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RESEARCH ARTICLE

REUSE POTENTIAL OF TEXTILE DYEING WASTEWATER THROUGH VERMIFILTRATION

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ABSTRACT

Study was conducted to explore the reuse potential of the textile dyeing wastewater generated from textile dye industry. Earthworms proved to be master bio processing agents for the management of organic effluents from diverse sources ranging from domestic sewage to industrial refuse. In this context, the present paper describes the application of vermiculture based wastewater technology with the primary objective of converting liquid effluent into eco-friendly safe water. Vermifiltration of wastewater using waste eater earthworms is a newly conceived novel technology. The biological oxygen demand (BOD_5), chemical oxygen demand (COD), total dissolved solids (TDS) and total suspended solids (TSS) decreased by 85-89%, 76-80%, 73-77% and 71-76% respectively through vermifiltration.

INTRODUCTION

Water is the essential constituent of any form of life. On an average, a human being consumes about 2 liters of water every day and it accounts for about 70% of the weight of human body. In India alone the International Water Management Institute (IWMI) predicts that by 2025, one person in three will line in conditions of absolute water scarcity (IWMI, 2003). Besides rapidly depleting groundwater table, the country faces another major problem on the water front-groundwater contamination a problem which has affected as many as 19 states (MoEF, 2009). With only four cities in India having 100% treatment capacity installed, there is a large gap between generation and treatment of water in India. Textile industry is one of the fastest growing industries and significantly contributes to the economic growth. However, this industry also has high water consumption and subsequently produces high discharge rate of wastewater with high load of contaminants. The release of dyes into the environment during textile fiber dyeing and finishing processes is a main source of water pollution. Individual wastewater treatment through physical, biological or chemical method is often very costly and results in large amount of sludge. Thus, there is a need to look for alternative treatment processes that covers from pre to post wastewater treatment stage. Effluents from textile dyeing unit contains large amount of heavy metals, which affects physico-chemical properties of water. The effluents increase the pollution load and cause severe damage to the aquatic life, which in turn affect the human life (Singh *et al*., 1995, Malik *et al*., 2002; Yadev *et al*., 2004). In most case huge amount of diverse nature of effluent released from varied industries are disposed in open environment causing pollution of soil and water bodies (Kumar *et al*., 2000). Vermifiltration is a relatively new technology to process organically polluted water using earthworms. It was first advocated by the late professor Jose Toha at the university of Chile in 1992 (Bouche and Qiu, 1998; Aguilera, 2003; Wang *et al*., 2010). Vermifiltration technology uses earthworms as bio-filters in wastewater treatments, whereby the earthworms feed on the organic pollutants in the wastewater. This results in reduced biological oxygen demand (BOD), chemical oxygen demand (COD), total soluble solids (TSS), total dissolved suspended solids (TDSS) and turbidity by over 80% (Sinha *et al*., 2008). The Vermifiltration process is facilitated by the earthworm activity whereby they act as bio-filters reducing the unwanted organic waste loading in the wastewater (Sinha *et al*., 2007, 2010; Azuar *et al*., 2012; Malek *et al*., 2012; Xing *et al*., 2010). Additionally, the soil and gravel particles employed as part of the vermifilter bed contribute to the filtration and cleaning of the sewage wastewater by adsorption of the organic impurities on their surfaces (Sinha *et al*., 2007; Azuar *et al*., 2012; Wang *et al*., 2010). The vermifiltration process is therefore a combined action of the earthworms as well as the soil, sand and gravel particles. The vermifiltration technology was proposed as an alternative sewage wastewater treatment method in developing countries that are being faced with wastewater treatment challenges (Xing *et al*., 2012). This treated water has been recommended for use in irrigation purposes (Morand *et al*., 2011; Sinha *et al*., 2008).

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The aim of the present study was to have an economic and environmentally safe management option for chemical wastewater generated from textile dyeing industry through vermifiltration.

MATERIALS AND METHODS

Materials

Eudrilus eugeniae purchased from Periyar Maniammai University, Vallam, Thanjavur district and was cultured in the Environmental biotechnology Unit of P.G and Research Department of Zoology, Tiruchirappalli – 620 023, Tamilnadu**.** Textile dyeing wastewater is obtained from a Textile Industry, Tirupur. The experiments were carried out in the Environmental Biotechnology Unit.

Non-Vermifilter (NVF) reactor

The size of the reactor is 36cm (long) x 36 cm (wide) x 36 cm (height). It has an upper filtering unit and lower collection unit. Filtering units were filled with gravel, sand and garden soil. The bottom most layers was filled up to 7 cm with gravel aggregated of size 10mm -20mm, followed by gravel of size 2mm – 4 mm size up to 7 cm, sand of size 1mm – 2mm up to 7 cm and the top most layer with garden soil up to 7 cm.

Vermifilter (VF) reactor

Vermifilter (VF) reactor is same as that of NVF reactor except for the presence of earthworms.

Experimental design

Plastic drums of 10 liter capacity with a tap were filled with six liters of dyeing wastewater. These drums were kept on an elevated platform just near the VF reactor. One end of the flexible rubber tube was fitted to the tap of the plastic drum and the other end was placed over the VF reactor. The wastewater distribution system consisted of simple 0.5 inch flexible rubber pipe with hole for trickling wastewater on the soil surface of vermibed (Ghatnekar *et al*., 2010). Wastewater from the drums flowed through the perforated rubber pipe by gravity. The wastewater percolated down through various layers in the VF bed passing through the soil layer inhabited by earthworms, the sandy layer and the gravels and at the end was collected in a collection unit at the bottom of the kit. To find the efficiency of VF and NVF units 60%, 40% and 20% diluted treated textile wastewater was used. The hydraulic retention time (HRT) in the VF bed was kept uniformly for 8-9 hours in all experiments.

Hydraulic Retention Time (HRT)

It is also very essential for the wastewater to remain in contact with the worms in the filter bed for certain period of time. This is called Hydraulic retention time (HRT). HRT depends on the flow rate of wastewater to the vermifiltration unit, volume of soil profile and quality of soil used. High hydraulic loading rate leads to reduced HRT in soil and could reduce the treatment efficiency. High hydraulic loading rates will vary from soil to soil (Sinha *et al*., 2008).

Physico-chemical parameters

Filtered water collected at the collection unit of both VF and NVF were analyzed to study the pH value, Biological oxygen demand (BOD_5), Chemical oxygen demand (COD), Total dissolved solids (TDS) and Total suspended solids (TSS). All the parameters were analyzed according to the standard methods for the examination of water and wastewater (APHA, 1999). All the samples were analyzed in triplicate and the results were averaged during a working condition.

RESULTS AND DISCUSSION

The physico-chemical characterization of wastewater and analysis of wastewater from textile dyeing during VF and NVF treatment is presented in Table -1 and Table - 2.

Table 1. Physico-chemical characteristics of the raw and diluted TDW

Parameter (mg/L)	Raw Wastewater	Diluted textile dyeing wastewater		
		20%	40%	60%
P^H	10.5	8.31	8.36	8.38
BOD_5	320	264	275	281
COD	667	498	527	552
TDS	7458	5378	5582	5567
TSS	20.02	14.86	15.18	16.72

All values are expressed in mg/L, except pH

Table 2. Physico-chemical characteristics of the TDW at different concentration

Parameter (mg/L)	Non-Vermifilter			Vermifilter		
	20%	40%	60%	20%	40%	60%
P^H	7.60	7.72	6.90	7.06	7.32	7.01
BOD_5	80.6	83.4	86.7	30.5	37.2	40.0
COD	180	186	192	105	112	115
TDS	2081	2217	2113	1128	1514	1304
TSS	6.09	6.05	6.17	4.08	4.48	4.12

All values are expressed in mg/L, except pH

pH

The pH value of raw wastewater, diluted wastewater, filtered wastewater from VF and NVF units were observed. The pH of the raw wastewater and diluted wastewater (20%, 40% and 60%) was 10.5 and 8.31, 8.36, 8.38 respectively. The pH recorded at different concentrations after the experiments were 7.06, 7.32, 7.01 in VF and 7.60, 7.72, 6.90 in NVF. pH values of treated wastewater with earthworms were found to be less than the diluted water.

Status of BOD_5

BOD is the most important parameters used to determine degree of pollution of aquatic life. In present study BOD of the raw wastewater was 320mg/L. The BOD of 20%, 40% and 60% were 264mg/L, 275mg/L and 281mg/L respectively. BOD removal at different dilutions in VF was 30.5mg/L, 37.5mg/L and 40.0mg/L while for NVF it was 80.6mg/L, 83.4mg/L and 86.7mg/L. The earthworms in the VF removed BOD_5 loads by about 82-85% while in NVF it was 85-89%. Earthworms significantly degraded the wastewater organics by enzymatic actions where by the earthworms worked as biological catalysts resulting in faster biochemical reactions hence high BOD removal in the VF (Sinha *et al.*, 2010; Xing *et al.*, 2010). This has been indicated as the major difference between microbial degradation and vermidegradation.

Status of COD

The COD of the raw wastewater was 667mg/L. The COD of 20%, 40% and 60% diluted wastewater was 498mg/L, 527mg/L and 552mg/L respectively. COD removal at various concentration for VF was 105mg/L, 112mg/L and 115mg/L while for NVF it was 180mg/L, 186mg/L and 192mg/L respectively. The average COD removal from the dyeing wastewater by earthworms is over 76-80% while that without earthworms is just over 64-66% for NVF. COD removal by earthworms is not as significant as the BOD, as but at least much higher than the microbial system. The enzymes in the gut of earthworms help in the degradation of several of those chemical which cannot be decomposed by microbes (Ghatnekar *et al*., 2010).

Fig.1: BOD_5 of TDW

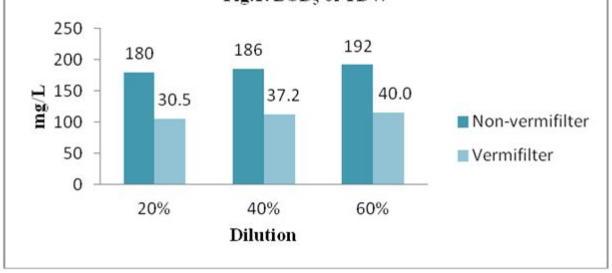


Fig.2: COD of TDW

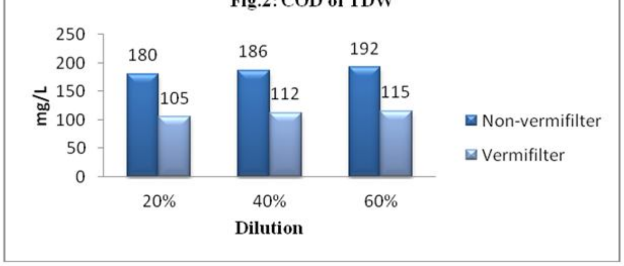


Fig.3: TDS of TDW

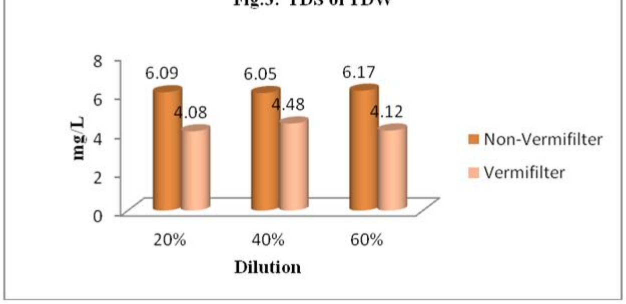
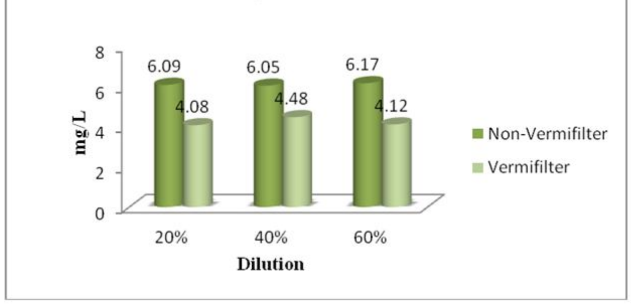


Fig.4: TSS of TDW



TDS and TSS

The raw waste water had 7458mg/L of the total dissolved solids (TDS) and 20.02 mg/L of total suspended solids. These values decreases after dilutions (20%, 40% and 60%) The results are shown in Table -1. TDS removal in VF was 1128mg/L, 1514mg/L and 1304mg/L while in NVF it was 2081mg/L, 2217mg/L and 2113mg/L respectively. TSS removal in VF was 4.08mg/L, 4.48mg/L, 4.12mg/L and in NVF 6.09mg/L, 6.05mg/L, and 6.17mg/L respectively. The earthworms in the VF significantly removed the TDS and TSS from the dyeing wastewater by about 73-77% and 71-76% while the NVF bed indicated a 61-63% and 60-64% decrease. Earthworms ingest solid particles of wastewater and excrete them as finer particles. These finer particles trapped in the voids vermifilter and caused high removal efficiency of TSS and TDS from wastewater (Sinha *et al.*, 2008).

Conclusion

Conventional treatment results into formation of sludge which requires safe disposal in secured landfills at additional cast. Vermifiltration is an alternative, sustainable technology for wastewater treatment. In vermifiltration there is no sludge formation. This is also an odour free process. Vermifiltration successfully lowers the BOD, COD, TDS and TSS as well neutralizes the pH. The treated sewage wastewater can be used for irrigation purposes.

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