INFLUENCE OF THE STAGE NUMBER ON THE QUALITY OF DOMESTIC WASTE WATER TREATED WITH TYPHA DOMINGENSIS FILTER PLANTS

ABSTRACT

To achieve "good ecological status for water and aquatic environments", extensive treatment techniques have been developed. The goal of this work is to study the two stages efficiency of filters planted with Typha domingensis. Two tanks in series of filters planted with reeds were used. Each tank consists of a tank of $1m^3$ in volume fitted with drainage pipes pierced with holes. Three different layers of gravel were laid over the drain pipes. From the comparison of the characterization of raw domestic wastewater and treated water, it appears that the reductions obtained at the outlet of the 2nd floor are more satisfactory than at the outlet of the 1st floor. The reductions at the exit of the 2nd floor are: 91.7% for total suspended solids; 98.3% for COD; 94.7% for BOD_5; 79.9% for NTK and 49.8% for Pt.

Keywords : *Planted filters, Typha domingensis, stage*

1. INTRODUCTION

Currently, Benin is experiencing a rapid population increase, about 10,008,749 in 2013 and a forecast of 12,120,000 in 2021, according to INSAE 2013 RGPH4 [1]. This galloping increase leads to a significant increase in the volumes of domestic wastewater discharged by users depending on the type of activity. The increasing volumes of domestic wastewater discharged into nature due to lack of infrastructure pose a threat to the environment. To achieve "good ecological status of water and aquatic environments", it is necessary to set up suitable infrastructures called treatment plants. Nevertheless, the choice of process must be established beforehand. Several types of treatments exist. These are physico-chemical treatments and biological treatments. Physico-chemical treatments require the use of chemicals that are expensive and dangerous for the environment (AKOWANOU, 2012) [2]. As for biological processes, there are two categories: intensive systems (activated sludge, biodisk, etc.) and extensive systems (lagooning and filters planted with reeds). Intensive systems require high technical expertise and enormous financial costs for installation and operation (Winkler, 2005) [3]. Extensive processes use natural systems and rely on the natural purification capacity of aquatic plants. These extensive treatment processes are now a viable alternative. The German Käthe Seidel, quoted in Vymazal [4], was the first to experiment with this type of domestic wastewater treatment system in the 1960s. with the aim of improving knowledge related to the functioning of natural wetlands. Then the wastewater treatment process by planted filters was developed by adapting to all types of wastewater. The general objective of this study is to study the influence of the use of two stages of filters planted with Typha domingensis on the removal of pollutants from domestic wastewater. Specifically, it will be necessary to characterize the raw effluents at the filter inlet and the treated water at the filter outlet. This characterization will make it possible to evaluate the water purification performance of the filters. Thus the efficiency of each filter stage will be determined.

2. MATERIALS AND METHODS

The methodology adopted is divided into four steps. First, the experimental pilot was set up Then, the plants were installed in the pilot and two (2) months of adaptation were necessary. Then sampling took place and consisted of taking raw wastewater from the inlet of each filter stage and taking treated water from the outlet of each filter stage. Finally, the data analysis was devoted to determining the abatements for each parameter analyzed according to the formula:

$$Yield\ (X) = \frac{Ci(X) - Cf(X)}{Ci(X)} 100 \qquad (1).$$

This research work was carried out on the University Campus of Abomey-Calavi, located in the commune of Abomey-Calavi in Benin. The domestic wastewater used comes from university residences. In the absence of a wastewater disposal network on the Abomey-Calavi University Campus, domestic wastewater was taken directly from septic tanks. The filters planted with reeds were fed for two months with the raw wastewater used for the experiment.

The Technology Center for Drinking Water and Sanitation served as a venue for hands-on experiments. The mini-station used to evaluate the performance of the filter planted with reeds was installed there. The University Campus of Abomey-Calavi enjoys a subequatorial climate. The year is divided into four seasons: two rainy seasons, the first with heavy rains from April to July, the second less important from late September to November and two dry seasons including the first from August to September and the great one from December to March.

The bed consists of a cubic PVC tank 1.10 m long, 0.90 m wide and 1.00m high. Drains made of PVC tubes (Ø 32 mm) notched with slots were installed at the bottom of the tank to collect the treated effluent on the bottom of the filter. The holes (5 mm slots spaced 15 cm apart) are turned downwards. The ends of the drains were connected to the atmosphere by sealed tubes and vents covered with caps.

The tubes and vents have diameters comparable and compatible with those of drains. Leak tests and tests were carried out before and after the materials were installed to verify the correct operation of the pilot. The bed of planted filters consists of three layers according to the recommendations of Molle [5]:

- o The filter layer composed of gravel with a diameter between 2 and 8 mm and a thickness of 30 cm
- o The transition layer composed of gravel with a diameter between 5 and 10 mm and a thickness of 15 cm
- o The draining layer composed of gravel with a diameter between 20 and 40 mm and a thickness of 15 cm.

Several types of reeds develop in the municipality of Calavi. We chose to experiment with Typha Domingensis. 12 seedlings were then introduced into the bed. The bed was fed for two (2) months with lightly charged domestic wastewater from the septic tank of one of the university residence buildings.

This period of acclimatization allowed the plants to adapt to the environment and allow time for the biofilm to develop. The experiment was carried out based on a tarpaulin system. According to Molle [5], the volume of each tarpaulin must make it possible to obtain a water slide of 5 cm maximum height above the filter layer. This is equivalent to a tarpaulin volume of:

$V = L * l * \square = 1{,}10 * 0{,}90 * (0{,}60 + 0{,}05) = 0{,}644m$ (2)

Samples were taken each day at the same time. Dissolved oxygen, pH and conductivity were taken in situ using an oximeter (WTW type OXI 730), a phmeter (WTW type pH 3110 SET 3) and a conductivity meter (HANNA Instruments type HI 98311). Turbidity was determined using a turbidity meter (MERCK Turbiquant type 1100 IR). The determination of Kjeldahl nitrogen was carried out after selenium mineralization according to AFNOR standards (NF EN 25663) [6]. Total phosphorus was obtained using a spectrophotometer (DR 2800). Turbidity was determined using a turbidity meter (MERCK Turbiquant type 1100 IR). The determination of Kjeldahl nitrogen was carried out after selenium mineralization according to AFNOR standards (NF EN 25663) [6]. Total phosphorus was obtained using a spectrophotometer (DR 2800).

Table 1 : Methods used for parameter analysis

Parameters	***Méthods***	***Norms***
Dissolved Oxygen	Electrochemical Method	NFT 90-106
Temperature		
pH and eH	Potentiometric method	NF T 90-008
Conductivity	Electrochemical measure	NF EN 27888
TSS	Method by filtration	NF EN 872
COD	Volumetric method	NF T 90-101
DBO_5	Manométric method	
TKN	Method by minéralisation	NF EN 25663
TP	Atomic absorption spectrophotometry	-

The average annual rainfall is around 1200 mm. The average monthly temperature varies between 27°C and 31°C with a difference of ± 3.2°C between the hottest month (March) and the coldest month (August) (IITA, 2014) [9].

2. RESULTS AND DISCUSSION

In this part, we will present the results from the characterization of domestic wastewater. Table 2 presents the values of the parameters resulting from the analysis of domestic wastewater at the inlet of filters. The wastewater discharged must meet standards set out in Decree No. 2001-109 of 4 April 2001 setting standards for the quality of waste water in the Republic of Benin [10]. The pH of domestic wastewater entering the filters is between 6 and 9. This pH value meets Beninese standards. Beninese regulations require a temperature of 25°C at the level of water discharged into watercourses. Consequently, the temperature of the domestic wastewater studied (26.2 ° C) is not in line with the standards in force in Benin.

The value of the rH is between 15 and 23. The medium is therefore favorable to the oxidation of organic compounds. Thus, domestic wastewater has the characteristics of an anoxic receiving environment. As for the value of conductivity, it is greater than 500 µS/cm. Therefore, the domestic wastewater studied is highly mineralized. The dissolved oxygen value is high (3.5 mgO2/L) compared to the values generally encountered. This dissolved oxygen value may be due to the existence of a small permanent opening when designing the septic tank from which domestic wastewater originates.

Table 2 : Physico-chemical parameters at the filter inlet

Parameters	***Units***	***Values***
pH	-	5,87
Temperature	°C	26,2
eH	mV	59,6
rH	-	15,2
Conductivity	µS/cm	734,7
Dissolved oxygen	mgO_2/L	3,5

Table 3 shows the values of the global pollution measurement parameters, obtained at the end of the analysis of domestic wastewater at the inlet of the filters.

The values of the MES and COD observed correspond to the values generally encountered at the level of urban wastewater. While the BOD5, NTK and Pt values are lower than the usual values for urban wastewater. When comparing the values of the global pollution parameters to the limit concentrations of the standards, we see that the domestic wastewater studied must not be discharged into the environment without treatment. Without treatment, the organic matter contained in this domestic wastewater will lead to the consumption of dissolved oxygen present in the receiving watercourse and consequently the decrease or even the disappearance of aquatic fauna. Without prior treatment, the TSS of this domestic wastewater will lead to the limitation of the life of photosynthetic organisms and the appearance of deposits that will disturb benthic life. The input of nitrogen and phosphorus material into the receiving watercourse will cause eutrophication.

Table 3 : Global pollution measurement parameters at filter inlet

Parameters	***Values***	***Usual values***	**Norms**
TSS (mg/L)	120	100-400	60
COD (mgO_2/L)	539,1	300-1000	125
BOD_5 (mgO_2/L)	81,33	150-500	25
TKN (mg/L)	3,73	1030-100	15
TP (mg/L)	5,54	30-100	2

Table 4 shows the concentrations obtained at the end of the treatment cycle on each floor.

Table 4 : Global pollution measurement parameters at the outlet of filters

Parameters	***Ci (entry)***	***Cf (exit1)***	**Cf (exit2)**	**Norms**
TSS (mg/L)	120	**20**	**10**	60
COD (mgO_2/L)	539,1	**34,66**	**9,2**	125
BOD_5 (mgO_2/L)	81,33	**8,33**	**4,33**	25

TKN (mg/L)	3,73	**4,85**	**0,75**	15
TP (mg/L)	5,54	**2,91**	**2,78**	2

At the end of the four days of treatment, we find that the concentrations obtained at the first stage for TSS, COD and BOD5 are below the limit concentrations. These concentrations therefore comply with the standards in force in Benin. Water from the second stage has also been treated. Indeed, we find that the concentrations at the exit of the second stage are lower than the concentrations at the exit of the first stage. In addition, the second-stage output concentrations for TSS, COD and BOD_5 are also below the standard limit concentrations. The concentrations at the exit of the second stage for TSS, COD and BOD_5 comply with the regulations. These concentrations are in line with the Beninese standard.

Regarding TSS, COD, and BOD_5, the first stage of filter planted with Typha domingensis allows us to reach concentrations of TSS, COD and BOD_5 that are in line with Beninese regulations. The second stage of Typha domingensis planted filter allows us to refine the treatment at the level of TSS, COD, and BOD_5. The value of the TKN concentration at the outlet of the first stage is higher than the concentration of TKN at the entrance of the first stage. This means that during the stay of domestic wastewater in the first floor, there was an input of nitrogenous matter. These nitrogenous materials can come from the products of the degradation of organic matter.

In addition, we can say that the nitrogenous materials present in the domestic wastewater at the entrance of the first floor have not undergone any treatment. This may be justified by the fact that to break down nitrogenous materials, microorganisms need oxygen. However, the oxygen present in the environment is used to degrade organic matter. As a result, there is no more oxygen available in the first stage to degrade nitrogenous matter. The water leaving the first stage contains little organic matter.

The oxygen available in the second stage will be used mainly to degrade the nitrogenous materials, hence the value of the TKN concentration which is almost zero at the exit of the second stage. Given the low concentration of TKN in raw domestic wastewater, the increase in this concentration at the outlet of the first stage is not significant. Nevertheless, the concentrations of TKN at the exit of the first and second stages comply with Beninese standards. The degradation of phosphorus in the first stage reduces the initial concentration by a factor of 2. Phosphorus treatment in the second stage is low. Phosphorus concentrations at the outlet of the first and second stages do not comply with regulations.

Table 5 : Pollution elimination

Parameters	***Exit1***	***Exit2***	**Norms**
TSS (%)	83,3	91,7	70
COD (%)	93,6	98,3	75
BOD_5 (%)	89,8	94,7	70
TKN (%)	**0**	79,9	70
TP (%)	**47,5**	**49,8**	80

Table 5 shows the yields obtained for physico-chemical parameters at the end of the treatment cycle on each floor. These efficiencies were calculated from filter inlet concentrations, first stage outlet concentrations and second stage output concentrations. We note that at the exit of the first and second stage for TSS, COD and BOD_5, the yields obtained are above the limit yields required by Beninese standards. Consequently, these yields in TSS, COD and BOD_5 comply with the standards in force in Benin. The TKN yield on the 2nd floor is in line with Beninese regulations. Unlike the TKN yield on the 1st floor. As far as phosphorus is concerned, yields are very low well below the yield required by Beninese regulations.

3. CONCLUSION

The study focused on the treatment of domestic wastewater by planted filters of vertical flow Typha domingensis. The experiment gave very good results except for phosphorus. Indeed, at the level of TSS, COD, BOD_5 and TKN, the concentrations and yields obtained at the first and second stages are in line with Beninese regulations. In addition, the results obtained on the second floor are better compared to the result on the first floor. Nevertheless, phosphorus removal remains the major problem of filters planted with reeds. The installation of a third stage is necessary to remove phosphorus materials. We suggest a third floor consisting of either a water lettuce lagoon basin or a planted bed where the gravel layer will be replaced by a more absorbent granular support such as quartz or apatite. Overall, this study shows that filters planted with multi-storey reeds are suitable for treating domestic wastewater. This study can be popularized with town halls so that filters planted on several floors are installed in all households in Benin. This is in order to reduce the impact of domestic wastewater discharged into nature without treatment; on the quality of water resources in Benin.

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