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Purifying Performance of the STEP of Mrirt (Natural lagoon)

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Abstract

The purifying system of the domestic lagoon sewage remains one of the most widely used processes in Morocco (81% of lagoon-type wastewater treatment plants) since it is the most technical solution which is suited to the economic and climatic conditions of our country. Throughout this work, we tended to study the purifying performance of the wastewater treatment plant in the town of Mrirt, by measuring the parameters, which indicate the pollution degree, namely BOD5, COD and TSS. According to the results obtained from those parameters, we determined the causes of the non-conformity of rejection for the global parameters of pollution with respect to the unfiltered samples and proposed the solutions for the good purification of the STEP with a tertiary treatment, which is based on the physicochemical methods of the water discharged into the natural environments. In the light of this work, the monthly results throughout the last two years (2012-2013) concerning the parameters of the raw and purified wastewater studied and discharged from the town of Mrirt have shown that the average BOD5 which is recorded at the inlet and the outlet of the STEP is respectively 575 mg O2 / l and 159 mg O2 / l. On the basis of the obtained results, it can be said that the most suitable kind of the natural lagooning process in Morocco (the town of Mrirt) remains very sensitive to the various factors influencing the effluent yield of the STEP such as the accumulation of sludge at the level of the anaerobic basins, the climate change out of the seasons (temperature variation), residence period, volumetric and superficial load, the algal development ...etc.

Keywords: *Mrirt, constructed wetlands; physico-chemical parameters; the levels of pollution; wastewater treatment plant; wastewater treatment; wastewater treatment.*

1. Introduction

A health problem arose dramatically since the early beginning of urbanization. The concentration of all kinds of wastes occurred because of the increase in population density, such as human wastes, fecal matter and urine [1]. These (liquid) wastes creates more problems partly because they are olfactively present and partly because they are the source of a multitude of infections and diseases. According to the World Health Organization (WHO), 80% of diseases affecting the world's population are partly linked to the insufficient evacuation of faecal matter. [2] The hydraulic disposal of this urban waste Liquids (sewage), which can sometimes be mixed with storm water, is carried out by using the so-called liquid sanitation. The latter is a fundamental part of the water cycle, the receiving environment and the urban environment through the evacuation of sewage and storm water [3]. It is both a noble mission and a valuable means to fight pollution and to safeguard the health of the environment whose objective is twofold [4]. On the one hand, it ensures the public hygiene by collecting and evacuating wastewaters, on the other hand, it protects the environment by purifying the wastewaters before it is discharged into the natural environment. The liquid sanitation has a role to recover the water, which is used by man in his daily life, and to evacuate them without stagnation as quickly as possible to a treatment facility, which is called sewage treatment plant (STEP) [5]. Wastewater treatment allows the water to be recovered in several areas. It contributes to the solving of the water scarcity problems currently experienced by several countries, particularly in arid zones [6]. The most commonly used wastewater treatment systems are based on biological principles and therefore presented in two different systems: Intensive Systems that require a lot of space and Intensive Systems that require a lot of energy [7].The plant of wastewater treatment allows raw wastewater to be treated in order to reduce the degree of pollution so that it can be reused or discharged into the receiving medium without inconveniences [8], and be envisaged to take account of the need for urban irrigation in agriculture. They have the advantage of adapting to the constraints and the socio-economic context of the developing countries [9]. The most well-known are the stabilization basins (the lagoon), which include anaerobic, facultative and maturing basins. The choice of wastewater treatment by lagooning is based on various economic, ecological, landscape and pedagogical parameters [10]. This type of treatment generally comprises the following steps: Pretreatment, Primary treatment, Secondary treatment, Tertiary treatment, and the physicochemical methods such as membrane processes, adsorption and other constituents, which are part of my research topic [11].

On the other hand, this process consists of a series of basins, in which the wastewater is discharged and passes successively and naturally from one basin to the other, by gravity system during a long residence time [12]. The natural lagooning depends on various climatic factors, especially temperature, wind, rainfall, and sunshine. The purification yield varies according to the size, shape and number of basins, which depends on the residence time and local climatic conditions [13]. Moreover, the discharge standards specify the characteristics of these waters according to the subsequent use and impose hence the level of purification to be achieved [14, 15]. In comparison with the wastewater treatment systems already tested in Morocco, the lagoon remains the most replied [16], although it is not very satisfactory.

2. Materials and Methods

2.1. General description of the town of Mrirt

The town of Mrirt is located in the Middle Atlas of Morocco in the region of Meknes-Tafilalet and belongs to the province of Khenifra from which it is separated by thirty kilometers. Closed to Mrirt there is the mountain JebelAouam which contains lead and zinc mines and the villages of Tighza and El Hammam. Following its demographic and urban development due mainly to the proximity of rich mineral resources, Mrirt, which was

previously attached to the rural municipality of El Hammam, became an urban commune after the communal division of 1992. It was then administratively divided into three communes (Mrirt, El Hammam and Ain Oum Erbiâ).
Figure 1 shows the location of the town of Mrirt.

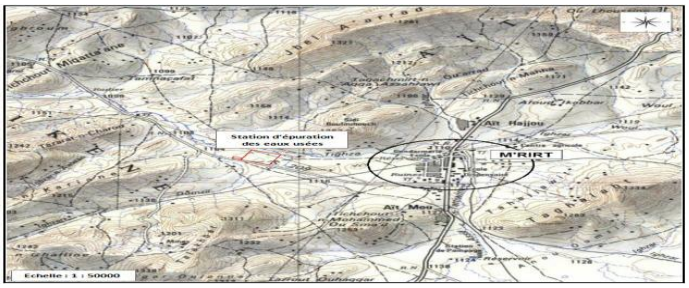

Figure 1: Location of the city of Mrirt

2.2. Characteristics of the Mrirt

The Mrirt STEP was commissioned in June 2003. It is a natural lagoon type, located just at the entrance to the town of Mrirt on the left side of the main road; the raw sewage arrives at the STEP by means of a pumping station. The STEP is sized for a capacity of 1800 m3 / d for a population equivalent of 31000 Eh. It is designed to receive urban wastewaters from the city and is characterized by a fall in temperature in winter (monthly average of about 7 ° C and summer of 27 ° C). The STEP includes a lifting station, which is equipped with an electromagnetic flowmeter at its outlet and three water-discharging pumps to the pretreatment system [17]. The STEP includes a pretreatment system consisting of a manual bar screen with inclined bars and treatment structures which consists of:

• Four anaerobic ponds each about 50 m long and 30 m wide and 3.5 m deep, and a bottom surface of 28 m long and 14 m wide

• Four optional basins each 211 m long, 64 m wide and 1.5 m high. The station also includes 16 drying beds with a depth of 3.5 m per bed. The purified wastewater will be discharged into the Oued Tighza river. Figure 2 shows schematically the status of the anaerobic and optional STEP of Mrirt basins.

Figure 2: The state of the wastewater treatment basins of the STEP.

2.3 Characteristics of Urban Wastewaters

Apart from the toxic content of microbial contamination, the degree of pollution of domestic wastewater, sometimes mixed with industrial wastewater, is often characterized by the following parameters (usually expressed in mg / l): Suspension (MES), oxidizable materials (MO), dissolved salts, nitrogen and total phosphorus [18].Therefore, a better knowledge of the different fractions constituting the pollution to be treated contributes to a better adaptation of the treatment of wastewater, one distinguishes:

• The decantable fraction, which can be removed by a simple physical treatment,

• The colloidal fraction, which corresponds to the pollution that can flocculate by adding the reagent.

• The soluble fraction, which will be biologically eliminated.

In our case, we are interested in the characterization of domestic wastewater with several parameters, namely pollutants. (BOD5, COD, Nitrogen and Phosphorus) and Bacteriological Characteristics (fecal coliforms and faecal streptococci).

3. Results and Discussions

3.1. The study of incoming raw sewage characteristics (EUB) at the STEP during (2012-2013)

3.1.1 Quantitative assessment of effluents from STEP

Figure 3 shows the different flows of the EUB entering the STEP during 2012-2013 in line with the nominal flow of the STEP.

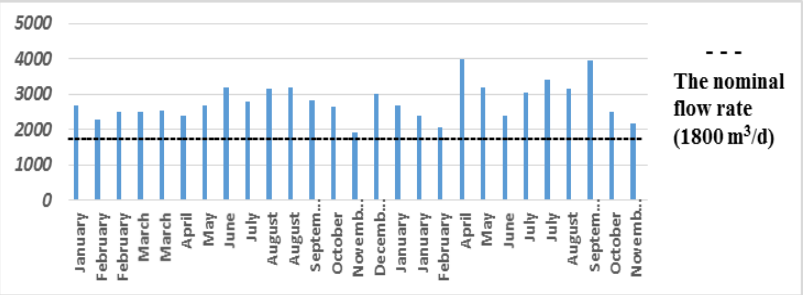

Figure 3: Change in the inbound entering to the STEP during the years 2012-2013.

Figure 3 above shows that:

• The flows recorded during the two years vary between 1927 m^3 / d (November 2012) and 4000 m^3 / d (April 2013).

• 100 % of the flows recorded at the inlet of the STEP, as shown in FIG. 3, exceeds the nominal flow rate of the STEP (1800 m^3 / d).

This overflow of the nominal flow of the STEP has a direct impact on the purification performances of the STEP.

This increase in flows is related to the increase in the population growth rate and consequently to the increase in drinking water consumption (STEP was commissioned in 2003).

3.1.2. Qualitative evaluation of the STEP effluents during 2012-2013

A. Evaluating the incoming polluting load at the STEP during 2012-2013.

The incoming pollutant load at the STEP is given by the equation: Pollutant loading = [BOD5] * Flow rate.

Figure 4 shows the values of the pollutant load of the incoming Mrirt EUBs at the STEP:

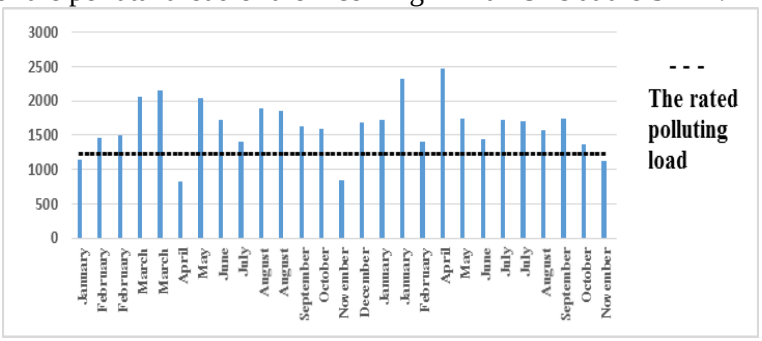

Figure 4: Evolution of the incoming pollutant load at the STEP in Kg of BOD5 / d

The figure above shows that:

• The pollutant loads recorded at the entrance of the STEP during 2012-2013 vary between 818 Kg of BOD5 / d recorded in April 2012 and 2500 kg of BOD5 / d recorded in April 2013.

• 85% of the companions carried out in 2012-2013 record polluting loads higher than the nominal pollutant load of the STEP (1200 Kg of BOD5 / d).

This shows that the STEP operates in organic and hydraulic overload as shown in figure 3 (quantitative evaluation).

In order to evaluate the qualitative characteristics of the incoming raw water at the STEP, comparative values of the global parameters of pollution MES, BOD5 and DCO were compared to the usual ranges of Moroccan urban wastewater [19]. These are presented in Table 1.

Table 1: The typical ranges of the Moroccan urban wastewaters

Parameters	Usual Range
Total MES (mg / l)	250 - 500
Raw BOD5 (mg O2 / l)	200 – 400
Raw COD (mg O2 / l	500 – 800
COD/BOD5	2 - 2.5
MES/BOD5	1.2-1.5

The variation of the values of the incoming pollutions parameters MES, DBO5 and DCO are represented in FIGS. 5, 6 and 7 respectively.

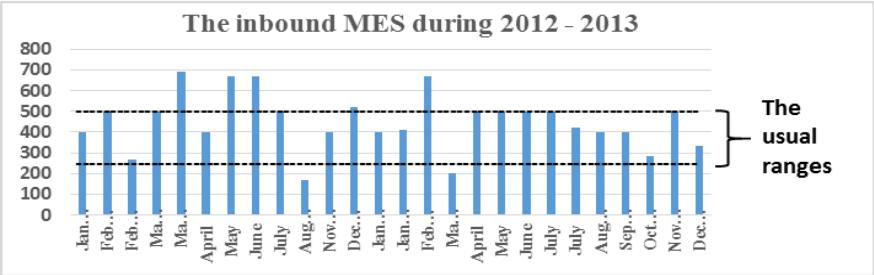

Figure 5: the evolution of the MES at the entrance of Mrirt STEP during 2012-2013

The figure above shows that:

• 73% of TSS values are included in the usual range of the Moroccan urban wastewater.

• 19% in MES are above the same usual range.

• 8% in MES are below the same range.

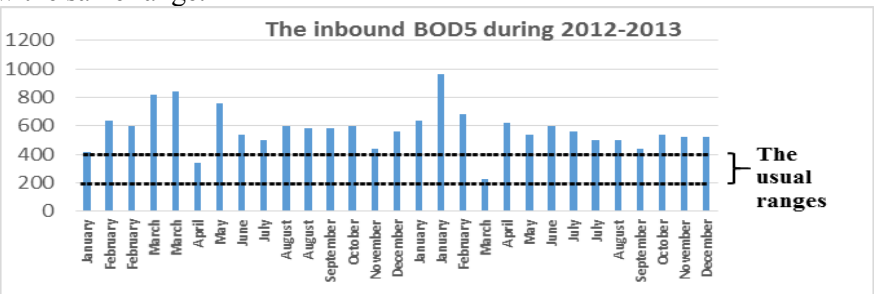

Figure 6: the evolution of BOD5 at the entrance of the Mrirt STEP during 2012-2013

The figure above shows that:

• 93% of BOD5 values are above the usual range.
• 7% in BOD5 are included in the usual range.

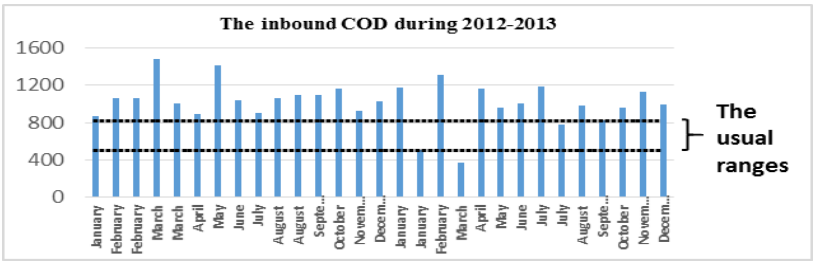

Figure 7: the evolution of the COD at the entrance of Mrirt STEP during 2012-2013

The figure above shows that:
• 89% of COD values are above the usual range of the Moroccan urban wastewater.
• 7% in COD are included in the same range.
• 4% in COD is less than the same range.
From the results, which are presented above it, can be concluded that the incoming raw sewage at the STEP is concentrated.

B. the COD / BOD5 and the MES / BOD5 ratios of incoming raw sewage at the Mrirt station during 2012-2013
In order to obtain an idea about the biodegradability of the organic matter, the COD / BOD5 and the MES / DBO5 ratios are determined.

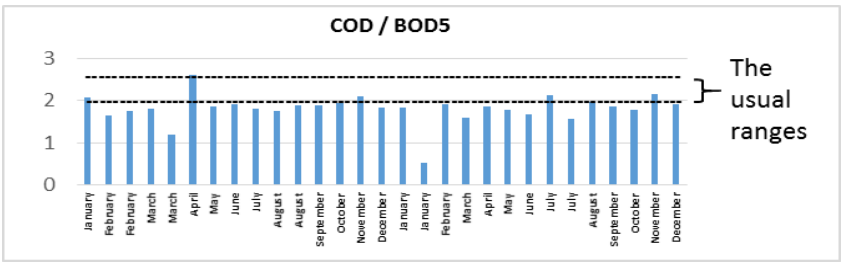

Figure 8: Variation of the COD / BOD5 ratio at the entrance of Mrirt STEP during 2012-2013

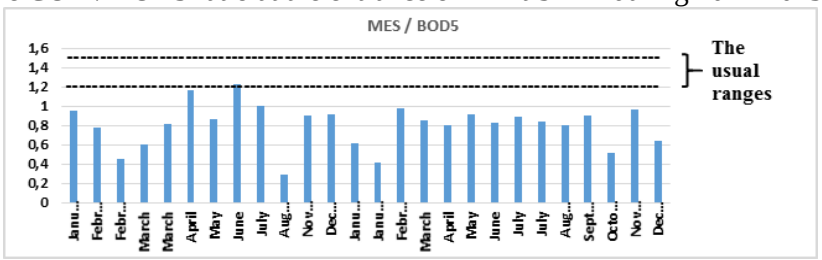

Figure 9: Change in the MES / BOD_5 ratio at the entry of Mrirt STEP during 2012-2013.

The results of the COD / BOD5 and the MES / BOD5 ratios of raw sewage at the entrance of the STEP during 2012-2013 show that:

For the COD / BOD5 :

• 84 % of COD / BOD5 ratios are below the usual range of Moroccan urban wastewater.
• 16 % of COD / BOD5 ratios are included at the same usual range.

For the MES / BOD5 :

• 96% of the TSS / BOD5 ratios are below the usual range of Moroccan urban wastewater.
• 4 % of the MES / BOD5 ratios are included in the same usual ranges.

According to the obtained results, the raw sewage in the town is domestic and is readily biodegradable.

For the low MES / BOD5 ratio, this could be related to the shutdown, the pumping phase, and the stagnation of wastewater in the sewerage network.

3.2. Evaluation of the effluent released from the STEP during 2012-2013

This evaluation aims at studying the purification performance of the STEP and the conformity of its rejection for the three normative parameters with respect to the specific limit values for urban waste set by [20]. The rejection conformity of the STEP was based on the Moroccan domestic discharge standards of the decree 1607-06 of 25 July 2006. The latter provides for two discharge standards: article 2 for the STEPs put into service before the publication of the decree i.e. before July 25th , 2006 (the case of Mrirt STEP) and article 1 for the STEPs commissioned after the publication of the decree). We noted that for the STEPs which are put into service after July 25th 2006, the domestic discharge limit values to be applied and those of Article 1 with a period of 10 years has been granted to these STEPs for their upgrades.

Table 2: Specific limit values of wastewater discharged from urban areas of the STEPs commissioned before 2006(Article 2) and the STEPs put into service after 2006 (Article 1)

Parameters	Specific limit values for domestic releases	
	Article 1	Article 2
BOD5 (mg O2/l)	120	300
COD (mg O2 / l	250	600
MES (mg/l)	150	250

Figures 10, 11 and 12 show the evolution of the quality of the treated wastewater and its level of conformity in relation to the specific limit values for the discharges from the urban agglomerations.

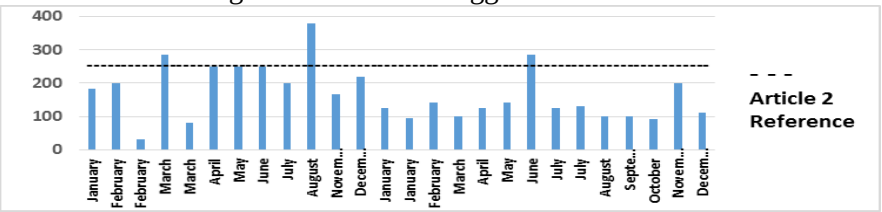

Figure 10: Variation of the MES at the output of Mrirt STEP during 2012-2013.

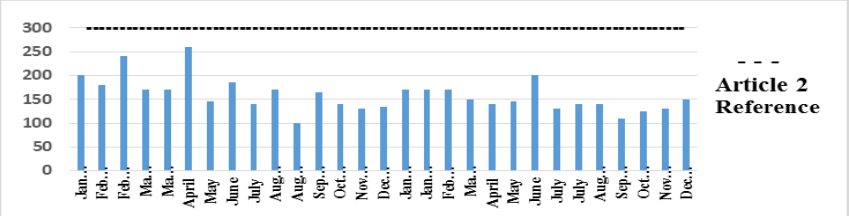

Figure 11: Change in the BOD5 at the output of Mrirt STEP during 2012-2013

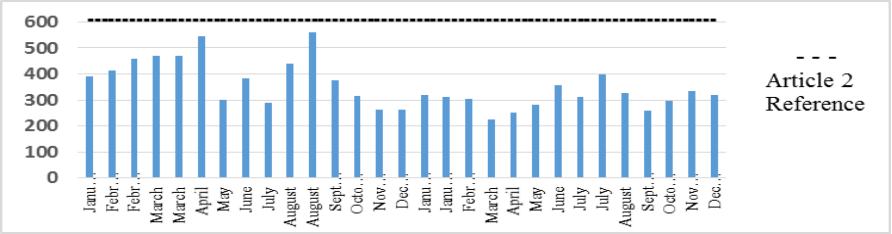

Figure 12: variation of the COD at the output of Mrirt STEP during 2012-2013

With reference to Article 2 of the Decree No 1607-06 of 25 July 2006 laying down the specific discharge limits applicable to the discharges of wastewaters from the urban agglomerations, the effluent of the STEP has values for the analyzed parameters as follows:

• **For the MES**

• 88 % of the campaigns carried out have SSM values below the specific domestic discharge limit set by the Moroccan standards. This exceedance was observed in March and August 2012 and in June 2013

• The maximum concentration corresponds to 380 mg / l (recorded in August 2012) while the minimum concentration was 32 mg / l in February 2012.

• **For the BOD5:**

• 100 % of the realized campaigns have the BOD5 concentrations below the specific limit value of the domestic discharge set by the Moroccan standards.

• **For the COD:**

• 100 % of realized campaigns have the COD concentrations below the value of the specific domestic discharge limit set by the Moroccan standards.

According to the follow-up of evaluation of the purification performance of the STEP of Mrirt carried out during 2012-2013, we conclude that the rejection of the STEP was in conformity for all the realized campaigns.

However, this discharge would not be compliant with the STEPs, which are put into service after the publication of the decree 1607-06. Therefore, it is the specific limit values, which are applicable from 25 July 2006.

The average percentages of compliance are given in the table below:

Parameters	Raw MES	Raw BOD5	Raw COD
Average Percentage of Compliance	97	100	100

3.2.1. Optimization of the BOD5 concentrations released from Mrirt STEP through the use of filter.

The graphs below are showing the variation between the BOD5 before and after filtration.

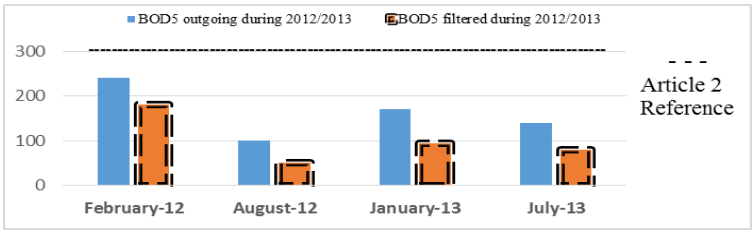

Figure 13: Change in the BOD5 which is raw and which is filtered at the output of Mrirt STEP during 2012-2013

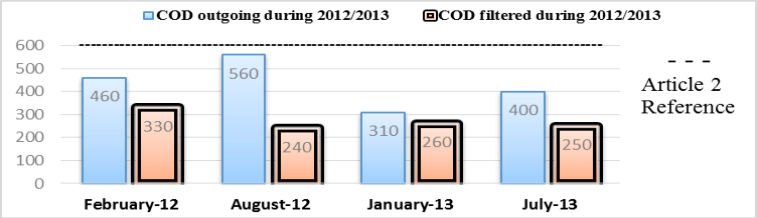

Figure 14: Change in the COD which is raw and which is filtered at the output of Mrirt STEP during 2012-2013

In order to achieve a reduction in the organic matter caused by the algal development, the samples taken at the exit of the STEP were filtered. The analysis of the purified wastewater after filtration shows that the reduction in BOD5 and COD was very important. This explains why the algal development has a direct impact on water quality.

3.2.2. Calculation of the purification yields of the STEP

Table 4 shows the yield for the parameters MES, BOD5 and CTE of the step in comparison with those laid down in the European directive of 21 May 1991.

Table 3: European Guidelines for the treatment of urban wastewaters

Parameters	Minimum percentage of gross reduction
Total suspended solids (SS)	90%
Biochemical oxygen demand (BOD5)	70 – 90%
Chemical Oxygen Demand (COD)	75%

Figures 15, 16 and 17 are showing the evolution of purification yields during 2012-2013

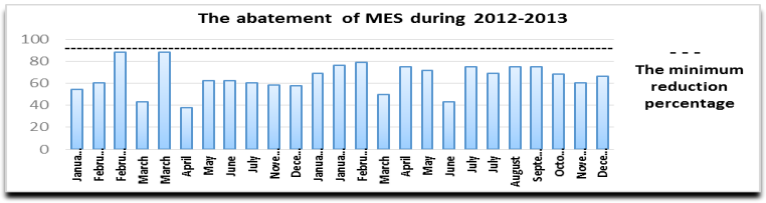

Figure 15: Evolution of the effluent yield in the SSM at the output of the STEP during 2012-2013

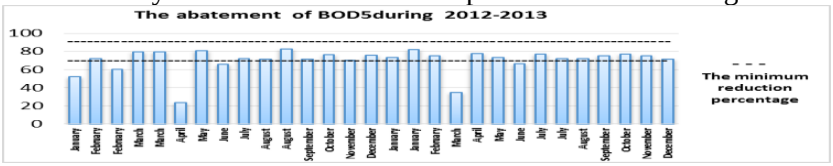

Figure 16: Evolution of the effluent yield in BOD5 at the output of the STEP during 2012-2013

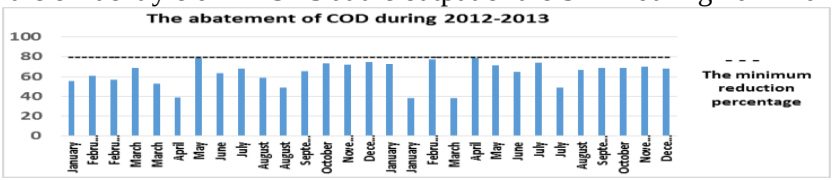

Figure 17: Evolution of the effluent yield in COD at the output of the STEP during 2012-2013

The reduction recorded for the campaigns carried out in 2012-2013 for the three parameters MES, BOD5 and COD is as follows:

- 100 % of TSS results are below the minimum reduction (between 38% and 90%).
- 74 % of the results obtained for the BOD5 show satisfactory yields (varies between 24% and 84%).
- 90 % of the COD results are below the minimum reduction (between 38% and 80%).

From the above results, it can be concluded that the STEP has unsatisfactory yields especially for the BOD5 and the COD compared to the STEP with a secondary treatment stage. This could be related to:

- Excessive algal proliferation.
- The accumulation of sludge in the anaerobic basins, which affects the residence time; and sometimes causes the passage of sludge from the anaerobic basins to the optional ones.
- Hydraulic and organic overhead at the STEP
- Weather conditions.

3.3. General recommendations for Mrirt STEP

According to this study:

For the proper purification of the STEP, it is advisable to put in place certain measures for a better management of the STEP. Among these, we quote:

- Provide a sand trap in the pretreatment phase so as to avoid the passage of sand to the anaerobic tanks and avoid its cementing.
- Provide a double input to feed the optional tanks and to avoid the creation of dead zones at the level of the latter.
- Proceed with the equitable distribution of the flows between the basins for the proper functioning of the basins.
- To solve the problem of intensive proliferation of algae and to improve the purification yields in SS.
- To solve the problem of intensive proliferation of algae to improve the purification yields in MES.
- Ensure that the planning of sludge removal is carried out and to avoid any malfunction during the operation.
- Weed control in the dikes and between the ponds to avoid the presence of rodents and subsequently the degradation of the STEP waterproofing.
- Ensure a good waterproofing of the basins to protect the groundwater.
- Foresee the extension of the STEP, which is currently saturated.
- A tertiary treatment system is recommended to improve the quality of the purified waters by the natural lagoon system and by adding a possible filtration step for the elimination of the algae, which are the cause of the elevation of organic charges.

4. Conclusion

In the light of studying the purification performance of Mrirt natural wastewater treatment plant and the analysis carried out on the treated and filtered wastewater, we can provide the following information:

- The hydraulic and organic load of the incoming raw sewage influences the purifying system of the STEP. It also has a relation with the other different factors like the temperature, the volumetric load, and the conditions surrounding these waters passing through the different basins of the natural lagoon.
- The data generated by the study concerning the physicochemical parameters of the monitoring campaigns carried out at the input and output of the STEP show that the COD / BOD5 and the MES / BOD5 ratios are comparable with the usual wastewater ratios in urban areas. Thus the diagnosis of the quality assessment of outflowing purified wastewater is based on the Moroccan and European standards of domestic discharge. This allowed us to analyze the compliance of the effluent at the outlet of the STEP for the three normative parameters MES, BOD5 and COD.
- The results of study of the purification performance of Mrirt STEP during 2012-2013 show that:

• The STEP operated hydraulically and organic over its nominal value.

• The incoming raw sewage at the STEP is relatively concentrated once compared to the usual ranges of the urban Moroccan wastewaters.

• the purified wastewater conforms to the discharge standards for the STEP put into service before the publication of the decree n ° 1607-06 in 25 July 2006 (Article 2), but they will be non-compliant for the STEPs put into service after publishing the Order (Article 1).

• The results of the purification yields for the MES, BOD5 and COD are less satisfactory once compared to the minimum percentages of reduction which are fixed by the European directives n ° 91/271 of 21/05/1991.

•The analysis carried out on the treated filtered waters gave satisfactory results for 93% of the campaigns achieved and 42% for the unfiltered. Thus, filtration is an operation which can be envisaged for the elimination of the microorganisms which are the basis of the non- compliance of the rejection of Mrirt STEP.

Finally, we can say that natural lagooning is a wastewater treatment process whose yields depend on various factors like the accumulation of sludge in anaerobic basins, decreases in temperature, seasonal effect, residence time, algal development and high concentration of raw sewage.

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