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TREATMENT OF TERTIARY HOSPITAL WASTEWATER IN A PILOT-SCALE NATURAL TREATMENT SYSTEM (REEDBED TECHNOLOGY)

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ABSTRACT

Tertiary hospital wastewater in Nigeria constitutes a risk to public health due to inadequate treatment as the conventional treatment plants proved non-sustainable. Conventional treatment systems require high level of operation skills, communities that operate such are constantly faced with the annual energy and labour cost. The wastewater treatment system at University College Hospital, had completely broken down due to poor maintenance caused by lack of spare parts, unstable power supply and inadequate funding. Reedbed technology using locally available macrophytes was evaluated in treating the wastewater from the University College Hospital, Ibadan. The wastewater quality parameters pH, Suspended Solids (SS), Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Ammonia (NH_3), Nitrates (NO_3^-), and Phosphates (PO_4^{3-}), contents were followed for the assessment of performance of the biological treatment. Flow-rates were monitored using a Valeport Braystoke BFM002 miniature current meter. Five beds were used in the experiment each bed has 10-15 mm sized granite overlaid by 0.2 m washed sand as media with 0.2 m void volume. Composition of wastewater displayed considerable variability (pH 7.5±0.3, NO_3^- 0.2±0.1 mg/L, PO_4^{3-} 3.9±2.5 mg/L, NH_3 19.5±6.3 mg/L, SS 204.1±23.9 mg/L, DO 0.9±0.8 mg/L and BOD 310.6±29.9 mg/L). The pilot scale reedbed 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. Reedbed Technology *using Vetiveria nigritana* and *Phragmites karka* was found to be efficient in wastewater treatment. The design and construction of this treatment facility did not entail the use of any mechanical component and, thus, the maintenance requirement is minimal

KEYWORDS: Phragmites Karka, Reedbed, Tertiary Hospital, Vetiveria Nigritana, Wastewater.

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. Of the country's rivers, 43 were drafted to be in need of dredging as they are grossly polluted and silted as a result of discharged domestic wastewater. Some of these include River Kaduna, River Ogba in Edo State, River Ogunpa in Oyo State and River Ogun. It has been reported that pollution of rivers resulted in mortality and morbidity of over 4.6 million people due to diarrhea, and other infectious diseases (Akpata and Ekundayo, 1998).

Environmental degradation includes offensive odour and breeding of insect vectors of public health importance results. Discharge of nutrients-rich wastewater with 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 using Reedbed technology (Salmon *et al*, 1998; Adewole, *et al*., 2009a; Adewole *et al*., 2009b)

Reedbed 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. Reedbed 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. Reedbed is a complex integrated system in which water, plants, animals, microorganisms and the environment, sun, soil and air interact to improve wastewater 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 rhizosphere and inlet zone while anoxic and anaerobic treatment takes place at the middle and base of the system.

This present study was aimed at investigating the efficiency of Reedbed Technology using locally available macrophytes (*Vetiver*ia *nigritana* and *Phragmites karka*) on the removal of pollutants from wastewater generated in a tertiary hospital. The limitation of this study is the provision that has to be made for settling of the raw wastewater before passage into the reedbed to prevent incessant clogging in the substrate.

MATERIALS AND METHODS

The study area of the research work is the University College sewage farm, University College Teaching Hospital (UCH), (N 07.40583^0, E 03.90384^0 203m), Ibadan, Nigeria. The existing treatment plant which consists of a primary clarification tank, trickling filter, secondary clarification tank and aeration tank has eight drying beds that are supposed to be charged with stabilized sludge from the digester with a total surface area of 900 m^2. One of the existing disused concrete walled drying beds was used as the pilot scale reedbed. The sludge drying bed was divided into two equal parts and the first half of the bed was partitioned into five cells (Plate 1). The cell at the centre was used as the control bed and 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 × 340 cm while the remaining three were 250 x 340 cm each. They were separated by sandcrete blocks and 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 – 15 mm size granite, while the fine substrate layer was 200 mm thick (Cu = 2.435 and Cc = 1.094). Transplanted rhizomes of the two locally available macrophytes, *Phragmites karka* and *Vetiveria nigritana* were used. *Vetiveria nigritana* were collected from the Department of Agronomy, University of Ibadan and *Phragmites karka* were obtained from Igbobele water course, Badagry, Nigeria.

Plate 1: Pilot Scale Reedbed 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 100 mm for uniformity of loading and proper aeration. The effluent from the underdrain of the trickling filters' media were collected from the inspection chamber and was used to feed the Reedbed. Effluent from the bed was collected through an opening of 6mm 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. Samples were stored at 4^0C and analysis conducted within three hours of sample collection.

RESULTS AND DISCUSSION

The raw sewage 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 the raw sewage in UCH

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
Total 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 sewage 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 varied during the time of the day and season of the year as shown in Figure 1. The peak flow of 221.30±3.81 m^3/day and 367.85±26.36 m^3/day in the dry and wet season respectively occurred between 7:00 am and 8:00 am. The lowest flowrates of 0.80 m^3/sec to 0.90 m^3/sec (69.12 m^3/day and 177.7 m^3/day) for the dry and wet seasons respectively were observed between the hours of 12 noon and 2 pm

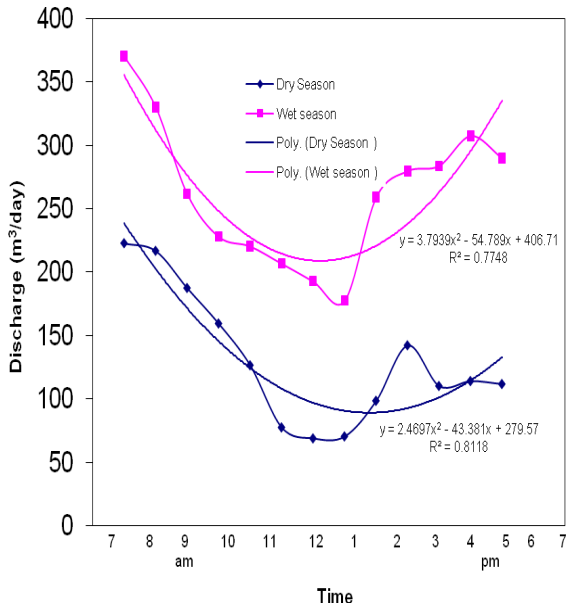

Fig. 1: Variation in wastewater discharge with time at the University College Hospital Ibadan.

The average flow rate of wastewater during the dry and wet seasons were 131.5±51.9 m^3/day and 262.2±56.2 m^3/day respectively. Effluents from the pilot scale Reedbed showed tremendous improvement in the reduction of pollutants. The influent fed into the prototype having BOD of 293.5 ± 20.43 mg/L was reduced to 53.83 ± 16.2 mg/L and 44.03 ± 17.5 mg/L for the cells with *V. nigritana* and *P. karka* respectively. The study also showed that Reedbed accounts for a large fraction of TSS removal in wastewater with a reduction from 213.5 ± 9.24 mg/L to 59.78 ± 10.15 mg/L and 57.64 ± 8.23 mg/L for *V. nigritana* and *P. karka* respectively.
Nitrate was reduced from 0.141 ± 0.003 mg/L to 0.055 ± 0.011 mg/L and 0.049 ± 0.014 mg/L while Phosphate level was reduced from 2.36 ± 0.05 mg/L to 0.52 ± 0.21 mg/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 ± 15.6 mg/L, 105.63 ± 8.81 mg/L, 0.126 ± 0.019 mg/L and 1.37 ± 0.179 mg/L respectively.

CONCLUSIONS

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. The natural wastewater treatment system (Reedbed Technology) adopted in this study requires low cost and minimal maintenance facility for wastewater treatment. Reedbed technology does not require highly skill personnel and the problem associated with annual labour and energy cost is reduced using this technology. The study shows a technology that requires low-cost and minimal maintenance facility for wastewater treatment. The study reveals that Reedbed Technology using locally available macrophytes (*Vetiveria nigritana and Phragmites Karka*) is efficient for the treatment of wastewater from a tertiary healthcare facility. *Phragmites karka* yields higher treatment efficiency for Biochemical Oxygen Demand, Suspended Solids, Phosphate and Nitrate than *Vetiveria nigritana.*

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