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Original Research Paper

Characterization and Treatment of Grey Water for Recycling

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ABSTRACT

This study is aimed to evaluate the characteristics of grey water in MNIT Jaipur campus. The grey water from kitchen water, laundry water, bath water, wash basin water and the composite water was passed through a sand filter model which was fabricated. Turbidity removal percentage was 81%. Total alkalinity was 865.7 mg/L. TDS was also found to be high in laundry water with the average value of 4237.8ppm. Bath water showed the highest concentration of chloride in the feed water with average value being 62.55mg/L. The product water quality was found to improve continually over the duration of testing.

INTRODUCTION

As freshwater becomes increasingly scarce, it is necessary for policy makers and leaders to shift attention to alternative sources of water. Faced with the twin problems of water scarcity and limited access to safe alternative sources of water, some countries and many of their citizens are turning towards a formal recognition of the role that wastewater use can play in supplementing existing sources of water (Hernandez Leal et al. 2010).

People are now waking up to the benefits of grey water reuse, and the term "wastewater" is in many respects a misnomer. May be a more appropriate term for this water would be "used water". Grey water refers to the wastewater that comes from kitchens, bathrooms and laundry. While bathroom and laundry waters are relatively benign, kitchen water deserves special attention since it is loaded with organic matter from food waste. Grey water is distinct from black water (that comes from the toilet) as there are fewer health and environmental risks associated with its use (Devine et al. 1998). It is estimated that 55%-65% of household water effluent is grey water (Burnat 2007, Diener & Morel 2006). Grey water including its separation, containment and use, is a simple, home-based Water Demand Management (WDM) strategy that has benefits at the household level as an alternative water resource to optimize productivity, if used wisely and appropriately. Grey water after proper treatment can be used for various purposes like irrigation, urinal flushing, etc. Reuse of grey water serves two purposes: reduces fresh water requirement and reduces sewage generation (U.S. EPA 2004). As awareness of the potential and challenges associated with grey water recovery and use have become apparent, more attention is being placed on how treatment and use at the household level can be promoted. Grey water fundamentally preserves the existing freshwater supply, and in that way is a significant WDM strategy. Estimates of the proportion of household wastewater, that is grey water, usually vary from 65% up to 80% (Burnat 2007). No matter the amount, its use conserves water supply by negating the need to acquire water from the municipal network, or, in unserved areas, from private vendors.

Grey water treatment options: Grey water reuse methods can range from low cost methods such as the manual bucketing of grey water from the outlet of bathroom to primary treatment methods that coarsely screen oils, greases and solids from the grey water before irrigation via small trench systems, to more expensive secondary treatment systems that treat and disinfect the grey water to a high standard before using for irrigation. The choice of system depends on a number of factors including whether a new system is being installed or a disused wastewater system is being converted because the household has been connected to sewer.

Slow sand filters are probably the most effective, simplest and least expensive water treatment process for developing countries (www.epa.gov) . They require few technical components and usually no chemicals. They consist of fine sand supported by gravel. They capture particles near the surface of the bed and are usually cleaned by scraping away the top layer of sand that contains the particles (CPHEEO 1991).

MATERIALS AND METHODS

To evaluate the potential of slow sand filter as treatment option for grey water, sand filter model was fabricated at PhE Lab, MNIT, Jaipur. The specifications for the designed sand filter are:

Filter unit: The filter unit was fabricated in the Hydraulics Laboratory in MNIT, Jaipur. It was fabricated using 2mm galvanized iron sheets. The sheet was welded to form a hollow cylinder with an inside diameter of 43 cm. Mseal adhesive was used to avoid leakages. Its dimensions were: 0.50 m height and 0.43 m diameter and it was checked that there were no leaks by filling it with water.

Filter media: Sand which served as filter media was properly washed and cleaned before it was put in the filter. The sand was obtained locally and sieved to obtain a media with required sand size. Sand of effective size 0.2 mm and uniform coefficient 2.5 was used.

Base material: Gravels were used as base layer. The layer of sand was supported on gravel, which permits the filtered water to move freely to the under drains. The supporting gravel was washed out and placed in three layers. Table 1 describes the specifications of the base material used. The total layer was divided into three parts with the topmost layer of 23 mm depth and size of gravel being 2 to 4.75 mm, whereas the bottom layer of depth 23 mm and size of gravel being 40 to 63 mm.

Under drainage system: The filter media and the base materials were supported over the under drainage system which eventually collects the filtered water and delivers it to the clean water reservoir. Perforated pipe was used for under drainage system.

PROCESS DESCRIPTION

The Fig. 1 describes the line diagram of the process involved. In first feeding reservoir (F1) the sample was put. From this F1 tank, an outlet pipe was connected to second tank (F2) through floating ball valve. This floating ball was used to maintain the head in F2 basin. From F2 basin the sample was sent to filter unit (drum). On the top of the filter unit perforated plate was fixed so that the sand layer was not disturbed with the direct flow of water. Through this, it was also assured that the schmutzdecke was not disturbed by the turbulence of water. For the under drainage system, perforated pipe was used. This perforated pipe was connected to the outlet pipe for sample collection. Samples of both the feed and product water were collected for analysis to assess treatment performance.

First, with all the outlet valves closed, the filter was charged with clean water, introduced from the bottom to a level of about 10 cm above the sand bed. This was done to drive out the air bubbles from the filter bed and then the inflow was started.

The influent and the effluent samples from the sand filter were analyzed for different physical and chemical parameters like alkalinity, chloride, hardness, nitrate, turbidity, TSS, TDS, pH, BOD and COD using standard methods (APHA, AWWA, WPCF 1981).

RESULTS AND DISCUSSION

Table 2 shows the consolidated values of influent and effluent of grey water treatment.

The average value of alkalinity in the influent ranged from 238 mg/L to 865 mg/L with laundry water having higher values due to the use of detergents, whereas the alkalinity levels in the effluent ranged from 178 mg/L to 416 mg/L. Composite water and bath water showed the little re-

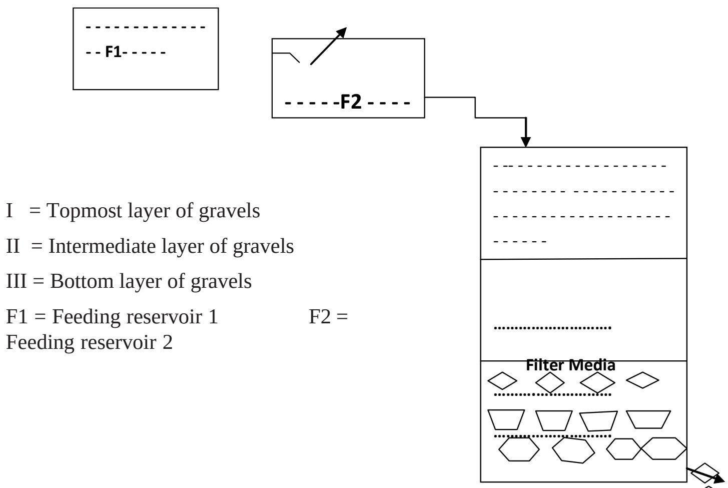


Fig. 1: Diagram of fabricated model for grey water treatment.

Figure 2: Average concentrations of different parameters in Kitchen water

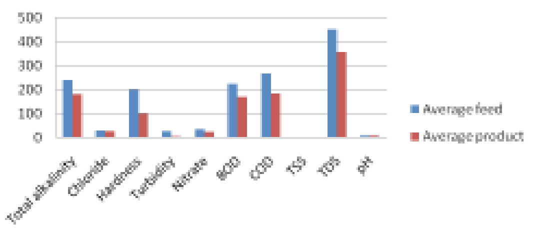


Figure 3: Average concentrations of different parameters in Laundry water

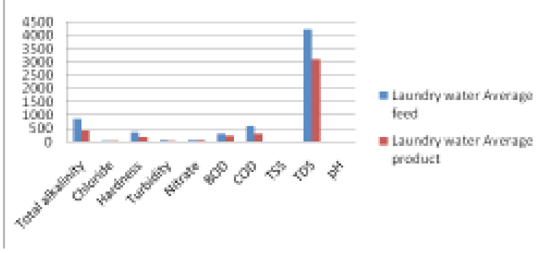


Figure 4: Average concentrations of different parameters in Bath water

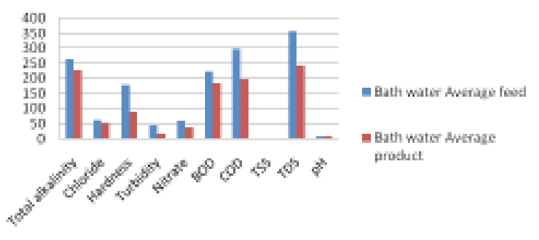
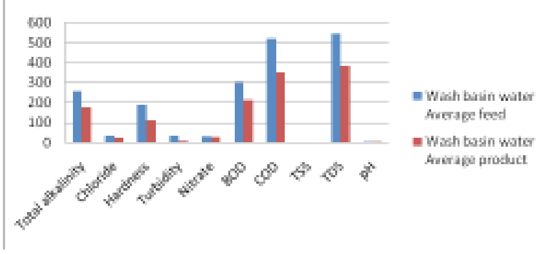


Figure 5: Average concentrations of different parameters in Wash basin water



duction in the values with reduction of more than 20%; kitchen water and wash basin water showed the moderate reduction between 20-50%, and the laundry water showed the maximum reduction of more than 50%. According to IS: 3307, in the wastewater to be discharged onto land for irrigation, the chloride value should be 600 mg/L, whereas according to IS: 2490 standards for wastewater to be discharged into inland surface water it is 1000 mg/L. The values of chloride in the influent have ranged from 29 mg/L to 62 mg/L, whereas the effluent levels have ranged from 23 to 49 mg/L. The average reduction of hardness in the kitchen, laundry and bath water samples showed the highest reduction percentage of more than 50%, whereas the wash basin water showed the moderate reduction between 20-50%. Turbidity, one of the most important parameters to monitor the performance of filter, has ranged from 24 ppm to 77 ppm in the feed water, whereas the effluent levels have ranged from 4ppm to 33ppm. The average values of nitrate in the feed water have ranged from 32.54 mg/L in the wash basin water to 66.69 mg/L in laundry water, whereas the average effluent values have ranged from 22.61 mg/L in kitchen water to 45.26 mg/L in laundry water.

According to IS: 3307, the BOD in wastewater to be discharged onto land for irrigation is 500mg/L. The average value of the BOD in the influent ranged from 196.07 mg/L in the composite sample to 310.71 mg/L in laundry water. The average values of COD in the effluent ranged from 183.24 mg/L in kitchen water to 350.77 mg/L in wash basin water. The average percent reduction of TSS was moderate with values ranging from 20-50%. The average values of pH in the effluent ranged from 7.4 in laundry water to 7.7 in bath water.

Fig. 2 shows the average influent and effluent concentration of different physical and chemical parameters in kitchen water. Turbidity showed the highest reduction of 61.28 % followed by hardness with 51.25 %. The pH reduction was of not significant. Laundry water average influent and effluent concentrations of different parameters are shown in Fig. 3. Total dissolved solids showed the highest peak due to the presence of detergent products dissolved in sample. The highest reduction was of turbidity with 69.87%. High alkalinity values were noticed due to use of detergents and soap products.

Figs. 4 and 5 show the average concentrations of different parameters in bath water and wash basin water respectively. The percent reduction of TSS in bath water was 42%, whereas in wash basin water it was 31%. There was 73% reduction of turbidity in wash basin water, whereas it was 64% in bath water. Approximately 50% reduction of hard-

Table 1: Base material specifications (depth and size).

Layers	Depth (mm)	Size (mm)
Topmost layer (I)	23	2 to 4.75
Intermediate layer (II)	23	4.75 to 40
Bottom layer (III)	23	40 to 63

Table 2: Average influent and effluent values. St Dev = Standard Deviation

Parameter	Kitchen water		Laundry Water		Bath water		Wash basin water		Composite sample	
	Average feed (± St Dev)	Average product (± St Dev)	Average feed (± St Dev)	Average product (± St Dev)	Average feed (± St Dev)	Average product (± St Dev)	Average feed (± St Dev)	Average product (± St Dev)	Average feed (± St Dev)	Average product (± St Dev)
Tot. alkalinity	238.57 (±10.3)	180.95 (±11.01)	865.7 (±11.53)	416.71 (±7.92)	264.2 (±9.6)	228.27 (±6.29)	258.5 (±4.96)	178.57 (±8.03)	305.78 (±8.99)	263.94 (±4.1)
Chloride	29.01 (±1.5)	25.09 (±2.3)	31.94 (±4.16)	23.61 (±2.07)	62.55 (±5.24)	49.7 (±3.9)	34.19 (±2.81)	24.81 (±1.68)	45.72 (±4.03)	38.47 (±4.07)
Hardness	200.42 (±10.02)	97.69 (±3.45)	350.28 (±7.2)	167.91 (±5.64)	180 (±4.37)	89.37 (±5.70)	188.2 (±5.68)	110.23 (±5.68)	181.42 (±5.06)	166.07 (±3.34)
Turbidity	24.42 (±2.77)	4.57 (±2.38)	54.15 (±2.58)	16.42 (±2.12)	45.42 (±2.55)	16.28 (±3.69)	34.85 (±3.6)	9.28 (±1.82)	77.71 (±2.81)	33.14 (±2.41)
Nitrate	34.52 (±3.56)	22.61 (±2.29)	66.69 (±3.62)	45.26 (±2.43)	59.51 (±1.20)	38.74 (±4.64)	32.54 (±2.44)	28.35 (±2.03)	57.99 (±1.82)	47.96 (±2.45)
BOD	224.42 (±4.03)	168.45 (±4.90)	310.71 (±7.75)	220.41 (±3.93)	222.85 (±3.39)	183 (±3.98)	302.14 (±7.95)	214.35 (±5.59)	196.07 (±6.52)	158.27 (±5.19)
COD	265.26 (±3.24)	184.24 (±7.88)	565.42 (±7.15)	303.27 (±4.95)	298.97 (±5.89)	198.63 (±4.69)	520.85 (±5.18)	350.77 (±4.02)	399.513 (±6.41)	33.31 (±4.63)
TSS	1.37 (±0.37)	1.18 (±0.41)	3.15 (±0.53)	1.82 (±0.95)	1.91 (±0.79)	1.09 (±0.80)	2.95 (±0.13)	2.03 (±0.46)	1.16 (±0.18)	0.31 (±0.17)
TDS	451.42 (±6.92)	357 (±4.86)	4237.8 (±3.68)	3108 (±5.31)	355.14 (±4.70)	242.85 (±5.19)	546.85 (±5.54)	383.71 (±4.16)	786.28 (±3.7)	539.28 (±5.14)
pH	7.7 (±0.13)	7.5 (±0.05)	7.9 (±0.18)	7.4 (±0.22)	8.05 (±0.10)	7.7 (±0.17)	7.5 (±0.07)	7.2 (±0.10)	7.9 (±0.18)	7.5 (±0.09)

The units are in mg/L except pH and turbidity.

ness was noticed in both the samples. Percentage reduction of pH in both the samples was of no significance. There was low reduction of BOD in both the samples with 17% in bath water and 29% in wash basin water.

CONCLUSIONS

The model was fabricated successfully and run for steady state condition. Samples of kitchen water, laundry water, bath water and wash basin water were collected from different sites from MNIT, Jaipur campus and analysed for physical and chemical parameters. There was high variation in the quality of grey water due to factors such as water use efficiencies of appliances, individual habits, products used (soaps, shampoos, detergents) and other site specific characteristics. It was found that the common contaminants in the kitchen water are suspended solids, which are added due to the presence of food particles in the water. They have to be screened out before treatment to avoid any blockages. Bath water and basin water was mainly contaminated by suspended particles like dirt, lint and hair. There was a sharp increase in the pH value. During the preliminary runs the filtrate obtained showed the negligible percentage removal in contaminants. This was due to the reason that the filter was filled with the freshly cleaned sand and thus there was no biological layer developed on the sand bed. It was found that there is a small decrease in the pH in the filtrate. This is probably due to dissolution of carbon dioxide as a result of biological activity in the top layer.

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