Nigerian counterparts by helping them build their capability to confront the threats posed by Boko Haram to Nigeria on one hand, and to the United States interests on the other (Myers 2008).

The second way the U.S. can help the Nigeria government to combat the dangers posed by the Boko Haram terror sect is for the U.S. government to form a relationship with Nigerians in diaspora, especially those living in the United States so as to learn more about the group, the driving factors, intents, sources of funding, and their sponsors so as to develop plan to target their economic life line and financial buoyancy. Moreover, the U.S. government should increase intelligence sharing with their Nigerian counterparts so as to in the words of President W. H. Bush "Anti-Terrorism Strategy' Defeat, Deny, Defend, and Diminish Boko Haram's capability. The strategy outlined by President W.H. Bush, if applied to the Nigeria situation could go a long way in the fight against terrorism in Nigeria in the area of denying the group a safe haven to operate financially, sponsorship, training, and plans to execute their attacks. Given the fact that without money, terrorists' organizations cannot operate successfully, stopping their flow of income is one of the ways of destabilizing and defeating Boko Haram in Nigeria.

The third policy recommendation for the defeat of the Boko Haram terror group is for the government of Nigeria to put in place social and economic structures that could help alleviate and diminish conditions such as poverty, unemployment, as well as educational empowerment of the youths who are vulnerable to the group's exploitation. Additionally, the government of Nigeria should remain focus in its resolve to root out religious bigots such as Boko Haram who hide under the guise of religion to inflict pain on innocent Nigerians. There should be no compromise in the war against Boko Haram because the integrity, unity, and national security of Nigeria are at stake.

6 CONCLUSION

History has shown that there is religious fanatical movement in Nigeria, as well as in the Sahel region of the continent of Africa (Johnson 2009; Henry Jackson Society 2014). In 1980, there was the appearance of the Maitatsine religious sect that killed hundreds of innocent citizens in the North East of Nigeria until they were defeated following government decisive response that quickly saw the group disappear and fled into the neighboring Chad and Niger republics respectively. Some observers believe that the Boko Haram group may have been nurtured to maturity from outside of Nigeria and received financial support from the Salafist groups in Saudi Arabia and their training from the rebel groups in the Sahel region (Henry Jackson Society 2014). The group has succeeded in exploiting many national issues such as poverty, unemployment, corruption, extra-judicial killings by the police, and the general poverty in the Northern states, as well as lack of education to boost their hold in the North Eastern states of Nigeria. While it is true that insecurity is a global issue, the strange thing is that the government of Nigeria has not been able to deal with the challenges posed by the Boko Haram's terror organizations. Most importantly, the United States should pursue a policy that could lead to the identification of Boko Haram sponsors so as to freeze their accounts here in the U.S. Further, the government of the United States should also pursue a policy that can help Nigeria diversify its economy and reduce its over-dependence on oil. Specifically, programs aimed at boosting the agricultural sector could help provide employment among the restive youths in the north, as well as in other parts of Nigeria.

REFERENCES

[1] Adejumo, A. Problem and Challenges of Insecurity in Nigeria (2011). [Online] Available: http://chatafrik. Com/articles/Nigerian-affairs/items/338-the problems-and-challenges-of-insecurity-in-nigeria.html (February 23, 2015).
[2] Africa Program at the Council on Foreign Relations (2014). "Nigeria Security Tracker". [Online] Available: *www.cfr.org* (February 21, 2015).
[3] Amy B. Zegart, *Flawed by Design: The Evolution of the CIA, JCS, and NSC*, Stanford University Press, 1999.
[4] Bartolotta, Christopher (23 September 2011). "Terrorism in Nigeria: the Rise of Boko Haram". *The Whitehead Journal of Diplomacy and International Relations*. Publication, 2011.
[5] Bovard, J., Terrorism and Tyranny: Trampling Freedom, Justice, and Peace to Rid the World of Evil. New York: Palgrove Macmillan, 2003.
[6] Conklin, F., Criminology*, 7th edition.* Boston: Pearson Education, Inc, 2007.
[7] Dambazau, A. B., *Criminology and Criminal Justice*. Ibadan: Spectrum Books Ltd, 2007.
[8] Dapo, Akinrefon "Let Return to Aburi Accord –Adeniyi" *Vanguard Politics Publication,* 2012.

[9] Dokubo, C. “Enhancing Nigeria’s National Security Interest through International Relations”, *Nigerian Journal of International Affairs*, 2010, 1: 25-44.
[10] Egburonu, S, et al, “Tension as groups flee over Boko Haram Threats”, The Nation on Sunday Publication, 2012.
[11] Emele, Onu. "Amnesty Says 'Gruesome' Nigerian Footage Shows War Crimes". Bloomberg Publication, 2014.
[12] Emezi, C. “Ethnic Foundations of the Nigerian Society”, in C. A. Ndoh and C. E. Emezi (eds.), Nigerian Politics. Owerri: CRC Publications Limited, 1997.
[13] Farouk Chothia “Who are Nigeria's Boko Haram Islamists?” *BBC African Service, 2015.*
[14] Funsho Balogun , “Methods of A killing Machine” in TheNews, Inside Boko Haram: Methods and Tactics of a Terror Machine. Lagos. August 1, 2012.
[15] Ikime, O., “Towards Understanding the ‘National Question’’’. *African Event Publication*, 1987.
[16] Johnson, L.K “Introduction” in L.K Johnson (Ed) *Handbook of Intelligence Studies:* New York: Routledge, 2009.
[17] Jump up "Rewards for Justice - First Reward Offers for Terrorists in West Africa". U.S. Department of State. June 3, 2013.
[18] Kirk, Ross. "Revolt in the North: Interpreting Boko Haram's war on western education". *African Arguments*, 2014.
[19] Myers, R., The National Military Strategy of the United States of America. (Washington: Office of the Joint Chiefs of Staff Publication, 2008.
[20] Neumann, P.R, and Smith, M.L.R. The *Strategy of Terrorism: How It Works, and Why It Fails*. New York: Rutledge, 2008.
[21] Onyemaizu, C. “In the Maze of Violence,” The Source, 2006, 19, 22: 10 –21.
[22] Onuoh, Felix. "Nigeria Islamists better armed, motivated than army: governor". Reuters Publication, 26 July 2014.
[23] Oshodi, J. “Orientation on Terrorism: The Psychological approach; *The National Scholar*: 2011, 8, 2: 20-22.
[24] Otite, O. *Ethnic Pluralism and Ethnicity in Nigeria*. Ibadan: Shameson C.I Limited, 1990.
[25] Tim, Cocks. "Jonathan's PR offensive backfires in Nigeria and abroad". Yahoo! News/Reuters Publication, 2014.

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Linguistics and Literary Criticism: Shall the Twain Never Meet?

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ABSTRACT: It was a commonplace among traditional linguists and literary scholars that their disciplines were far apart from each other, and that there could be only very little interaction between them. In the late 20-th century, however, the fields of conventional linguistics and traditional literary studies were profoundly unsettled by major paradigm shifts like the decisive turn to text linguistics and discourse analysis, and new trends in literary theory (theoretical criticism). It is against the background of these shifts that the present paper investigates the relationship between modern linguistics (in the guise of text linguistics, discourse analysis, pragmatics, transformational-generative linguistics, semantics, etc.) and literary criticism, both theoretical and practical. By grappling with these two questions – 'Is there a common denominator between linguistics and literary criticism?' and 'Are literary texts fully amenable to a strictly linguistic analysis' -, this article traces the historical development of modern linguistics from conventional linguistics and of literary theory from traditional literary studies, while contrasting conventional linguistics and traditional literary studies, and comparing text linguistics/discourse analysis and literary theory. Ultimately, the paper establishes 'text', 'discourse' and 'language' as commonalities between linguistics and literary criticism, and takes the stance in favour of the irreducibility of literary texts to exclusively linguistic methods and techniques of analysis.

KEYWORDS: Conventional linguistics, discourse, discourse analysis, language, literary theory, modern linguistics, text, text linguistics, traditional literary studies.

1 INTRODUCTION

It is a truism to say that linguistics has conquered the world of other disciplines, probably much faster and more determinedly than any other science. Since its establishment in the early 20th C, modern structural linguistics has had an indescribably intensive contact with other sciences, and linguistic knowledge has been increasingly applied to practical fields ranging from biology, mathematics and computer science to sociology and education (Kambale 2011: 3). As a matter of fact, Ferdinand de Saussure's vision of semiotics has left its imprint on psychoanalysis (Lacan 1966), philosophy (Althusser 1965, Foucault 1966, Derrida 1967) and anthropology (Lévi-Strauss 1949, McQuown 1969), as well as on sociology (Baudrillard 1968) and economics (Baudrillard 1970). As far as education is concerned, modern structural linguistics (Bloomfield 1933) and transformational-generative linguistics (Chomsky 1957) caused a great leap forward in the teaching/learning of foreign languages (Hayes 1969, DeCamp 1969).

Still, some disciplines have continued to shield themselves against and to stage a fierce resistance to the invasion attempts made by linguistics. One such discipline is philology: the curious hostility between philologists and linguists can still be felt on the academic scene where they accused each other of 'pedantry' (Anttila 1975: 145). Another one is literary criticism: some literary critics have, in fact, accused linguistic methods and techniques of being reductionistic in the sense that they tend to overemphasize the 'form' to the detriment of the 'content' and, hence, they break the unity of the two components by absolutizing one of them (Ihwe 1975: 134). Other critics have questioned the linguist's right to analyze literary texts. These specialists of literature have been disturbed by what they felt as the linguist's 'imperialistic intrusion' into

their 'profession' or their 'private business', or as the linguist's attempt to violate the autonomy and relevancy of literary criticism, as a discipline in its own right (Hayes 1969: 199).

This paper aims to address the problem 'linguistics and literary criticism' by grappling with the following two questions: 1) Is there a common denominator between linguistics and literary criticism? 2) Are literary texts fully amenable to a strictly linguistic analysis? These two questions, which echo the above-mentioned denunciation of reductionism and intrusion, are intrinsically related, but, for the sake of convenience, I shall deal with them by turns. But before I tackle them, I shall first sketch a historical development of modern linguistics (text linguistics and discourse analysis) from conventional linguistics, and of literary theory from traditional literary studies. I shall do so by contrasting conventional linguistics and traditional literary studies, and then by comparing text linguistics/discourse analysis and literary theory.

2 LINGUISTICS AND LITERARY CRITICISM: BRIDGING THE DIVIDE

For a very long period of time, roughly from the 1880s to the 1960s, it was tacitly established among linguists and literary scholars that their specific disciplines were distinctive and could not interact much. This disparity is not attributable to mere feelings of mutual rivalry, insecurity, or mistrust, but to the fundamental difference between linguistics and literary studies in their traditional conceptions and directions. De Beaugrande (1993: 423-428) presents and briefly discusses a schematic set of contrasts between conventional linguistics and traditional literary studies which account for the absence of interaction between them in past decades. These contrasts are:

1. While *language*, conceived as an abstract *system*, was the object of linguistics, the *literary text*, apprehended as a concrete *artifact*, constituted the object of literary studies.
2. The linguist used to draw his/her material from *data*, all the samples of language gathered and compared in detail by means of *fieldwork* and *introspection*. The literary scholar, on the contrary, used to derive his/her material from the *canon* of literary texts established mainly by *tradition*.
3. Linguistics adopted a *synchronic* approach to language by viewing it in its current state rather than in its evolution. Literary studies, in contrast, remained determinedly *historical* as the teaching/learning of literature was organized into frames of time periods where contemporary literature was treated at best marginally alongside the canon of 'classics' of the past.
4. The *ideal speaker* who 'knows' the language and can produce an unlimited set of utterances (or sentences) was the operable construct of linguistics, while the *real author* as a biographical and historical figure was the concern of literary studies. Concomitantly, linguistics assumed an *ideal hearer* who is endowed with essentially the same linguistic knowledge as the ideal speaker. In literary studies, however, the *scholar* claimed to be the proper (qualified, discerning, etc.) *reader* for the literary work, and went so far as to present his own reading in the name of the *real author*, thereby merging *author* with *authority*, if not indeed with *authoritarian* posture.
5. Unlike linguistics, which targeted the entire ('homogenous') *community* of speakers, literary studies had, as their widest group of addressees, the *school* or *movement* to which an identifiable set of real authors could be assigned by conspicuous stylistic or thematic attributes.
6. Linguistics sought to formulate the most *general* principles, with a particular emphasis on generalizations applying to an entire language or, better still, to all languages ('universals'). Literary studies, on the contrary, accorded much attention to the *special* or even *unique* quality of the literary work.
7. Whereas linguistics addressed the *rules of language* encoding the patterns, usually formal, which apply to all or most instances, literary studies addressed the *conventions of genre*, some of which are based on form and others on theme or topic.
8. In linguistics, *style* was studied as *choice*, i.e. the selection of certain options offered by the overall language system. In literary studies, however, *style* was perceived as *ornamentation*, i.e. an aesthetically pleasing addition of 'schemes' and 'tropes' existing independently of the 'content' or 'message' of the work.
9. Linguistics resolved to be *non-evaluative* in that it recorded and described language irrespective of prescriptive and proscriptive attitudes about 'good' and 'bad' or 'correct' and 'incorrect'. Literary studies, on the other hand, remained *evaluative*, in spite of occasional acknowledgements of the obscuring and distortive tendency of values.
10. The goal of linguistics was the *description* of a *whole language* as a total system, a characterization of its phonological, morphological and grammatical regularities in compact and perspicuous format. In contrast, the goal of literary studies

was to a large extent the *advocacy of one's interpretation* of a particular work and, in conjunction, of the work itself as a meritorious exemplar worthy of such explication.

11. Statements and claims in linguistics were *confirmed by data* as additional samples were collected and compared to a given formulation. In literary studies, the implicit standard for confirming an interpretation was the *eloquence* of the scholar in persuading, convincing and creating harmony and order.

12. Prospective linguists underwent *training by method*, the most noteworthy being the technique for eliciting, recording and analyzing data by fieldwork. Prospective literary scholars, on the contrary, were *trained by imitating* the interpretive performances of established scholars, including their teachers, upon concrete works.

13. While linguistics was characterized by *collective research* among teams and each contributor sought to expand or stipulate the accumulating model (or 'grammar'), literary studies were devoted to *individual research*, and each contributor wanted to shine the most among his peers by overturning previous interpretations of the same work.

14. Although linguistics has gleaned enormous practical achievements in descriptive fieldwork, it has had a reputation for being *theory-centered*. Literary studies, though steadily influenced by such disciplines as philosophy, aesthetics and history of ideas, have had a reputation for being *practice-centered*. That is, they were based firmly on the activities of reading and interpreting rather than on the formulation of abstract principles.

It flows from the above contrastive sets that traditional linguistics systematically studied language as a whole, thus covering all aspects and uses of language, as well as all styles (Robins 1973: 336). Yet, its central interest was 'every day' or 'normal' texts[1] about which it made statements along the lines of the complementary concepts of 'structure', i.e. the constructional elements of texts and the regularities of their arrangement, and 'function', or the occurrence and use of texts within a speech community (Ihwe 1975: 131). As to traditional literary studies, they consisted in making pronouncements or judgments about literary works in a way to assess their specific 'value' in 'literature', their 'canonizability', and to categorize them and their authors into established schools or movements. As such, they were solely concerned with a particular genre of language use or production: canonical literary texts or those texts whose properties make them fall into the category of 'canonical literature', and which characteristically comprise a certain number of peculiar ('unordinary', 'deviant', etc.) uses and styles.

Traditional linguistics and traditional literary studies were thus antipodes, but their conventional grounds of opposition gave way to an auspicious scenario for a fundamental reconciliation as a result of the major paradigm shifts that profoundly unsettled the conventions on both sides from the 1970-80s onward. On the side of linguistics, pressure from problems inherent in 'non-textual' ('sentence') linguistics resulted in a decisive turn toward text linguistics and discourse analysis. The former focuses more on 'written discourse' and the latter on 'spoken texts', but both are concerned with text organizations. Richards, Platt and Weber (1985: 84 and 292) highlight the closeness of the two branches of linguistics in these terms:

> *Discourse analysis is the study of how sentences in spoken and written language form larger meaningful units such as paragraphs, conversations, interviews, etc. (…). Some linguists use the term text linguistics for the study of written discourse. [Text linguistics] studies spoken or written texts, e.g. a descriptive passage, a scene in a play, a conversation. It is concerned, for instance, with the way the parts of a text are organized and related to one another in order to form a meaningful whole. Some linguists prefer to include the study of all spoken texts, particularly if they are longer than one sentence, under discourse analysis.*

As to the side of literary studies, primacy was accorded to literary theory which shifted the concern from the individual text to the general conditions of literature or 'literariness'. De Beaugrande (1993: 429-434) draws a number of parallels between the trends in text linguistics/discourse analysis and literary theory. Here, I shall sketch only eight of them which I deem as major ones:

1. In discourse analysis, a strong stress is put equally on the social and cognitive aspects of *text* and *discourse*. In literary theory, however, the social aspects are emphasized only by politically left-wing scholars, and the cognitive ones mainly by those whose conceptual perspective is phenomenology, gestalt theory and sociology of knowledge.

[1] *The expression 'text' refers here to all linguistic entities that are part and parcel of language use. In this sense, a 'text' has an all-inclusive scope, from a simple interjection to a complex opus with several volumes.*

2. While the scope of text linguistics is, in theory, all-encompassing in that it is concerned with *all* text types, the scope of literary theory has remained *selective*, in spite of the attempts to transcend the traditional 'canon'.
3. Data about text production and text reception have a critical importance, and the techniques of data collection are both empirical and diversified in text linguistics and discourse analysis. In literary theory, on the contrary, data are still mainly speculative, and data-gathering techniques are comfortably established inside literary institutions.
4. The orientation of text linguistics/discourse analysis is *dynamic* and *procedural*, while the orientation of literary theory is *programmatic*. That is, literary theory views literature as a complex of projects for navigating the complexities of literary communication (de Beaugrande 1993: 438). The dynamic nature of the programmatic approaches adopted in literary theory draws it closer to text linguistics/discourse analysis, although their procedurality is questionable.
5. In text linguistics/discourse analysis, text and discourse have as their addressee the *community as a social complex* of different classes and groups among whom the distribution of power and solidarity is unequal within the 'prevailing order'. In literary theory, far from being ensconced in schools or movements, authors and works are placed in a *horizon*, i.e. against the background of the cultural meanings within which literary production took place (Eagleton 1996: 72). In this light, the concept of *community as social complex* has some logical connection with the concept of *horizon* in the sense that literary expectations exist among a substratum of that complex.
6. Text linguistics sets a careful *balance* between a *general* outlook (whole language) and a *specific* one (specific data/single text). That is, text linguists do not easily consider their data as a representative sample of the whole language, nor do they regard them as less valuable, informative, or 'scientific' altogether. As to literary theory, it favours a *dialectic between innovation and expectation* whereby the specific achievement of a single work is seen in terms of how it skillfully modifies prior systems of shaping and sense-making. Against this background, there is a partial compatibility between the *balance of general and specific* in text linguistics and the *balance of innovation vs. expectation* in literary theory. Text linguistics is concerned with a broad range of intermediary constructs between the whole language and the single text, and these constructs constitute the framework within which anything may be more or less innovative or expected in literature.
7. Text linguistics does not rely on an algorithmic rule to apply invariably to all data and in all situations. Rather, it operates with a *strategy*, i.e. a procedural *interactive heuristic* which has sufficient flexibility and power as to take due care of the peculiarity or novelty of each situation in which it manages topics and goals, and, hence, to handle many contexts and needs. Likewise, literary theory affirms the *instability of genre* and the *diversity of style*. As such, it praises as 'valid' a work which does not merely conform to its genre, but modifies it and even cuts across genres. It also credits with a 'distinctive' identity a style (i.e. *mode of literary discursivity*) which maintains the dialectic between innovation and expectation. In this light, text linguistics and literary theory are quite proximate in the sense that the linguistic concept of *strategy as heuristic* is likely to be of some help in the evaluation of the *instability of genre* and the *diversity of style* in literature.
8. In discourse analysis, discourse is *evaluated by interactional criteria*, such as *efficiency*, *effectiveness* and *appropriateness*, which are not normative or rule-enforcing, but must be demonstrably relevant to the success of communicative events. Similarly, in literary theory, a text does not have a stable value: the reader may appraise it differently every time s/he engages with it, and this *engagement* also has a *transient value*. As de Beaugrande (1993: 443) observes, the fact that literary theory encourages readers to be self-reliant

> *would constitute one application to discursive practices that would also support an advocacy for a literary model of communication as the development and enrichment of the self and the imagination. This would clearly constitute confirmation both by social relevance and by increased insight.*

The parallels between text linguistics/discourse analysis and literary theory highlighted above show a rapprochement, or a marked progress towards the bridging of the incommensurable gulf of stark contrasts that existed between traditional linguistics and traditional literary studies. Against the background of this rapprochement stand a number of differences which flow from the individuality, or idiosyncrasy, of each discipline as an autonomous entity. Rather than acting like 'iron curtains' which intensify paranoia and worsen hostilities, these differences are considerably open borders which encourage mutual acceptance, mutual respect and partnership among the practitioners of text linguistics/discourse analysis and literary theory.

Now that this rapprochement has been firmly established, the next step is to address directly the first question: *Is there a common denominator between linguistics and literary criticism*? Before so, it is worth bringing to light the fact that linguistics refers here to 'modern' linguistics in the guise of text linguistics and discourse analysis, as discussed in parallel with literary theory, and even of transformational-generative linguistics, semantics and pragmatics. And literary criticism should be

understood as the umbrella term for studies that are concerned with the definition, classification, analysis, interpretation and evaluation of works of literature. As such, literary criticism has two mutually inclusive and dependent components: a theoretical component (theoretical criticism or literary theory) and a practical one (practical or applied criticism). In the words of Abrams (1999: 50),

> *Theoretical criticism proposes an explicit theory of literature, in the sense of general principles, together with a set of terms, distinctions, and categories, to be applied to identifying and analyzing works of literature, as well as the criteria (the standards, or norms) by which these works and their writers have to be evaluated […]. Practical criticism, or applied criticism, [however], concerns itself with the discussion of particular works and writers; in an applied critique, the theoretical principles controlling the mode of the analysis, interpretation, and evaluation are often left implicit, or brought in only as the occasion demands.*

With this precision in mind and taking on board the parallel sets outlined above, it is obvious that linguistics is wider in scope than literary criticism: since not all texts are considered as 'literary', the field of linguistics encompasses the uses of language that are much larger than those of a purely 'literary' nature. On the other hand, the criticism of a literary phenomenon is a matter of analyses that transcend the study of texts from a strictly linguistic perspective. Thus, the domains of linguistics and literary criticism do not coincide strictly, but they have common denominators – text and discourse which are accepted as central entities on both sides, although these terms have a wide range of interpretation (de Beaugrande 1993: 441). It is on the ground of these common denominators that linguistic theories, methods and techniques have been informing the theory and practice of criticism in literature since the late 1970s. Structuralist literary critics, for instance, have espoused Saussure's concepts and language analysis procedures as a model for analyzing the forms and organization of large-scale literary structures, and some of them analyze literary texts from the 'pragmatic' perspective, i.e. as systematic plays of codes which effect the interpretive responses of the reader. Likewise, stylisticians and Russian formalists have applied Continental and American linguistics to the analysis of distinctive uses of language in literary texts (Abrams 1999: 141). Discourse analysis has also been helpful in the examination of *dialogue* in novels, short-stories and plays: the chief aim of its application has been the explanation of how characters in a literary work, and readers alike, are constantly able to infer meanings that are not asserted or specified in a conversational exchange. This increasing and enduring commitment of critics with linguistics shows, among other things, that precise knowledge of the mechanisms that regulate the language of a text is of paramount importance in the analysis, interpretation and evaluation of that text (Gary-Prieur 1985: 13-14).

Indeed, language, the 'medium' or 'vehicle' of literature (Griffith 1982: 10), takes on particular importance in all literary texts. This importance varies from genre to genre. Robins (1973: 336-337) gives the example of European literature in which poetry and oratory prose depend more on the linguistic material out of which they are composed than narratives and stories in prose. In poetry, too, lyrical poetry depends much more on language itself than dramatic poetry does. There are also literary texts which owe their specificity and their aesthetic value to the peculiar or unordinary forms of language used in them. Far from being the private property of literary critics, these works constitute an important corpus of specific data that linguists can use for the study of a given language, or, more generally, for the study of the use that human beings make of language.

Additionally, there are texts that pose some linguistic problems. As a matter of fact, for old texts (by Chaucer, for example), the language is simply an obstacle to reading, and in order to read these texts, one has to 'learn' the form of English in which they are written as a foreign language. Fortunately, such texts have already been 'translated' into modern English to make them accessible to a wide readership. But even modern English texts have their own share of language-related problems, such as the change in the meaning of a word over time or the acceptability of this or that construction. Therefore, for an in-depth study of a given 'text', it is mandatory that the knowledge of the structural and functional behavior of the language (in which that text is written) be coupled with the knowledge of its historical development.

It is on the basis of the importance of language in literature that no critic can satisfactorily study a literary text without paying due attention to its medium, language (Hayes 1969: 198), in the same way as no one can study music without knowing harmony, or painting without knowing the physics of colours (Gary-Prieur 1985: 12). Also, it is on this basis that the linguist has the right to make literary judgments. It is undeniable that one part of the 'aesthetic appreciation' of literature, whether it concerns the entire production of an author, or just a particular text, written or spoken, lies on the specific use of the linguistic material at the phonetic, morphosyntactic and lexical levels. Therefore, the application of the tools of linguistic science to the study of literary texts can prove useful at the specific stage of 'language evaluation'.

Now that I have, hopefully, addressed the question about whether or not linguistics and literary criticism have a common ground, it appears that linguistics and literary criticism simply cannot be like East and West, the twain that shall never meet, according to a famed ballad by Kipling. Their disciplinary connection is undeniable, and the reinforcement of this rapprochement is one of the undying concerns of not only some literary critics (deconstructionists, Russian formalists,

semioticians, structuralists and stylisticians), but also of some linguists at both collective and individual levels. In fact, the Ninth International Congress of Linguists discussed, for the first time in the history of such important cultivated conferences, the connection between linguistic stylistics and poetics (Hayes 1969: 197). Also, influential scholars, such as Roman Jakobson, Morris Halle and Archibald Hill, have endeavoured to study literary texts along the lines of the methods of linguistics, and some have suggested that criticism depends first upon detailed analysis.

Roman Jakobson strongly believed that it was as much anachronistic for linguists to exclude or distance from their field of investigation the poetic or literary text, as for literary critics to refuse to resort to linguistic tools in their analysis. As far as Jakobson's personal case is concerned, Faye et al. (1972: 48-49) report, it is *poetics* (literature) that led him to *linguistics*: at school, he was very much interested in poetry, and he used to think of specializing in literary history. But soon he realized that his questions touching on the analysis of literary works - for example the question about the grammar of poetic language - were likely to get answers only from a linguistic perspective. Jakobson later presented his contributions to the explication and analysis of literary texts along the lines of linguistic methods in his 1960 famous essay "Linguistics and Poetics", and in his now-classic book *Poetry of Grammar and Grammar of Poetry*.

Linguist Morris Halle, Jakobson's student and disciple, soon followed suit. As a pioneer of generative phonology, he was the first to be interested in and to discuss the relative similitude between the study of metrics (poetics) and the study of phonology (linguistics). And he published remarkable essays on Chaucer, on metrics, and on iambic verses. As Faye et al. (1972: 58) report, the conjoint works of Morris Halle and Samuel Jay Keyser in generative phonology have found a fertile ground of application in poetics, and more especially in prosody.

As to Archibald Hill, in his now-acclaimed articles "Analysis of *The Windhover*: An Experiment in Structural Method" and "Some Points in the Analysis of Keats' *Grecian Urn*", he attempted to move from linguistic analysis to literary criticism without, however, making any overt distinction between them. In commenting upon one of his studies, Hayes (1969: 199) reports, Hill said:

> *I do not know, and do not much care, whether the method I have followed is linguistic or literary. There is a reason for my indifference. I think of the two disciplines as one, and I do not believe that it is impossible to carry on both, either successively or at the same time.*

Hill's bold and worrisome indifference calls to mind the second question: *Are literary texts fully amenable to a strictly linguistic analysis?* This question is so complex that it cannot be answered straight out. Two important considerations will capture this complexity, and pave the way to an unequivocal answer. The first consideration is that since linguistics aims to attain scientific, objective knowledge, its investigation method is purely analytical. The linguist thus reduces a 'text' to a tissue of relations or to elements that relate to one another following the laws of association. From this perspective, a 'text' is just the sum total of elements that the linguist is tasked with enumerating and delineating precisely. After the 'text' writer has achieved a synthesis in their own way, it is now the business of the linguist to generate an analytic or a structural knowledge of this whole by breaking it down into its constituent parts. It is problematic to apply this way the insights of structural linguistics to complex literary works. While transformational-generative linguistics, for example, can elucidate deep structures, it cannot account for literary effects which are often achieved by highly individual means. Also, generative grammars of narrative have difficulty providing much insight into works more elaborate than folktales or detective stories (Damrosch 2003: 518-519).

The second consideration is that a 'literary text' is not just any text: it is a 'work of art' *sui generis* like a painting or a sculpture. Therefore, contrary to what Ihwe (1975: 133) claims, not all the properties that make a given 'text' into an instance of 'literature' are describable in solely linguistic terms. As a work of art, a 'literary text' is not composed according to the laws of analytic thought, i.e. by summing elements, and, hence, it is not pliable to a reader's perception through a step-by-step revelation of its parts (Piguet 1967: 114). It is as much counterproductive to 'appraise' a painting, or a sculpture, by considering *first* its colours and lines, *then* its structures and, *finally*, its aesthetic values, as to 'appreciate' a poem by moving successively from the lexical units and phrasal categories that make up each verse to their grammatical functions and the semantic relationships between them. Of course, structure-oriented analysts will ask pointedly: Why is it so? Well, the reason is that, as an artifact, a 'literary text' is a whole that has precedence over its parts. To borrow a metaphor from Schopenhauer, a literary text is a large diamond which, cut up into little bits, will entirely lose the value it had as a whole; or an army which, when divided up into small bodies of soldiers, loses all its strength. A literary text enjoys some kind of irreducible wholeness, some kind of unity that exists even before the distinction between 'signifier' and 'signified'. This unity challenges all sorts of linguistic dissociations, and calls for a *Gestalt approach*, or an approach that counterbalances systemization and close attention to details: we need to see both the forest and the trees.

It is deducible from the above premises, or considerations, that 'literary texts' cannot be fully amenable to a strictly linguistic analysis. This analysis tries hard to decompose a 'literary text', which is an artistic phenomenon, and, by so doing, it collides time and again with indecomposable units of meaning. Every 'literary text', just like every work of art, is made up of global units of meaning that can be perceived by an 'artistic mind', but that cannot be rendered adequately by an 'analytic mind' (Piguet 1967: 114). For this reason, these global units of meaning are impassable obstacles to a purely analytic study of literary texts. If a 'literary text', as a work of art, is characterized by 'internal totality', or the union of the 'word' and the 'thing', then it cannot be decomposed analytically without ceasing to exist altogether. That is why both pure analysts (who neglect this 'unity' by decomposing 'literary texts' into their constituents) and formalists (who view 'literary texts' as associations of formal elements) have been accused of committing a crime known as 'reductionism'.

Linguists will not hear anything to do with this accusation, though. To them it is a 'story' completely made up by literature essentialists to establish the categorial particularity of literature by the 'non-linguistic side' of texts and, hence, to justify the divorce between 'literary texts' and the analytical methods of linguistics. On the one hand, they averred that the paradigm shifts that occurred in linguistics over time make it possible to 'analyze' the 'content' in terms of the 'linguistic side' of texts. As Ihwe (1975: 134) observes, this kind of analysis

> *is already true in principle for so-called 'Russian Formalism' in a later phase of its development […]. Today the accent in linguistics lies more on the question of what role semantics should play and what form of semantics is needed in a fully formalized grammar theory […]. There are first attempts to come to a unitary theory on the basis of results established from the theory of 'narrative' structures, a point arguing for the extension of contemporary theories of grammar and thus also of the linguistic concept of structure.*

On the other hand, linguists dismissed literary critics' pronouncements as being 'too vague and too imprecise to be of much value' (Hayes 1969: 198), and moved on to affirm in earnest that, with just a little adjustment of the general categories along the lines of which 'ordinary texts' are described, 'literary texts' also fall entirely within the compass of their enquiry. And, all the more so, literary theory or criticism is basically an appendage of linguistics that preserves some independence solely because of a special refinement of the techniques of description (Ihwe 1975: 137). This is also a line of reasoning one finds in Jakobson's (1960) essay 'Linguistics and Poetics' and in his remarks concluding the Ninth International Congress of Linguists: 'The study of poetry [is] inseparable from linguistics and [is] its pertinent task'[2] (Hayes 1969: 197).

This view, however, fails to take into account this fundamental difference between linguistic analysis and literary criticism: the primary interest of linguistic analysis is empirical data, while the chief concern of literary criticism is value. And, as David Lodge (1960) quite rightly observed in his book *Language of Fiction*, values are not amenable to scientific method. Linguistic analysis is thus too 'descriptive' and 'objectifying' to be sensitive to the 'aesthetic appeal' of 'literary texts', and, when solely applied too strictly, its methods can destroy or seriously impair the 'beauty' of such texts. Analysts cast a scientific look at a 'literary text', i.e. they consider it simply as an 'object'. As such, they study it 'objectively' to reach its meaning. Critics, however, go beyond as to view it in terms of the expression of a 'subjective' experience and, hence, as a 'reality'. This literary reality is made up of a system of signs which is characterized, from the outset, by an irreducible unity. It is a fact of the mind that comprises both the being of the creator (poet, novelist or playwright) and a literary language intermediating between this creator and his/her universe. The fundamental relation of this system of meaning covers extremely complex phenomena that can be perceived directly and from within (literary criticism perspective) or approached from without by using a method (linguistic analysis perspective) that tries to account for objects of art (Piguet 1967: 120).

This distinctness does not mean that linguistics and literary criticism are poles apart from each other, and that linguists do not, therefore, have the right to make literary judgments. It rather means that there can never be between them any relation of *substitution*, but only that of *complementarity*, i.e. a mutually enriching connection based on an uncondescending exchange of ideas. Actually, a constant interpenetration of analysis and criticism is somehow unavoidable, especially when the critic's point of departure is the study of the language of a 'literary text'. On the one hand, a holistic assessment of a 'literary text' cannot overlook its 'style', and the study of style inevitably passes by the consideration of the general means of expression common to all speakers of the language in which that text is written. On the other hand, a linguist's attempt to an inventory of different stylistic traits specific to a given code (language) simply cannot overlook individual styles as they are

[2] *Frye rebels against such an 'imperialistic' view in his Anatomy of Criticism (1957), where he argues that literary criticism should draw directly from literature the necessary instruments of analysis, and that it should be free from the dependence on other disciplines such as philosophy, psychoanalysis, history, etc.*

displayed in 'literary texts'. More importantly, since artistic awareness is perceptive in nature, a better understanding and appreciation of 'literary texts' calls for the critic's inner aesthetic perception to be coupled with adequate discursive knowledge following the laws of this perception, and not those of the speech made about it (Piguet 1967: 115). This entails that it is necessary for the critic to be trained not only in the study of literature as art, but also in that of language. As to the language scientist, a radical refinement and adjustment of their methods is needed for literary texts to fall within the realm of their study. Radicalism means here that, in addition to their being conversant with literary aesthetics, the linguist should subordinate their analytic and descriptive methods to the laws of artistic perceptiveness and sensitiveness as required by literary texts.

3 CONCLUSION

Linguistics and literary criticism are two disciplines whose definitively established borders cannot be blurred. There are three main reasons for this impossibility. The first is orientational: linguistics has a scientific orientation and, as such, it is primarily interested in objective, verifiable data. As to literary criticism, in spite of the wish and enterprise of scholars like Frye and Hirsch to establish it as a 'science', it remains more artistic than empirical and systematic. In this regard, literary criticism always takes an aesthetic orientation and is, therefore, chiefly concerned with value.

The second reason is methodological: since linguistics is scientific in nature, its method is strictly 'analytical' and 'descriptive'. It is typical of a linguist to proceed by breaking a whole down into its components and to move from the outside (structure-function) of a text into its inside (content), by leaning on the former and paying more attention to language. On the contrary, the method of literary criticism is essentially 'perceptive', 'intuitive' and 'evaluative'. A critic attempts to perceive a text in its irreducible artistic wholeness. Since his/her focal point is the inside of texts, the critic listens more to the voice of the artist (writer).

The last reason, which is teleological, is that linguistics, as a scientific investigation, aims at drawing from the study of texts a set of workable, abstract principles or of sufficiently generalizable results about language behaviour and use. Likewise, literary criticism is a rigorous inquiry that intends to lay out an *organon* of methods (Wellek and Warren 1987: 19), i.e. a set of universal terms, general principles and criteria for the evaluation of literary texts. However, it also seeks to uncover the individual characteristics of each text in terms of the aspects of existential experience that underlie it, its quality or value, as well as the formal and stylistic choices made by its author.

The impossibility of border blurring does not, however, imply that no interdisciplinary connection can take place. In fact, a fruitful exchange of findings and perceptive observations should be encouraged because linguistics and literary criticism are contiguous disciplines that converge on the understanding of language, texts and discourses. On the one hand, since language is the vehicle of literature and the object of linguistics, the linguist has the right to make literary judgments. Furthermore, the methods of linguistics can be of help at some stages in the analysis of literary texts. On the other hand, the procedures of literary criticism can inform the practice of the linguistic analysis of texts. In the light of this complementarity, any contretemps between linguists and critics as to the germaneness of each other's specific contributions is intolerable. It is beneficial to both to adopt this philosophical attitude which consists in listening to and learning from each other for self and mutual enrichment, and in seeking the unification of apparent irreconcilables.

REFERENCES

[1] Anttila, R., *Linguistics and Philology*, In: R. Bartsch and T. Vennemann (Eds.), Linguistics and Neighboring Disciplines, The Hague: North-Holland Publishing Company, pp. 145-157, 1975.
[2] C. Lévi-Strauss, *Structural Anthropology*, Vol. 2. (Trans. M. Layton). Chicago: The University of Chicago Press, 1958.
[3] DeCamp, D., *Linguistics and Teaching Foreign Languages*, In: A. A. Hill (Ed.), Linguistics. Washington, D.C: Voice of America/Forum Lectures, pp. 157-168, 1969.
[4] D. Damrosch, "World Literature, National Contexts," *Modern Philology*, vol. 100, no. 4, Toward World Literature: A Special Centennial, pp. 512-531. Chicago: The Chicago University Press, 2003.
[5] D. Lodge, *Language of Fiction*. London: Routledge and Kegan Paul, 1966.
[6] Hayes, C. W., *Linguistics and Literature: Prose and Poetry*, In: A. A. Hill (Ed.), Linguistics. Washington, D.C: Voice of America/Forum Lectures, pp. 197-211, 1969.
[7] Ihwe, J., *Linguistics and the Theory of Literature*, In: R. Bartsch and T. Vennemann (Eds.), Linguistics and Neighboring Disciplines. The Hague: North-Holland Publishing Company, pp. 131-144, 1975.
[8] J. Baudrillard, *The System of Objects*. (Trans. J. Benedict). London: Verso, 1968.
[9] ----------, *The Consumer Society: Its Myths and Structures*. London: SAGE Publications Ltd, 1970.

[10] J. Derrida, *Of Grammatology* (Trans. G. Spivak). Baltimore: Johns Hopkins University Press, 1967.
[11] ----------, *Writing and Difference* (Trans. A. Bass). Chicago: The University of Chicago Press, 1967.
[12] J. Lacan, *Ecrits*: *The First Complete Edition in English* (Trans. B. Fink). New York: W. W. Norton & Co, 1966.
[13] J. P. Faye, J. Paris, J. Roubaud et M. Ronat, *Hypothèses: Trois entretiens et trois études sur la linguistique et la poétique – Roman Jakobson, Morris Halle, Noam Chomsky*. Paris : Editions Seghers/Laffont, 1972.
[14] J. Richards, J. Platt and H. Weber, *Longman Dictionary of Applied Linguistics*. Essex, England: Longman Group Limited, 1985.
[15] K. J. Griffith, *Writing Essays About Literature: A Guide and Style Sheet*. Washington: Harcourt Brace Jovanovich, Inc, 1982.
[16] L. Althusser, *For Marx* (Trans. B. Brewster). London: Verso, 1965.
[17] L. Althusser and E. Balibar, *Reading Capital* (Trans. B. Brewster). London: The New Left Books, 1965.
[18] L. Bloomfield, *Language*. New York: Holt, 1933.
[19] M. B. Kambale, *A Course in Applied Linguistics for Fourth Year English Students*. Bukavu: ISP, Department of English, 2011.
[20] McQuown, M. A., *Linguistics and Anthropology*, In: A. A. Hill (Ed.), Linguistics. Washington, D.C: Voice of America/Forum Lectures, pp. 171-183, 1969.
[21] M. Foucault, *The Order of Things: An Archeology of Human Sciences*. New York: Pantheon Books, 1966.
[22] M. H. Abrams, *A Glossary of Literary Terms*. Boston, Massachusetts: Heinle and Heinle, 1999.
[23] M. N. Gary-Prieur, *De la grammaire à la linguistique : l'étude de la phrase*. Paris: Armand Colin, 1985.
[24] N. Chomsky, *Syntactic Structures*. The Hague: Mouton, 1957.
[25] N. Frye, *Anatomy of Criticism*. Princeton, New Jersey: Princeton University Press, 1957.
[26] Piguet, J. C., *Langage et Art*, In: *Le Langage II : Actes du 13ème Congrès des Sociétés de Philosophie de Langue Française*. Neuchâtel : à la Baconnière, pp. 111-126, 1967.
[27] R. de Beaugrande, "Closing the Gap between Linguistics and Literary Study: Discourse Analysis and Literary Theory," *Journal of Advanced Composition*, vol. 13, no. 2, pp. 423-448, 1993.
[28] R. H. Robins, *Linguistique Générale : Une Introduction*. (Trad. S. Delesalle et P. Guivarc'h). Paris: Armand Colin, 1973.
[29] R. Wellek and A. Warren, *Theory of Literature*, 3rd Ed. New York: Harcourt Brace & Company, 1984.
[30] T. Eagleton, *Literary Theory: An Introduction*, 2nd Ed. Minnesota: University of Minnesota Press, 1996.