# Assessing the Efficacy of Locally Available Sand for the Removal of COD, BOD, TKN, Nitrates, Phosphates, Ammonical Nitrogen, Nitrate Nitrogen from Grey Water by Slow Sand Filtration

Dr. Urmila Brighu, Kanika Saxena, Swati Singh
Department of Civil Engineering,
Malaviya National Institute of Technology Jaipur,
India

***Abstract*–The removal of COD, BOD, TKN, nitrates, phosphates, $NH_3$-N, $NO_3$-N from the greywater was studied in a slow sand filter. The impact of the filtration rates was assessed. The filtration rates of 10 ml/min and 20 ml/min were used. The sand showed good removal capacity for nitrates although there was leaching of nitrates in the initial 4 hours, after that the effluent concentration of nitrates was reduced to <1 mg/l. The removal of nitrates was 100% after 4 to 5 days in both the filters.The removal of phosphates for the rates of 10 ml/min and 20 ml/min was 97.85% and 79.13 % respectively. The maximum removal of TKN was 83.33 % for both the filters after 10 days. The maximum removal of BOD and COD was up to 95.5 % and 79.16 %.**

***Keywords – Slow sand filtration, greywater, Nitrogen removal, COD removal, BOD removal***

## I. INTRODUCTION

Lately most of the developing countries around the world are facing water scarcity. It is estimated that within the next 50 years, more than 40% of the world's population will face the problem of water scarcity[1]. Therefore, there arises a need of waste water recycling. Particularly in arid regions greywater finds a great potential for reuse for purposes like landscaping. This could reduce the demand for potable water by 50 %[2]. Greywater (GW) has attracted global attention as an alternative water source over the last few decades. For the reliable reuse and treatment of GW it is important to characterize GW. Household greywater (GW), comprising wastewater from bathing (light GW) as well as that from laundry, excluding wastewater from toilets, is not waste but an alternative water source. In a number of known domestic activities (toilet flushing, soaking, window cleaning or car washing, irrigation etc.), the use of potable water is not necessary. An average person typically produces 150-250 liters of domestic wastewater per day, and GW accounts for up to 75% of household wastewater. The quality of GW depends on the quality of the water supply, type of the source, the type of distribution system, household occupancy and the occupants' genders, age distribution and activities.

The analysis of the quality of GW streams originating from different sources is essential before reuse. The concentrations of organic compounds, solids, salts, pathogens, phosphorus and nitrogen forms in GW vary widely by source and depend significantly on the volume of water used[3]. Treated greywater is most appropriate for water applications that are frequently used and require low-quality water. Toilet flushing is the best application. The 27% of domestic water used for toilet flushing could be entirely replaced by treated GW. The 12% of water that is used for applications such as garden watering and car washing could also be replaced by treated GW[4].

Water from recycling systems should fulfill four criteria: hygienic safety, aesthetics, environmental tolerance and technical and economic feasibility [5]. Greywater treatment systems of varying complexities are being used around the world. The most popular treatment methods are physical (filtration, sedimentation), biological (aerobic and anaerobic methods), chemical (coagulation, adsorption and oxidative processes) and natural systems or a combination thereof. It is very difficult to identify the best treatment system for greywater, as each has its own advantages and disadvantages, and each regiondiffers in preferences and specialization.

The physical treatments include coarse sand filtration and membrane filtration, followed mostly by a disinfection step. The coarse filter can be used in conjunction with some other method because alone it has limited effect on the removal of the various parametersof greywater. The slow sand filtration is an efficient method because of the fine sand and biological processes. [6].

Using physical method of treatment is an economical option. Various waste water parameters can be satisfactorily removed by using sand filtration. The COD, the turbidity, the SS and TN were reduced from 171 mg/l, 20 NTU, 44 mg/l and 11.4 mg/l in the influent to 78 mg/l, 16.5 NTU, 18.6 mg/l and 7.1 mg/l respectively in the effluent[4].

The soil treatment system could remove organic pollutants and total phosphors partially. Due to the nitrification and de-nitrification reactions in the soil treatment system, nitrogen can be eliminated effectively. Obviously, the soil filter applied in this study cannot be regarded as a single filtration but a combination of filtration and biodegradation.

Obviously, coarse filtration and soil filtration alone are not able to reduce the physical, chemical and microbiological parameters to the values required by the non-potable reuse guideline. The micro filtration and the ultrafiltration membrane provide a limited removal of the dissolved organics but an excellent removal of the suspended solids, turbidity and pathogens.

## II. METHODOLOGY

### *A. System setup*

A lab scale column of the locally available sand was setup. The total height of the column was 42 cmand diameter was 6.5 cm. The filter was constructed by using properly graded gravels. The depth of the gravels was 7 cm and the sand was filled over to make the complete depth of the filter equal to 30 cm (gravels + sand). The weight of the sand was 1.025 kg. Two holes of 1cm diameter were drilled done at the top andother at the bottom for the inlet and outlet arrangement of the greywater respectively. The constant inlet flow rate was maintained using peristaltic pump. The filter was operated for 6 hours every day and was operated until it to clogged. Two columns were run with flow rates 10 mL/min and 20 mL/min the corresponding rates in RPM in the pump were 3.1 RPM and 6.2 RPM respectively.

*Sampling:* The samples of greywater were collected from the Gargi Girls hostel in the MNIT campus, Jaipur during morning hours between 9 -10 a.m. The occupancy of the hostel is about 400 members. The samples were collected in plastic cans of 5 L capacity. The filtered samples were collected in sanitized glass beakers of 1L capacity. This greywater did not include kitchen waste water.

### *B. Sand characterization*

The sand was collected from the MNIT campus. The pH of sand was found out to be 8.05 (sand and distilled water in 1:1 ratio). The conductivity was 0.211 µS/cm (sand: water = 1:2.5). The sand was washed and sieved. The fraction of sand of the size 150-300 µm was used for filter bed. The bulk density of sand was 1.43 g/cm$^3$.

### *C. Greywater characterization*

The organic parameters BOD, COD, TKN, ammonical nitrogen were determined as soon as possible. Conductivity and pH were also determined. The inorganic parameters like phosphates and nitrates were determined without a maximum delay of 48 hours. The pH was determined using Benchtop pH meter. Stannous chloride method was used for the determination of phosphates. Shimadzu Spectrophotometer was used for ammonical nitrogen, phosphates and COD determination.

## III. RESULTS AND DISCUSSION

### *A. Greywater characteristics*

Complete and summarized data is reported in the table (TABLE I.). The pH, conductivity, COD, BOD, TKN, $NH_3$-N, nitrates, phosphates, SS, DS showed a good compatibility with the literature.

TABLE 1. GREYWATER CHARACTERISTIC

| **Parameter** | **Mean** | **Standard Deviation** |
|---|---|---|
| pH | 7.48 | 0.32 |
| Phosphates(mg/L) | 0.1114 | 0.068 |
| Nitrates(mg/L) | 6.95 | 5.68 |
| TKN(mg/L) | 2.98 | 1.12 |
| Ammonical Nitrogen(mg/L) | 1.82 | 1.01 |
| COD(mg/L) | 89.13 | 14.5 |
| BOD(mg/L) | 56.12 | 12 |
| Conductivity (µS/cm) | 0.7037 | 0.1 |

### *B. Nitrate Removal*

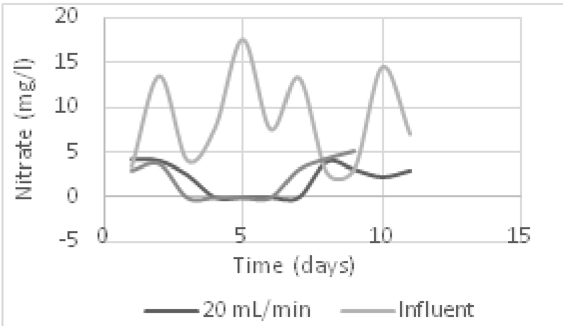


*Fig 1. Nitrate removal with time*

The sand showed a good nitrate removal capacity. Initially the sand leached out the nitrates which were already present in the sand. After 1 hr of filter operation the effluent concentration of nitrogen went as high as 81.1 mg/l, indicating leaching of nitrates from the sand as it was already known that Jaipur sand is rich in nitrates. After a continuous operation of the filter at the rate of 20 ml/min the nitrate concentration in the effluent reduced gradually. After the end of 1, 2, 3 and 4 hours it was 81.1 mg/l, 6.7 mg/l, 4.82 mg/l, 4.26 mg/l respectively. In the case of filter with influent loading rate of 10 ml/min after 1, 2 and 3 hours the nitrate concentration of the effluent was 112 mg/l, 7.56 mg/l and 3.25 mg/l respectively. At the end of 4$^{th}$ day the nitrate concentration reduced to less than 1 indicating the adsorption of nitrate ions on the sand surface. Again after 7 to 8 days nitrates started to leach after the surface of the sand could not accommodate more nitrate ions.

### *C. TKN and ammonical -N removal*

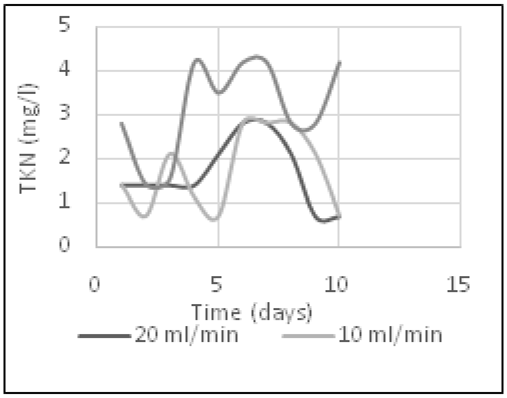


*Fig. 2 TKN removal with time*

The sand was moderately effective for the removal of TKN and $NH_3$-N. The concentration of TKN initially reduced and after 4 to 5 days it again increased (Fig. II). The mean removal of 60% of $NH_3$-N by slow sand filter has been reported.[7]. There is higher nitrification rate in the attached growth systems than the suspended growth systems.[8]. If the initial loading rate is maintained low the microbiological growth is promoted and TKN removal efficiency is increased.[9]. A significant amount of $NH_4^+$ removal takes place by adsorption on organic matter physically and chemically[10].

### *D. Phosphate Removal*

The removal of phosphates by slow sand filtration was found to be very effective. The filter with filtration rate 10 ml/min showed better performance than the one with 20 ml/min. The maximum removal efficiency of phosphates was 97.85% for the filtration rate of 10 ml/min at the end of 10th day and 79.13% for 20 ml/min at the end of 9$^{th}$ day. The removal of phosphates can be attributed to the adsorption mechanism on the positively charged species of sand.

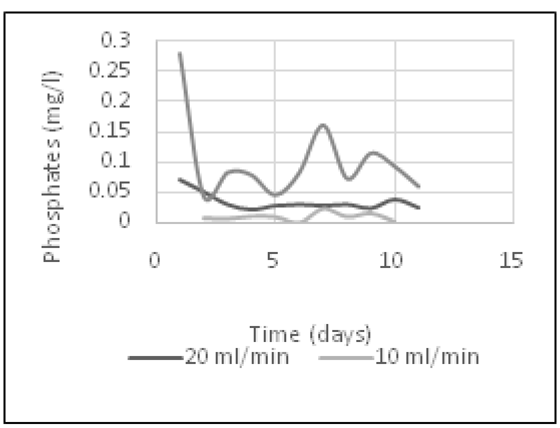


*Fig. 3 Phosphate removal with time*

### *E. COD Removal*

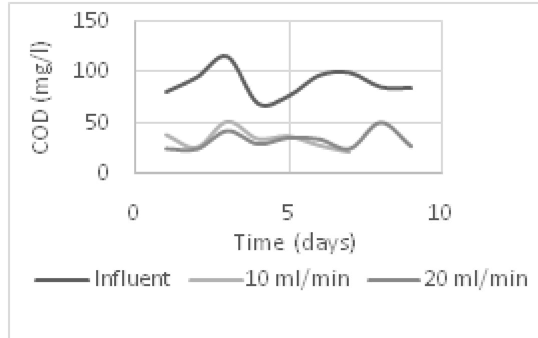


*Fig. 4 COD removal with time*

There is extremely efficient removal of COD from the very beginning of the filter run. The maximum removal for 10 ml/min and 20 ml/min was 79.16 % after 7 days and 52.06 % after 3 days respectively.

### *F. BOD Removal*

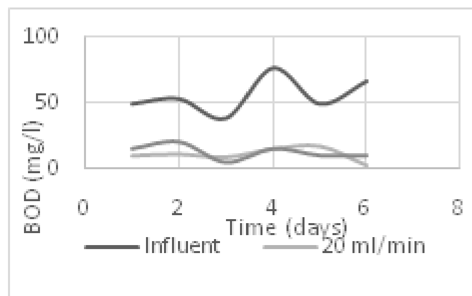


*Fig. 5 BOD removal with time*

There is efficient BOD removal as expected in slow sand filtration. The removal efficiency of BOD was as high as 95.5 % at the end of 7$^{th}$ day from the filtration rate of 20 ml/min.The removal efficiency of the filter with 10 ml/min filtration rate was 85.07 % at the end of 7$^{th}$ day.

## IV. CONCLUSIONS

The locally available sand has a good potential for removal of nitrates, phosphates, TKN, ammonical nitrogen, COD and BOD from the greywater. Sand filtration alone may not suffice but sand filtration followed by disinfection may prove to be a good method of treating greywater.

## V. ACKNOWLEDGMENT

The authors wish to thank Malaviya National Institute of Technology, Jaipur, India for their support.

## REFERENCES

[1] M. C. Sandeep Thakur, "GREY WATER RECYCLING," *Journal of Environmental Science and Sustainability (JESS)*, vol. 1, no. 4, pp. 117-119, 2013.

[2] O. S. Z. R. E. R. A. Gross, "Recycled vertical flow constructed wetland (RVFCW)—a novel method of recycling greywater for

irrigation in small communities and households," *Chemosphere,* no. 66, p. 916–923, 2007.

[3] A. S. E. B. A. U. N. B. Ildiko Bodnar, "QUALITATIVE CHARACTERIZATION OF HOUSEHOLD GREYWATER IN THE NORTHERN GREAT PLAIN REGION OF HUNGARY," *Environmental Engineering and Management Journal,* vol. 13, no. 11, 2014.

[4] K. W. R. O. Fangyue Li, "Review of the technological approaches for grey water treatment and reuses," *Science of the Total Environment ,* vol. 407, pp. 3439-3449, 2009.

[5] Nolde, "Greywater reuse systems for toilet ¯ushing in multi-storey buildings ± over ten years experience in Berlin," *Urban Water ,* vol. 1, pp. 275-284, 1999.

[6] M. S. N. G. S. S. L.C. Campos, "Biomass development in slow sand filters," *Water Research ,* no. 36, p. 4543–4551, 2002.

[7] A. D. A. A. Z. M. Bahgat, "Sand-filters used for wastewater treatment: buildup and distribution of microorganisms," *Wat. Res.,* vol. 33, no. 8, pp. 1949-1955, 1999.

[8] D. K. H.-E. L. S.-I. L. Hong-Duck Ryu, "Nitrogen removal from low carbon-to-nitrogen wastewater in four-stage biological aerated filter system," *Process Biochemistry,* vol. 432, pp. 729-735, 2008.

[9] C. Sukru Aslan, "Biological denitrification of drinking water in a slow sand filter," *Journal of Hazardous Materials,* vol. 148, pp. 253-258, 2007.

[10] L. M. N. O. M. Achak, "Removal of organic pollutants and nutrients from olive mill wastewater by a sand filter," *Journal of Environmental Management,* vol. 90, p. 2771–2779, 2009.