Upflow-Down flow filter- Suitable & Economical system of Greywater Recycling & Reuse

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ABSTRACT:

Greywater recycling & reuse is an effective and economical way of solving water scarcity. This practice conserves fresh water and reduce pollution load on the receiving environment. Greywater from VJTI's hostels was treated in lab scale model of Upflow-Downflow filter. Laboratory analyses of samples for various parameters are checked for their allowable limits to reuse treated wastewater for toilet flushing and gardening for the flow of 6.25 l/hr, 8 l/hr & 10 l/hr. The test results shows that the average removal efficiency of suspended solids is 92.7%, COD is 88.1% and oil & grease is 74.2%. It is observed that with increase in flow from 6.25 l/hr to 10 l/hr there is increase in removal efficiency of suspended solids by 4.9%. Whereas decrease in removal efficiency of COD is 2.17 % and oil & grease is 6.2%. The cost of recycled water is comes out to be a 4.81 Rs/Kl. This reuse/recycle of greywater will save nearly 54000 Rs per annum. The advantage of this treatment is easy operation and maintenance, economical, use of locally available material and no requirement of energy source and good outlet quality water.

Key words: Greywater, Recycle & reuse, Upflow-Down flow filter

1. Introduction:

Population growth coupled with ever-increasing urbanization, results in continuous growth of water demand in many regions around the world. This necessitates the development of additional resources, e.g., exploitation of more distant and deeper sources, construction of new dams and long conveyance systems, and seawater desalination. Utilizing these new sources usually entails high direct costs i.e. construction, operation and maintenance, and is likely to result in high indirect costs. Therefore, lowering the overall water demand has recently become an important issue for water utilities and regulatory bodies. This could be achieved by a combination of different

measures such as increasing the efficiency of water supply systems, installation of water-efficient appliances, raising public awareness to water saving and reusing wastewater. When considering water reuse, on-site greywater reuse has the potential to play a significant role.

Greywater is wastewater originating from all household appliances except toilets, comprising 60–70% of the in-house water demand. Grey water is much easier to treat and recycle than sewage due to their lower level of impurities like BOD, Suspended solids etc.

In this context Greywater, recycle systems are ideal for residential complexes, as well as hotels, hospitals and large institutions. Greywater, which after treatment may be used for toilet flushing, gardening, car washing and low end uses inside any residential or institution, thus reducing the fresh water requirement to a much extent. Various treatment systems like Upflow-Downflow filter, wetland, reed bed, Rotating Biological Contactor, Duckweed etc. are used for greywater treatment.

2. Greywater Characterization:

The study is carried out in Veermata Jijabai Technological Institute, Matunga, Mumbai (VJTI). The student population in A&B, C and D Hostel blocks are 225, 210 and 280 respectively. The rate of water supply is 135 l/c/d.

To establish the general characteristics of greywater of institute, samples of greywater were collected and analyzed. It includes wastewater from bathroom, clothes washing and basin but does not contain kitchen or mess wastewater. General characteristics of greywater observed is pH- 6.4 to 7.6, Suspended solid – 100 to 160 mg/l, COD- 80 to 168 mg/l, BOD- 44- 115 mg/l & Oil and Grease – 20-50 mg/l.

3. Lab scale model of Upflow-Downflow treatment:

After studying these characteristics, it is observed that the BOD and suspended solids are reasonably low as compared to black water. Various treatment systems like wetland, reed

bed, RBC, Duckweed, Filtration are varying in complexity and degree of treatment can be used for greywater treatment.

The suggest treatment consist of settling tank of detention time of two hours. After settling Upflow Downflow filter is provided consisting of four compartments of filter media. Chlorine dose is given for disinfecting purpose at the outlet of the treatment system. The treatment system is as shown in picture below.

Filter unit is made up of acrylic sheet imported make (as shown in picture).There are four compartment containing filter media of course gravel (20-40mm), fine gravel (5-20mm), course sand (1-5mm) and fine sand (0.1-1mm) sequentially. There is 20mm two PVC nipples provided to pass greywater from one compartment to other. Raw greywater is put into the bottom of first column of filter and collected at the top of second column. This water is again fed to the third column of filter from the bottom and is collected at the top of fourth column.

4. Working procedure of Model treatment:

Raw Grey water (50 liters) is collected, from hostel blocks of VJTI's and poured in the raw grey water holding tank. The flow of 6.25 l/hr is maintained by adjusting the tap. The model is design for 8 hrs/ day running.Greywater pass from holding tank to settling tank. In settling tank heavy solids are settled by gravity. Then greywater passed through Upflow-Down flow filter unit. Due to filter action and attached growth microbiological

activity impurities like Suspended solids, BOD, COD, oil & grease etc get reduced. Chlorination was carried out for disinfection of the recycled water. This treated water was stored in a treated water storage tank and samples of the same are collected and tested.

Samples of greywater treated through these model, inlet and outlet parameters of these samples are analyzed. The results of the analysis performed in the laboratory are as below.

5. Observation & Discussion:

The reuse specific or reclaimed water standards are not there in India. Hence, standards collected from CPCB, EPA and Indian standards for disposal on land are considered as limiting value for treated water quality for toilet flushing and gardening purpose.

(A) Flow rate : 6.25 l /hr

Detention time in settling tank : 2.07 hrs

Filtration rate : 100 $l/m^2/hr$

Table 5.1 Comparison of raw and treated greywater quality

	pH		SS (mg/l)		COD (mg/l)		O&G (mg/l)		SS Remo-val (%)	COD Remo-val (%)	O & G Remo-val (%)
Allowable limit	6.5- 8.5		< 10		<50		<10				
Date	In	Out	In	Out	Inlet	Out	In	Out	-	-	-
09.2.09	6.8	7.5	100	0	170.8	10.0	40	10	100.0	94.1	75.0
10.2.09	7	7.9	100	10	171.9	31.9	60	15	90.0	81.4	75.0
25.2.09	6.7	8	120	10	193.8	11.3	35	7	91.7	94.2	80.0
02.3.09	6.7	7.2	116	12	201.9	11.5	38	4	89.7	94.3	89.5
03.3.09	6.8	8.1	148	20	192.4	11.9	24	10	86.5	93.8	58.3
17.3.09	6.9	8.1	106	12	154.0	13.1	30	5	88.7	91.5	83.3
18.3.09	6.9	8	104	16	173.8	33.3	25	5	84.6	80.8	80.0
19.3.09	7	8.2	98	20	194.7	33.8	39	7	79.6	82.6	82.1
20.3.09	7.1	8.3	90	10	211.9	31.5	40	10	88.9	85.1	75.0
21.3.09	6.9	8.2	96	10	174.0	13.3	30	6	89.6	92.4	80.0

	pH		SS (mg/l)		COD (mg/l)		O&G (mg/l)		SS Remo-val (%)	COD Remo-val (%)	O & G Remo-val (%)
Allowable limit	6.5- 8.5		< 10		<50		<10				
23.3.09	7	8	132	5	193.1	12.6	20	4	96.2	93.5	80.0
24.3.09	6.8	7.8	123	7	214.9	34.0	34	6	94.3	84.2	82.4
25.3.09	6.8	8.1	160	14	195.9	15.4	20	4	91.3	92.1	80.0
26.3.09	6.5	7.7	142	11	213.1	32.0	23	6	92.3	85.0	73.9

- pH of inlet is in the range of 6.5- 7.1 & outlet is 7.2-8.3 which is within the permissible limits.
- In initial stage, filter media is having more pores, hence some suspended solids may escape with treated water flow. Hence, some outlet samples SS are more than the permissible limit.
- The average removal efficiency of suspended solid is 90.2%, COD is 88.9% and O & G is 78.2%. Most of the outlet sample's parameter are within the allowable permissible limit.

(B) Flow rate : 8.0 l /hr

Detention time in settling tank : 1.62 hrs

Filtration rate : 128 $l/m^2/hr$

Table 5.2 Comparison of raw and treated greywater quality

	pH		SS (mg/l)		COD (mg/l)		O & G (mg/l)		SS Remo-val (%)	COD Remo-val (%)	O & G Remo-val (%)
Allowable limit	6.5- 8.5		< 10		<50		<10				
Date	In	Out	In	Out	In	Out	In	Out	-	-	-
20.4.09	6.9	7.8	184	9	194.3	13.1	25	5	95.1	93.3	80.0
21.4.09	6.9	7.9	102	11	213.8	33.6	20	5	89.2	84.3	75.0
22.4.09	6.8	8	135	10	213.3	33.1	17	6	92.6	84.5	64.7

	pH		SS (mg/l)		COD (mg/l)		O & G (mg/l)		SS Remo-val (%)	COD Remo-val (%)	O & G Remo-val (%)
Allowable limit	6.5- 8.5		< 10		<50		<10				
Date	In	Out	In	Out	In	Out	In	Out	-	-	-
23.4.09	6.9	8	107	14	255.2	34.2	16	7	86.9	86.6	56.3
24.4.09	6.9	7.7	125	12	193.1	12.4	23	6	90.4	93.6	73.9
25.4.09	7	7.9	152	10	203.1	22.0	32	8	93.4	89.2	75.0
27.4.09	6.7	7.6	135	7	185.4	24.3	19	4	94.8	86.9	78.9
28.4.09	6.8	8	106	5	155.6	14.9	28	9	95.3	90.4	67.9
29.4.09	7	8.2	110	6	234.3	33.3	25	6	94.5	85.8	76.0
04.5.09	7	8	165	12	174.9	14.3	50	14	92.7	91.8	72.0
05.5.09	6.7	8.2	125	9	215.9	14.7	35	12	92.8	93.2	65.7
06.5.09	6.8	8	175	10	235.4	34.7	27	7	94.3	85.3	74.1
07.5.09	6.9	8	120	7	175.2	14.0	26	7	94.2	92.0	73.1
08.5.09	6.7	7.8	151	10	95.6	14.5	15	3	93.4	84.8	80.0

- pH of inlet is in the range of 6.7- 7.0 & outlet is 7.6 - 8.2 which is within the permissible limits of 6.5-8.5 specified by CPCB.
- The removal efficiency of suspended solids is in the range of 86.9 – 95.3%, COD is 84.3 – 93.6 % and O & G is 56.3- 80%.
- The average removal efficiency of suspended solid is 92.8%, COD is 88.7% and O & G is 72.3%.

(C) Flow rate : 10.0 l /hr

Detention time in settling tank : 1.3 hrs

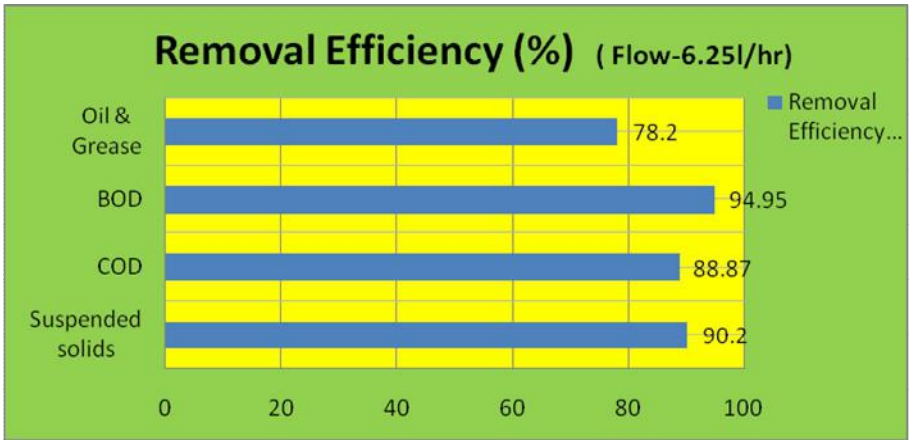
Filtration rate : 160 l/m^2/hr

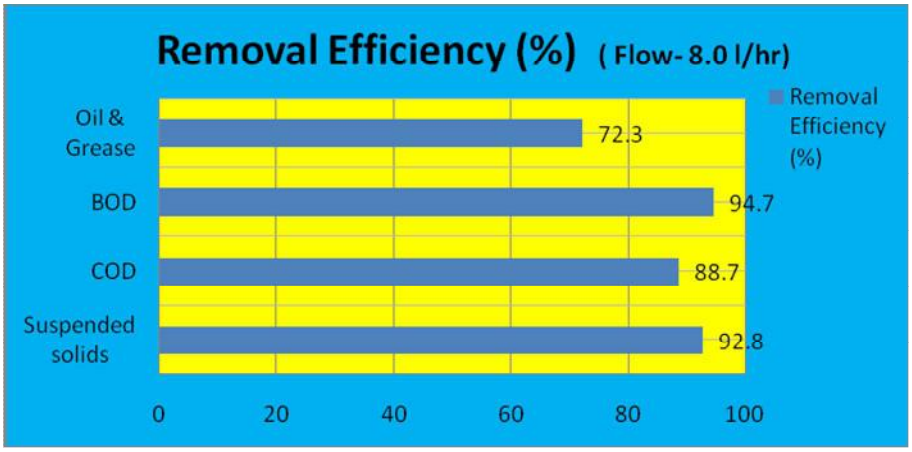
Table 5.3 Comparison of raw and treated greywater quality

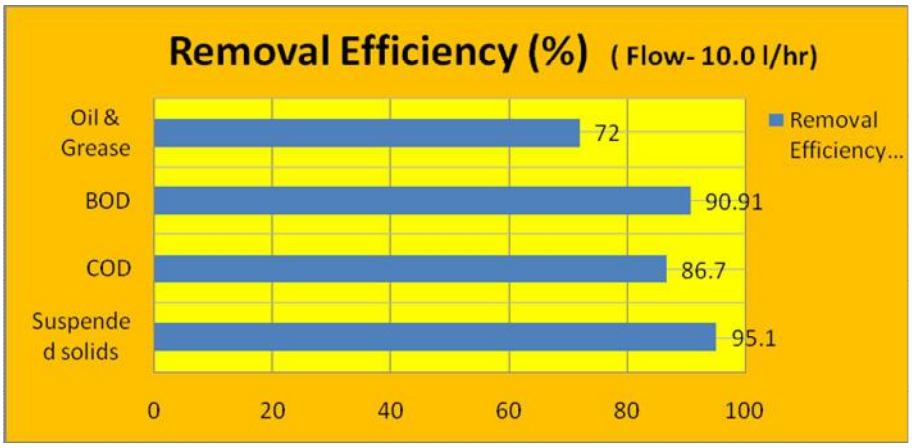
	pH		SS (mg/l)		COD (mg/l)		O &G (mg/l)		SS Remo-val (%)	COD Remo-val (%)	O&G Remo-val (%)
Allowable limit	6.5- 8.5		< 10		<50		<10				
Date	In	Out	In	Out	In	Out	In	Out	-	-	-
11.5.09	6.7	8.2	117	6	115.4	14.71	15	4	94.9	87.3	73.3
12.5.09	6.8	8.1	110	5	194.25	13.56	21	5	95.5	93.0	76.2
13.5.09	6.6	8	101	6	215.17	34.71	33	9	94.1	83.9	72.7
14.5.09	6.9	7.9	150	7	235.86	45.4	22	6	95.3	80.8	72.7
15.5.09	7	7.8	93	4	96.55	5.86	18	5	95.7	93.9	72.2
18.5.09	6.8	8	112	5	134.71	13.56	30	8	95.5	89.9	73.3
19.5.09	6.8	8.1	155	7	195.17	34.48	23	5	95.5	82.3	78.3
20.5.09	6.7	7.9	102	6	114.25	23.1	15	5	94.1	79.8	66.7
21.5.09	6.9	8.2	110	6	135.4	14.48	18	6	94.5	89.3	66.7
22.5.09	6.7	8	90	4	93.1	12.64	22	7	95.6	86.4	68.2

- pH of inlet is in the range of 6.6- 7.0 & outlet is 7.8 - 8.2 which is within the permissible limits of 6.5-8.5 specified by CPCB.
- The removal efficiency of suspended solids is in the range of 94.1 – 95.7%, COD is 79.8 – 93.9 % and O & G is 66.7- 78.3%.
- The average removal efficiency of suspended solid is 95.1%, COD is 88.1% and O & G is 72.0%. The reclaimed water parameters are within the permissible limit to be reused for gardening & flushing toilets.

6. Removal Efficiency of various parameters:







7. Overall performance of model:

1. Overall removal efficiency of COD is 88.09 %, for Suspended solid is 92.7% and for oil and grease is 74.17%.
2. The efficiency of settling is decreased with the increase of flow in settling tank, but remaining suspended solids are trap in filter unit. Hence overall removal efficiency was not affected.
3. The removal efficiency of COD & O&G is reduced as increase of flow.
4. Few results of BOD and Suspended solids are above the permissible limit. In such cases, greywater will be diluted with water to maintain the required standard. If the more number of sample showing BOD more than the permissible limit then one polishing unit of charcoal or activated carbon should be provided after filter to reduce BOD to the permissible limit. To reduce the suspended solids coagulant like drumstick, polyelectrolyte can be applied to greywater before settling tank.
5. As per BOD test results average COD/ BOD in inlet samples is 1.7 where as in outlet samples it is 3.5.
6. Septic condition will be created if grey water is stagnant for more than 8 hrs. Hence, adequate aeration by providing baffles and mixing must be provided to prevent odors and solids deposition in storage tank.
7. Provide continuous flow in filter to avoid water warm in water above the filter media in plant.

8. Maintenance of Plant:

Following points should be taken care for efficient use of plant

- Periodic maintenance of systems with filtering devices by cleaning with clear water and replacing the media as an when required
- Sedimentation tanks require desludging at regular intervals
- Warning signs should be maintained in good order
- Irrigation area should be maintained to prevent the entry of rainfall runoff
- When conducting maintenance involving greywater the user should avoid direct contact with the skin

- Use of greywater only for toilet flushing and to completely avoid use for anal cleaning or hand washing

9. Economical analysis of the proposed system for VJTI

A. **Capital cost of treatment unit** = Rs. 543137

B. **Operation and maintenance cost**:

Total quantity of treated water : 67925 l/d

i) Operation cost

i.a) Electricity charges = Rs. 89.52

i.b) Establishment cost = Rs. 200

i.c) Chemical cost = Rs. 16.30/- per day

Total operating cost = i.a + i.b + i.c = Rs. 305.82 /- per day

(ii) Cost of Replacement of filter media = Rs. 20.71/- per day

Cost of treated water = Rs. 4.81 /- per 1000 lit

Cost of fresh water = Rs. 7.00/- per 1000lit

Saving / day = Rs. 146. 94

Annual saving = Rs. 54363

Pay back period = 10 yrs

Conclusion:

The average removal efficiency of suspended solids is 92.7%, COD is 88.1% and oil & grease is 74.2%.

It is observed that with increase in flow from 6.25 l/hr to 10 l/hr there is increase in removal efficiency of suspended solids by 4.9%. Whereas decrease in removal efficiency of COD is 2.17 % and oil & grease is 6.2%. The increase in the suspended solid removal efficiency is because of reduction in pore space with respect to time of operation of the filter. As more and more suspended solids trap in the pore of filter media that reduce the pore space within the filter media, cause increase the trapping of suspended solid with the time of use.

Upflow-downflow filter treatment is applied in VJTI campus the cost of recycled water is comes out to be a 4.81 Rs/Kl which is less than the prevailing municipal water rates of 7.0 Rs/Kl of Mumbai Municipal Corporation. This reuse/recycle of greywater will save nearly 54000 Rs per annum. The payback period calculated is comes out to ten years.

The disinfection is carried out by application of chlorine. The optimum dose of hypochloride solution required is 40-60 ml/ 1000 liter of treated water. The sludge generated in settling tank may start to stale or create foul smell after seven days, hence desludging period should not be provided more than seven days. The volume of sludge generated in period of seven days is nearly 880 liters which is 1.3% of volume of greywater passed per day.

It is observed that at different flow the treated greywater meet the criteria of permissible standard limit. Moreover, the system used for recycling of greywater is compact, economical and easy to operate. Therefore, it may be concluded that this treatment system is suitable for treatment of greywater of hostels or Institutions for gardening and/or flushing toilets.

Mumbai Municipal Corporation has made recycling mandatory for new large complexes. This is a much-needed move in the right direction. It must be accompanied with public awareness building so that people will understand, support and implement such initiatives, which, along with other water conservation measures, will be a permanent solution to water scarcity. Government bodies should promote reuse of grey water concept by making it compulsory in housing societies, Institutions, hotels etc by providing one of the regulation in byelaw.

References:

- *US EPA, 2004*, Guidelines for water reuse, U.S. Environmental Protection Agency, Washington DC.
- *Neeri and Unicef, 2007*: Greywater reuse in rural school, Guidance Manual
- *AATSE* (Australian Academy of Technological Sciences and Engineering) (2004). Water recycling in Australia. Parkville, Victoria: AATSE
- E. Friedler, M. Hadari,Israel, 2005,*Research Paper :*Economic feasibility of on-site greywater reuse in multi-storey buildings
- Metcalf & Eddy, wastewater Engineering, Treatment, Disposal, Reuse, Tata McGrow-Hill, New Delhi.
- Jawad Al-Sulaimi & Takashi Asano, wastewater Reclamation and Reuse, New Age International, Delhi.
- Manual on sewerage and sewage treatment (2nd Edition) CPHEEO Govt. of India, ministry of urban development New Delhi.
- Water and waste water reuse, An environmentally sound approach for sustainable urban water management, UNEP (www.unep.org)
- World health Organization, Drinking water quality standards & safe use of waste water.
- Water reclaimation & reuse standards, Washington State Department of Ecology (www.standards_ecy.wa.gov)
- Web sites:
    - www.oasisdesign.net
    - http://www.grey-water.com