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EVALUATION OF EARTHWORM AS BIOFILTRATION AGENT IN ORGANICALLY POLUTED WATER

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ABSTRACT
This research work evaluated the potentials of earthworms in the treatment of organically polluted water. Physiochemical parameters tested based on APHA standards to evaluate the qualities of water were Biolgical Oxygen Demand(BOD), Chemical Oxygen Demand(COD), Total Soluble Solids(TSS), Total Dissolved Solid (TDS), Electrical conductivity, pH, and temperature. The experiment was carried out in three batches in a vermi-filter where mass and time was varied to evaluate the removal efficiencies of organic matter from waste water samples using the physiochemical parameters. The results of the experiment showed that the removal percentages of BOD, COD, TSS, TDS was between 65.5 - 80%, 68.2-85.8%, 59.1-92.7% and 60.6-91.5% respectively depending on the hydraulic retention time of the waste water in the vermifilter and masses of the earthworm in each vermin-filter. Earthworm successfully treated organically polluted water.

Keywords; *vermifiltration, vermifilter, earthworms, hydraulic retention time, organically polluted water*

INTRODUCTION

Domestic waste water could either be black water or grey water. Water generated from the toilet is referred to as black water, while grey water originates from various locations like kitchen, bathroom, laundry, cloth washers and bath tubs. Black water is normally handled through septic tank as the quantity is not as much as grey water. Quantity of grey water generation depends on availability of water, habits of people as well as locality of which about 80% returns as municipal waste water in the sewer system (Bhise and Anaokar, 2015). Sewage has to be treated to reduce the organic loads before discharging into the natural environment (rivers and oceans). Otherwise, aerobic bacteria in the sewage will consume more Dissolved Oxygen (DO) from the river or ocean water to decompose these organic materials thereby depleting the DO values. This would seriously affect the survival of the aquatic organisms in the rivers and oceans. Vermifiltration, a biotechnological process involving the use of waste eater earthworms, could be used to treat the sewage generated. The body of the earthworm functions as a biofilter and has been found to have effectively reduced Biological Oxygen Demand (BOD5), Chemical Oxygen Demand (COD), Total Dissolved Solid (TDS) and Total Suspended Solids (TSS) by over 90, 80 – 90, 90 -92 and 90 – 95% respectively (Lakshmi, *et al.,* 2014, Bhise and Anaokar, 2015). Earthworms are considered because they can tolerate high concentrations of organic matter in the environment. They also assist in ventilation of air in soil medium as they breathe through their skin. Earthworms also create aerobic conditions in the waste materials by their burrowing actions, which thereby inhibits the action of anaerobic microorganism which release foul-smelling hydrogen sulphide and *mercaptans* (Hughes *et al.,* 2011; Sinha *et al.,* 2008). Furthermore, human pathogens are typical component of domestic sewage and their control is one of the fundamental reasons for wastewater treatment, because it is a complex phenomenon and is largely ignored. Pathogen removal in vermifilter is closely associated with the natural die-off, predationor physio-chemical properties of the filter material, because pathogens are mainly sobbed by filter media or die off by the micro flora associated with the filter bed where earthworms thrive. Factors to consider in selection of soil media for vermifiltration: soil low in organic matter as the type of soil used affects the quality of the effluent. It is also important to note that the volume of the soil profile is a determinant of the efficacy of the hydraulic retention time of earthworms in the soil media. Specie of earthworms commonly used include *Eisenia fetida*(Red Wriggler Worms) and *Perionyx exacvatus*(Malaysian or Indian Blue Worms) as they have generally been considered as waste eaters. While *E. fetidais* widely used and is particularly used for smaller home based vermifilter, for a larger group like a community, *P. excavatusis* advised because it reproduces at a faster rate, ensuring earlier stabilization, while producing more worm castings, which is vermicompost. salts Concentration in the waste water should also be considered before starting the process, it is very important to know the salt especially NaCl and Na_2S0_4 concentration of the wastewater because earthworms will not thrive in water that has concentration of between 0.5% and 1%. Hydraulic retention time, which is the time taken by the waste water to flow through the soil media (vermifilter bed) in which earthworms inhabits is also very important, because the longer the waste water remains in the vermifilter in contact with earthworms, the greater the efficiency of vermi-filtration. The objective of this work is to determine the effect of retention time and the mass of the earthworm on the treatment of domestic waste water

MATERIALS AND METHODS

About 2500 pieces of earthworms (*Eisenia fetida*) were obtained from the Federal University of Agriculture, Abeokuta (FUNAAB) environs and about 700g were put in each tank. Domestic waste used for the experiment was collected from IyalodeTinubu female hostel of FUNAAB in a 50liters plastic polymer. Samples of waste water were taken immediately to Department of water resources management laboratory for the determination of to evaluate the qualities of water such as BOD, COD, TSS, TDS, Electrical conductivity, pH, and temperature values of both the raw waste water and the treated water.

Determination of Biological Oxygen Demand

Biological oxygen demand (BOD, also called biochemical oxygen demand) is the amount of dissolved oxygen needed (i.e., demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20°C and is often used as a surrogate of the degree of organic pollution of waste water.BOD is used as a gauge for the effectiveness of waste water treatment plants (Sinha, *et al.,* 2007).

Determination of Chemical Oxygen Demand

Chemical oxygen demand is used to measure the amount of organic matter in a water sample. It determines the amount of organic pollutants in waste water samples which makes COD a good measure of water quality determination. The unit of measurement is milligram per litre(mg/l) (Sinha *et al.,* 2007).

Determination of Total Dissolved Solid

Total dissolved solid (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular suspended form. Generally the

operational definition is that the solids must be small enough to survive filtration through a filter with two-micrometer (nominal size or smaller) pores. Total dissolved solids are normally discussed only for fresh water systems, as salinity includes some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects) it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants (Sinha, *et al.,* 2007).

Determination of Total Suspended Solids

Total suspended solid (TSS) is the dry-weight of particles trapped by a filter. It is a water quality parameter used for example to assess the quality of wastewater after treatment in a wastewater treatment plant.TSS of a water or wastewater sample is determined by pouring a carefully measured volume of water through a pre-weighed filter of a specified pore size, then weighing the filter again after drying to remove all water. The gain in weight is a dry weight measure of the particulates present in the water sample expressed in units derived or calculated from the volume of water filtered (typically milligrams per litre or mg/L) (Sinha, *et al.,* 2007).

Determination of Electrical Conductivity

Electrical conductivity (EC) of water is its ability to conduct an electric current. Salts or other chemicals that dissolve in water can break down into positively and negatively charged ions. These free ions in the water conduct electricity, so the water electrical conductivity depends on the concentration of ions. The EC of water is an indicator of the purity of water. It is usually tested using an electrical conductivity meter (Sinha, *et al.,* 2007).

Determination of PH Value

Acidic and basic are two extremes that describe chemical property chemicals. Mixing acids and bases can cancel out or neutralize their extreme effects. A substance that is neither acidic nor basic is neutral. The pH scale measures how acidic or basic a substance is. The pH scale ranges from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic. A pH greater than 7 is basic. A pH meter is used to test for this or and sometimes a litmus paper.

Experimental Setup

The experimental setup consisted of a 75 liter head tank made of plastic polymer kept on an elevated platform and connected through a pipe network to five 50 Litre plastic polymer vermifilter drums. The virmifilter had its bottom layers filled with aggregates of sizes 6.0-7.0 cm and filled up to the depth of 0.1 m. Next to this, was a layer of aggregates 2.0-3.0 cm and filled up to another depth of 0.1m. The top most layer was then made up of 15cm of garden soil and was the one in which worms were introduced into. A control experiment was set up similar to the above setup except for the absence of earthworm. The setup was left for a week to allow earth worm acclimatize in the soil bed as their new environment. The collected water samples were taken to the laboratory immediately for the experimental runs. The experiment was replicated three times. A period of 5days was allowed between each experimental run for cleaning the vermifilter reactor.

The waste water percolated down through various layers in the vermifilter bed passing through the soil layer inhabited by earthworms, the sandy layer, the gravel, and at the end treated water was collected in a container at the bottom of the vermifilter bed. Waste water were retained in the vermifilter bed was kept uniformly at intervals of 6 hours in all experiments. All experiments for both the vermifilter and the control bio-filter were replicated 3 times. The control bio-filter bed was the exact replica of the vermifiltration bed but had no earthworms

After starting the experimental runs, samples were taken for experimenting to the laboratory for analysis of the waste water samples for BOD, COD, TSS, TDS, PH, Temperature, electrical conductivity and odour. After 6, 12, 18 and 24hours respectively, the collected (treated) effluent was taken to the laboratory for further analysis with the above parameters. The analysis was replicated 3times with the untreated and treated waste water samples.

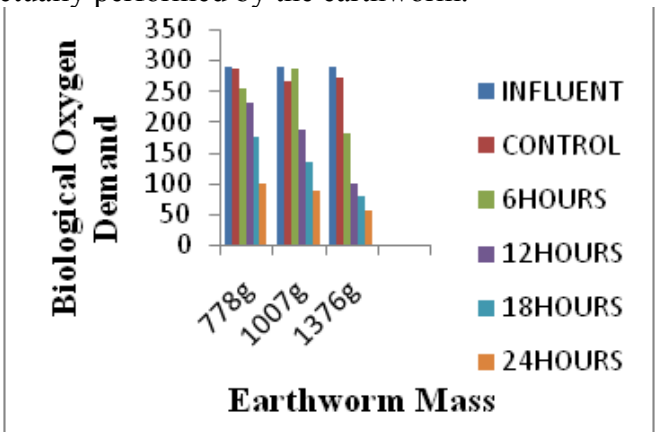
(a)

(b)

Plate 1 (a) Samples of EiseniaFetida used for the experiment (b) The vermi-filter set-up

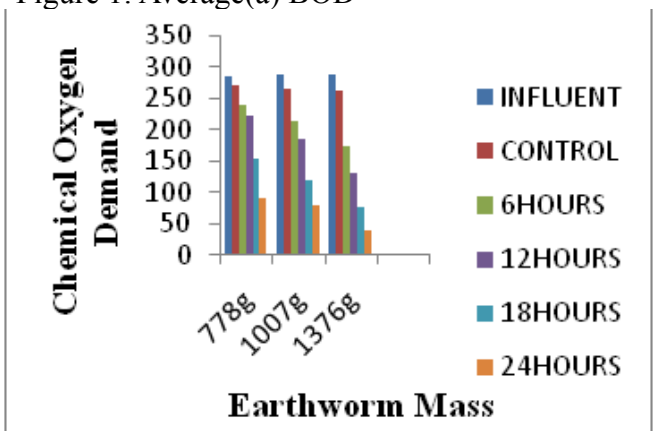
RESULTS AND DISCUSSION

Figures 1 and 2 gave the average values BOD COD as well as TSS and TDS respectively, with respect to the mass of earthworm. It could be observed that the more retention time and the mass of the earthworm the more the reduction in the values of BOD, COD, TSS and TDS which is an indication both the retention time and the mass of earthworm played an important role in the reduction of organic matter of domestic waste water. The reduction of organic matter was well pronounced in the set ups with earthworm compared with the control an indication that the reduction was actually performed by the earthworm.



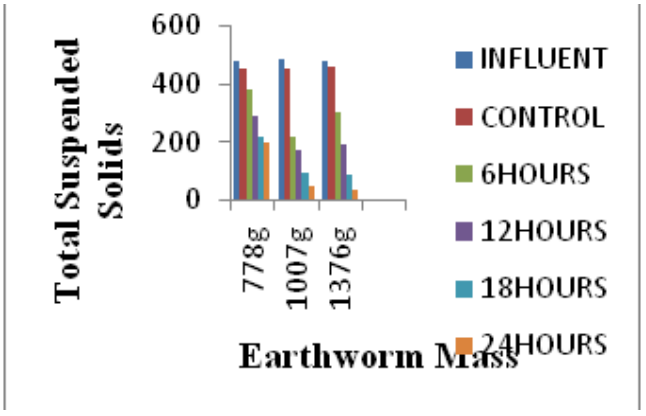
(a)

Figure 1: Average(a) BOD



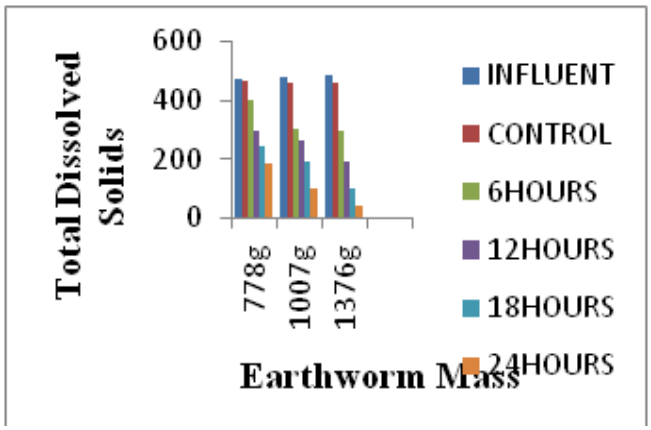
(b)

Figure 1: (b) COD for Different Masses of Earthworms



(a)

Figure 2: Average (a) Total Suspended Solids



(b)

Figure 2:(b) Total Dissolved Solid for Different Masses of Earthworms

From the table 1 it can be established that mass and time both has effect on the BOD, COD, TSS and TDS since the f_{val} values are greater than the $f_{(cr)}$values. For electrical conductivity, time has an obvious effect but the mass of the earthworms doesn't affect the treatment process. But for temperature and pH, both mass and time has no effect on the treatment process because the f_{val} values are less compared to the $f_{(cr)}$ values. The above analysis further proves the effectiveness of hydraulic retention time on the efficiency of earthworms in waste water treatment.

Table 1: Analysis of variance showing the effect of time and mass on the physiochemical parameters of treated water

		F_{val}	P_{val}	F_{cr} value
BOD	mass	5.228328	0.023103	3.862548
	time	13.95271	0.000987	3.862548
COD	mass	6.298875	0.013649	3.862548
	time	15.73985	0.000987	3.862548
TSS	mass	6.877389	0.010512	3.862548
	time	13.51854	0.001107	3.862548
TDS	mass	6.55805	0.01212	3.862548
	Time	16.78952	0.000498	3.862548
E.C	mass	1.13707	0.385232	3.862548
	Time	109.3879	2.12E-07	3.862548
TEMP	mass	0.001846	0.999882	3.862548
	Time	1.295829	0.334286	3.862548
PH	mass	0.373026	0.774601	3.862548
	time	3.73112	0.054244	3.862548

On the overall, a great increase in organic matter removal was noticed in the cause of the experiment as the percentage removal efficiencies increased significantly as the earthworm masses increased. But it was also observed that there was little difference in the PH and temperature values.

CONCLUSION

From the above research, it is evident that earthworms are good biofilter and since they are readily available this method is an economic friendly way of waste water treatment. It can also be observed that the more the earthworm body mass and the more the retention hours, the more the reduction in COD,BOD,TSS,TDS among others.

Removal of COD, BOD, TSS, and TDS was found to be 71%, 75.5%, 80.5 %, and 77% respectively after the experiment which falls within the limit of irrigation water as recommended by WHO (WHO, 2006)

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