International Research Journal of Environmental Sciences ISSN 2319–1414
Vol. **9(2),** 7-12, April **(2020)** *Int. Res. J. Environmental Sci.*

Design of grey water treatment system based on Vermifiltration

Parul S. Saler[1] and Tanaya H. Nerlekar[2*]
[1]Environment cepartment, K.I.T.'s College of Engineering, Kolhapur Maharashtra, India
[2]Environment department, K.I.T.'s College of Engineering, (an Autonomous Institute) Kolhapur, Maharashtra, India
nerlekartanaya@gmail.com

Available online at: www.isca.in, www.isca.me
Received 10th May 2019, revised 4th November 2019, accepted 25th January 2020

Abstract

In today's modern world vermifilter is extensively used as it is environment friendly and economically suitable technology for grey water treatment. Vermifilter system needs to have lot of improvement in structural and functional behaviour. In view of this, presented research is been carried out. In this paper integration of vermifilter with plant is been focussed, which helps in improvement of grey water treatment. Integrating vermifilters have improved system steadiness and implementation on the large scale. Moreover author has also discussed few more parameters e.g. hydraulic retention time (HRT) and hydraulic loading rate (HLR).

Keywords: Grey water, grey water treatment, hydraulic retention time, hydraulic loading rate and Vermifilter.

Introduction

Water is considered as most important and priceless commodity on planet Earth. The main reasons for water shortage are increase in population and industrial development[1]. Urbanization and industrialization have increased rapid depletion of natural water resources, and it demands to find alternate source of water at least for non potable needs. Most promising method to overcome water shortage is by reclamation and reuse of municipal and industrial water[2]. As per the Water Reuse Association to use water at least once before it process for natural water cycle. The recycled water can be used for various purposes like landscape irrigation, replenishing a ground water basin, agricultural purpose or toilet flushing. Waste water generated from bathroom, kitchen and laundry is termed as grey water. Grey water can be used for two different purpose reduction in fresh water and sewage generation. As per international survey conducted 50-80% of home water is grey water. Grey water offers advantage of need not to treat again. Developing countries has a great opportunity to increase grey water use. Secondary treatment is not compulsory for the grey water therefore the operation of treatment is very simple and easy.

The Kolhapur Institute of Technology's College of Engineering (Autonomous), is situated in western Maharashtra. The spacious campus contain several buildings for different departments and workshop. There is also separate hostel facility for boys and girls. The water is supplied to college campus from Gokul Shirgaon Gram panchayat and in summer due to water shortage through private tanker. The water is stored in the open well. There is an underground reservoir to store the water. In addition to this one open well is located near to the ladies hostel. The water is supplied to the ladies hostel from this open well as well as from reservoir as and when needed. The grey water at ladies hostel is separated from the black water. The black water is treated through the septic tank but the grey water is allowed to flow to the nearby empty plot, reserved for future expansion. This is causing problem of water logging and odour. It is proposed to treat this grey water so that it can be reused for landscaping and thus burden on fresh water can be reduced.

Vermifiltration process is done at liquid state, this process is carried in order to treat sludge, industrial and domestic waste water. Vermifiltration process is based on combined action of earthworm and microorganisms. Vermifiltration can be done in decentralised way which makes it more economical and it offers very good advantage over rest biological processes like fixed activation sludge technique or septic tanks, rotating biological contactor or trickling filters.

Planting macrophyte (plants) on vermifilter bed increases filtration performance. Earlier literatures are available on vermifiltration or vermifiltration with plant filter system, detail reports are presented for utilization of both the systems at its fullest to achieve maximum efficiency.

Literature Review: Vermifilteration is a low cost treatment, used to treat wastewater as well as grey water. In vermifiltration technique earthworms are used in filter with the combination of soil and cow dung. The different filter medias were also used like riverbed gravels, mud balls, coal and glass balls. The comparison between vemifilter and non-vermifilter in which the vermifilter shows the better removal efficiencies for COD, BOD, TS, TSS. The earthworms is used to treat organic pollutants from wastewater using mechanism of degradation. The various species of earthworms are used in vermifiltration technique mainly the Indian blue worms, tiger worms, red tiger worms, the African night crawler and the red worms. It was observed that among all the species the tiger worms i.e. Eisenia fetida is highly effective than other species of earthworms.

Materials and methods

By using lab material and material resourced from local vendors non vermifilter and vermifilter is been prepared. Non vermifilter has a four layers, gravels of 20mm size is been used for bottom layer to a height of 40mm. Second layer from bottom is made up of aggregates of 10mm size and to a height of 30mm. Above this two layers sand of size 2.36mm with a height of 30mm and uppermost layers consist of normal soil with a height of 120 mm.

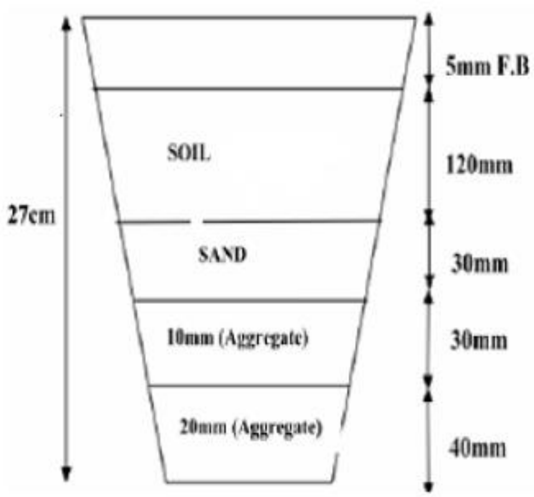


Figure-1: Construction of non vermifilter[3]

Vermifilter also has four layers. Bottom layers has gravels of size 20mm and height of 40mm. Second layer from bottom has 10 mm gravels with a height of 30mm. On top of that 2.36mm IS sieves is been used with a height of 30 mm. Uppermost layer has a soil and cow dung with 1:3 proportion with a height of 120 mm. The soil layer consist of earthworms. The species of earthworms is Eisenia Fetida (tiger worms).

Figure-2: Vermifilter actual photo in lab.

The vermifilter with plant contain the two types of plants one is of Colocasia esculenta and another one is of Canna indica.

Analysis: Hydraulic Retention Time (HRT): The time taken for the wastewater to flow through the soil bed is known as Hydraulic retention time. During earthworm period physical and biochemical activity takes place for removing nutrients which removes sewage waste water BOD, COD, turbidity and TDS. To obtain maximum HRT slow flow of grey water discharge is preferred. It is also mentioned in literature that volume of soil profile increases the HRT. While carrying out this study the HRT taken is 4 hrs and by the formula calculated flow rate is 3 ml/min. The formula is follows:

HRT= (ρ X Vs)/Qw

HRT = Hydraulic retention time (hrs.)

Vs = volume of the soil bed (m^3)

ρ = Porosity of the vermifilter bed through which the sewage wastewater flows

Qw = Flow rate of sewage wastewater through the soil bed (m^3/hr.)

(a) (b)

Figure-3: Vermifilter plants (a) Colocasia esculents and (b) Canna Indica.

Hydraulic Loading Rate (HLR): It can be presented as:
HLR = V/(A*T)
Where: V = Volumetric flow of the waste water (m^3), A = Area of filter (m^2), T = Time required by the waste water to flow through filter.

When HLR is maximum, wastewater gets removed from the outlet fastly, it helps in reducing the contact time and increases the HRT. Although care must be taken so that time taken by the biofilm which is part of filter media has sufficient contact time with grey water.

For the HLR 1 – 3 m^3/m^2/day the flow was 34ml/min – 102ml/min respectively.

For HLR = 4 hrs for plant Colocasia esculenta:
Table-1: % Reduction of COD and BOD

		Parameters		
HRT	Setup	pH	COD	BOD
4 hrs	control	8.01	33.71	27.3
	VF	7.89	50.49	63.65
	VF + P	7.68	65.96	69.13

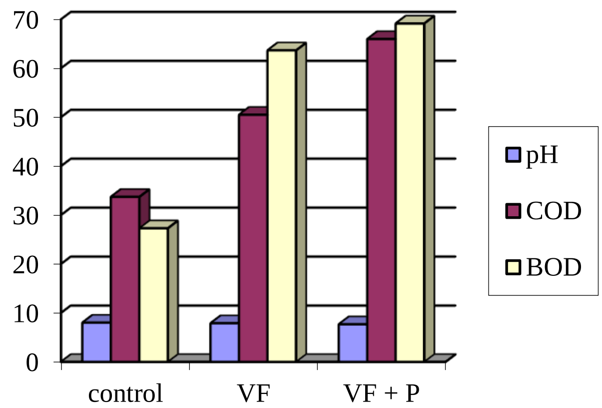


Figure-4: Graphical representation of the % reduction of COD and BOD is as follows:

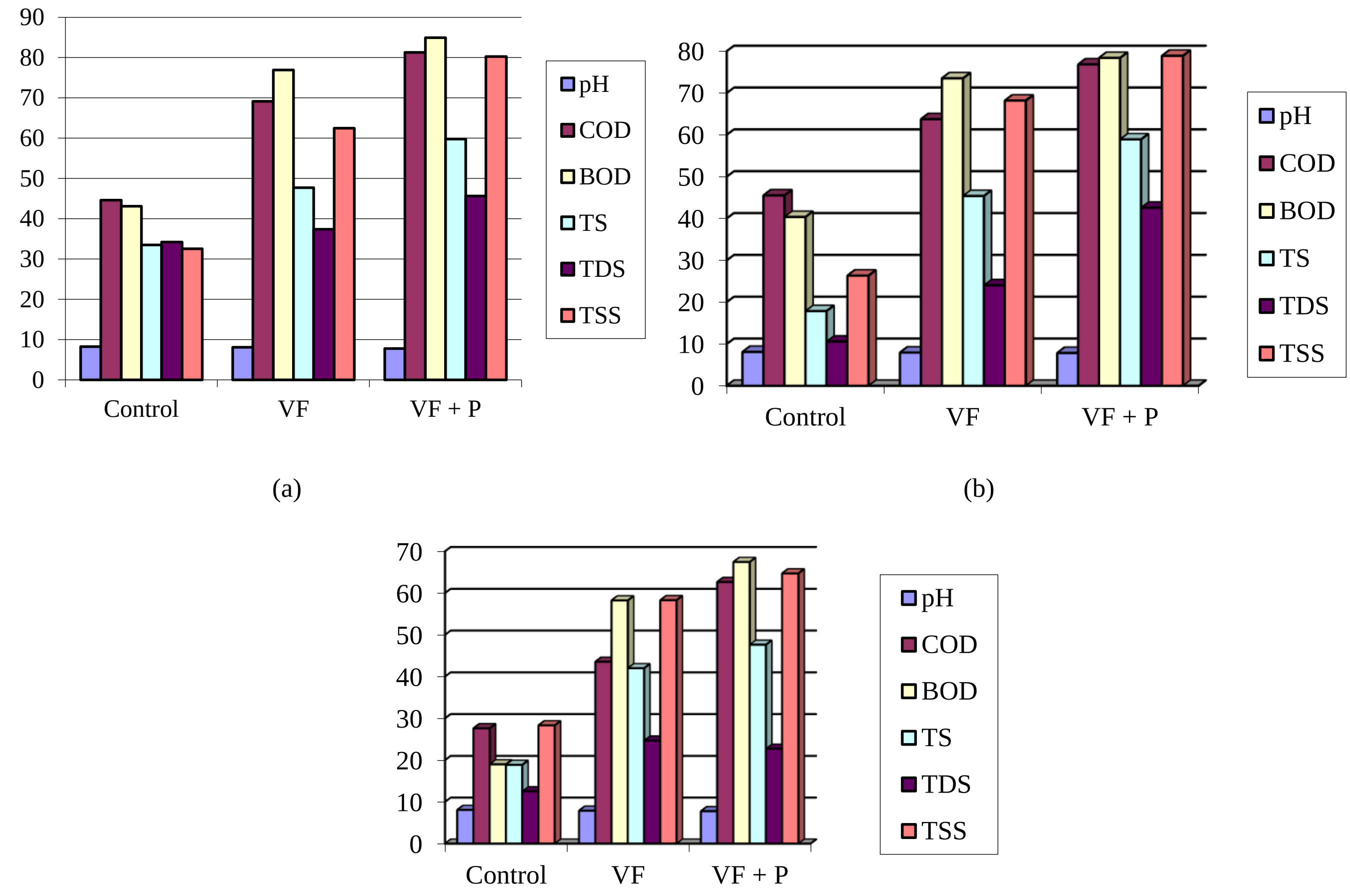
For plant Colocasia esculenta: The % reduction for COD, BOD, TS, TDS and TSS for HLR 1 m^3/m^2/day, 2 m^3/m^2/day and 3 m^3/m^2/day for plant colocasia esculenta are show in Table-2.

For plant canna indica: The % reduction for COD, BOD, TS, TDS and TSS for HLR 1 m^3/m^2/day, 2 m^3/m^2/day and 3 m^3/m^2/day for plant canna indica are show in Table-3.

Table-2: % Reduction for COD, BOD, TS, TDS and TSS for HLR 1 m^3/m^2/day, 2m^3/m^2/day and 3 m^3/m^2/day for plant colocasia esculenta

HLR		Parameters					
	Setup	pH	COD	BOD	TS	TDS	TSS
1 m^3/m^2/day	Control	8.24	44.58	43.11	33.52	34.22	32.54
	VF	8.08	69.18	76.92	47.68	37.41	62.45
	VF + P	7.8	81.3	84.92	59.77	45.68	80.26
	Setup	pH	COD	BOD	TS	TDS	TSS
2 m^3/m^2/day	Control	8.1	45.52	40.36	17.86	10.56	26.34
	VF	7.94	63.74	73.51	45.38	24.03	68.19
	VF + P	7.84	76.84	78.39	58.91	42.57	78.89
	Setup	pH	COD	BOD	TS	TDS	TSS
3 m^3/m^2/day	Control	8.07	27.62	18.98	18.86	12.52	28.32
	VF	7.88	43.54	58.23	42	24.67	58.29
	VF + P	7.77	62.64	67.43	47.62	22.71	64.7

Except pH, all parameters in mg/lt



(a) (b)

(c)

Figure-5: Graphical representation of (a) HLR = 1 $m^3/m^2/day$ the flow is of 34 ml/min. (b) HLR = 2 $m^3/m^2/day$ the flow is of 68 ml/min. (c) HLR = 3 $m^3/m^2/day$ the flow is of 102 ml/min.

Table-3: % reduction for COD, BOD, TS, TDS and TSS for HLR 1 $m^3/m^2/day$, 2 $m^3/m^2/day$ and 3 $m^3/m^2/day$ for plant Canna Indica.

HLR		Parameters					
	Setup	pH	COD	BOD	TS	TDS	TSS
1 $m^3/m^2/day$	Control	8.09	41.81	40	28.66	30	27.3
	VF	7.88	64.07	74.61	38.11	40.69	34.64
	VF + P	7.77	77.04	77.46	54.8	45.75	66.91
	Setup	pH	COD	BOD	TS	TDS	TSS
2 $m^3/m^2/day$	Control	8.07	34.97	25.23	18.79	12.5	29.16
	VF	7.91	47.38	36.18	37.61	23.78	58.97
	VF + P	7.78	72.18	70.11	46.12	33.79	64.95

Except pH, all parameters in mg/lt

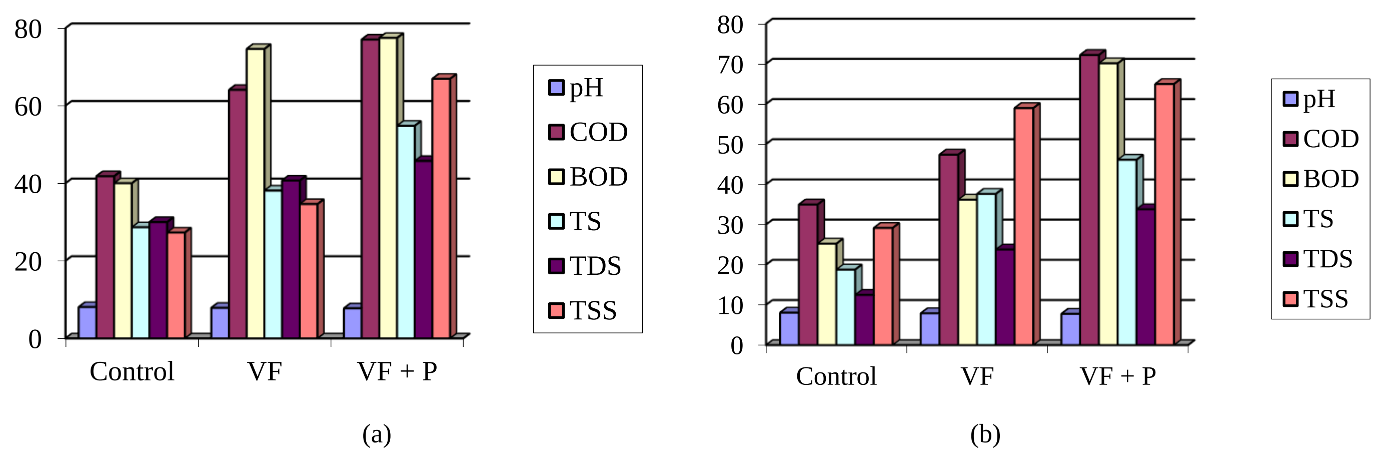


Figure-6: Graphical representation of (a) HLR = 1 m³/m²/day the flow is of 34 ml/min. (b) HLR = 2 m³/m²/day the flow is of 68 ml/min.

Result and discussion

For HRT is 4 hrs then the flow is 3 ml/min, the better reduction was given by the vermifilter with colocasia plant. The % reduction where 66% and 69% for COD and BOD respectively. But the flow is very less. For design flow of 1 m³/m²/day, the highest reduction was given by vermifilter with plants which was 43%, 83%, 86% and 83% for turbidity, COD, BOD and TSS respectively and all the parameters where well within the stipulated limit for utilization of the water for irrigation. For design flow of 2 m³/m²/day once again the best performance by vermifilter with colocasia esculenta plant which was 78%, 81% and 79% for COD, BOD and TSS respectively. However it was observed that the TSS in treated water exceeded permissible limit of 100 mg/lt. For design flow of 3 m³/m²/day once again good performance by vermifilter with colocasia esculenta plant which was 34%, 62%, 68% and 65% for turbidity, COD, BOD and TSS respectively. However it was observed that the TSS in treated water exceeded permissible limit of 100 mg/lt. For design flow of 3 m³/m²/day once again good performance by vermifilter with colocasia esculenta plant which was 62%, 68% and 65% for COD, BOD and TSS respectively. However it was observed that the TSS in treated water exceeded permissible limit of 100mg/lt.

For design flow of 1 m³/m²/day good performance by vermifilter with Canna indica plant which was 77%, 77% and 67% for COD, BOD and TSS respectively. However it was observed that the TSS in treated water exceeded permissible limit of 100mg/l. For design flow of 2m³/m²/day good performance by vermifilter with Canna indica plant which was 72%, 70% and 65% for COD, BOD and TSS respectively. However it was observed that the TSS in treated water exceeded permissible limit of 100 mg/l.

Conclusion

Vermifilter with plants gives better reduction than that of vermifilter. Vermifilter with plants can be used for treatment of grey water and treated water can be utilized for irrigation or gardening purpose. Flow of 1 m³/m²/day can effectively treat the grey water to make the stipulated Std for turbidity, COD, BOD and TSS. The higher flow with HLR 2 and 3 m³/m²/day gives better reduction but the TSS exceeded the permissible limit of 100 mg/l. The colocasia esculenta gives the better reduction than that of canna Indica plant.

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