Tertiary Hospital Wastewater Treatment using Reed Bed Technology Planted with V*etiveria nigritana* benth and P*hragmites karka* retz

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Abstract

Tertiary hospital wastewater in Nigeria constitutes a risk to public health due to inadequate treatment. Reed bed technology using locally available macrophytes holds tremendous potentials for biological wastewater treatment. The use of *Vetiver*ia *nigritana* and *Phragmites karka* in CW for the removal of organic and inorganic pollutants from tertiary hospital was therefore investigated. Characteristics of wastewater such as pH, Nitrates (NO_3^-), Phosphates (PO_4^{3-}) and Ammonia (NH_3) contents, Suspended Solids (SS), Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO) from the University College Hospital, Ibadan were evaluated using American Public Health Association's (APHA) methods. The optimal dilution ratio of wastewater was determined by varying wastewater concentration (3:1, 1:3, 1:1, 4:0 and 0:4 wastewater to water) while monitoring growth rate of the macrophytes. Four 3.1 x 3.4 x 0.7 m Reed bed prototypes with *Vetiver*ia *nigritana* and *Phragmites karka* planted on 0.2 m deep, 10-15 mm sized granite overlaid by 0.2m washed sand and control bed were evaluated. Composition of wastewater displayed considerable variability (pH 7.5 ± 0.3, NO_3^- 2 ± 0.1mg/L, 3 PO_4^{3-} 3.9 ± 2.5mg/L, NH_3 19.5 ± 6.3mg/L, SS 204.1 ± 23.9mg/L, DO 0.9 ± 0.8 mg/L and BOD 310.6 ± 29.9 mg/L). The 1:3 waste water to water dilution ratios supported the most rapid growth of macrophytes. The prototype reed bed showed reduction of BOD 82.0% and 85.0%, TDS 72.0% and 73.0%, PO_4^{3-} 78.0% and 81.0%, NO_3^- 61.0% and 65.0% for *V. nigritana and P. karka* respectively. *Vetiveria nigritana* and *Phragmites karka* were found to be efficient in wastewater treatment using Reed bed Technology.

Keywords: Reed bed, *Vetiver*ia *nigritana*, *Phragmites karka,* wastewater, tertiary hospital

Introduction

Severe water pollution and insufficient supply are some of the major problems facing the water environment around the globe. The scarcity of fresh water is predicted to become the greatest single threat to international stability, global food supply and human health. Water quality deterioration can be attributed to pollution entering surface and groundwater from sources such as runoff, municipal and industrial discharges (Truong, 2000; Hanping *et al*, 2004).

In Nigeria, domestic wastewater disposal into near-by river is a common phenomenon. Most urban rivers and streams are dumping ground for domestic wastewater as exemplified by River Kaduna, River Ogba in Edo State, River Ogunpa in Oyo State and River Ogun. Organic contaminants entering the systems from municipal wastewater treatment plants or as raw wastewater is some of the major sources of organic wastes entering our waterways. It has been reported that 4.6 million people died from diarrhea disease and a sizeable number of casualties was experienced from ascariasis, guinea worm and trachoma due to deterioration of the water quality (Akpata and Ekundayo, 1998).

Water quality deterioration due to Nigeria's tertiary hospitals has various environmental consequences, the immediate environment is seriously affected, septicity which causes offensive odour and breeding of flies that are capable of threatening the health of the community results; the receiving waters is not spared as wastewater flows through the largely populated residential and commercial areas of neighbouring cities and there is uncontrolled access to the water by the public. Discharge of nutrients-rich wastewater, nitrates and phosphates in particular would lead to eutrophication, which will seriously destabilize the ecosystem of the water bodies.

In the past years there has been an increasing interest in using more rustic methods to treat urban wastewater as well as industrial wastewater containing heavy metals or organic chemicals. Reed bed technology offering an alternative treatment that can satisfy these requirements are currently being used (Salmon *et al*, 1998). Reed bed technology is an engineered system designed and constructed to utilize natural processes for water quality improvement, it combines physical, chemical and biological treatment processes in water quality improvement. Reed bed involves wetland vegetation, soils and the associated microbial assemblages to assist in treating wastewaters (Davies *et al*, 2005). It is a wastewater treatment facility duplicating the processes occurring in natural wetlands. Reed bed is a complex integrated system in which water, plants, animals, microorganisms and the environment; sun, soil and air interact to improve water quality. Distinctive features of this system according to Cooper *et al,* (1989) include the roots of the plants that grow vertically and horizontally to provide maximum contact with the wastewater and substrate. Effluents are treated by aerobic biological activity at the rhizophere and inlet zone while anoxic and anaerobic treatment takes place at the middle and base of the system.

The choice of substrate in Reed bed is of major importance as it provides support for the living organisms, serves as storage medium for many contaminants, many chemical and biological (especially microbial) transformations take place within the substrates, their permeability affects the movement of water through the wetlands (Calheiros, *et al*, 2008). Vegetation in CW performs remarkable metabolic and absorption functions, their transport system take up nutrients and contaminants from the substrates or water. Macrophytes have been shown to have a significant and positive effect on wastewater pollution removal (Brisson and Chazarenc, 2008; Akratos and Tsihrintzis, 2007).

This present study is aimed at investigating the efficiency of Reed bed Technology; using locally available macrophytes (*Vetiver*ia *nigritana* and *Phragmites karka*) on the removal of pollutants from wastewater generated in a tertiary hospital.

Methodology

The study area of the research work is the University College sewage farm, University College Teaching Hospital (N 07.40583^0, E 03.90384^0 203m), Ibadan (UCH), Oyo State. The existing treatment plant in UCH has eight drying beds that are supposed to be charged with stabilized sludge from the digester with a total surface area of 900m^2. One of the existing disused concrete walled drying beds was used as the reed bed. The sludge drying bed was divided into two equal parts and the first half of the bed was partitioned into five cells (Plate 1). Each of the included cell was rectangular in cross-section and the cells at the edges were trapezoidal in cross-section. The cell at the centre was used as the control bed, to either side were two beds planted with *Vetiveria nigritana* and *Phragmites karka.*

All the beds have a uniform depth of 0.7 m; the two cells at the edges were 310 x 340 cm while the remaining three were 250 x 340 cm each. They were separated by sandcrete blocks, well rendered to prevent percolation of wastewater. Each of the beds has a slope of 2% to allow the wastewater pass through the bed under gravity with ease.

The substrate materials used in this study were washed granite and washed sand. The coarse substrate was made up of 200 mm deep 10-15mm granite, while the fine substrate layer was 200mm thick (Cu = 2.435 and Cc = 1.094). Transplanted rhizomes of the two locally available macrophytes, *Phragmites karka* (commonly known as reeds) and *Vetiveria nigritana* (the Nigerian specie of Vetiver) were used. *Vetiveria nigritana* was collected from the Department of Agronomy, University of Ibadan and *Phragmites karka* obtained from Igbobele water course, Badagry, Nigeria.

Plate 1: Reed bed prototype cells showing the irrigation pipe and the sludge drying beds

The beds were irrigated uniformly with a pumping machine connected to a 150 mm diameter PVC pipe, this was perforated at intervals of 100mm for uniformity of loading and proper aeration. The effluent from the under drain of the trickling filters' media were collected from the inspection chamber and was used to feed the Reed bed. Effluent from the bed was collected through an opening of 6 mm diameter PVC pipe attached to the base of the cell. The Valeport 'Braystoke' BFM002 miniature current meter designed for the measurement of flow velocities in effluent water was used for flow measurement. Samples were collected and analysed using standard methods for examination of water and wastewater (APHA, 1994). Samples were stored at 4^0C and analysis conducted within three hours of sample collection.

Results and Discussion

The raw wastewater discharged into the treatment plant is mainly domestic in character with minor effluents joining from the wards, theatres and clinics. Toxic chemicals from the pathology laboratories are discharged into septic tanks attached to the laboratories. A summary of the physical and chemical parameters of the influent grey water during the study period is presented in Table 1.

Table 1: Characteristics of Wastewater from the University College Hospital

Parameters	**Range**	**Mean**
Temperature ^{0}C	24.9-32	30.48±0.96
Ph	7.1 – 7.9	7.49±0.27
Dissolved Oxygen (mg/l)	0.05 – 2.01	0.84±0.79
Dissolved Solids (mg/l)	414 – 630	481±81.11
Suspended Solids	167 – 231	204.1±23.9
BOD (mg/l)	210 – 370.6	310.56±29.91
NO_3 – N (mg/l)	0.032 – 0.150	0.141±0.06
PO_4 – P (mg/l)	2.014 – 8.50	3.94±2.52
NH_4 – N (mg/l)	10.2 – 30.0	19.45±6.31

Pollutant parameters in the wastewater displayed considerable variability in concentration throughout the study period. These variations are consistent with reported variability of pollutant concentration in wastewater within individual sites. The wastewater generated at the University College Hospital varies during the time of the day and season of the year (Figure 1). The peak flow of 221.30 ± 3.81m^3/day and 367.85 ± 26.36m^3/day in the dry and wet season respectively occurred between 7:00am and 8:00am. The lowest flow rates of 0.80m^3/sec to 0.90m^3/sec (69.12m^3/day and 177.7m^3/day) for the dry and wet seasons respectively were observed between the hours of 12noon and 2pm.

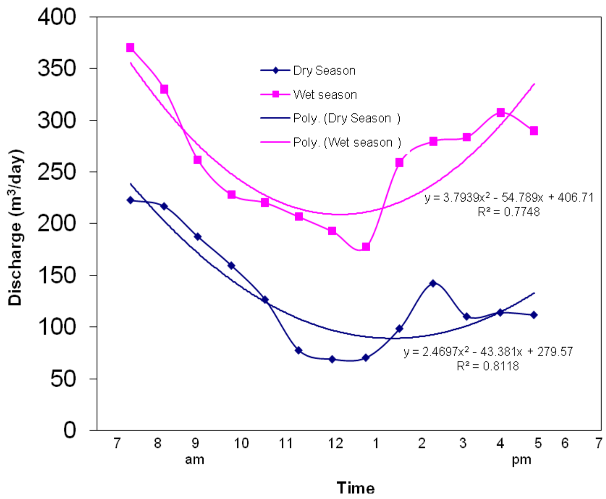

Figure 1: Variation in wastewater discharge with time at the University College Hospital Ibadan

Figure 2 shows optimal dilution ratio of wastewater by varying the concentration of wastewater on the height of plants, width of stem and number of leaves of *P. karka*. The results agree with the work of Bragato *et al,* (2006) where low nutrient concentration of the sewage entering the wetland had minimal effect on the growth of *Phragmites australis.*

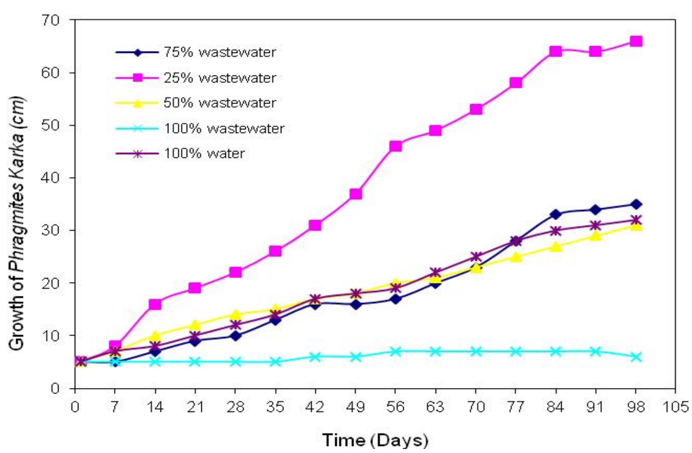

Figure2: Effect of variation in concentration of wastewater on the growth rate of *Phragmites Karka*

The results obtained from the dilution of wastewater on the growth rate of *V. nigritana* showed that it has high tolerant rate at elevated levels of nutrients, as opined by Ralph and Truong (2004). The 1:3 ratio mix of wastewater to water still proved to be the best mix at the initial stage of growth as observed in *P. karka*, it could be seen from Figure 3 that the nutrient concentration did not adversely affect the other proportions during the initial growth as was observed in *P. karka*.

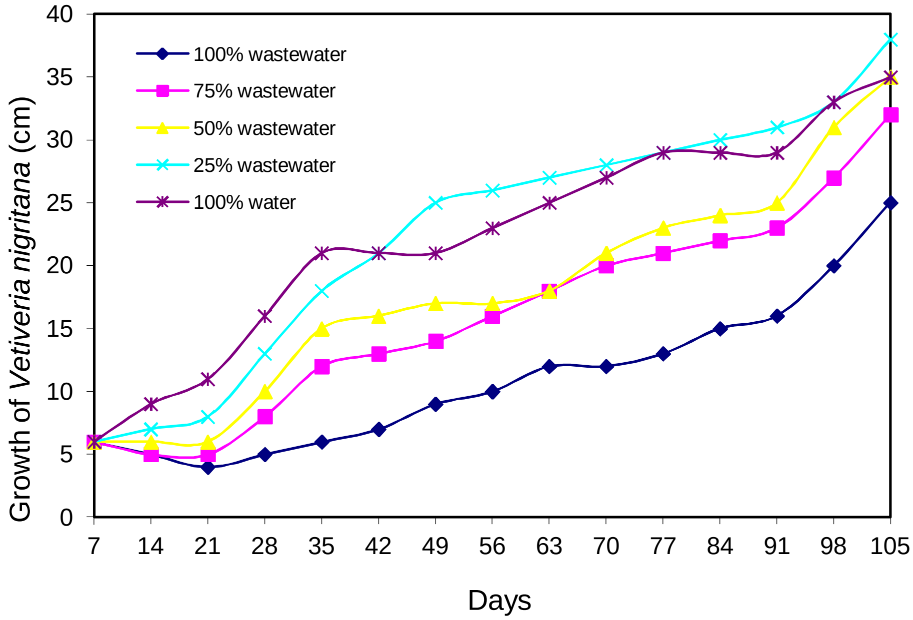

Figure 3: Effect of variation in concentration of wastewater on the growth rate of *V. nigritana*

Effluents from the prototype Reed bed showed tremendous improvement in the reduction of wastewater pollutants. The influent fed into the prototype having BOD of 293.5 ± 20.43mg/L was reduced to 53.83 ± 16.2mg/L and 44.03 ± 17.5mg/L for the cells with *V. nigritana* and *P. karka* respectively. The prototype also showed that Reed bed accounts for a large fraction of TSS removal in wastewater with a reduction from 213.5 ± 9.24mg/L to 59.78 ± 10.15mg/L and 57.64 ± 8.23mg/L for *V. nigritana* and *P. karka* respectively.

Nitrate was reduced from 0.141 ± 0.003mg/L to 0.055 ± 0.011mg/L and 0.049 ± 0.014mg/L while Phosphate level was reduced from 2.36 ± 0.05mg/L to 0.52 ± 0.21mg/L and 0.45 ± 0.65mg/L for *V. nigritana* and *P. karka* respectively. Results from the control bed gave BOD, TSS, NO_3 and PO_4 values of 132.5 ± 15.6mg/L, 105.63 ± 8.81mg/L, 0.126 ± 0.019mg/L and 1.37 ± 0.179mg/L respectively.

Conclusion

The composition of wastewater generated from the University College Hospital Treatment plant is similar to that of domestic wastewater and is in the medium classification of wastewater. The wastewater discharges from the treatment plant has two peak periods during the dry and wet season and the flow rate could be represented by a polynomial mathematical model. The study also reveals that Reed bed Technology using locally available macrophytes (*Vetiveria nigritana and Phragmites Karka*) is efficient for the treatment of wastewater from a tertiary healthcare facility.

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