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GREYWATER RECLAMATION BY VERMIFILTERS

[1]Shamitha D, [1]Suraj S, [1]Nandini Hiremath,

[2] Sadashiva Murthy BM, [3]Hemalatha Prabhuswamy

Student*1, Professor*2, Research Scholar*3, JSS Science and Technology University, Dept of Environmental Engineering, Mysuru

ABSTRACT

This paper investigates the utilization of vermifilters for treating greywater samples collected from the kitchen source and handwash sink of a Physically Differently Abled hostel located in the JSS campus, Mysuru. The primary objective is to evaluate the effectiveness of vermifilters, utilizing Eisenia fetida earthworms, in reducing parameter values by more than 80% after treatment. The design parameters considered for the vermifilter system are hydraulic retention time (HRT) and flow rate. Laboratory experiments were conducted on the greywater samples, analyzing parameters such as suspended solids, nutrients, and pathogens before and after treatment. The results demonstrate that vermifilters effectively reduced the concentrations of the selected parameters by over 80% after treatment. Additionally, the influence of design parameters, specifically HRT and flow rate, on the treatment efficiency of vermifilters was investigated. Optimal combinations of these parameters were identified, leading to enhanced treatment effectiveness and achieving the desired reduction in parameter values. The findings of this paper provide valuable insights into the application of vermifilters for greywater treatment in similar contexts, such as Physically Differently Abled hostels. The significant reduction in parameter values highlights the potential of vermifilters as sustainable and cost-effective solutions for greywater reclamation. Moreover, the study emphasizes the importance of considering design parameters to optimize vermifilter performance and showcases the efficacy of Eisenia fetida earthworms in the treatment process.

Keywords: *Vermifiltration. Earthworms Vermicast.Greywater. Activated Carbon.*

1.INTRODUCTION

The establishment of a greywater treatment system is essential. The system will aid in the removal of toxins and pollutants from the water, making it safer for plants and the environment. greywater treatment system decreases the burden on the public sewerage system. When there is a reduced flow of polluted water in the system, there is a reducedenvironmental impact. To solve this problem a low-cost and eco-friendly type of wastewater treatment is usedthat is Vermifiltration technique. The vermifiltration technique is the latest technique which is used to treat wastewater by saving cost, and energy. Compare to conventionalwater treatment no chemicals are used in this type of treatment technique. The vermifilter is a simple filtering system that is made using a plastic container. The bottomlayer is filled up with gravels which provide space for aeration and percolation of water,above this layer is a layer of sand, covered with cow dung, and clay and loaded with vermis.

2.METHODOLOGY

2.1 Sample Collection

The greywater samples were collected by grab sampling from the sampling location injerry cans of 20-liter capacity and stored in the fridge for further analysis.

2.2 Characterization

2.3 Design Consideration for Filtration

The initial characterization of the two greywater samples i.e., from the handwash sink and kitchen source was conducted. pH, TDS, TS, Chlorides, Alkalinity, nitrates, sulphates, phosphates, COD, BOD, TC, FC, and FS are the parameters considered for characterization.

According to the literature survey, the Hydraulic Retention Time (HRT) was set to 2hours. Based on the HRT, the flow rate was calculated using the equation.:

HRT= (porosity of the filter bed x Volume of the filter) / Wastewater flow rate

The average porosity value is assumed be 0.3 for the volume of the filter bed of 0.0147 m^3. Hence, the flow rate obtained was 35 ml/min and it was set constant using a peristaltic pump.

2.4 Experimental methods for various parameters

i) pH- pH meter
ii) Alkalinity - volumetric method
iii) Chlorides - Argentometric method
iv)Sulphate- Turbidimetric method
v) Nitrate - PDA method
vi)Phosphate – AM spectrophotometric method
vii) BOD - Dilution method
viii) COD - Closed reflux titrimetric method

2.5 Experimental setup

Fig 1. Filter Units arranged in order (from left – non- vermifilter, Vermifilter, and vermifilter with activated carbon

The experimental setup consists of setting up three different filter units- Non vermifilter, vermifilter, and vermifilter with activated carbon. The details of the filter setup are described in the sections below. These filters are connected to the peristaltic pump to maintain a constant flowrate.

Fig 2 shows vermifilter with activated carbon showing different layers

This filter system consists of five layers. The bottom-most layer consists of coarse aggregates of 20mm in size, above it a layer of aggregates of size 10mm is placed. Above this, a layer of river sand is put. An additional layer of activated carbon is spreadon top of it. The topmost layer is covered with soil, earthworms (Eisenia fetida), and cow dung. and a small depth is provided as a freeboard.

Table. 1: Results of initial and final characterization of greywater sample fromhandwash sink (S2).

Sl.No	Parameters	Before Treatment	After Treatment		
			NVF	VF	VF with Activated Carbon
1	pH	5.8	7.28	8.04	7.26
2	Total Solids, mg/L	2000	800	1600	400
3	Chloride, mg/L	265.91	183.94	221.93	73.97
4	Alkalinity, mg/L	572	460	564	460
5	Nitrate, mg/L	5.7309	0.5595	1.4357	0.488
6	Phosphate, mg/L	128.4	88.54	125.85	63.77
7	Sulphate, mg/L	4.290	3.772	1.52	0.21
8	BOD, mg/L	468.7	69.8	89.4	43.1
9	COD, mg/L	435.37	62.72	73.79	40.58
10	Oil and Grease, mg/L	280	86.48	92.33	68.42
11	TC, CFU/100ml	>1100	>1100	>1100	>1100
12	FC, CFU/100ml	>1100	240	290	210
13	FS, CFU/100ml	>1100	290	240	160

3. RESULTS AND DISCUSSION

Table. 2: Results of initial and final characterization of greywater sample from handwash sink (S1).

Sl.No	Parameters	Before Treatment	After Treatment		
			NVF	VF	VF with Activated Carbon
1	pH	5.59	7.40	8.36	8.58
2	TDS, mg/L	944	758	880	640
3	Total Solids, mg/L	996	840	960	720
4	Chloride, mg/L	153.95	145.95	185.94	193.93
5	Alkalinity, mg/L	468	456	444	516
6	Nitrate, mg/L	1.78	1.54	1.63	0.963
7	Phosphate, mg/L	142.9	97.28	102.3	87.50
8	Sulphate, mg/L	13.47	0.0497	4.15	5.12
9	BOD, mg/L	435.3	62.72	73.79	40.58
10	COD, mg/L	553.4	36.89	92.84	84.86
11	Oil and Grease, mg/L	306	96.32	102.3	84.56
12	TC, CFU/100ml	>1100	>1100	>1100	>1100
13	FC, CFU/100ml	>1100	>1100	>1100	>1100
14	FS, CFU/100ml	>1100	290	240	160

Fig 3 indicates that the pH was neutralized in all the filter units of Sample 1 and Sample 2. The pH of the greywater sample has changed from acidic condition to neutral. The presence of acidic compounds or low-pH substances in the wastewater result in an acidic initial condition. Total solid concentration was reduced by a certain proportion. Figures 4. shows that at 2 hours of detention time, the range in vermifilter of sample (including VFAC) 1 and 2 are 27% and 40% respectively, but it was discovered that the range in non-vermifilters of sample 1 and 2 are 15 % and 60 %. When using a non-vermifilter, a geological and microbiological system is used to remove suspended solid from liquid waste.

3.1

Performance of various parameters variation before and after treatment

Without the help of earthworms, it was revealed that they are primarily eliminated through "adsorption" on the soil, sand, and gravel surfaces. The earthworms in a vermifilter continuously consume these substances, preventing the formation of sludge and choking hazards. Fig 5 shows the variation of TDS before and after treatment. From Fig 6 the Nitrate reduction efficiency in both Sample 1 and 2 are 90% and 13% in Non vermiflters as compared to 80 % and 27 % in Vermiflters (including Vermiflters with activated carbon). As per the Fig 9 the percentage reduction in concentration of BOD in vermifilter (S1 and S2) ranges 85% and 87 % while in non-vermifilter it was found to be 85% in both the samples at 2hrs of detention time. The earthworm degrades the wastewater organic by 'enzymatic action' (which work as biological bringing the pace and rapidity in biochemical reaction) and that is the reason for BOD removal in vermifilter. From Fig 6 the Nitrate reduction efficiency in both Greywater sample from handwash sink and 2 are 90% and 13% in Non vermiflters as compared to 80 % and 27 % in Vermiflters (including Vermiflters with activated carbon).

It can be seen from figure 10 that percentage of reduction in concentration of COD in vermifilter ranges around 83%, whereas in Vermifilter with activated carbon the reduction efficiency is around 90% and 84% respectively. COD reduction was greatly affected by detention time, higher the detention time lower will be COD. Earthworms secrete the enzyme that helps in the degradation of several other chemical which cannot be decomposed by microbes while in non-vermifilter, it was found to be 89 %. There was also significant reduction in biological paramaters as per Fig 12 and 13 except the FC value in Sample 2, which failed to show any changes.

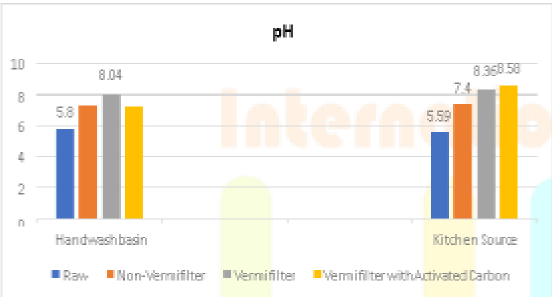

Fig 3: Variation in pH, before and after treatment of greywater samples

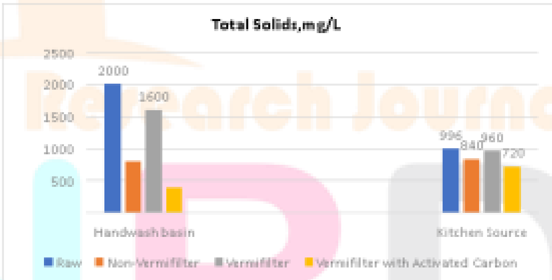

Fig 4: Variation in TS, before and after treatment of greywater samples

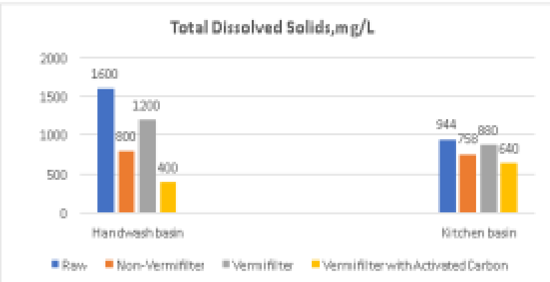

Fig 5: Variation in TDS, before and after treatment of greywater samples

Fig 6: Variation in Nitrate, before and after treatment of greywater samples

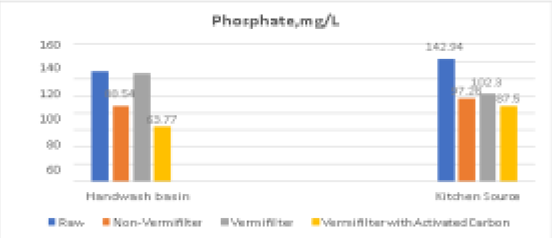

Fig 7: Variation in Phosphate, before and after treatment of greywater samples

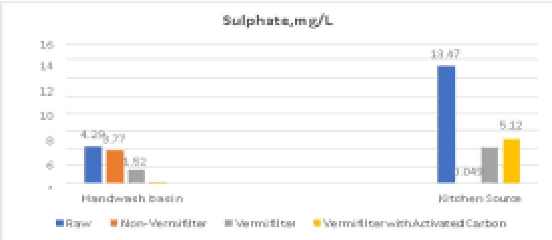

Fig 8: Variation in Sulphate, before and after treatment of greywater samples

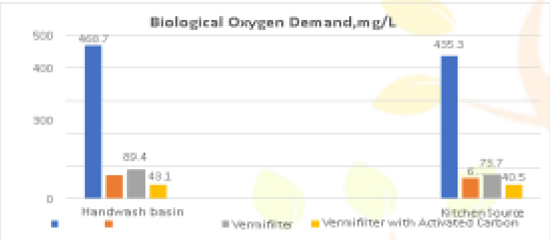

Fig 9: Variation in BOD, before and after treatment of greywater samples

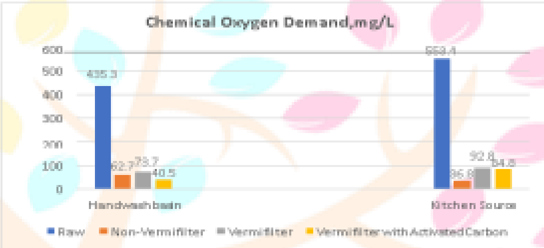

Fig 10: Variation in COD, before and after treatment of greywater samples

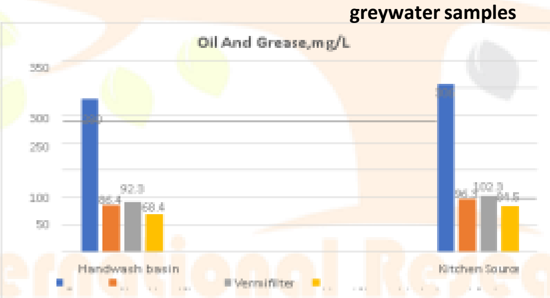

Fig 11: Variation in O&G, before and after treatment of greywater samples

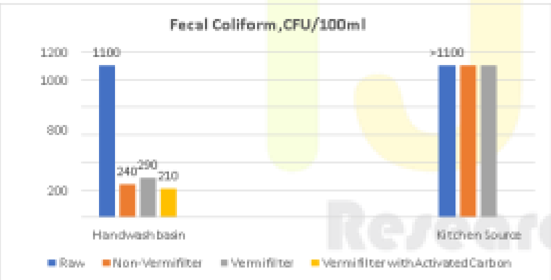

Fig 12: Variation in FC, before and after treatment of greywater samples

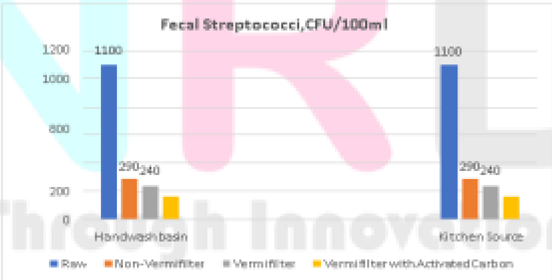

Fig 13: Variation in FS, before and after treatment of greywater samples

CONCLUSION

The greywater sample considered for analysis showed higher concentrations of TDS, COD, BOD, and Fecal Streptococci initially. Earthworms significantly degrade the waste materials without the generation of sludge. The soil acts as a filter in trapping thesolids and absorbing dissolved organic compounds. This helps in the reduction of BODand COD of the greywater. Earthworms excrete castings that are rich in nutrients whichenhance the fertility of the soil and the growth of plants. Of the three filters, the removal efficiency was maximum in the vermifilter, with BOD, COD, and FS removalof 93%, 82%, and 78% respectively. The design of the vermifilter ensures the removalof organic pollutants in greywater sample with respect to wastewater flow rate, and hydraulic retention time. The required results were not attained from the vermifilter without any activated carbon. The reason for the inaccurate results is that the soil was not compacted, and the earthworms are experiencing seepage in the collection container. Due to this, the vermifilter unit failed to generate the intended outcomes. There was no problem of any foul odor in the vermifilter throughout the experiment and some foul odor emanating from non-vermifilter. Grey water smoothly percolates from the soil bed in vermifilter and while it was constantly chocking in non-vermifilter.

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