ASSESSMENT OF THE EFFICIENCY OF CONSTRUCTED WETLAND IN DOMESTIC WASTEWATER TREATMENT AT THE UNIVERSITY OF LAGOS, NIGERIA.

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Abstract

The present study was undertaken to assess the reduction of physical, chemical and biological parameters in the domestic sewage generated within the University of Lagos community using constructed wetland. Influent (raw wastewater) and effluent (treated wastewater from the constructed wetland) samples were collected and analysed for various parameters. Average removal efficiencies of measured parameters from treated effluents are 75.27% for Total Dissolved Solids(TDS), 98.18% for Turbidity, 89.72% for Colour,74% for Conductivity,58.08% for Dissolved Oxygen(DO), 75.22% for Iron, 67.14% for Sulphate, 92.73% for Nitrate,89.92% for Manganese, 76.53% for Biochemical Oxygen Demand(BOD) and 92.86% for Total Coliform. All the parameters are within the Federal Environmental Protection Agency (FEPA) Effluent Limitation Guidelines in Nigeria stipulated values for effluent discharge into receiving water bodies. The study concludes that constructed wetland is efficient in the treatment of the domestic sewage. The wastewater discharged into the neighbouring lagoon by the University of Lagos is not polluting the water body.
Keywords: Constructed wetlands, total coliform, biochemical oxygen demand, Federal Environmental Protection Agency.

INTRODUCTION

All over the world, much wastewater is being generated and most of them, especially in developing countries, are not treated before being discharged into water bodies. Aquatic ecosystems are used either directly or indirectly as recipients of potentially toxic liquids from domestic, agricultural and industrial wastes (Demirezen, *et al.*, 2007). Untreated or partially treated wastewater release is harmful to the environment, thus wastewater discharge should be regulated to protect the environment. Abdel-Halim *et al.*,2008 noted that about two-thirds of the population in developing countries have no hygienic means of disposing excreta and total wastewater which implies that inadequate sanitation are the prime causes of disease in such countries.

Raw sewage contains mostly water (about 95%) which often comes from washing and flushing toilets. They also contain organic particles (such as feaces, food, paper fibres, plant materials etc), inorganic particles(such as sand, metal particles, ceramics etc), pathogens and non-pathogenic organism, animals such as protozoa, insects etc, macro solids such as sanitary napkins, diapers etc; Gases such as hydrogen sulphide, methane etc and toxins amidst others. The rich/wide diversity of raw sewage makes them habitat for various organisms and plants.

The mechanisms of water quality improvement in constructed wetlands are numerous and interrelated. These include settling of suspended particulate matter, filtration and chemical precipitation, chemical transformation, adsorption and ion exchange on the surfaces of plants, substrate, sediment, and litter, breakdown and transformation of pollutants by microorganisms and plants, uptake and transformation of nutrients bymicroorganisms and plants and predation and natural die-off of pathogens.

For more than two decades, have used constructed wetlands to improve the quality of contaminated water and wastewaters (Maine *et al* 2009; Murray-Gulde *et al.*, 2005 Zhang *et al.*, 2010.) Constructed wetlands have successfully being used for environmental pollution control despite the fact that it was initially designed for use in domestic wastewater (Scholz & Lee, 2005). Constructed wetlands are engineered waste water treatment systems that involve lots of treatment processes including biological, chemical and physical processes resembling natural treatment wetlands (Adeniran, 2011). They are made of shallow ponds on which aquatic plants are grown. Constructed wetlands are constructed with impervious day and synthetic lines and engineered structures control direction of flow, retention and water level (Ewemoje & Sangodoyin; 2011)

The two major types of constructed wetlands are the Surface flow (SF) wetland which consists of a shallow basin, soil or other medium to support the roots of vegetation, and a water control structure that maintains a shallow depth of water and the Subsurface flow (SSF) wetland consists of a sealed basin with a porous substrate of rock or gravel. The water level is designed to remain below the top of the substrate (EPA 1993). Constructed wetlands are known to have a high buffering capacity. Effluent quality is therefore normally quite stable. On the other hand, adverse effects can be expected from low temperatures (especially inhibition of N-removal), peak flows(wash out of solids) and clogging of subsurface flow systems. Removal percentages are mainly dependent on temperature, hydraulic residence time (HRT) and loading rate (Rousseau *et al.* 2008).

In this study, the combined Surface Flow and Subsurface flow wetland was employed for the treatment of the domestic waste water produced in the University of Lagos before discharge into the lagoon.

MATERIALS AND METHODS

The Study area

The university of Lagos, Lagos Nigeria is located in Lagos **on 06°25’N 03°27’E on the West African Coast** and has a direct link to the Lagos lagoon. Figure 1.0

Fig. 1.0: The University of Lagos, Nigeria(Adeniran,2011)

The wastewater from the University community are conveyed in sewers to the central sewage pumping treatment plant located at Services Area of the University at the precinct of the Lagos lagoon. Large particles screened off in a Primary Treatment Inception Chamber before channelling into a Septic Tank and to the constructed wetland system. The wetland was constructed to a depth of 0.65m and divided into six cells, each of 8m×7m. Water hyacinth was planted on the first cell which is a Surface Flow constructed wetland. The other five cells subsurface flow constructed wetland and contained different sizes of gravel and ocean sharp sand as the wetland media. The five cells are planted with common cattail (*typha latifolia*) as the wetland plant. Figure 2.0.

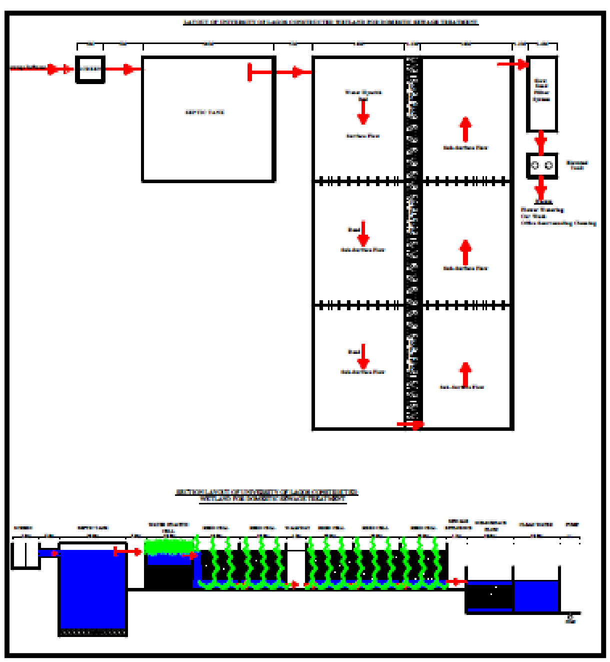

Fig. 2.0: Layout and Section of the University of Lagos Constructed Wetland (Adeniran, 2011)

Sample collection and analysis

Sampling was done within the period of August 2010-August 2011 and was taken daily in the morning between 7:30 to 8:30am. Samples were collected in plastic containers at designated points in the constructed wetland and taken to the laboratory for immediate analysis.

Waste water quality testing was carried out with the use of Hanna HI 83200 multiparameter photometer. The principle of operation of the equipment is based on the interaction between electromagnetic radiation and matter during absorption of light. The optical system of HI 83200 is based on a special miniature tungsten lamp and narrow-band interference filters. For each of the chemical parameters, 10ml of the sample was dispensed into the curettes and the corresponding chemical reagents added (in accordance to the manufacturer's specification). Corresponding measurements were read-off the LCD display. The colour of the sample was measure in the HI 83200 multiparameter photometer after filtering using Whatman No. 42 filter paper. The conductivity, Turbidity, pH and total dissolved solids were also measured using the Adwa conductivity meter, Hanna microprocessor turbidity meter, Beckman 350 pH meter and HM digital TDS meter respectively.

Results of laboratory analysis were subjected to data evaluation by statistical methods.

RESULTS AND DISCUSSION

Results

The results, which are the mean of the data collected for one year, are presented in Tables 1.0 and 2.0 for the physical and Chemical/Micro-biological parameters respectively. The comparisons with FEPA standards are shown in Table 3.0.

Table 1: % Removal Efficiencies - Physical Parameters

Parameters	Units	Influent	Effluent	% removal
pH		7.10	7.76	-9.29
TDS	Mg/l	469	116	75.27
Turbidity	HTU	108.75	1.98	98.18
Colour	PCU	428	44	89.72
Conductivity	μΩ/cm	1.00	0.26	74.00

Table 2: % Removal Efficiencies – Chemical Parameters

Parameters	Units	Influent	Effluent	% removal
Dissolved Oxygen	mg/l	3.14	7.49	-58.08

Iron	mg/l	1.13	0.28	75.22
Sulphate	mg/l	58.50	35	67.14
Nitrate	mg/l	27.50	2.0	92.73
Manganese	mg/l	60	0.61	89.92
BOD	mg/l	54.54	12.80	76.53
Total coliforms	Cfu/100ml	>874.17	62.44	92.86

Table 3: Effluent Physico-chemical and Microbiological parameters compared with the Nigerian Effluent limitation Guidelines (FEPA,1991).

Parameter	Units	Effluent	Limit for discharge to surface water
PH		7.76	6-9
TDS	mg/l	116	2000
Turbidity	HTU	1.98	Not stated
Colour (	PCU	44	7(Lovibond unit)
Conductivity	μΩ/cm	0.26	Not stated
Dissolved oxygen	Mg/l	7.49	
Iron(Fe)	Mg/l	0.28	10
Sulphate	Mg/l	39	500
Nitrate	Mg/l	2.0	10
Manganese(Mn)	Mg/l	0.61	20
Coliform	MPN/100ml	393.1	400MPN/100ml
BOD	Mg/l	12.80	30

Discussions

From Table 1, there is no appreciable difference in influent and effluent pH values, although both are within FEPA standards. Studies by Longe and Ogundipe, 2010 revealed that effluent from the University of Lagos treatment plant has pH between 7.1 and 9.0.

The total dissolved solids value of the effluent is well within the FEPA limits, similar results were obtained by Asia and

Akporhonor (2007). A 75% reduction was obtained in the TDS value of the effluent compared to the influent.

The constructed wetland removed 98% of the turbidity. The turbidity value of the influent was 108.75FTU while the effluent had a turbidity value of 1.98FTU. Decrease in turbidity can be attributed to the fact that there is a decrease in Total dissolved and suspended solids. Efficiency of constructed wetland in the removal of turbidity may depend on the sand granules, soil particle sizes and depth of the bed according to the findings of Prasad et al., 2006. The decrease in turbidity is directly related to the colour, an 89% removal was observed in the colour of influent to effluent.

The presence of free oxygen in water is an indication of the ability of that water to support biological life .Ademoroti,1996 noted that healthy body of wa ter should have a dissolved oxygen of at least 5.2mg/l. Low oxygen concentration is associated with heavy organic matter contamination(Prasad *et al.*,2006). This study revealed an improvement in the effluent DO value (7.49mg/l) compared with the influent value (3.14mg/l). It should be noted that the negative value (-58.08%) obtained is an improvement as Dissolved oxygen values are expected to increase with efficiency of the constructed wetland. Improvement noticed in dissolved oxygen after treatment in the constructed wetland may be due to reduction in organic pollution load and bacterial population due to their retention in the beds and simultaneous mixing of atmospheric oxygen (Prasad *et al.*,2006). Analysed influent concentrations of Iron (1.13mg/l), Nitrate (27.5mg/l) and Manganese (60mg/l) showed an appreciable level of purification in the constructed wetland to obtain effluent values of 0.28mg/l, 2.0mg/l and 0.61mg/l respectively. These values are within the acceptable limits of FEPA. Nitrogen concentration in different forms gives a useful indication of the level of micronutrients in the waters and hence their ability to support plant growth. A high content of NO_3-N and NO_2-N in water may be toxic to babies (Kempster *et al*,. 1997). High NO_3-N concentration promotes the eutrophication of water bodies and create aenarobic condition with excessive growth of algae. The flora and fauna of the water bodies are thereby destroyed (Adeniran, 2011).

Although sulphate is classified as non toxic, intake of water containing high sulphate content can cause diarrhoea. Presence of sulphate in domestic wastewater may be due to the addition of detergent wastes from washing (Sharma and Dubey, 2011). A 67.14% removal in sulphate was observed from influent (58.5mg/l) to effluent (35.00mg/l).The constructed wetland is quite efficient in the removal of sulphates and it should also be noted that plants do not make use of sulphates. However, the effluent value still conforms to FEPA standards.

Biological Oxygen Demand (BOD) is the measure of the oxygen required by microorganisms whilst breaking down organic matter .Obtained mean values for BOD, 54.54mg/l and 12.80mg/l at influent and effluent respectively indicates a 76.53% purification performance. Constructed wetlands are known to be highly efficient in reduction of BOD (Prasad *et al.*, 2006 Babatunde *et al.*, 2008, Asia and Akporhonor, 2007).

The study reveals that the percentage removal of total coliform is 92.86%.The main processes that are involved with pathogen removal is sedimentation. Sediments of wetlands tend to accumulate as vast amounts of coliforms and bacteria. These sediments also give some bacteria the ability to survive longer. Karim *et a*l tested whether sedimentation played a significant role in reducing pathogens in wetlands; He observed that there were not large differences in the amount of feacal coliform in the water column and sediments. However, multispecies wetland showed 73 and 58 percent removal of pathogens

(Karim *et al,*.2004).Prasad et al (2006) in another study noted that the depth of the beds plays a significant role in the reduction of bacterial populations. The reduction of 82.4% was observed in a 2 feet (600mm) deep bed while a reduction of 6.2% was found in beds that are 1 feet (300mm) deep. The depth of the constructed wetland in UNILAG is 650mm which may also account for the better efficiency in coliform removal.

CONCLUSION

The results from the study reveal a good performance of the University of Lagos Constructed wetland. The constructed wetland is found to be highly efficient in the treatment of sewage in terms of physical parameters, however, no appreciable difference was noticed in the pH values of both influent and effluent. The removal efficiency of the facility for most physical, chemical and biological parameters is well above average and the effluent values are within the FEPA's Effluent Limitation Guidelines in Nigeria (1991).

Further studies will be based on the improvement of the constructed wetland for better performance through the examination of the possibilities of the use of a various species of constructed wetland plants. Pilot studies in this respect are on-going.

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