

Performance of sand and wood chips in tertiary treatment of effluent discharged by lagoons

ABSTRACT

In Burkina Faso, as in most developing countries, access to water and sanitation remains a challenge. This justifies the reuse of wastewater to provide additional quantities of water for different uses in order to fill up water deficits. In this context, the wastewater from the city of Ouagadougou is treated by lagoons for its reuse on gardening plots downstream of the station. Since several years these plots have been disaffected and abandoned due to the quality of the discharged water. This work aims to experiment complementary treatments to improve water quality for agricultural reuse. Indeed, pilots of infiltration-percolation on sand and on wood chips have been implemented during 3 months in Institute of Research in Applied Science and Technology. A comparative analysis of the treated waters according to the ISO and AFNOR standards showed that the various filters gave satisfactory purification yields which are in agreement with the quality objectives imposed by the national standards for parameters such as Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD₅), nitrogen and faecal coliforms. The respective removals of COD by the sand filter (FS) and the wood chip filter (FC) were 94% and 91%, while BOD₅ was eliminated with yields of 84% and 64% respectively. Regarding nutrients as ammonium and nitrate, the station gave the effluents conform with the discharge standards but the filters have made it possible to improve their quality. FS and FC gave satisfactory yields of 97 % and 92% for the faecal coliforms removal. Although the non-negligible abatement levels of 81-93% for faecal streptococci and *Bacillus cereus*, the pilots did not meet the standards for these parameters; In sum, this study revealed that wood chips have interesting quality for wastewater treatment but the sand has a better purifying capacity for a finishing treatment.

Keywords: Sewage, lagoons, sand, wood chips, infiltration-percolation, COD, faecal coliforms.

1. INTRODUCTION

In a context of significant population growth and climate change, with consequences in terms of drought and / or flooding, developing countries are struggling to meet the needs of people in terms of sanitation and water supply for domestic use, industrial use and agricultural use. Growing and urgent food needs justify the reuse of raw or partly treated wastewater in peri-urban agriculture for the production of various vegetables, which sale generates substantial incomes for farmers, even if the population are exposed to contamination risk by pathogenic germs and heavy metals [1]. However, this practice is not without its health consequences since the level of contamination of these waters by pathogenic germs, heavy metals and hydrocarbons is important [2]. Burkina Faso, like other sub-Saharan countries, is not an exception. Indeed, with an annual increase of 3.1%, the rapid population growth in urban areas singularly, induces a strong pressure on natural resources in general and water resources coupled with a notorious lack of adequate sanitation systems [3]. The strategic plan to clean up the cities of Burkina Faso, allowed to Ouagadougou to get sewerage networks that drains the domestic wastewater from the city center and those from the industrial zone to a lagoons treatment plant which has been operational since 2004. However, the purification report on wastewater quality at the outlet of the station remains unsatisfactory regarding the quality objectives assigned to the receiving environment. That explains the abandonment of the site by the gardeners. Indeed, the effluents from the station present a strong reddish coloration, high concentrations of suspended solid and especially loads in faecal coliforms higher than WHO standards for the irrigation. In addition, wastewater mainly from industrial sources is characterized by high sodium contents, high alkalizing power with high contents of carbonate and bicarbonate ions [1]. This explains why the experiment seems not to be conclusive since the gardeners installed on the plots downstream of the station have all abandoned the site in terms of water quality that is not compatible with their crops [1]. The objective of this study is to experiment the complementary treatment by biological processes to improve the quality of the water coming from the station. The specific objectives are: To ensure the complementary treatment of the water coming from the station by infiltration percolation on wood chips and on sand; To determine the purification performance of these filters in relation with the quality of the water discharged from the station.

2. MATERIALS AND METHODS

2.1 Materials

All packing and storage sampling equipment is recorded in the table 1 below.

Table 1: Equipment used

Material	Use
Drums	Pilots
Sand, medium gravel, coarse gravel, wood chip	Media for infiltration
plastic bottle (physical and chemical analyzes) glass sterilized vials (bacteriological analyzes)	Sampling
Cooler	Transport to the laboratory
Refrigerator (at a maximum temperature of 4 °C)	Storage

2.2 Conception of pilots

2.2.1 The experimental device

The experimental devices consist of two cylindrical drums with a capacity of 160 liters each with a height of 75 cm. The bottom of each drum was perforated over the entire surface with holes of 5 cm to ensure the gravity evacuation of the treated water by infiltration-percolation. The first pilot was used as a sand filter called FS and the second was the wood chip filter named FC.

2.2.2 Composition of filter media

2.2.2.1 Sand

Among the granular materials used in wastewater treatment, the sand is the most commonly used; Depending on the need, it is necessary to know the characteristics of the sand in order to make the best choice regarding the application for which it is intended. In this study, a river sand with medium particle size was used.

2.2.2.2 The Wood chips

Wood is a natural composite material composed of fibers with complex structure. Generally, wood is a building material whose industrial processing generates wood chips which can be recovered for other uses, such as energy recovery as fuel and as a clean, natural and low cost adsorbent. The structural properties of wood and the presence of longitudinal cavities present an interest in the treatment of wastewater by fixing various undesirable elements on the walls and pores of the material. Wood from various species of trees, naturally or chemically treated, have been the subject of several studies about their ability to fix various pollutants in wastewater [4][5][6]. The ability of wood chips to fix adsorbates such as pollutants can be greatly improved by chemical treatment. But in the present study sawdust was used in its raw state without prior chemical treatment.

2.2.3 Construction of filter beds

The pilots (Figure 1) were installed in the Institute of Research in Applied Sciences and Technologies located in Ouagadougou. They consist of bottom to top of:

- A drainage layer 5.5 cm high, made of coarse gravel;
- A transition layer 10 cm high, made of fine gravel to avoid the migration of sand or wood chips within the drainage layer;
- A filtration layer of 20 cm high made by medium sand or wood chips after application of compacting pressure.



Figure 1 : Top view of sand filter and wood chip filter before feeding

2.3 Methodological approach

2.3.1 Hydraulic regime and sampling mode

The feeding effluent is taken from the final maturation tank of the lagoons for feeding the pilots. Before feeding the pilots with wastewater, the massifs were washed with clean water for four consecutive days to rid them of fine sand and waste. The choice of applied hydraulic loads is very important because it determines the quality of the treatment and the correct functioning of the system. The applied hydraulic regime affects the hydrodynamic properties of the filtration materials. It is chosen according to the type of wastewater and the quality objectives assigned to the receiving environment. A starting volume of $20 \text{ l/m}^2/\text{day}$ with two days of feeding and two days of rest was applied initially. After two weeks of feeding, the FS showed a beginning of clogging inducing difficulties of filtration. Then a review of the hydraulic load was done, and the rate of 10.5 l/m^2 was adopted. To simulate the daily peaks of wastewater production, feeding is done twice a day at 8 am and at 3 pm.

The actual sampling began when a regular hydraulic regime was observed. To be able to compare the effectiveness of the treatment, analyzes were carried out on the treated water from the station (raw water) and on the filtrate taken from the pilots after the second day of treatment (the first day of rest). Physical and chemical parameters such as temperature, pH, dissolved oxygen and conductivity are recorded during the sampling in order to avoid any changes. Finally, the samples are stored in the freezer for analysis of the other parameters. Concerning the bacteriological parameters, the samples are transported the same day to the laboratory to be seeded for avoiding any multiplication of the bacterial flora.

2.3.2 Sample analysis methods

Temperature, Hydrogen Potential (pH), Dissolved Oxygen (Dissolved O_2) and Electrical Conductivity (EC) were measured in situ with the HACH HQ40d Multi Parameters, following the same protocol by simply changing probes depending on the parameter to be measured. The reading is done after stabilizing the display. The method is in accordance with the AFNOR 90 008 standard. The determination of the Suspended Solids (SS) was carried out by gravimetry after vacuum filtration with a GF/C glass microfiber filter and oven drying at $105 \pm 2^\circ \text{C}$, according to French standard NF 90-105. The Chemical Oxygen Demand (COD) was determined by oxidation with an excess of potassium dichromate in an acid medium at 150°C in the presence of silver sulphate as catalyst and mercury sulphate intended to avoid interference of chloride ions according to AFNOR T-90-101. The reading of the value is done by HACH DR / 2400 spectrophotometer at the appropriate wavelength. The five-day Biochemical Oxygen Demand (BOD_5) was determined by the incubation method for five days in the dark and at 20°C using a "Lovibond OxiDirect." Apparatus according to standard NF 90-103. Ammonia nitrogen (NH_4^+), nitrates (NO_3^-)...were determined by the colorimetric method with a Palintest 7100 spectrophotometer at the appropriate wavelengths.

Concerning bacteriological parameters, the analyzes were carried out following well-defined steps according to standards required for each microorganism, according to the methods indicated in the Table 2 below. The handling protocol is the same for all germs but the culture media used, the incubation temperatures and the applied standards that are specific to each microorganism change. The samples were analyzed immediately the sampling day.

Table 2: Methods of microbiological analysis

Microorganisms	Culture medium	Incubation temperature	Standard	Incubation duration
Total coliforms	Violet Red Bile Lactose Agar (VRBL)	37°C	International Standard ISO 4832 (2006)	24H
Faecal coliforms	Purple Red Bile Lactose Agar (VRBL)	44°C	Standard AFNOR NF V 08-060 (2009)	24H
Bacillus cereus	Selective agar for Bacillus cereus (Base according to Mossel)	30°C	International Standard ISO7932: 1993	48H
Streptococci	Streptococcus Isolation	37°C	International Standard ISO 4832 (2006)	48-72H

The data collected were analyzed with Excel.

3. RESULTS AND DISCUSSION

3.1 Results

Table 3 below summarizes the average values of the various parameters analyzed.

Table 3 : Mean values of physico-chemical parameters and bacteriological parameters

	Raw water (RW)	Sand filter (FS)	Wood shipFilter (FC)	Samplingnumber	National standards
Temperature (°C)	28,31	28,32	28,51	10	18-40
pH	8,72	8,35	8,17	10	6,5-9
DissolvedOxygen (mg/l)	2,81	4,95	4,3	10	
ElectricalConductivity (µS/cm)	1282	1056	1131	10	2700
TSS (mg/l)	240	50	69	10	150 (for lagoons)
Ammonium (mg/l)	0,85	0,67	2,71	10	1
Nitrates (mg/l)	6,6	5,16	4,37	10	11.29
BOD ₅ (mg/l)	250	39	90	10	40
COD (mg/l)	1264	75	110	10	150
Total Coliform (UFC/100 ml)	38750	605	7275	10	2000
Faecal coliforms(UFC/100 ml)	9750	305	5075	10	2000
<i>Bacillus cereus</i> (UFC/100 ml)	38500	4400	2750	10	2000
Streptococcus (UFC/100 ml)	64500	12500	9450	10	2000

3. 2 Discussion

3. 2.1. Physical and chemical parameters

3.2.1.1 The hydrogen potential (pH)

It characterizes many physical and chemical equilibrium and depends on multiple factors, including the origin of the water. The pH variations are related to the photosynthetic activity of the medium. The consumption of CO_2 by the aquatic flora during the photosynthesis reactions tends to displace the carbonic balance in the direction of its production and thus to raise the pH. Thus, a low pH may be indicative of low productivity due to absence or excess of algae. Generally, bacteria well grow at pH between 5 and 9 and with pH between 6.5 and 8 the domestic wastewater is favorable to the development of the microorganisms scrubbing, in both the anaerobic and aerobic phenomena[7]. It is also important to notice that the biological purification is strongly disturbed for values of pH <4.5 or pH > 9.

The average pH values of wastewater and filtrates are within the range allowed by national regulations (between 6.5 and 9.5). The pH decreases during the treatment for the two pilots, although these pH remain alkaline (Figure 2). Indeed, the raw water has an average pH of 8.72 while the values obtained at the pilot FS range from 6.72 to 9.01 with an average of 8.30 while those of FC vary between 6.31 and 9 with an average of 8.16. Thus, FS has higher pH values compared to FC.

According some research results, the alkalinity of the water coming from the lagoons is due to the fact that it mainly receives brewery wastewater which discharges strongly basic waters rich in ions (Na^+ , OH^- , Ca^{2+} , CO_3^{2-} , HCO_3^- ...)[8]. After the treatment by the sand and the organic material, it can be noted that the wood chip reduces much more the pH. This could be explained by the purifying power of wood chip. This power would lie in the composition of the wood and some factors may explain this decrease in pH as the accumulation of H^+ following the activity of nitrifying bacteria and the accumulation of CO_2 due to the degradation of organic matter by bacteria Heterotrophs[9]. Consequently wood chips can be used as a filter material if it is desired to have a pH tending towards the acid zone.

The temperature also influences the kinetics of reactions. But during this study, its values recorded (28.31 to 28.51) are well below the limit set by the national standard, which is 40 °C.

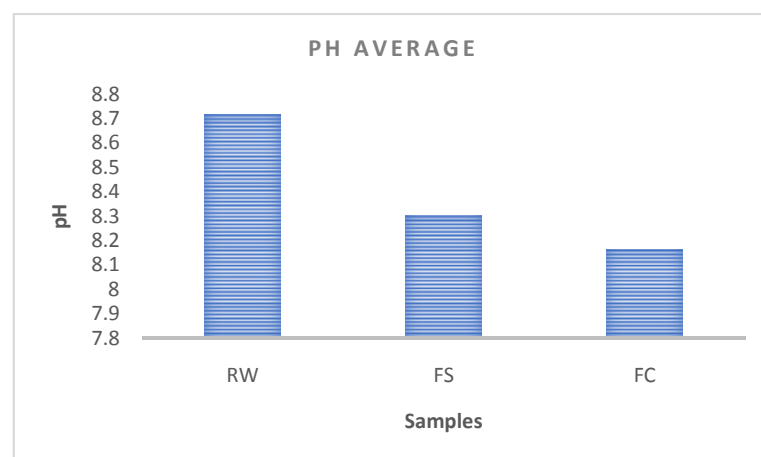


Figure 2 : Evolution of pH

3.2.1.2. Electrical conductivity

Electrical conductivity measures the ability of water to conduct electricity. It is the conductance of a column of water between two metal electrodes with a surface area of 1 cm^2 and at distance of 1 cm from each other. Electrical conductivity is a quick and convenient way to evaluate the mineralization or salinity of a water, although the relationship is linear only for weak conductivities ($C < 100 \mu\text{S}/\text{cm}$) and deviates from it more than the mineralization is high. Most of the dissolved matter in water is in the form of cations Ca^{2+} , Mg^{2+} , K^+ , Na^+ ... and anions SO_4^{2-} , Cl^- , HCO_3^- , PO_4^{3-} , NO_3^- ... The conductivity depends also from the temperature of the water: it is more important when the

temperature increases and vice versa. The variations of conductivity make it possible to show the presence of pollutions because of mixing or infiltration. Its measurement allows to detect an anomaly indicating the probable presence of pollution, by comparison of the measured value with which one expected. The conductivity of a natural water is between 50 and 1500 $\mu\text{S}/\text{cm}$. The Figure 3 shows the conductivity values of FS and FC lower than those of the waste water from the station but which are all below the limit value set by the standard. So, the average conductivity of the raw water is 1282 $\mu\text{S}/\text{cm}$ while the filtrates of FS and FC gave 1056 $\mu\text{S}/\text{cm}$ and 1131 $\mu\text{S}/\text{cm}$ respectively. In general, there is a slight decrease in conductivity which results in a reduction of the dissolved salts in the water. The result obtained show that sand reduces the conductivity more than wood chips. This result is contrary to those of others authors had observed a greater elimination of salts by an organic support such as coconut fibers compared to sand [10]. In sum, the wastewater treated by the two supports always showed high salinity levels so that their agricultural reuse could present a toxicity to the crops due to the accumulation of certain ions which prove to be a stress for the plants and can be a cause of reduction of crop yield [1][11]. In addition, the excessive presence of salts in irrigation waters is a source of soil clogging.

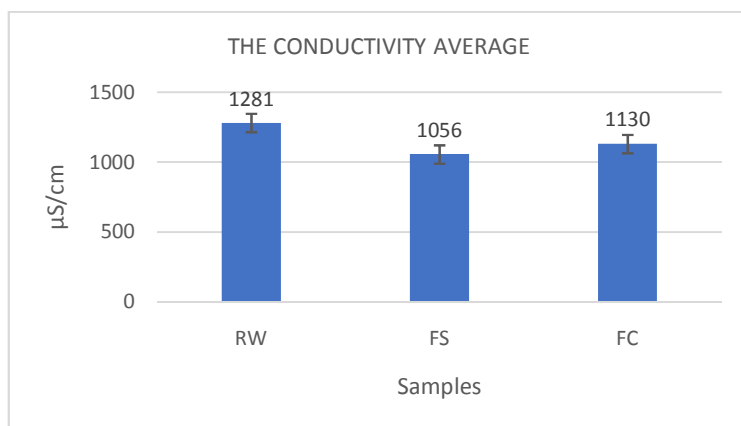


Figure 3 : Variation of Electrical Conductivity

3.2.1.3. The ammonium ions (NH_4^+)

Organic nitrogen is converted to ammonium (NH_4^+) by the action of anaerobic microorganisms. The presence of NH_4^+ in water is indicative of organic pollution due to agricultural, domestic or industrial activities. Ammonium represents a lesser danger, but depending on the characteristics of certain soils, its presence may lead to nitrogen enrichment or acidification with the disappearance of aquatic fauna and flora [12]. Analysis of the ammonium ions shows a decrease of NH_4^+ concentration concerning sand filter and an increase for the wood chip filter compared to the wastewater as shown in Figure 4. Thus, at the station outlet, the NH_4^+ value of the wastewater is 1.09 mg/l compared to 0.86 and 3.48 mg/l respectively for the sand and wood chip filters. The sand filter gives treated water with NH_4^+ levels in accordance with the standard (1 mg/l), contrasting wood chips with values more than twice the permissible limit. The reduction of ammonium ions concentrations by the sand filter is due to an aerobic degradation process with nitrification [12]. As for the increase of the NH_4^+ content in the filtrate resulting from the wood chips filter, this could be explained by the fact that the organic chips are rich in nitrogen, so that the organic nitrogen is firstly subjected to a process which transforms organic nitrogen into NH_4^+ before the nitrification step occurs if the conditions are favorable. The initial leaching carried out on the organic material for four days was therefore not sufficient to eliminate the nitrogenous compounds (the polyphenols) of the wood. It is important to remember, however, that the presence of nitrogen in its ammonia form in the environment is a public health problem because it evolves towards nitrates which are sources of eutrophication in conjunction with orthophosphates. So, the use of wastewater with high levels of nitrogen in agriculture causes an imbalance in the availability of nutrients for plants. That will affect negatively crop yields by increasing their fragility to stress [13]. Nevertheless, it should be noted that in the present case, the water coming from the lagoons is conform with the discharge standards concerning ammonium level.

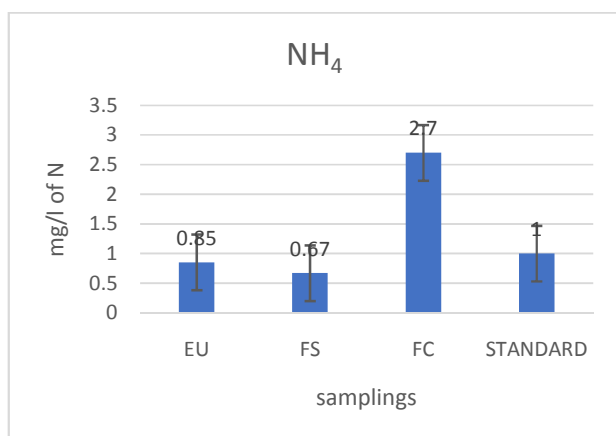
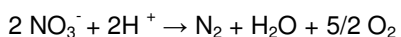


Figure 4: Variation of NH₄⁺ concentrations

3.2.1.4. The nitrates (NO₃⁻)

Nitrates are naturally present in water but in small amounts. Nitrates and orthophosphates are nutrients for plants, which partly justifies the reuse of wastewater in agriculture. The presence of nitrates in the natural environment is due to anthropogenic activities such as the use of fertilizers, manure, domestic and industrial wastewater but also to the decomposition of living organisms (animals and plants). Their massive presence has adverse consequences on the environment especially aquatic and on human health because of their association with orthophosphates, which can conduct to an eutrophication of surface waters. Moreover, they are very soluble in water and can easily contaminate the ground water. They would be responsible of infants methemoglobinemia by consumption of water rich in nitrate. It is also believed that they could be potentially carcinogenic by the formation of nitrosamines resulting from the reaction between nitrites and amines or amides although no studies have established certain causal relationships[14]. Besides, in acid medium, nitrates can turn into nitrites that turn out to be toxic.

The nitrate concentrations obtained during this study are very low compared to the limit of the national standard which is 50 mg of NO₃⁻/l, corresponding to 11.39 mg of N /l. The respective average values of 6.6, 5.16 and 4.37 mg of N /l were recorded for the lagoons, the sand filter and the wood chip filter. In general, there is a much more remarkable decrease with the wood chip filter. This decrease could be due to the process of denitrification or the nitrates turn into atmospheric nitrogen (nitrogen diazote N₂) under the action of denitrifying bacteria according to the following equation:



The nitrate contents are generally low for both pilots because the wastewater at the station exit contained low concentrations of NH₄⁺ (Figure 5). Moreover, these values remain low compared to the nitrate contents of the wastewater. This indicates that there is really no nitrification. However, the previous Figure indicates an increase in ammonium at the outlet of the wood chip filter; This suggests an elimination of nitrogen by this filtration medium by volatilization thanks to the action of specific denitrifying bacteria which could transform nitrate into atmospheric nitrogen[10].

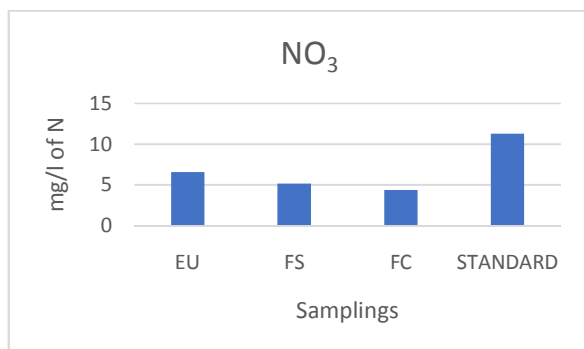


Figure 5: Evolution of NO₃⁻ concentrations

3.2.1.5. Total suspended solid (TSS)

TSS are solids contained in wastewater and are separable by filtration or centrifugation. They include all inorganic or organic materials which are not soluble in water. They constitute an important parameter which clearly indicates the degree of pollution of an effluent. The TSS is responsible for the organic clogging of the pores of filters during the infiltration of wastewater. However, a mineralized deposit on the surface of a filter can improve the purification performance of the filter because it increases the depth of the filter. This part is well aerated and it serves as a support for the scrubbing microorganisms [10]. The assessment of the suspended solids concentration during the study revealed a significant decrease regarding the levels observed with the treated water from the lagoons. For this purpose the national standards authorized 150 mg/l for natural lagoons discharged water and 60 mg/l for another treatment technologies. Indeed, the average of total suspended solids content at the station exit is 240 mg/l, which is well above the norm as shown by the Figure 6. On the other hand, after filtering with sand and wood chips, the average of TSS contents are respectively 50 and 68 mg/l, corresponding to 79% and 71% elimination efficiency. In general, this reduction could be explained by the purifying power of the materials used. Considering the similarity of the structure of the wood chips and the coconut substrate, it could be hypothesized that the higher TSS contents of the water from the wood chip filters are due to the high porosity and the low level of compaction of this material contrary to the sand which is best compacted in the presence of water and offers smaller inter-granular spaces [4][10][15]. Thus, for this parameter, the sand retains the greatest purifying power. The high TSS levels of treated water discharged by the lagoons can be one of the causes of the departure of gardeners. In fact, the TSS are responsible for the clogging which make the soil compact and which do not allow the infiltration of water. This phenomenon results in the impoverishment and degradation of the soils producing a very low yield of production [13].

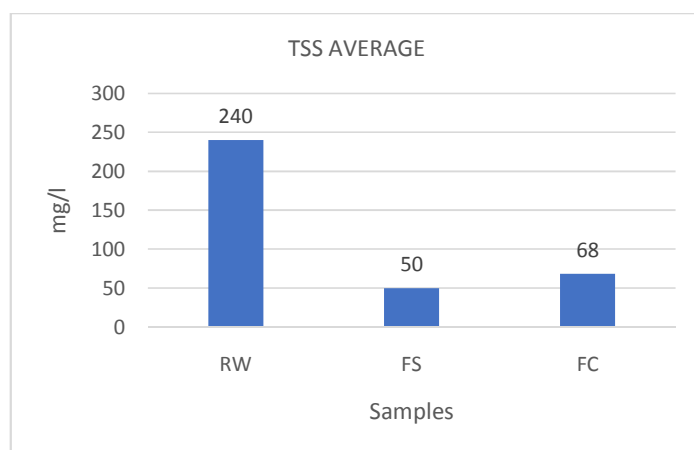


Figure 6: Evolution of TSS levels

3.2.1.6. Chemical oxygen demand (COD)

The Chemical Oxygen Demand expresses the amount of dissolved oxygen required to chemically oxidize all oxidable substances contained in an effluent (oxidable mineral salts, biodegradable or non-biodegradable organic compounds, ...). The Chemical Oxygen Demand is an indicator of organic pollution. Its measurement makes it possible to evaluate the effectiveness of wastewater treatment and to predict the impact of these waters on the environment concerning the risk of asphyxia through the determination of oxygen consumption during the oxidation reactions.

About the present study, the Figure 7 shows a largely decreasing curve of COD values. COD values for raw water coming from lagoons are higher than the national standard that sets the limit value at 150 mg/l. However, after treatment with FS and FC, the mean values of 69 and 110 mg/l respectively, corresponding to removal efficiency of 94% and 91% are noted. This decrease of COD values could be due to the degradation of pollutants, but also to the considerable reduction of TSS by retention within the filters [8]. The higher values of COD from FC compared to the sand filter could be explained by the structure of the wood chips which are more porous and less compact than sand; This fact is corroborated by its greater value of TSS content. This porous structure of the wood chips favors a more rapid percolation of the effluent while the reactor is in a progressive phase of biofilm installation. this biofilm ensures the elimination of biodegradable pollution [10]. In spite of its performance

compared to sand, wood chips are nevertheless a good material of oxidable carbon elimination (biodegradable and non-biodegradable).

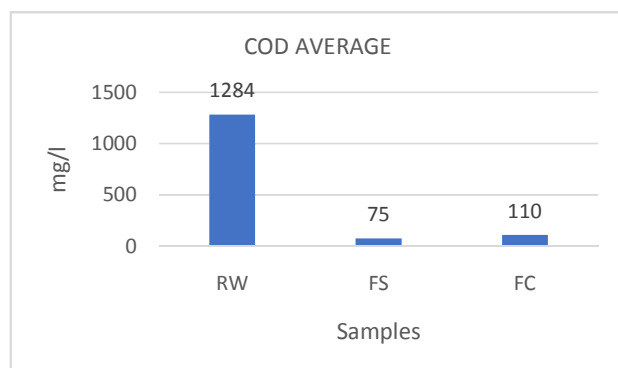


Figure 7 : COD removal

3.2.1.7. Biochemical Oxygen Demand (BOD)

It represents the amount of oxygen that is used by aerobic microorganisms for the destruction of biodegradable organic matter at a temperature of 20 °C in the dark during five days. BOD₅ is used to assess the biodegradable organic content of water. It is therefore an indirect measure of the degree of pollution of a water by biodegradable organic matter. BOD₅ is less than or equal to COD.

In this study, the respective mean concentrations measured for BOD₅ were 250 mg/l for treated water by lagoons, 39 mg/l for sand filtrate and 90 mg/l for wood chip filtrates whereas the quality objective imposed by the national regulation is 40 mg/l at most (Figure 8). It is found that the filtrates from the sand reactor conform to the standard whereas the removal efficiencies of the BOD₅ are 84% and 64% respectively for sand and wood chips. The lower efficiency of removal of the BOD₅ from the wood chip reactor could be explained by a low capacity of the wood chips to ensure the biodegradation of the organic pollution considering the very porous structure of the massif which favors a more percolation regarding its short residence time (contact time with the scrub biomass) compared to the sand.

Moreover, the ratio COD/BOD₅ = 5.13 indicates that raw water (RW) coming from station exit is not more biodegradable. This means that lagoons allowed the good removal of biodegradable pollution of city wastewater.

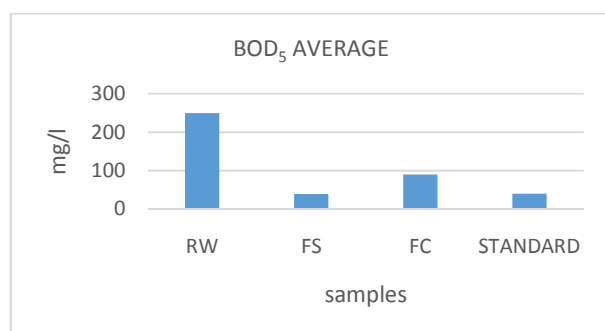


Figure 8: Evolution of BOD₅

3.2.2 Evolution of bacteriological parameters

3.2.2.1 Faecal coliforms and total coliforms

The wastewater is charged with microorganisms depending on their origin. They contain the microorganisms excreted with fecal matter. This normal enteric flora is accompanied by pathogenic organisms, causing water-borne diseases. All of these organisms can be classified into four major groups: bacteria, viruses, protozoa and helminths. Bacteria are the most commonly encountered microorganisms in wastewater. It would be difficult to identify all microorganisms for characterizing the effectiveness of wastewater treatment; Therefore, it is common to identify faecal pathogens such as

faecal coliforms and *Escherichia coli* (*E. coli*), which are much more representative. The Figure 9 presents the average content of faecal coliforms and total coliforms at the end of the treatment by the two pilots. The mean values of the treated water collected at the lagoons exit are well above the limit value imposed by the standard which is 2000 CFU/100 ml.

The sand filter shows a greater ability to remove faecal coliforms and total coliforms than wood chips filter. Nevertheless, it is important to note that the 94% removal capacity of the wood chips reactor is not negligible, indicating that the material has properties that allows it to reduce fecal pollution.

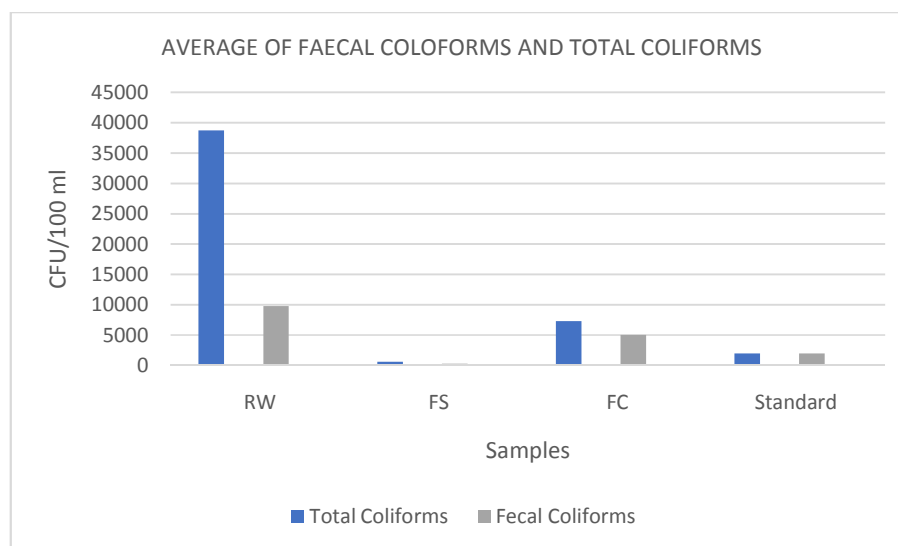


Figure 9: Total coliforms and faecal coliforms average

3.2.2.2. Faecal streptococci

These bacteria belong to the family *Streptococcaceae*. These germs colonize the intestines of humans and warm-blooded animals. Their presence in the water environment proves faecal pollution of the water. However, faecal streptococci can also be found in soil, plants and insects. The analysis of faecal streptococci gave values that are higher than national standards even after treatment with the filter materials as shown in the Figure 10 below. Despite the removal efficiencies of 81% and 85% for sand and wood chips, the faecal *Streptococcus* contents remain unusual both for the water withdrawn at the lagoons outlet and for the filtrates after treatments with mean values of 12500 and 9450 CFU/100 ml respectively. However, the standard requires levels not more than 2000 CFU/100 ml. In any case, despite the non-conformity with the norm, the streptococcal contents are considerably reduced after the treatment with the two pilots as shown in the Figure below. To make the filtrates conform to the norm, the height of filters massive can be more important.

3.2.2.3. Bacillus cereus

The genus *Bacillus* is composed of a set of bacteria belonging to the family *Bacillaceae*. They are Gram-positive, heterotrophic, aerobic or anaerobic aerobic bacilli, drawing their energy from breathing or fermentation. These bacteria can produce endospores allowing them to withstand adverse environmental conditions [16]. Analysis of *Bacillus cereus* in this study resulted in decreasing mean concentrations but still well above the acceptable limit as shown in Figure 10. *Bacillus cereus* levels in wastewater are 38500 CFU/100 ml compared to 4400 CFU/100 ml and 2750 CFU/100 ml respectively for treated water from the sand filter and wood chips filter; The corresponding yields are 88% and 93% respectively. The analysis reveals that wood chips better eliminate *Bacillus Cereus* than sand. Thus, wood chips have an appreciable ability to eliminate *Bacillus Cereus* which may warrant further investigation in subsequent work.

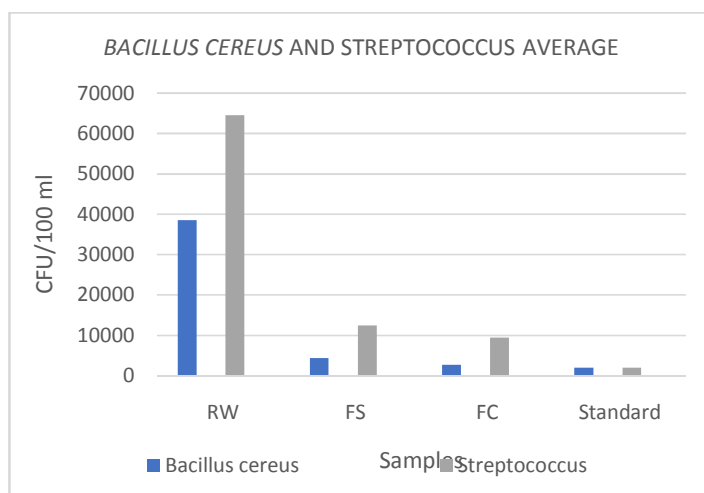


Figure 10 : Evolution of *BacillusCereus* and streptococcus averages

4. Conclusion

In conclusion, it can be noted that in general there is a decrease of the concentrations for all the parameters after the treatment on sand and on wood chips. However, some parameters such as Faecal streptococci, *Bacillus Cereus* still show values above the acceptable limit even after treatment, due to high pollution loads of the treated water coming from lagoons. For parameters, such as conductivity, NH_4^+ , TSS, BOD₅, COD and Faecal coliforms, the sand has a greater purifying power. For the other parameters, such as pH, *Bacillus Cereus* and Faecal streptococci, wood chips ensure great abatements with remarkable purification yields more than 90%.

The purifying power of sand is well known, and this material has made it possible to detect wood chips performance which merits further investigation. At the end of this work, it is possible to envisage the reprocessing of wastewater from lagoons by infiltration-percolation before re-use in market gardening. This would be a great asset for the protection of the environment and could convince the gardeners to return to the lagoons site.

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