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Optimization of Domestic Wastewater Treatement in Kara City by Artificial Swamp

Moudassirou SEDOU[1,*], Seyf-Laye ALFA-SIKA MANDE[1,2,3], Ibrahim TCHAKALA[1,3], Oussama ISHAKA[1]

[1]Research Laboratory of Water and Environmental Engineering, University of Kara, BP. 404, Togo
[2]Beijing Key Laboratory of Water Resources & Environmental Engineering, China University of Geosciences (Beijing), Beijing 100083, P.R. China
[3]Laboratory of Applied Hydrology and Environment, University of Lomé, BP. 1515, Togo
*Corresponding author: sedoumoudassirou@gmail.com

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Abstract The present work aims to study three macrophytes. The plants Alocasia macrorrhizos, Ixora chinensis and Helicornia rostrata have been studied on a laboratory scale for their ability to eliminate Chemical Oxygen Demand (organic load), phosphorus and nitrates. The results of this study showed that the Alocasia macrorrhizos plant is more effective in the treatment of organic load. Of the three plants, Helicornia rostrata and Alocasia macrorrhizos remove phosphorus better, with a margin of 23.58% for Helicornia rostrata. All three macrophytes effectively remove nitrates. In view of the results obtained, the combination of Alocasia macrorrhizos and Helicornia rostrata would be suitable for the mixed treatment of organic load, phosphorus and nitrates.

Keywords: *macrophytes, elimination, organic, nitrates, phosphorus*

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1. Introduction

Water is unevenly distributed over the earth. Despite its inexhaustible appearance, the problem of scarcity is felt across much of the globe. Agricultural and industrial activities are responsible for most of the demand for water. In addition, population growth is accelerating the expansion of water supply. As the demand for water as a whole increases, the amount of water used and its aggregate pollutant loads are steadily increasing around the world. An estimated volume of about 2112 km^3 of wastewater is released into the environment each year [1]. Wastewater is water altered by human activities following domestic, industrial, artisanal, agricultural or other use. They are likely to pollute the environments in which they are released according to Anicet Thomas, et al., Https://tpephytoepuration.wordpress.com [2]. The main sources of wastewater are agriculture, industry and growing demography. The city of Kara is not spared by these sources, which generate water used above all for a demographic boom. This wastewater does not undergo treatment before discharge. "In the guide for the safe use of wastewater and excreta in agriculture and aquaculture published by the program in collaboration with the United Nations for the environment [3]; health protection requires that wastes undergo minimal treatment to eliminate pathogens. Without treatment, this wastewater disturbs the ecosystem, in particular aquatic, by eutrophication due to an excess of phosphorus and / or nitrogen according to studies by [4]. Eutrophication leads to the proliferation of potentially toxic algae and a decline in biodiversity. The clogging of the bronchi of fish by suspended matter (SS) suffocates them, for example. These SS and algae proliferation decrease dissolved oxygen and prevent light penetration.

This wastewater also affects groundwater. Following the observations made, domestic wastewater in Togo does not undergo a minimum of treatment before discharge, and it is detrimental to the receiving environments. What can we do when we cannot refrain from its use? Faced with the negative impacts of these waters on man and his environment, humanity has become aware of reducing these risks. They must undergo a minimum of treatment before rejection. It has been developed different treatment system to reduce pollution risk. These are: the classic system, the lagoon system, the sand filtration system and the system planted with macrophytes. The choice of the treatment process must meet the cost and effectiveness.

Intensive techniques using chemical reagents, because of their cost or the technicality required, are generally not suitable for small communities. There is therefore a real operational need for the development of an extensive technique, the planted filter technique combining purification efficiency, cost reduction, robustness and reduced maintenance. The role of vegetation is fundamental, mainly to prevent clogging, but also with regard to purification yields [5]. The planted filter system is an inexpensive technique compared to conventional methods which require more energy [6]. It would urge developing countries to look into such a technique reducing motor, human and chemical input. The method of treating effluents by higher plant species called macrophytes is one hundred percent natural and in which human intervention is limited [7]. Numerous studies have been carried out around the world and attest to the positive role of plants in artificial marshes, in particular of nutrients and heavy metals treatment [8-15].

The objective of this work is to study the purification capacity of plants and to select them in the application of domestic wastewater treatment.

2. Materials and Methods

2.1. Botanical and Ecological Description of Macrophytes

Table 1. Botanical and ecological description of macrophytes

Macrophytes	Botanical description	Ecological environments
Alocasia macrorhizos	-Foliage: Persistent with well-ribbed oval leaves, simple and alternate. - Inflorescence: in spathes. - Relatively long lifespan	Humid tropics
Heliconia rostrata	-Foliage: alternate, long - Inflorescence: spike - blooms from February to November but can flower all year round in good condition	Tropical humid zones and rainforests
Ixora chinensis	-Evergreen, leathery trees or shrubs - Flowering lasts all year with 6 weeks of rest. Flowers in inflorescence	Tropical and subtropical areas

2.2. Device Description

Batch tests in triplicate were carried out in buckets with a capacity of 5 L. In each bucket are implanted the macrophytes supplied with synthetic wastewater. Gravel previously washed with distilled water to remove any added nutrients and organic matter. This Gravel serves as a support for the macrophytes. Artificial wells are created using 2cm diameter of PVC pipe. These wells homogenize the solution through pores at different gradients (Figure 1). Sample is taken using syringes through this well to have a representative sample.

2.3. Sampling

From the device in Figure 1, samples are taken using a syringe from the artificial wells.

2.4. Chemical Analysis of Parameters

The open system reflux method or excess potassium dichromate oxidability method was used to analyze COD.

Phosphorus by absorption spectrometric method - molecular. In an acidic medium and in the presence of ammonium molybdate, orthophosphates give a phosphomolybdic complex which reduced by ascorbic acid, develops a blue color capable of spectrometric determination.

Nitrates by the method of absorption spectrometry - molecular with sulfosalicylic acid. Nitrates give sodium paranitrosalicylate, colored yellow and capable of spectrometric determination [9].

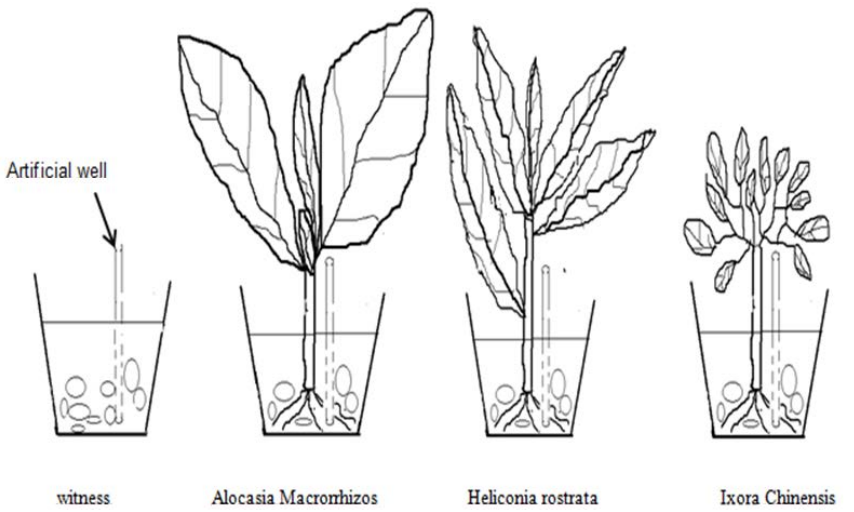

Figure 1. Studied parameters treatment device

3. Results and Discussion

3.1. Removal of COD

According to Figure 3, the removal of COD is slow in the first 10 days for P2 (16.8%) and P3 (7.2%) while the removing with P1 increased linearly. After 10 days, It increased rapidly and reached at 87.36%; 78.93% and 70.5% respectively for P1, P2 and P3 in 21 days.

These plants have an affinity for organic matter. The plant P1 is abled remove more (87.36%) followed by P2 (78.93%) and P3 (70.5%). These results are in the same direction as those obtained by [10] who used Phragmites Australis with 75.69% removal and Typha Latofilia with 71.60%.

An increase in pH is observed in the effluent of the various marshes compared to that of the crude synthetic effluent (Figure 2). It goes from 4.42 to values between

6.81 and 7.5. This pH values (between 5 and 8) obtained are favorable to the development of microorganisms [11].

The low removal in the first ten days is explained by the non-adaptation of the macrophytes to their new environment.

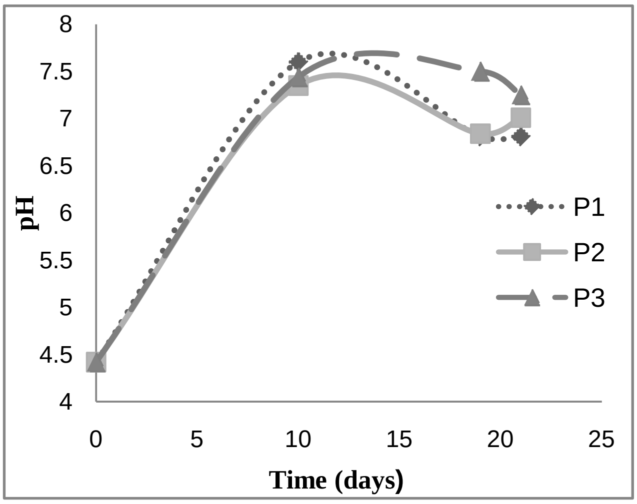

Figure 2. pH evolution during the removal of COD

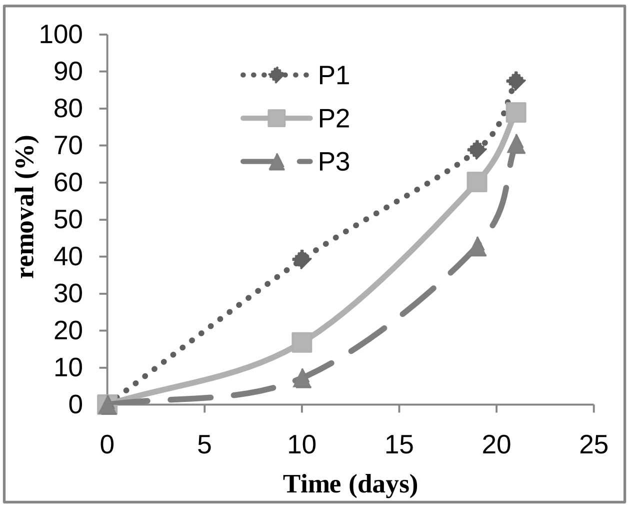

Figure 3. COD removal by differents plants

3.2. Removal of Phosphorus

Figure 6 reveal that Phosphorus removal by P1 and P2 upon the 14 first days is linearly increased. This removal of Phosphorus is constant and very low by P3 upon this period.

Beyond the 14 days, the removal is more exponential for P2 and P1 which are adapted to their new environment and remove more the polluant. The plant P2 remove more phosphorus with 74.48% in 20 days followed by P1 with 51.22%. After 14 days, phosphorus concentration is increased in P3 bucket. This concentration is higher than the control. This explain that P3 releases phosphorus.

These removal rates are evaluated against the control to determine the removal capacity or affinity of each plant for the pollutant. Analysis of the control solution shows an increase in the concentration from 20mg/L to 29.13mg/L of P in 20 days. The increasing of phosphorus concentration in control solution is explained by evaporation.

Figure 4 shows an increase in pH initially (1 day) for all the marshes as well as the control. The same observation is made for the conductivity in Figure 5. The conductivity is almost exponential in the three planted marshes, it is also increased in the control but lower than the marshes. This is explained by a mineralization of the synthetic pollutant and a supply of minerals by the roots of the macrophytes.

From day 3, the pH gradually decreases for plants P1, P2, P3 until day 13. From this day, the pH of P1 has decreased more than those of P2 and P3 but has increased in the synthetic effluent control from day 3 to day 20. The same observation is made in Figure 5 where the decrease in conductivity is explained by the removal of the pollutant by the plants. The results obtained show that the electrical conductivity (EC) in the control effluent is higher than that of planted marshes. The decrease of EC in planted marshes is explained by retention of dissolved salts by plants. These salts can be retained by various physicochemical and biochemical reactions (absorption, ionic exchanges, complexation, oxidation, neutralization) [12].

The plant P2 has more affinity for phosphorus followed by P1 and finally P3 which releases this pollutant after a period of accumulation.

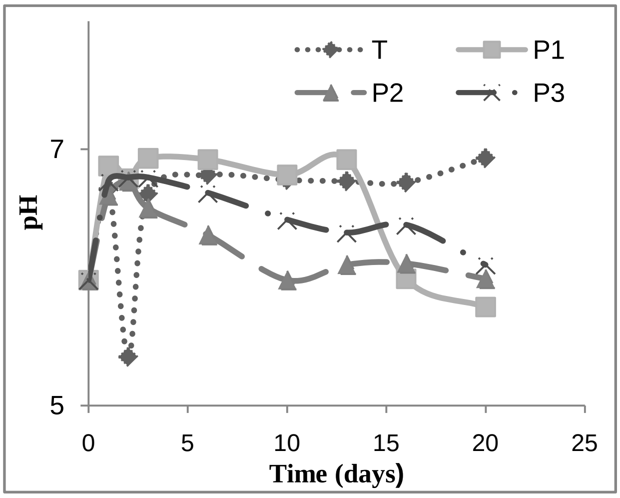

Figure 4. pH evolution in the removal of phosphorus

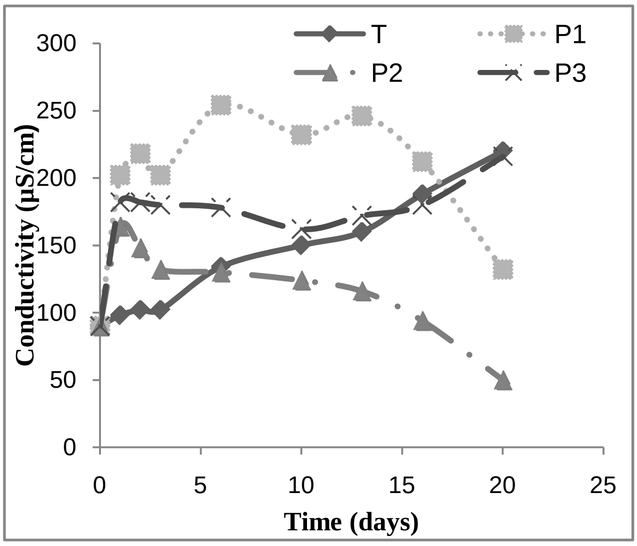

Figure 5. Electrical conductivity evolution in the removal of phosphorus

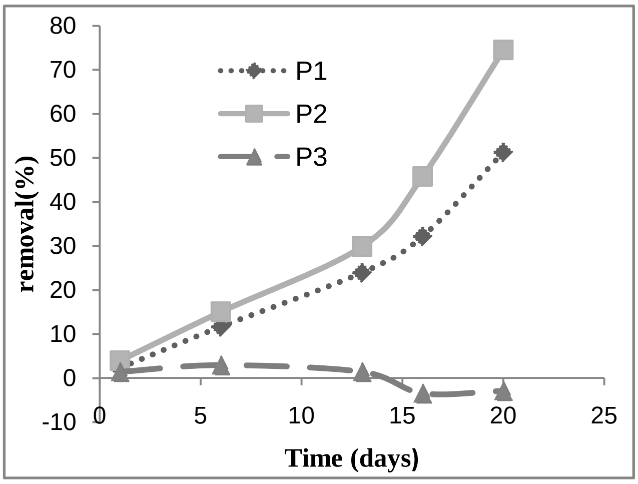

Figure 6. Phosphorus removal by differents plants

3.3. Removal of nitrates

Figure 7 shows a decrease of pH in the different marshes relative to the pH of the crude effluent and that of the control. The pH of the marsh of the P1 plant is lower (6.46 to 6.17) than that of the marsh at P2 (6.52 to 6.36) which is also lower than that of the marsh at P3 (6.63 to 6.98). This decrease in pH was observed by [13]. Electrical conductivity increased for all plant marshes within 20 hours (Figure 8). It would have been due to a supply of minerals by these plants. At the same time, the witness had a slight decrease.

Beyond 20 hours, the conductivity of the planted marshes decreases when that of the control increases. This decrease is explained by an assimilation of nitrates by plants.

Figure 9 shows the high rate of abatement by plants. It was exponential within 48 hours for the P1 plant from which we obtain a rate of 97.69% against 35.64% for P2 and 21.10% for P3. This elimination should be in the same direction as the electrical conductivity. The P1 plant reduces nitrates rapidly. Figure 9 shows that P1 removes more nitrates (99.87%) than P2 (99.65%) followed by P3 (74.05%) in six days. These removal rates are evaluated relative to the control, the concentration of the control varied from 20mg/L à 25.40mg/L of N. This study proves that nitrates are good nutrients for these plants and their elimination is beneficial for the environment.

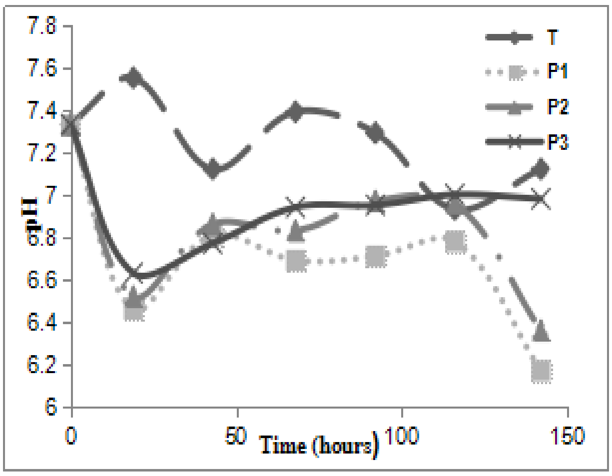

Figure 7. pH evolution in the removal of nitrates

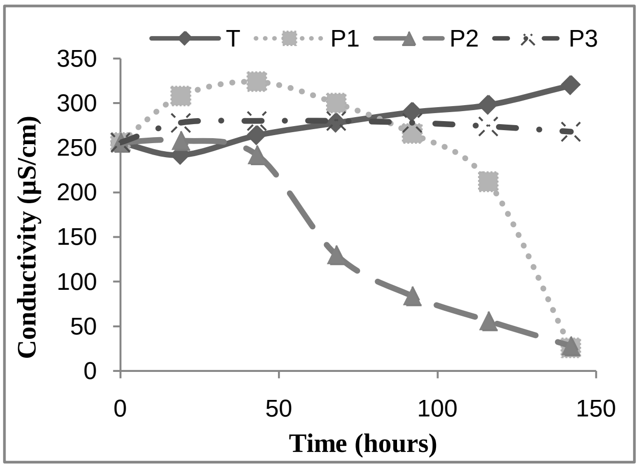

Figure 8. Electrical conductivity evolution as a function of time by action of plants

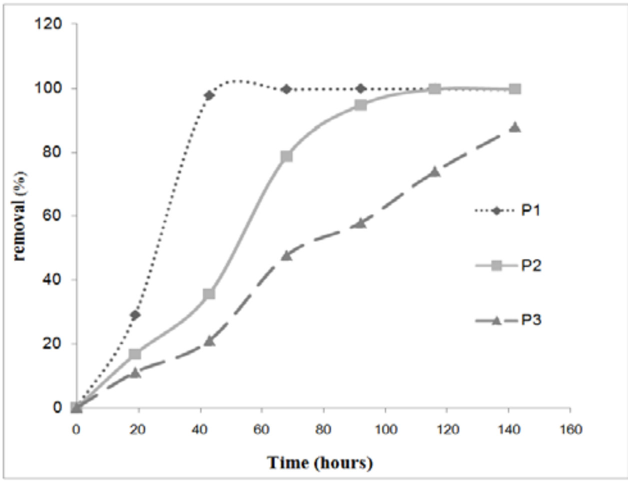

Figure 9. Nitrates removal as a function of time by differents plants

4. Conclusion

Phyto-purification is a technology to purify wastewater by using aquatic plants. Indeed, scientists are always looking for a better way to treat wastewater with minimum of expense and good efficiency. Phyto-purification is an advantageous ecological means of purification. The present study carried out in order to find local macrophytes useful in phytoremediation allowed us to compare three macrophytes in the removal of COD, phosphorus and nitrates. It appears that Alocasia macrorrhizos has more affinity to organic matter and nitrates than Helicornia rostrata and Ixora chinensis. In the removal of phosphorus, Helicornia rostrata is more suitable than Alocasia macrorrhizos in which a release of this parameter has been observed by Ixora chinensis. In six (6) days, with a concentration of 20 mg/L of N applied, the elimination rate was 99.70%; 99.61% and 87.97% respectively by Alocasia macrorrhizos, Helicornia rostrata and Ixora chinensis. An increase in the concentration was observed in the control marsh of nitrates and phosphorus. It goes from 20 mg/L to 29.13 mg/L of P for phosphorus and from 20 mg/L to 25.04 mg/L of N for nitrates. This observation is due to synthetic wastewater evaporation. The residence time for nitrate removal (146 hours) is low. There is a correlation between certain pollution parameters on the one hand and certain ions present on the other. This affinity between parameters could influence the removal. According to studies carried out by Mande et al. on “Nitrate in drinking water: A major polluting component of groundwater in Gulf region aquifers, South of Togo” [14], nitrates have no relation with calcium and sodium but 'have with magnesium, potassium, bicarbonate alkalinity, sulfate, chloride and electrical conductivity. Phytoremediation is widely used in heavy metal removal [15].

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