Comparative Analysis of Grey Water Treatment using Vermifilter Through Various Filter Depth Level

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***Abstract*:- Wastewater contains high number of organic solids and harmful contaminants. Due to these harmful substance wastewater treatments is essential but many developed and developing countries like India cannot construct and maintain the conventional centralized sewage treatment plants due to high cost of treatment and high amount of wastewater production. So, cost effective and eco-friendly decentralized sewage treatment system is needed in small areas. Hence vermifilteration can be very effective for small villages and colonies. In this system filter bed is inoculated with earthworms (*Eisenia fetida).* these earthworms body works as a "biofilter" and it has high efficiency to remove BOD, COD.TSS by the general mechanism of biodegradation and adsorption of organic wastes. Normally earthworms increase the hydraulic conductivity and total specific surface area by granulating the soil particles. It enhances the adsorption of soil material. In vermifilteration system Most of the TSS are trapped on top of vermifilter. In this study hostel grey water is taken and treated by vermifilter. This laboratory model consisted of three plastic containers and first container filled with 10 cm filter material and supporting layer of large size gravel as such other two filter containers filled with 15 cm, 20 cm filter material. Here HLR is given as 4.32 m3/m2/day for all three depth levels. Additionally, in this study treatment efficiency as well as kinetics of these various filter level are analyzed and compared with each other and these results indicated that vermifilteration is very effective after three weeks of time from initial setup and efficiency of treatment is directly proportional to depth of filter bed and vermifilteration is very effective to treat BOD, TS, TSS, TURBIDITY. And Rate of reaction of earthworms on grey water treatment was TS < TSS < TDS < COD < BOD < TURBIDITY so it can be used as decentralized treatment system in small areas, colonies in house itself.**

Key words: Vermifilter, bio filter, Eiseniafetida, Grey water, decentralized treatment.

INTRODUCTION

Generally Domestic sewage is a combination of grey water, yellow water, brown water. nearly 70% of fresh water bodies are affected by these domestic sewage (MOEF,2009) and also it affects the sub-surface water courses. In India production of sewage is 38000 MLD (MOEF,2009) out of this 12000 MLD of sewage only treated (CPCB 2009). To treat the waste water various types of treatments are used. Grey water is mainly originated from kitchen and bathroom so these waters consists of low number of organic solids and inorganic solids comparatively low than wastewater but these grey waters is one of the major parts of wastewater so treatment of grey water in house itself reduce the volume of wastewater production. untreated grey water consists of high amount of microorganism. These pathogens make grey water as harmful. So, treatment is essential before usage. According to United States Environmental Protection agency, grey water can be treated to varying degrees U (victor G.Ngnaga et. al,2012) It can be treated using various secondary treatment. Mainly we have used Activates sludge process, waste stabilization pond, Trickling filter. These treatments need huge amount of initial cost, maintenance cost and more power to operate these treatment unit. But the potential of these treatment system is decreased day by day because of increasing population. Vermi filtration of grey water using earthworms is a novel technology. Here earthworm body works as bio filter. It can reduce BOD by 90% and COD by 80- 90%, TDS by 90% and TSS by 95% (Bhise H.S, Anaohar G.S et al 2015) from grey water using general bio degradation of organic waste mechanism. Grey water is rich in nutrients. So, earthworms decompose here organic waste also it grinds, aerate, crush and acts as biological stimulator. In this system microbial activity also take place. These microbes get aeration from earthworms (Sinha et al 2008). And vermi filtration finally gives sludge free and odour free treated water. So vermi filtration has a great potential.

MATERIALS AND METHODOLOGY

Grey Water Sample Collection

For what analysis of initial and final quality and regarding the treatment grey water is collected from ladies' hostel of university college of engineering (BIT campus) to collect grey water specialized sampling and sample handling procedures are handled and to check Grey water quality some physical, chemical and biological parameters such as pH, Turbidity, TDS, TSS, TS, BOD, COD are taken.

Collection of Earthworms

Generally, earthworm species *Eisenia fetida,*

Eisenia Andrei, Eisenia eugenia etc. used in vermi filtration technique as decomposer. *E.Fetida* is exotic epigenic earthworm species. It has been identified as potential decomposer. It can live in hot tropical countries like India. It is popularly known as **Red worms**. It may be reddish orange and brown alternatively. It has a unique character which develops diverse microbial community also and it consume organic matter at the rate equal to their body weight every day. *Eisenia Eugenia* is alternative option to *Eisenis Fetida.*. A young individual earthworm of Eisenia fetida has 139 -140 mg.

Fig 1 Red earthworms

Preparation of bed Material for Earthworms

In top most of layer bed material for earth worms are placed. In this system we have used red soil as a bed material. These soils are mixed with pure garden soil and cow dung, the ratio of soil and cow dung are 3:1. It is mixed thoroughly and some quantity of saw dust also used. It is used as bulking agent. It is used for improve soil permeability.

Design and Formation of Vermi Filter as Bench Scale Reactor

The total study is carried out in department of civil engineering at university college of engineering (BIT). The assembly of set up of vermi filter is composed by pvc syntax tank of capacity 20 lit. vermi filter is cylindrical shape and upper and bottom portion of filter is opened. Here totally three filter are used. these setups have been designed to treat 5.2 m3/day. This bio reactor diameter is 25cm. and area of the filter is 0.05 m2. Depth of three filter media are 10 cm, 15cm, and 20 cm. this filter media has garden soil, red soil, cow dung. Saw dust and red earthworms. And total depth of three filters are 95cm, 100cm, 105cm including free board. These filter unit are dived into four parts upper most part is filter media as a depth of 10cm, 15cm, 20cm and second layer is 5 mm gravel and sand as depth of 15 cm height. In between first layer and second layer a wire mesh are used. In Third layer 10-15 mm gravel is placed as a depth of 20 cm. in final layer 20 mm gravel is placed as a depth of 20 cm. the earth worms are given around one week of settling time in the soil bed to acclimatize in the new environment. Wire mesh are used to resist earthworm movement from sand bed to gravel. In this setup poly propylene pipe system are used. Fig 2 and 3 shows the experimental setup and cross section of filter media.

Fig 2. Experimental setup at bench scale

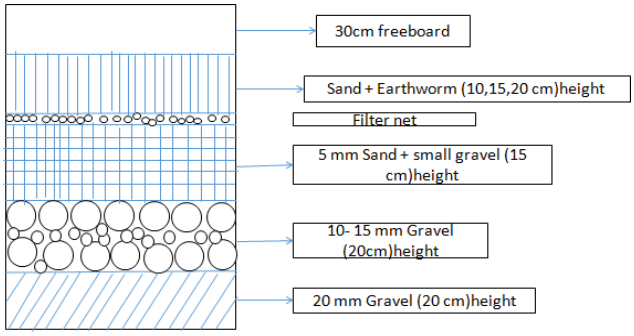


Fig 3 filter media layer

Determination of Hydraulic Loading Rate and Detention Time and Earthworm Volume.

Mostly these type study focused on finding efficiency and kinetics of treatment but efficiency of treatment will vary in different hydraulic loading rate generally in filter treatment and sedimentation treatment efficiency mainly depends upon hydraulic loading rate if we decrease HLR efficiency will be increased. But here standard surface area and standard HLR are used here HRT time only varied.

Discharge in each tape = 0.216 m^3/hr

HLR calculation:

HLR= Vg /(Af *t) Vg= volume of grey water

Af = area of filter
T = 1 hour
HLR = 4.32 m^3/m^2/hr

Determination of HRT (Hydraulic Retention time)

HRT= ϱ * Vs/ Q_W

ϱ=porosity of soil (96%) Vs= Af * tf Vs= volume ofsand + earthworm, Af = 0.05 m t_f = 0.1 m or 10 cm

Determination of earthworm volume Earth worm calculation = (3.14 * d2/ 4) * h h= depth of earthworm

Table 1 HLR and HRT of filter bed

Discharge in each tape = 0.216 m^3/hr		
HLR= 4.32 m^3/m^2/hr		
10 cm bed	HRT= 80 sec	5000 cm3
15 cm bed	HRT= 120 sec	7500 cm3
20 cm bed	HRT= 160 sec	10000 cm3

Removal Efficiency and Kinetics

The final removal efficiency for BOD and COD and all other parameters are found out by Efficiency (%R) = (Initial concentration – final concentration)/ Initial concentration. Here we have used biological conversion.

So, here first order reaction takes place

$$r = -k.c$$

r = rate of reaction kg/ m3.sec k= rate constant (1/sec) c = remain concentration This is continuing packed bed reactor, So

$$C = C0 / (1+ k.\Gamma)$$

RESULTS AND DISCUSSION

Analysis of Inflow Grey Water Samples

Grey water was collected from ladies' hostel as weekly once at three weeks of time. These three weeks of grey water initial characters were given in table 2.

Table 2 Characteristics of grey water

S.No	parameter	sample 1	sample 2	sample 3
1	pH	4.1	2.8	2.7
2	TS in ppm	2703	6106	2490
3	TSS in ppm	1561	4984	1394.2
4	TDS in ppm	1090	1100	1080
5	BOD in ppm	135	90	152
6	COD in ppm	9900	10170	10530
7	TURBIDITY	195	160	162

Experimental Results of Three Weeks Grey Water Samples

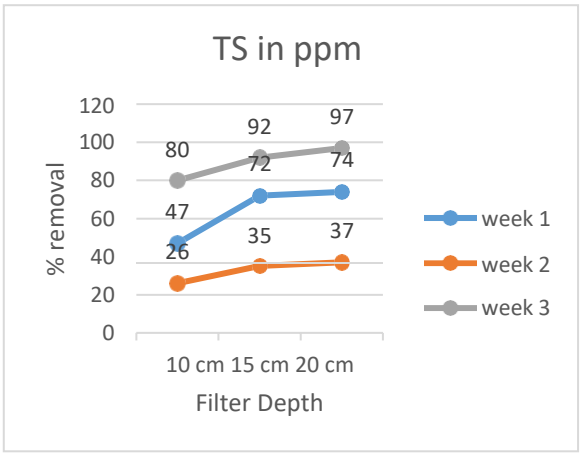
Totally three experimental set up were used. First setup had 10 cm sand depth and second setup had 15 cm sand depth and third setup had 20 cm sand depth. In this sand red earth worms were left for two weeks for stabilizing. grey water was pumped out by water pump shower at a rate of 4.32 m^3/m^2/hr. These grey waters were kept in set up for a week after finishing week 1 effluent treated grey water sample were collected from each tab. Before collection some amount of treated water were pumped out then grey water were collected. These grey water sample were analyzed. And rate of reaction constant (k)

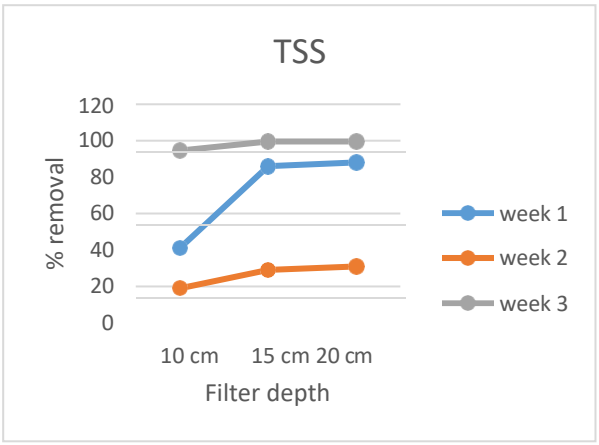
C = final concentration. C0 = initial concentration. K = rate constant Γ = detention time.

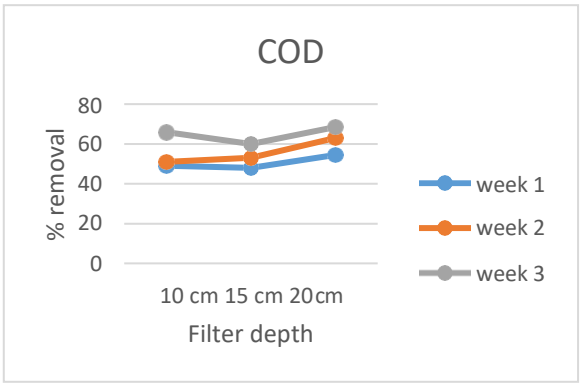
were calculated then the rate of reaction was calculated. In this experiment first two weeks earth worms were stabilized for soil temperature and moisture content so in this stabilizing duration treatment of grey water would be low so after two weeks grey water was pumped and kept for a week. In this time treatment of grey water would be low and second week and third week of times it gave considerably good results at a batch scale study. These studies were conducted as depth wise and experimental results showed that treatment efficiency would be increased as depth increased. Maximum at 20 cm depth treatment efficiency would be high because of high amount of biomass absorption and sand absorption and adsorption.

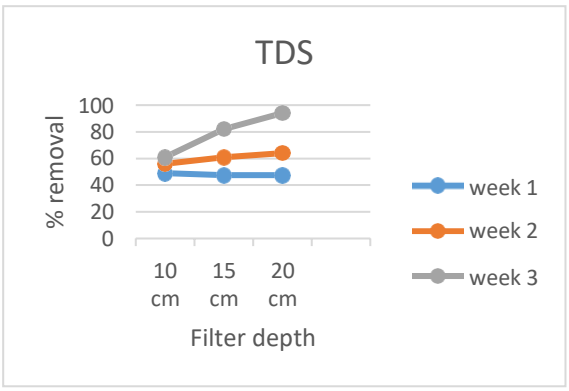
Table 3 Percentage Removal in % vermifilter performance at week 1,2,3

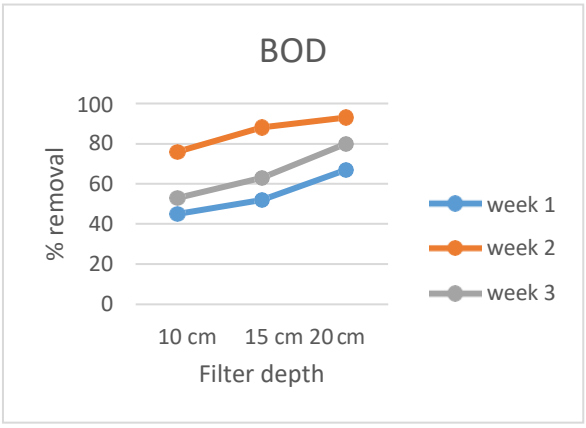
		Week 1			Week 2			Week3		
s.n	**parameters**	**10 cm**	**15 cm**	**20 cm**	**10 Cm**	**15 cm**	**20 cm**	**10 cm**	**15 cm**	**20 cm**
1	**TS in ppm**	47	72	74	26	35	37	80	92	97
2	**TSS in ppm**	41	86	88	19	29	31	94.5	99.5	99.5
3	**TDS in ppm**	49	47.5	47.5	56	61	64	61	82	94
4	**BOD in ppm**	45	52	67	76	88	93	53	63	80
5	**COD in ppm**	49	48	54.5	51	53	63	56	60	68.5
6	**TURBIDITY**	70	73	79.5	89	93	97.5	86.5	93	97

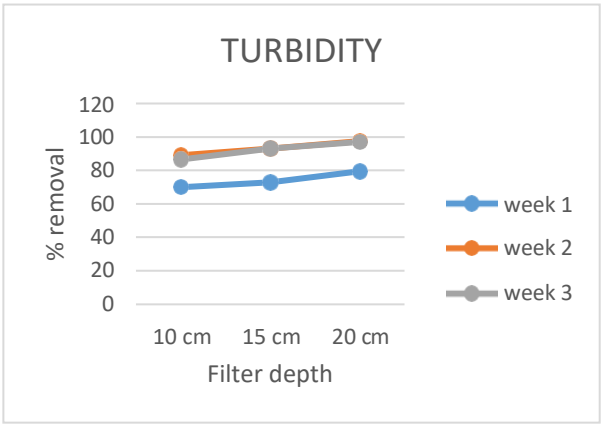












Above all results showed that vermifilteration is very effective to treat TS, BOD, TSS, TURBIDITY at third week of time and at 20 cm depth level. Vermi Treatment efficiency is directly proportional to depth and time.

Table 4 Rate of reaction for reaction of vermifilter at week 1,2,3

		Week 1			Week 2			Week3		
s. n	parameters	10 cm	15 cm	20 cm	10 cm	15 cm	20 cm	10 cm	15 cm	20 cm
1	pH	0.00999	0.00585	0.00499	0.0108	0.0076	0.003	0.010	0.006	0.003
2	TS in ppm	-10.4835	-12.2	-12.5312	-13.1	-13.49	-14.23	-24.9	-19.07	-15.1
3	TSS in ppm	-4.03132	-11.1584	-8.59376	-6.05	-12.04	-9.657	-16.48	-11.56	-8.651
4	TDS in ppm	-7.00024	-3.57524	-3.58775	-7.696	-4.204	-4.396	-8.229	-7.371	-6.344
5	BOD in ppm	-0.50003	-0.58331	-0.5625	-0.568	-0.658	-0.525	-1.008	-0.801	-0.759
6	COD in ppm	-3.05015	-2.99395	-3.375	-3.237	-3.346	-4.023	-7.362	-5.263	-4.515
7	TURBIDITY	-1.71251	-1.19168	-0.96876	-1.775	-1.242	-0.975	-1.749	-1.258	-0.982

Above all results rate of reaction results showed that rate of reaction of earthworms on grey water treatment was TS < TSS < TDS < COD < BOD < TURBIDITY

CONCLUSION

The present study has led to conclude that the vermifilteration is one of the extensions of normal slow sand filtration. Here performance of earthworms and soil depth were analyzed using vermifilteration. We have used grey water to know the performance of vermifilteration. In this study we have used three setups of vermifilteration each has 10cm soil, 15cm soil, 20cm soil and earthworms are evenly distributed to all three setups. Above all results showed that vermifilteration is very effective to treat TS, BOD, TSS, TURBIDITY at third week of time and at 20 cm depth level. Vermi Treatment efficiency is directly proportional to depth and time**.** Rate of reaction of earthworms on grey water treatment was TS < TSS < TDS < COD < BOD < TURBIDITY. so, it can be used one of the best decentralized treatment systems in house wide. Because it removes high amount of BOD. Generally domestic grey water consists of high amount BOD so it can be used in house wide. But in the case of industrial wastewater treatment vermifilteration cannot be alternatives of some other secondary treatment because of poor performance of COD and pH removal.

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