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Treatment of Pigsty Wastewater by Filters Reed Plants: Influence of Organic Load on the Efficiency of Echinochloa Pyramidalis

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Abstract: Context: Filters planted with reeds is an extensive treatment technology. Because of its relatively easy implementation and low operating cost, they arouse the enthusiasm of both decision-makers and scientists. The goal of this study is to assess the effect of organic load of a pigsty wastewater on the development of *Echinochloa pyramidalis*. Methodology: In order to achieve this objective, an experimental device has been installed. The device consisting of three tanks B1, B2 and B3 was supplied with wastewater from the pigsty after their characterization. After an experimental period set at 08 days, the treated effluents were then characterized. Results: The reduction obtained on the first filter pan (B1) is as follows: 60% of COD, 97.87% of MES, 90.81% of Pt and 65% of NTK. Regarding the second filter pan (B2), the reduction in COD is 20%, 96.60% for SS, 83.65% of Pt and -3.33% of NTK. As for the last experimental tank (B3) with a planted filter, the reduction is also 20% for COD, 98.30% MES, 67.68% Pt and 20% NTK. Conclusion and prospect: At the end of the experiment carried out, it is concluded that the organic load has an influence on the performance of the filters.

Keywords: Water Treatment, Planted Filters, Pigsty Wastewater, *Echinochloa Pyramidalis*

1. Introduction

Water is an essential resource for the developm of any living organism. However, the development of anthropogenic activities leads to the degradation of its natural quality. The wastewater thus produced, is poorly managed and is often discharged into natural ecosystems without prior treatment according to [1, 2]. This situation is especially observed in developing countries such as Benin and is explained by the lack of an adequate sanitation policy [3] and the lack of treatment processes adapted to our realities. In order to provide solutions to this sanitation problem, many wastewater treatment processes have emerged. Among these processes, reed-planted filters have proven successful in wastewater treatment and are likely to adequately address sanitation concerns in developing countries such as Benin. This process was tested for the first time in Benin by DEGUENON [4]. Thus, research continues in Benin on this process. The objective of this study is to evaluate the effect of organic loading of pigsty wastewater on the development of Echinochloa pyramidalis. 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.

The planted filter wastewater treatment process is based on the principle of fixed cultures i.e. aerobic biological purification in fine to coarse granular media. The filter bed is not regularly renewed or washed. Thewastewater treatment is therefore carried out by filtration and aerobic biological degradation [4]. The macrophyte planted filter is a wastewater treatment process using macrophytes [5]. This process, whose use is becoming increasingly widespread in the world, makes it possible to treat both (domestic and industrial wastewater) as well as rainwater [6]. There are two types of filters, namely: the vertical flow filter called vertical flow reed filter (FPRV) and the horizontal flow filter known as horizontal flow reed filter (HFRF). Horizontal flow filters, [5].

Käthe Seidel (1950) developed a cascade filter system consisting of two vertical stages fed with raw water, followed by several horizontal flow stages planted with water. with two vertical stages fed with raw water followed by several horizontal flow stages planted with iris and bulrushes. But it was not until 1960 that Reinhold Kickuth revealed the decisive role of role of the bacteria in the root zone by sketching the first models. The Denmark adopted this new procedure under the enlightened leadership of Hans Brix (1980). In general, Denmark. In general, Denmark is one of the countries where the planted filter in its various forms in its various forms, especially in individual sanitation, with a strong commitment from scientists, technicians and scientists, technicians and the government. In 1975, the Netherlands built the first filter in Lauwersoog the first full-scale vertical filter in Europe. It consists of a settling and distribution ditch of distribution ditch, drained and planted with Phragmites australis, and four infiltration compartments that are fed alternately [7]. Planted filter technology is a recently developed technology is a recently developed technique. In France, for example, the first planted filters were developed by Cemagref through a few through a few units in the 1980s. Various modifications aimed at simplifying the system and making it more and to make its operation more reliable were made before proceeding with its development [8]. The technology of planted filters is a technique that has which has seen its development increase since 1997. Currently, there is a strong demand for this type of treatment from This type of treatment is currently in great demand among elected officials. Indeed, it is a reliable technology, simple to operate and It is a reliable technology, easy to use and facilitates the management of sludge [4]. In addition, this process is well accepted by the population because of its image as 'natural', reinforced by its ability to integrate into the rural landscape [9]. Constructed Wetland" is the accepted term used by English speakers and in international and international communications. The choice of these two words is justified by the fact that the process started by constructing (Construted) wetland-like structures in the hope of restoring their purifying power [4]. Several studies have shown that the planted filter treatment process effectively treats domestic wastewater in developed countries with a temperate climate [10-12]. This technique has been used in developed countries for decades and to regulate the construction of these facilities, some governments have published guidelines [13-15, 8]. In developed countries, the planted filter treatment process has also proven to be a successful method for treating wastewater. In developed countries, the planted filter treatment process has also been proven in the treatment of industrial wastewater [4]. We note that there is a growing interest in this process in developing countries in tropical climates through studies of the developing countries in tropical climates through recent studies. In Africa for example, [16] Kivaisi in Tanzania; demonstrated the exceptional capacities of constructed wetlands to treatment of domestic wastewater in developing countries. Studies have proven the effectiveness of Panicum maximum [17] (Ouattara in Ivory Coast) and Typha ([18] in Tunisia for the treatment of domestic wastewater. In Asia, planted filters of Typha angustifolia and Cyperus involucratus ([19] Kantawanichkul in Thailand); Phragmites karka and Phragmites australis ([20] Parco in the Philippines) have given satisfactory results in the treatment of of highly loaded synthetic domestic wastewater and wastewater from laundries, respectively. Echinochloa pyramidalis planted filters have also proven to be effective in treating sewage sludge in tropical climates [21].

2. Materials and Methods

This research work was carried out on the Technological Center for Drinking Water and Sanitation of the University of Abomey-Calavi located on the University Campus of Abomey-Calavi (CUAC), in the commune of Abomey-Calavi in Benin. The mini station used for this study was installed there. The host site 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 experimental pilot consists of three tanks. Each bin is 29.6 cm long, 25.8 cm wide and 43 cm high. The three tanks are all equipped with an outlet valve to recover the treated effluents at the outlet of the filters. They were then each filled with a substrate composed of rolled, sorted and washed gravel. Leak tests and tests were carried out before and after the materials were installed to verify the correct operation of the pilot. Each bed of planted filters consists of three layers of gravel according to Molle's recommendations [10]: The filter layer is composed of gravel with a diameter between 2 and 8 mm and 20 cm thick, the transition layer is composed of gravel with a diameter between 3 and 20 mm and 10 cm thick and the draining layer is composed of gravel with a diameter between 20 and 60 mm and 5 cm thick. Several types of reeds develop in the municipality of Calavi. We chose to experiment in this study with Echinochloa Pyramidalis. Four seedlings of Echinochloa pyramidalis were introduced into each tank. The experiment was carried out based on a tarpaulin system.

With regard to the analyses carried out in the laboratory, physico-chemical parameters were evaluated. 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). As presented in Table 1, the determination of Kjeldahl nitrogen was carried out after selenium mineralization according to AFNOR standards [22]. Total phosphorus was obtained using a spectrophotometer (DR2800). For the determination of COD Chemical Oxygen Demand and MES Suspended Solids, the volumetric and filtration methods were used respectively according to AFNOR standards [23, 24]. 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 (August) [25].

Table 1. *Methods used for the analysis of physico-chemical parameters.*

Parameters physical-chimical	*Method of determination*
Temperature (°C)	
pH	Electrical Method
Conductivity	
TSS (mg/L)	Membrane filtration method NF EN 872
COD (mgO_2/L)	Volumetric method NF T90-101
TKN (mg/L)	Selenium meniralizer method NF EN 25663
TP (mg/L)	Method NF ISO 15587-1

The results of its analyses allowed us to calculate the purification yield of each basin by the formula:

$$Yield\ (X) = \frac{Ci(X) - Cf(X)}{Ci(X)} * 100 \quad (1)$$

3. Results and Discussion

For the results obtained at the end of the analyses, the characterization of the three effluents studied is presented in Table 2. The temperature values above 20°C and those of the pH between 6 and 8 make it possible to say that the three basins are favourable to the development of microorganisms responsible for reducing organic matter. Conductivity values above 1000 µS/cm show the high mineralization of its raw effluents. The high COD and NOS values allow us to say that the three effluents studied are highly loaded with organic matter.

Table 2. *Results obtained for physico-chemical parameters.*

Parameters	*Ci (Effluent B1)*	*Ci (Effluent B2)*	*Ci (Effluent B3)*
Tempetature (°C)	29,4	25,1	22,7
pH	6,71	7,56	7,46
Conductivity (µS/cm)	3726	2177	1128
TSS (mg/L)	9400	4700	2350
COD (mgO_2/L)	8320	4160	2080
TKN (mg/L)	336	168	84
TP (mg/L)	240,46	120,23	60,11

Figures 1 and 2 show the percentage reduction in TSS and COD respectively. The analysis of these two graphs shows that the B3 tank was more efficient in terms of ESS abatement (98.30%) than the other two basins while basin 1 was more efficient in terms of COD abatement (60%). However, the significant yield obtained on the three basins in terms of reduction of ESS (more than 95%) is explained by the fact that the massif implanted by macrophytes allows a good elimination of suspended solids. These results are consistent with those obtained by DEGUENON [4].

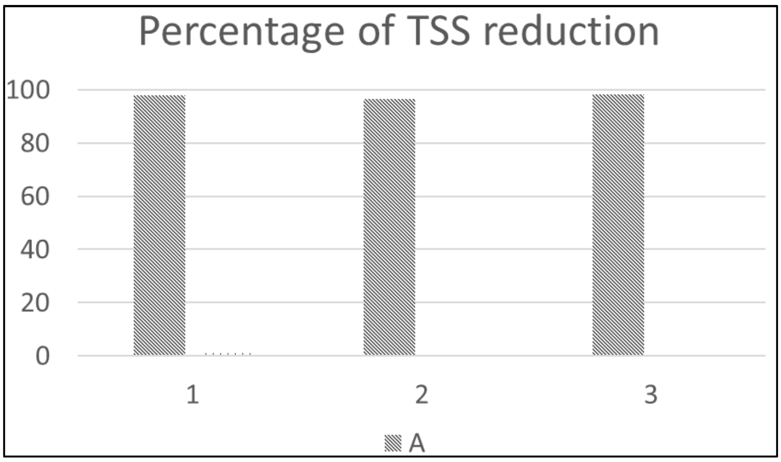

Figure 1. *Percentage of TSS reduction.*

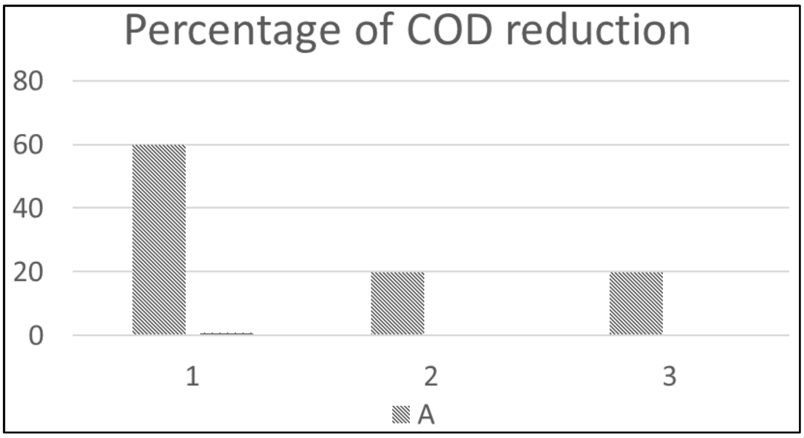

Figure 2. *Percentage of COD reduction.*

Figures 3 and 4 show the percentage reduction of phosphorus and NTK, respectively. The analysis of these two graphs shows that basin 1 performed well in terms of phosphorus (90.81%) and nitrogen (65%) abatement compared to the other two tanks. Nevertheless, there is also a good reduction of phosphorus in basins 2 and 3, this would be due to their use by macrophytes, KNOWLES [26] had claimed that plants could use them for their growth. As far as nitrogen is concerned. There is a negative reduction in basin 2 (-3.33%), which justifies that there has been no elimination of nitrogen in this basin.

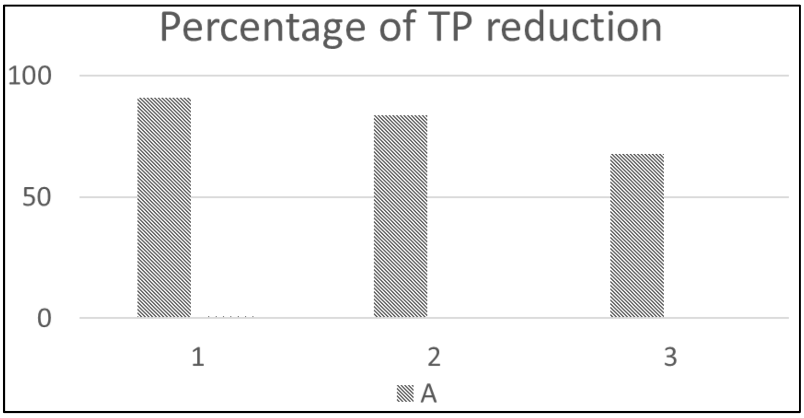

Figure 3. *Perrcentage of TP reduction.*

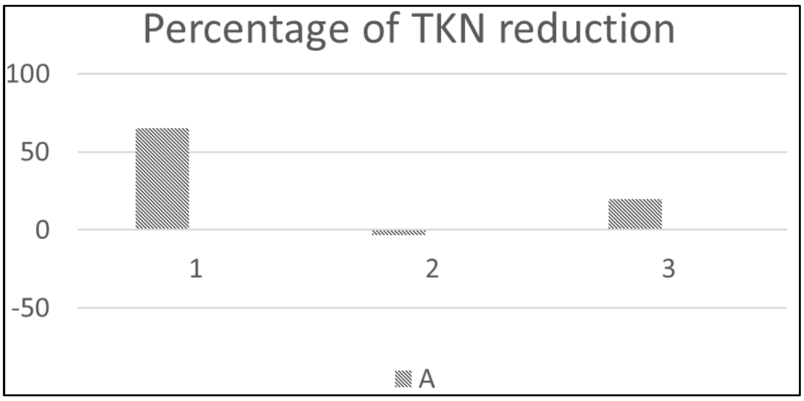

Figure 4. *Percentage of TKN reduction.*

In terms of concentration, Table 3 shows the elimination of COD. There is a decrease in COD concentration at the end of treatment in the three basins with the smallest concentration obtained on basin 3. This would be due to the low concentration brought to the entrance of the latter. This hypothesis is justified by BOUTIN [27], when they say "when a station is under load, the quality of the discharge is excellent".

Table 3. *Elimination of COD.*

Experimentation tanks	*B1*	*B2*	*B3*
Ci (mgO_2/L)	8320	4160	2080
Cf (mgO_2/L) 8 days after	3328	3328	1664

Table 4 shows the removal of suspended solids. A significant decrease in the concentration of TSS is observed in the three basins with the smallest concentration still recorded in basin 3. These results allow us to affirm that the granular system has allowed a good elimination of particulate pollution.

Table 4. *Elimination of TSS.*

Experimentation tanks	*B1*	*B2*	*B3*
Ci (mg/L)	9400	4700	2350
Cf (mg/L) 8 days after	200	160	40

Table 5 shows the removal of total phosphorus. Although phosphorus pollution remains a pollution that is difficult to eliminate by filters planted with reeds, a considerable decrease in phosphorus concentration is observed in all basins. The smallest concentration is observed on basin 2.

Table 5. *Elimination du Pt.*

Experimentation tanks	*B1*	*B2*	*B3*
Ci (mg/L)	240,46	120,23	60,11
Cf (mg/L) 8 days after	22,11	19,66	19,78

Table 6 shows the elimination of NTK. A decrease in nitrogen concentration is observed in basins 1 and 3, the smallest concentration is obtained in pond 3. As for basin 2, there was an increase in concentration. This input of nitrogenous matter would certainly be due to the degradation of organic matter from leaf debris and insects that would have accidentally fallen into pond 2 due to its location.

Table 6. *Elimination of TKN.*

Experimentation tanks	*B1*	*B2*	*B3*
Ci (mg/L)	336	168	84
Cf (mg/L) 8 days after	117,6	173,6	67,2

With regard to the behaviour of the plants during the experiment, the beginning of yellowing of the plants is observed in pond 1, which received the highest load of raw effluent. This confirms the hypothesis of Amougou [1] who states "when the planted filter is subjected to a high load, plants tend to degenerate thereby limiting its performance".

4. Conclusion

The study conducted on the Technological Center for Drinking Water and Sanitation of the University of Abomey-Calavi aimed to evaluate the influence of the organic load of pigsty water on the performance of filters planted with reeds: case of Echinochloa Pyramidalis. At the end of this work, it was noted that:

1) The first vertical flow filter tank B1 that received a high organic load was effective in removing COD, Pt and NTK than the other two tanks. And that the B3 filter tray was in the case of MES. Also, in terms of concentrations only the B3 tank gave a good purifying performance with regard to MES, COD and NTK. This is due to the low concentration of the raw effluent.
2) At the level of B1, there was degeneration of plants. This was probably caused by the high concentration of raw effluent at the first tank.

Overall, this study shows that filters planted with reeds are suitable for treating effluents from pig barns in Benin. This study can be popularized with town halls so that planted filters are installed in all pigsties in Benin. This is in order to reduce the impact of effluent discharges from pig barns on the quality of water resources in Benin.

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