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CHARACTERIZATION OF INDUSTRIAL WASTEWATER TREATED BY NATURAL LAGOON (PAPER MILL IN SIDI YAHIA GHARB, MOROCCO)

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ABSTRACT: The impact of industrial effluents on environment is an obvious reality and a serious threat in the medium term for the quality of surface water and ground water as well. The impact on the water environment surrounding the paper mill (CDM) in Sidi Yahia Gharb is mainly due to the use of water in the manufacturing of pulp using the Kraft process and the discharge of waste effluents in: the Maâmora forest, its water table and Sebou River.

The physicochemical characterization of wastewater studied during the probationary period 2012/2013 was used to assess their properties and degree of pollution. Raw release is characterized by an average pH of 6.3 in summer and in winter 7.9; an average temperature of 47°C in summer and 41°C in winter; an average (BOD5) of 334.3 mg/L in summer and 252.8 mg/L in winter; an average (COD) of 1072.2 mg/L in summer and 1567.5 mg/L in winter and average levels of (SS) 48.8 mg/L in summer and 86.6 mg/L in winter. These liquid wastes are of a mixed nature (COD/BOD5 is between 3 and 5).

During wastewater treatment, the average purification efficiency reaches 40.7% (BOD5), 38.5% (COD) and 66.1% (SS). This assessment allows us to say that biological Wastewater Treatment Plant (WWTP) of the CDM is inefficient and do not meet the standards of indirect discharges.

KEYWORDS: CDM, Wastewater Treatment Plant (WWTP), physicochemical parameters.

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1 INTRODUCTION

Water is a precious commodity that undergoes various types of pollution and degradation of various origins: industrial, domestic and agricultural. With the industrial revolution of the nineteenth century, the value of water vapor has not only the answer to the need of the industry but also the development of its productive capacity. Water has become an essential material for the operation of plants. Consequently, water is faced with difficult situations and causes disruption of all ecosystems especially aquatic systems. The major problems of water in Morocco today are related firstly to the overexploitation of water supplies, and secondly to the degradation of the quality of water resources given the inadequate and sometimes the lack of wastewater treatment [1]. In Morocco, the pulp and paper industry has always been linked to a greater need for water consumption. Indeed the paper industry ranks third in the world for the use of water (5 to 20 m3 per ton of paper produced) and is one of the industries with the greatest amount of effluent [2].

The present work aims to characterize the physicochemical properties of raw and treated wastewater of the industrial unit Cellulose Du Maroc (CDM) during the internship period 2012/2013. Its main objective is to highlight the degree of pollution from various industrial activities of this unit and deduce the performance of the water treatment station in question. This study is based on physicochemical parameters such as pH, temperature, biological oxygen demand (BOD5), chemical oxygen demand (COD) and suspended solids (SS).

2 MATERIALS AND METHODOLOGY

2.1 STUDY AREA

Cellulose Du Maroc is located 4KM from Sidi Yahia Gharb (Figure 1). The city of Sidi Yahia Gharb is a municipality within the province of Sidi Slimane and is part of the region of Gharb Cherarda Bni Hssein. Sidi Yahia center is located about 26 km north east of the city of Kenitra and connects the cities of Kenitra and Sidi Slimane on the main road RP3 [3]. The city of Sidi Yahia Gharb is located along South East Gharb plain, on the transition zone between the Maâmora and the Gharb water tables; it is a very low but large basin that covers an area of 616 ha. The population of this city, according to the 2004 census, is 31705 inhabitants. The climate of Sidi Yahia Gharb is marked by:

- The oceanic influence, within a sub humid bioclimatic zone with a moderate temperature in winter.
- Higher air humidity and lower temperature.

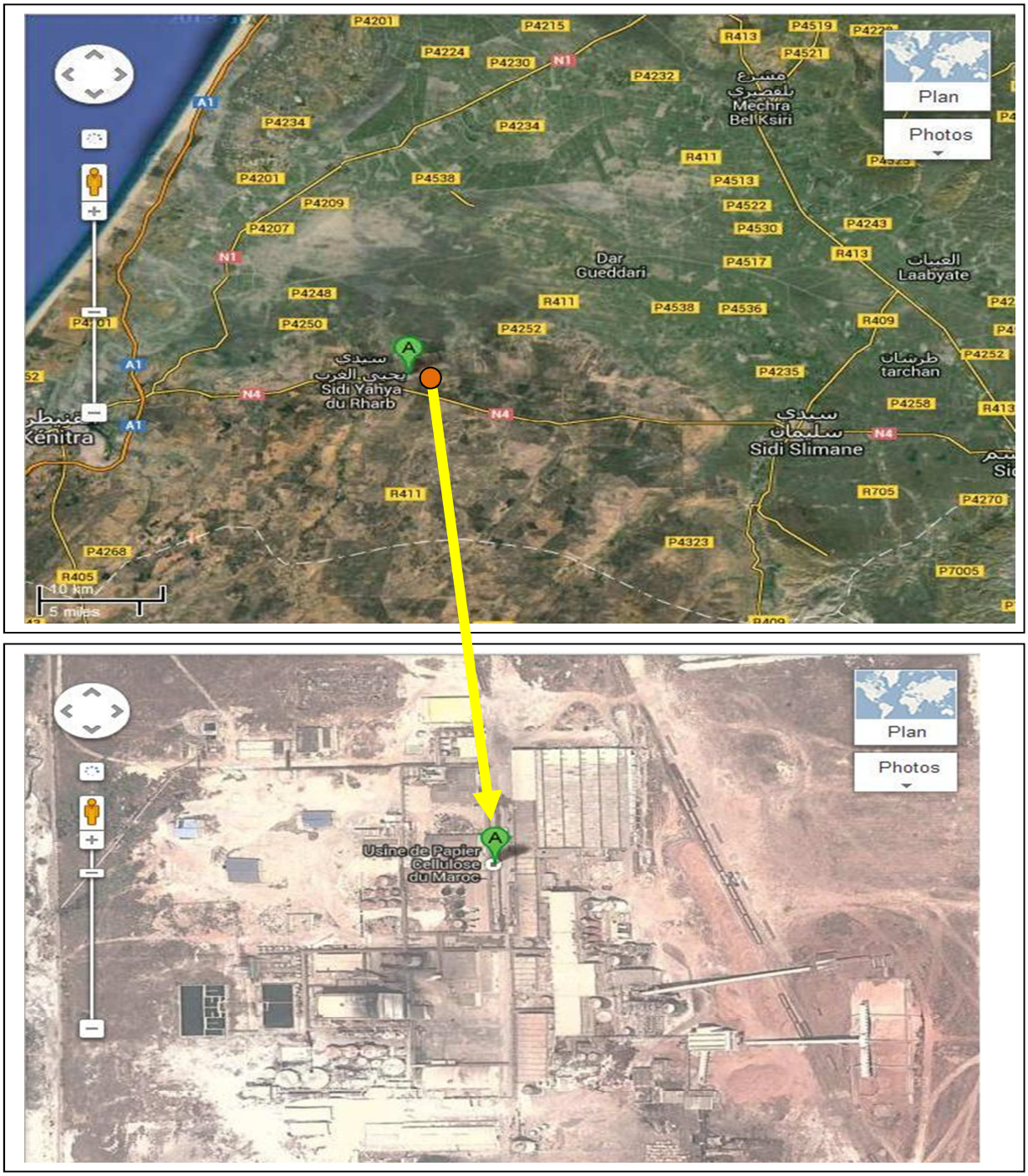

Fig.1. geographical location of Sidi Yahia Gharb and paper mill (CDM).

Founded in 1952, Cellulose Du Maroc (CDM) manufactures pulp by the KRAFT process using caustic soda (NaOH) and sodium sulfide (NaS_2) as cooking liquor (processed in sodium sulfate). Eucalyptus is used, 50% of which comes from Moroccan forests and the other part is imported. The choice of the location of this paper mill can be justified by the following factors:

- The presence of a large groundwater (Maâmora 390 km² in stretch).
- The existence of a road and rail infrastructure facilitating transactions.
- The presence of the port of Kenitra.
- The existence of a nucleus plantation covering 10 000 ha during its creation.

2.2 DESCRIPTION OF WASTEWATER TREATMENT OF CDM

Effluents from the paper mill of CDM are processed by the natural lagoon. This Wastewater Treatment Plant (WWTP) is composed of three basins in a series of varying depths of one meter to 1.5 meters. Wastewater can stay there for about 5 days in summer and winter. No mechanical ventilation, however, is provided for these two basins. The first basin is 300 m long by 30 m wide. The second tank has a width of 35 m and a length of 350 m. The last portion of the treatment cell is the maturation pond with a width of 35 m and a length of 380 m. This terminal provides the sedimentation of organic waste that remains in suspension and the elimination of pathogens.

2.3 SAMPLING AND ANALYSIS OF WASTE WATER

The sampling was carried out in the anaerobic wastewater treatment unit during the summer of 2012 (June, July and August 2012) and the winter of 2012/2013 (November, December 2012 and January 2013).

The samples were taken at two specific locations: at the entrance of the WWTP (raw wastewater) and the output of the WWTP (treated wastewater).

Wastewater samples were taken in a1 liter plastic container and then stored at about 4 ° C.

Physicochemical parameters under observation were: temperature, pH, Chemical Oxygen Demand (COD), biochemical oxygen demand for 5 days (BOD5) and suspended solids (SS).

The temperature and pH were determined by a Consort C831 pH meter with a temperature measuring probe.

The SS (Suspended Solids) are determined by filtering a volume of waste water by means of a borosilicate glass fiber filter.

The COD was determined by the colorimetric method (oxidation with potassium dichromate in acid) [4].

Biochemical oxygen demand (BOD5) was determined by the OxiTop method which is still one of the most important measures in hydrology. It assesses water and wastewater loads in biodegradable substances.

3 RESULTS AND DISCUSSIONS

In the paper mill, the water takes part in the manufacturing process as a factor of dispersion and transport of fibrous raw materials and additives. The many tasks assigned to water makes of it a key element both qualitatively and quantitatively. Detailed results of the physicochemical analysis of wastewater of Cellulose du Maroc are summarized in tables 1, 2, and 3.

Table 1. Physicochemical parameters of raw wastewater

Parameters	Number of samples	Summer				Winter			
		Min.	Max.	Average	Standard Deviation	Min.	Max.	Average	Standard Deviation
T (°C)	16	45	49	47	2	39	44	41	2,6
pH	16	5,1	7,18	6,3	1,1	7,36	8,25	7,9	0,5
BOD5 (mg/L)	16	301,67	382,75	334 ,3	42,8	195,90	325,5	252,8	66,2
COD (mg/L)	16	857	1427	1072,2	309,6	1221	1812,67	1567,5	308,7
SS (mg/L)	16	15,50	83,33	48,8	33,9	18	196	86,9	95,5
COD/BOD5	16	2,69	3,73	3,2	0,5	5,57	7,04	6,3	0,7

Table 2. Physicochemical parameters of treated wastewater

Parameters	Number of samples	Summer				Winter			
		Min.	Max.	Avg.	Std. Dev.	Min.	Max.	Avg.	Std. Dev.
T (°C)	16	32	35	33,3	1,5	30	41	34,3	5,9
pH	16	4,54	7,10	6,1	1,4	7,49	7,72	7,7	0,2
BOD5 (mg/L)	16	164,67	315,25	224,8	79,7	93,67	140,33	121,8	24,8
COD (mg/L)	16	425,5	782	597,2	178,6	792	1090	1023,8	206,8
SS (mg/L)	16	3,50	26,67	12,8	12,2	16	24	31,6	20,4
COD/BOD5	16	1,85	4,75	2 ,9	1,6	6,02	7,8	8,8	3,5

Table 3. Daily pollutants flux totals and corresponding average concentrations of (CDM), calculated from the average of two studies (summer & winter of 2012/2013).

Pollutants (2012/2013)	Flux rate (m^3/j)	Flux total at the entrance	Flux total eliminated	Flux totals at the exit	Average global output of the WWTP (en %)
COD_{avg} (mg/L)		1319.85	509.35	810.5	38,5%
COD (kg/day)	17000	22437450	8658950	13778500	
$BOD5_{avg}$ (mg/L)		293.4	119.7	173.3	40,7%
DBO5 (kg/day)	17000	4987800	2034900	2946100	
SS_{avg} (mg/L)		67.7	44.8	22.2	66,1%
SS (kg/day)	17000	1150900	761600	377400	

The demand for paper products will increase over the next decade and this trend will most likely have an impact on the aquatic environment. Given the drastic measures of legislation with regard to the discharge limits authorized in the natural environment, industries are paying more and more attention to the treatment of effluents.

Table 4. Specific Discharge Limit Values applicable to discharges from industries of pulp, paper and cardboard [5].

Parameters	Specific Discharge Limit Values	
	Pulp paper Industry	Pulp paper and cardboard industry
Temperature	30 °C	Do not exceed 10 ° C temperature of the receiving environment
pH	5,5-8,5	5,5-8,5
BOD5	100 mg/L	200 mg/L
COD	1000 mg/L	900 mg/L
SS	200 mg /L	400 mg/L
Iron (Fe)	3 mg/L	3 mg/L
Sulfide ($S2^-$)	2 mg/L	--
Arsenic (As)	0,1 mg/L	0,1 mg/L
Aluminium (Al)	10 mg/L	--
Zinc total	2 mg/L	mg/L

3.1 THE TEMPERATURE

Variations in the temperature of the WWTP have important effects because they influence the development of colonies of micro-organisms [6].

At the entrance to the WWTP, the water temperature is an average of 47°C in summer and 41°C in winter. At the outlet of the WWTP, the water temperature is an average of 34.3°C in summer and 33°C in winter. These temperature values

represent a risk of thermal pollution to the receiving environment, but in favor of an acceleration of the biological processes of waste water and mud, as they contribute to increasing the kinetics of degradation of organic matter [7].

3.2 pH

The pH is an efficient pollution indicator which varies according to the basic nature of the effluent (cooking, washing of resin: NaOH, NA_2S) or acid (dioxide, washing the resin: H_2S_4). The biological pH range is between 6.5 and 8.5 [8]. During the two sampling periods, the pH of the WWTP remained relatively constant at the output. However, it was noted that the pH of the raw effluent has large fluctuations. Indeed values vary between 4.6 and 8.25 units and the average value is around 6.3 to 7.9 in summer and winter. pH fluctuation of the raw effluent is due to the use of chemicals at the bleaching stage (ClO_2 and SO_2).

3.3 Suspended Solids (SS)

The effluents are better characterized and described in terms of BOD5, SS and COD. Suspended solids (SS) do not decrease enough during their passage through the WWTP. This stability is due to the fact that SS consist mainly of wood fibers, which because of their short length, are not retained by the sieve during the process of transformation [9]. In addition, remaining suspended solids (including lignin) are less biodegradable and usually take a long time to degrade [10]. At the entrance of the WWTP, suspended solids (SS) are on average 86.9 mg/L in summer and 48.8 mg/L in winter. At the end of WWTP, they are averaging 31.6 mg/L in summer and 12.8 mg/L in winter, while in a similar study by BeiSavance (1998) in Canada [11], the values averages found at the outlet of the WWTP are 27 mg/L was 50 mg/L in the winter. These values recorded at the entrance of the basin, both in summer and winter, indicate that they are within paper mill emissions standards (200 mg /L) [5].

3.4 Chemical Oxygen Demand: COD

COD is used to assess the concentration of organic or mineral materials, dissolved or suspended in water, through the amount of oxygen required for the total chemical oxidation. At the entrance to the WWTP, the average COD is 1072.2 mg/L in summer and 1567.5 mg/L in winter. At the outlet of the WWTP, the average COD is 597.2 mg/L in summer and is1023.8 mg/L in winter. In comparison with the COD of other food industries [12], these values are lower but they exceed the limits of discharges of pulp industries by the Moroccan standard (1000 mg/L) [5].

3.5 Biochemical Oxygen Demand: BOD5

BOD indicates the amount of oxygen which is used for the destruction of organic substances decomposed by biochemical processes [13]. At the entrance of the WWTP, BOD5 is in average 334.3 mg/L in summer and 252.8 mg/L in winter. At the output of WWTP, BOD5 is in average 224.8 mg/L in summer and 121.8 mg/L in winter. These values exceed the limits of paper discharges by the Moroccan standard (100 mg/L) [5].

3.6 The ratio COD/BOD5

The COD/BOD5 ratio is relevant to the definition of the chain of effluent treatment (COD/BOD5 ratio less than 3) [14]. Indeed, a low value of COD/BOD5 ratio implies the presence of a large proportion of biodegradable material and makes it possible to think of biological treatment. Conversely, a large value of this ratio indicates that much of the organic material is not biodegradable and, in this case, it is preferable to consider a physicochemical treatment. The results of this report stress the importance of pollutants which are less biodegradable or not biodegradable at all. At the entrance to the WWTP, the average ratio of COD/BOD5 is 3.2 in summer and 6.3 in winter. At the outlet of the WWTP, the COD/BOD5 ratio is 2.9 in summer and 8.8 in winter. The treatment efficiency of the WWTP of CDM classifies wastewater from the CDM as mixed (containing organic and inorganic materials) and less biodegradable since the COD/BOD5 ratio at the outlet of WWTP is between 3 and 5. Thus, the COD/BOD5 ratio confirms the specificity of wastewater from paper mills in general and the CDM in the city of Sidi Yahia, in particular, for being mixed; hence, a suitable biological treatment might be suitable.

3.7 FLOW POLLUTING TOTAL OF THE CDM

For COD, BOD5 and SS, table 3 shows that daily concentrations remain very high at the entrance and the exit of the WWTP. They get from 22437450 kg/day to 13778500 kg/day for the (COD), from 4987800 kg/day to 2946100 kg/day for (BOD5) and from 1150900 kg/day to 377400 kg/day for (SS) with a turnover rate of approximately 40.7%, 38.5% and 66.1% respectively. The high turnover rate of SS is mainly due, on the one hand, to the improvement of the system of fiber recovery in the processing plants, and secondly, to the fact that the suspended solids reside easily. Furthermore, it should be noted that the development of a foam layer is due to the hydrolysis of various fats used or generated during the manufacturing process of pulp.

4 CONCLUSION

This work was carried out in order to diagnose the physicochemical state of the wastewater of industrial paper mill of the city of Sidi Yahia Gharb and to assess the performance of its WWTP. We can safely conclude that:

The effluent from the CDM is relatively concentrated compared to the grid established for Moroccan pulp mill effluents. This wastewater concentration is reflected in this case by the mean values of COD and BOD5 exceeding the upper limits of normal range [5].

Temperatures and pH slightly exceed the standards of papermaking discharges.

The COD/BOD5 ratio, calculated through the monitoring results during the 2012/2013 study, shows an average value of 4.5.These liquid wastes are of a mixed nature, which means that these effluents contain biodegradable substances and other poorly biodegradable ones(lignin).

suspended solids (SS) meet specific limited values of papermaking releases set by Decree No. 5448 of 29 Jumada II 1427. Rabat 2006.

The purifying efficiency of the WWTP of CDM of BOD5, COD and SS are respectively 40.7%, 38.5% and 66.1%. These results are restricted because the treatment is limited in anaerobic lagoons.

This assessment enables us to say that the WWTP of the CDM is less effective. For this reason and to meet the Moroccan standards papermaking releases, we recommend two solutions:

1 - Improving the technique used by making optional and maturation lagoons.
2 - The transfer of the natural lagoons into aerated lagoons feeding the existing anaerobic lagoons by aerators.

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