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RESEARCH ARTICLE

A PILOT SCALE STUDY OF VERMI-BIOFILTER (VBF) FOR RESIDENTIAL QUARTER WASTEWATER

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Abstract

In the present study waste water is treated using VBF containing earth worms for the treatment of residential quarter wastewater. The performance of vermibiofiltration unit using the earthworm, for wastewater treatment was studied. The average removal efficiencies of the VBF were as follows: chemical oxygen demand (COD) 84.4%; Biological oxygen demand (BOD), 91.8%; Total dissolved solids, 97%; Total suspended solids, 97.4% and Turbidity 97 % after the Study. From the experiment data it was found that percentage reduction in concentration of BOD and COD in VBF was more efficient. There was no sludge formation in the process and was also an odor-free process and the resulting VBF water was clean enough to be reused for farm irrigation and gardens. Thus, earthworm activities had significant relationship with treatment efficiency of parameters by VBF of wastewater.

Keywords: VBF; wastewater; removal efficiency.

Introduction

Due to high establishment and running cost of a sewage treatment plant (STP) the majority of urban centers in developing world dispose urban runoff and sewerage water without any treatments. Developing countries cannot afford to construct sewage treatment plants in their cities. In such a scenario, alternatives are needed urgently for treating wastewaters which are low cost, without any significant negative impacts on the environment. Vermifilter (VF) was widely used to treat the wastewater, and appeared to have high treatment efficiencies, including synchronous stabilization of wastewater and sludge. Earthworms have also proved to be master bio-processing agents for the management of organic effluents from diverse sources ranging from domestic sewage to industrial refuse (Kharwade and Khedikar, 2011).

Vermifiltration is a low cost, odourless and non-labour intensive method of wastewater treatment (Sinha and and Bharambe, 2007; Malek et al, 2012). The resulting vermi-filtered water is clean and disinfected enough to be reused for farms irrigation, in parks and gardens (Sinha and and Bharambe, 2007; Sinha et al,2010; Ghatnekar et al ,2010; Azuar et al, 2012).During vermifiltration, there is no sludge formation in the reactor which requires additional expenditure on landfill disposal; instead a vermicompost which is a bio-fertilizer is formed (Sinha and and Bharambe, 2007; Sinha et al,2010a,b; Ghatnekar et al ,2010; Azuar et al,2012). Vermifiltration also removes heavy metals, solid and liquid organic waste in the wastewater through the action of earthworms (Sinha and and Bharambe, 2007; Sinha et al, 2010a,b;, Azuar et al, 2012, Xing et al, 2009).

The earthworms' body works as a bio-filter and various earthworm species have been used in vermifiltration of municipal wastewater (Sinha and and Bharambe, 2007; Sinha et al,2010a,b; Ghatnekar et al ,2010; Azuar et al,2012; Xing et al, 2009).

Various studies has been carried out on vermifiltration and it is tend to be a potential method for sewage treatment, with high removal rates of Chemical oxygen demand (COD), Biochemical oxygen demand (BOD) and suspended solid (SS) as well as some ability to remove N and P. Taylor et al (2003) studied the treatment of domestic wastewater using vermifilter beds and concluded that worms can reduce BOD and COD loads as well as the TDSS (total dissolved and suspended solids) significantly by more than 70-80% (Sinha et al, 2008). Sinha and Bharambe (2007) studied the vermifiltration of brewery and milk dairy wastewaters which have very high BOD and TSS loadings e.g. 6780 mg/l and 682 mg/l respectively from brewery and 1,39,200 mg/l and 3,60,00 mg/l respectively from the dairy industry. Earthworms removed the high BOD loads by 99 % in both cases and TSS by over 98 %. But the hydraulic retention times (HRTs) in case of brewery wastewater was 3-4 hours and 6-10 hours for the dairy wastewater (Sinha and and Bharambe, 2007).Xing et al, (2010) reported good performance of vermifilter system packed with quartz sands and ceramsite for domestic wastewater treatment. The removal rates for COD were 47.3 – 64.7 %; for BOD5 were 54.78 – 66.36 %; for SS were 57.18 – 77.90 %; total nitrogen (TN) were 7.63 – 14.90 %; and NH4-N were 21.01 – 62.31 % respectively(Xing et al, 2010).Wang et al., (2011) studied the performance of a novel three-stage tower vermifiltration system using earthworm *Eisenia fetida*, for rural domestic wastewater treatment in 131- day period. The average removal of COD was by 81.3%; ammonium by 98%; total nitrogen (as nitrates) by 60.2% and total phosphorus by 98.4% (Wang et al, 2011). Dhadse et. al., (2009) studied the vermifiltration of herbal pharmaceutical wastewater which has very high COD (21,960 - 26,000 mg/l), BOD (11,200 - 15,660 mg/l) and suspended solids (5,460 - 7,370 mg/l). COD was removed by 85.44 - 94.48 % and BOD by 89.77 – 96.26 % at 2 days hydraulic retention time (HRT) (Dhadse et al, 2009).

The present study focused on remove BOD, COD, TSS, TDS, nitrogen and phosphorous contents from the grey wastewater using vermifilter system for two different seasons of western Maharashtra regions.

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Material and Methods

The pilot study was carried out in the VBF containing about 55 kg of gravels with a layer of garden soil on top. This forms the VBF bed. It has provisions to collect the filtered water at the bottom in a chamber which opens out through a pipe fitted with tap. Above the chamber lies the net of wire mesh to allow only water to trickle down while holding the gravels above. The bottommost layer is made of gravel aggregates of size 8 cm to 10 cm and it fills up to the depth of 35 cm. Above this lies the aggregates of 4 to 6 cm sizes filling up to another 40 cm. On the top of this is the 35 cm layer of aggregates of 8-10 mm sizes mixed with sand. The topmost layer of about 15 cm consists of pure soil in which the earthworms are released. As the earthworms play the critical role in wastewater purification their number and population density (biomass) in soil, maturity and health are important factors. This may range from several hundreds to several thousands. There are reports about 8000 numbers of worms per square meter of the worm bed and in quality (biomass) as 10 kg per m^3 of soil for optimal function (Sinha and and Bharambe, 2007) .

In the top most layer of the filter system, bed material placed in which Earthworms were released. The bed materials consists of pure garden soil, saw dust and cow dung. The sprinkler system used for trickling water that allowed uniform distribution of wastewater on the soil surface (VBF). Wastewater from the drums flowed through the irrigation pipes by gravity. The wastewater percolated down through various layers in the VBF passing through the soil layer inhabited by earthworms, the sandy layer, and the gravels and at the end was collected from the bottom of the system. Next day this treated wastewater from both systems were collected and analyzed for BOD, COD, pH, turbidity and the TSS.

The regular analysis for the monitoring of the performance of the VBF included BOD, COD, TSS &TDS, Turbidity and pH. Analytical techniques established by standard methods were followed during the study (APHA, 2005).

Results and Discussion

The results showed that VBF could achieve good performance; the results were close to or even better than those of conventional wastewater treatments.

pH

pH measures the hydrogen ion concentration in a liquid. Results indicate that the pH value of raw sewage is almost neutralized by the earthworms in the VBF. The pH of the effluent from VBF was more than the influent. The pH of effluent of VBF obtained at the end of treatment process in each run was between 6.9 and 7.2 which could be due to earthworm mediated rapid mineralization of organic fractions of wastewater. Earthworm activity caused an in-built pH buffering ability by increasing the pH, hence neutralizing the sewage wastewater.

BOD & COD Removal

BOD describes the amount of dissolved oxygen essential to breakdown organic contaminants through aerobic bacteria. Also, the chemical decomposition of organic and inorganic contaminants in wastewater which cannot be biologically removed is term as COD. The Results indicate that the overall Efficiency of BOD and COD of the treated water from the VBF were found to be always greater than 91 % and 84 % of the residential quarter wastewater. Since the earthworms are primarily accountable to biodegrade waste as compared to inorganic waste through enzyme as a biocatalysts to quicker the rate of biochemical reaction, BOD removal efficiency was found to be much better than that of COD removal efficiency in VBF. Similar results were obtained by other researchers The BOD values remaining after vermin-biofiltration of the sewage water was acceptable for use of the treated sewage water for irrigation purposes i.e. BOD range of 10-20 mg/l . The COD values remaining after vermin-biofiltration of the sewage water were acceptable for use of the treated sewage water for irrigation purposes i.e. COD range of 25-50 mg/l.

TSS and TDS

Total dissolved and suspended solids refer to the organic and inorganic contaminants which are either suspended or dissolved in the wastewater. TSS and TDS both reduced during vermibiofiltration. In the initial period of experiments, TSS and TDS increased because of dissolution of minerals. Results show that the earthworms can significantly remove the suspended solids from the sewage by over 97%. The earthworms in the VBF significantly removed the TDS from the sewage water by about 97-98%. The earthworms in the VBF significantly removed the TSS from the sewage water by about 97.3-98.4%.

The sludge formed to due accumulation of solids in the conventional system clog the filter system. On the other hand, the VBF system was protecting from the congestion due to solid biomass. Earthwarms consume the solid biomass and clear the path for efficient process conditions and resulted into high removal efficiency of TSS and TDS from wastewater.

The TSS and TDS values (6-12 mg/l) remaining after vermibiofiltration of the sewage water were also acceptable for use of the treated sewage water for irrigation purposes i.e. TDS range of 8.6-12.12 mg/l and TSS range of 6-8.5 mg/l. However, values below 100mg/l are still acceptable.

Turbidity removal

Turbidity refers to the cloudiness of wastewater due to the presence of both macroscopic and microscopic suspended solids e.g. clay, silt and organic matter. There was a reduction in the sewage water turbidity by earthworms in the VBF by over 97 %. The geological system also played a very important role in turbidity removal by adsorption of suspended particles on the surface of the soil, sand and the gravels in addition to the earthworms' activity. The successful reduction of BOD, COD and TDS has a direct link to turbidity reduction as well such that the water can be successfully used for irrigational purposes.

Conclusion

Results of VBF technology are most cost effective, odor free for treatment with efficiency, economy and potential decentralization. When compared to the acceptable value for BOD in treated waste water is 10-20 mg/l, COD is 25-50 mg/l and pH is 7.0. The values obtained from the experimental are well within the limits, shows vermifiltration system has good performance in treatment of waste water. It is seen from experiment, reduction of waste water characteristic was greatly facilitated by addition of

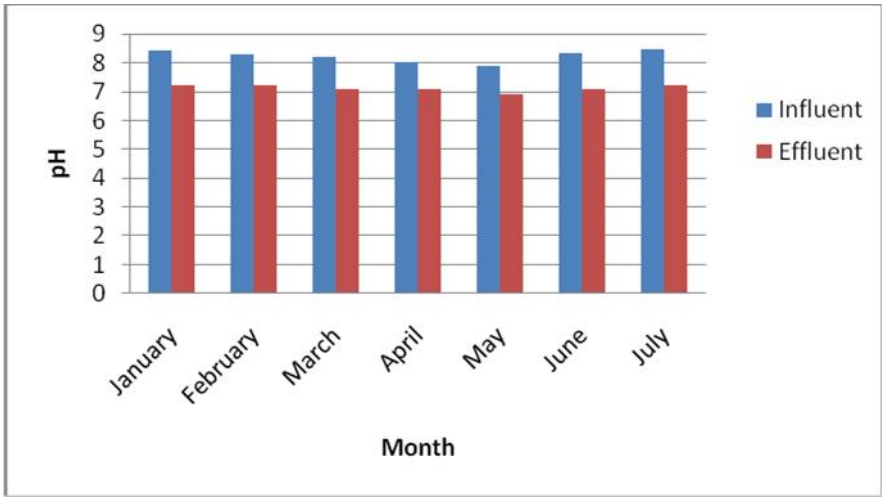

Figure 1. pH Vs Month

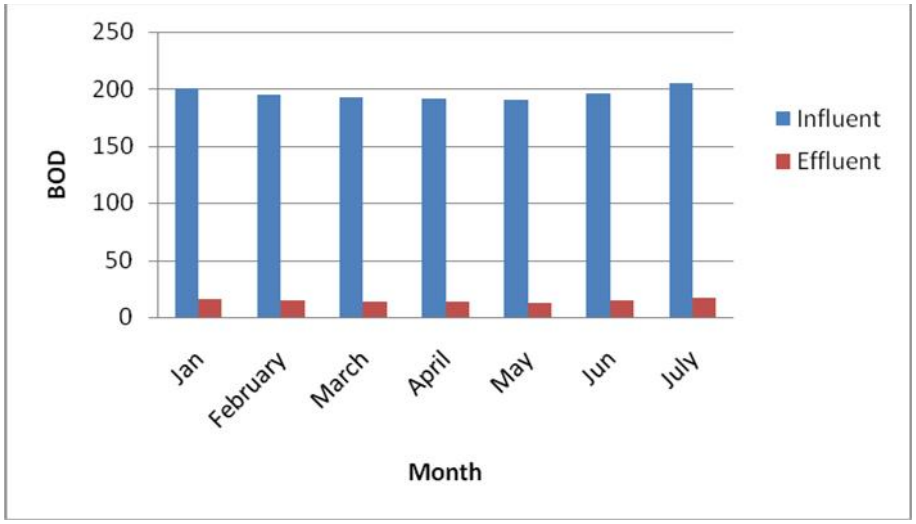

Figure 2: BOD Vs Month

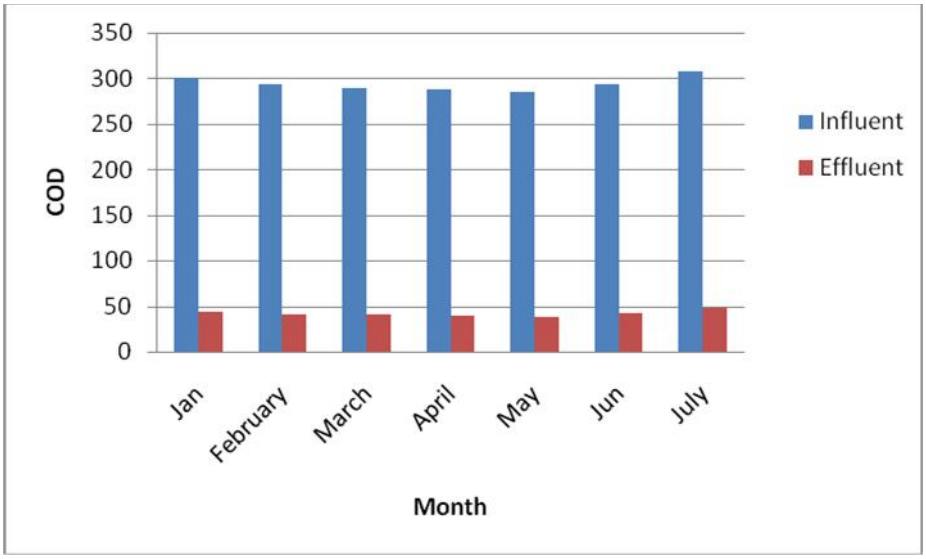

Figure 3: COD Vs Month

Figure 4: TSS Vs Month

Figure 5: TDS Vs Month

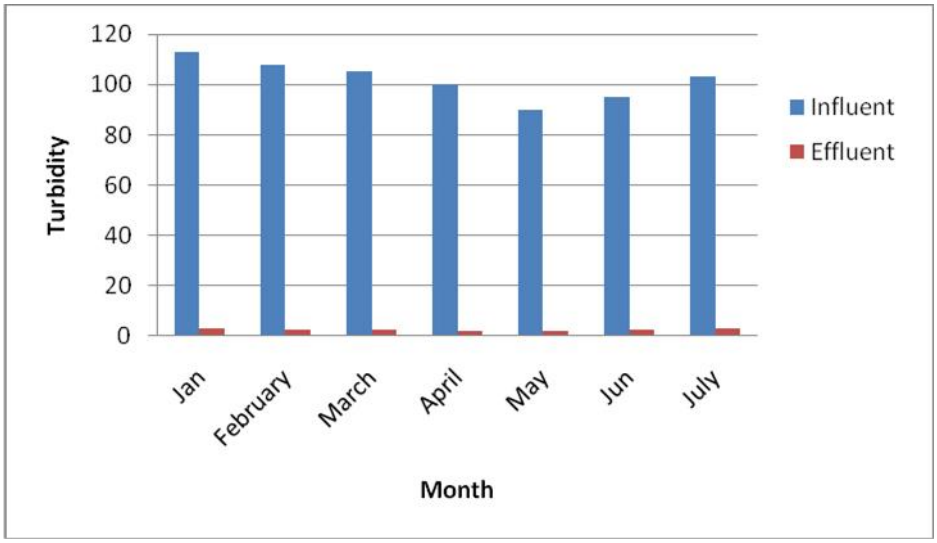

Figure 6: Turbidity Vs Month

sawdust to the soil, which could enhance the porosity of soil. This study may allow extension of methodology to applications like controlling water pollution in rural areas. The earthworm production, growth, breed and survive in the moist environment is very well was observed during the process of experiment.

The BOD, COD, TSS, TDS were reduced by 91.8%, 84.6%, 97.3% 97% respectively at optimum rate. In this system, no sludge was produced. On the other hand vermi compost was produced which can be used as fertilizer. The organic matter present in wastewater was consumed by earthworms converting it into value added vermi compost. The treated effluent had higher value of nitrate, phosphate which is best suited for sewage farming or horticulture.

Vermifiltration of sewage wastewater results in treated water which can be used for irrigation purposes and a bio-fertilizer, vermicompost instead of unwanted sewage sludge is also obtained. Vermifiltration of sewage wastewater resulted in neutralized water pH, decreased BOD, COD, TDS and turbidity.

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