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An Economically Viable Method by Indigenous Material for Decontamination of Greywater

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Abstract: The Greywater Treatment System was fabricated on laboratory scale. The burnt bricks, gravel and sawdust were used as filter medium with particle size of 1mm.The flow rate from sample holding tank to collection tank was 0.6L/min. The attempt was made to analyze the effects of filter mediums on decontamination of greywater samples. The experimental results showed that the burnt bricks reduced the mean total dissolved solids (TDS) 34.7% ± 2.67. The gravel exhibited the better results in mean turbidity removal 83.90% ± 1.89, reduced the mean BOD 19% ± 3.4 and mean COD 50.1± 4.1 improved the mean DO level twice compared to other filter mediums. The sawdust was effective to normalize the mean pH 7.0 ± 0.37, mean temperature 14.4^{0}C ± 2.13, and mean total suspended solids (TSS) 51.46% ± 3.2.

Keywords: Greywater, Filter Medium, Sawdust, Burnt Bricks, Temperature

1. INTRODUCTION

Greywater is the waste water that originates from a clothes washer, bathtub, shower, and sink contains fats, oils, grease, hair, lint, detergents, soaps, nutrients, salts, cleansers, fabric softeners and other chemicals including the chlorides, sodium, borax and sulfates at elevated level. Greywater is found both acidic and alkaline in nature that's why not suitable to irrigate root crops, or edible parts of food crops *(Eriksson et al. 2003)*. The reviewed literature said that worldwide greywater treatment methods were in preliminary stage. The number of researcher engages to determine the safe and economical treatment methods to overcome the water scarcity. The various technologies and methods were under review in developed and under developed countries and trying to discover their merits and demerits *(Jefferson et al. 2000)*. Many countries are practicing the greywater treatment and reuses tactics because raw greywater were the fully fecal and bacterial contaminated (Birks *et al.* 2004). The greywater recycling plant in London named" The Thames Water recycling plant" collected the greywater samples from three sources pretreated separately and mixed with the main stream then filtered with ultra fine membrane and reverse osmosis. The treated samples showed no significant microbiological growth with excellent water quality. In United Stats the pilot scale wetland system was constructed to explore the potential of greywater reuse in wetlands over a one year time and compared with black water. The microorganism contaminated water puts long lasting health effects however the greywater was comparatively safe than black water *(Greenway et al.2005)*. In greywater treatment plants the sand filters had limited effect than membrane separation because it separated the organic load efficiently *(Pidou et al. 2007)*. The greywater treatment in reactor through down-flow hanging sponge system revealed that the hydraulic retention times and down-flow hanging sponge system was interrelated component, by their adjustment the better results were obtained (*Faruqui et al. 2002)*. The characteristic and composition of greywater varies population to population and depends upon the inhabitants living styles, nature of occupants; age groups health status and water usage patterns. The bathroom greywater contaminated about 55% with hair, soaps, shampoos, hair dyes, toothpaste, lint, body fats, oils cleaning products and fecal contamination associated with bacteria and viruses through body washing. The Laundry greywater was about 34% by oils, greases, chemicals, soaps, nutrients and other compounds, the quality varies from first to last washed water. The first washed greywater were rich while the rinse water was lean. The kitchen greywater was roughly polluted about 11% with food particles, cooking oils, grease, detergents and other cleaning products as dishwashing powders (*Friedler et al. 2004, March et al.2004*). As the greywater microbial contaminated hence disposal was the key issue. There must be remarkable effect on quality and contamination level of stored greywater with respect to time. So the Dixon mathematical model was designed to observe the effect of residence time on greywater composition. The COD and DO were best fitted in designed model *(Dixon et al. 2000)*. The reuse of greywater would helpful to water conservation in water scarce areas. It provides the alternative water resource to keep clean underground aquifers. It gave the free disposal and minimizes the water shortage. The

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greywater was best substitute of fresh water as in irrigation, toilet flushing, tools, floors and vehicles cleaning. In fire sprinklers, hydrants, fire fighting engines and vehicles. The industrial applications included the boiler feeding and cooling water *(Ghunmi et al.2011).*

The purpose of study was the physical treatment of greywater by indigenous filter mediums. In that regard the floor mounted treatment unit was fabricated locally and placed in Unit Operation Laboratory, Chemical Engineering Department, MUET Jamshoro. The pre and post analysis were done after the elution from greywater treatment unit.

2. MATERIALS AND METHODS

2.1 Sample collection & filter medium Preparation

The greywater samples were collected according to standard procedure of sampling *(Veslisarg et al.2013)* from Teacher Hostel of MUET Jamshoro in six consecutive months. All the reading was taken replicate to validate the data. The estimated population was of 25 adults belonging to teaching profession. The samples were collected from the main discharge pipe behind the teaching hostel. The discharge pipe was elbow fitted to toilet flush, bath room, sink and kitchen wastewater.
Three filter mediums burnt bricks, gravel, and sawdust were selected for decontamination of greywater samples The burntbricks obtained from brick stalk holders of Sheikh Birkio district Hyderabad Sindh, sawdust were of freshly cut wood from timber market Hyderabad sindh. The gravel was an unconsolidated mixture of rock fragments and was taken from earth curst of MUET Teachers Hostel. The selected filter medium material was washed twice with double distilled water to eliminate the adhered impurities, dried, crushed in disc type black crusher (Shanghai Manufacturing)and sieved (vibrating screen shaker). The filter mediums of particle size 1mm were collected for analysis.

2.2 Fabrication of Treatment unit

The experimental unit was designed in view that greywater samples run through gravity from bed of burnt bricks, gravel and sawdust separately and collected in collection unit for analysis. For that the floor mounted vertical unit was fabricated **.** The frame consist of two horizontal racks for holding three separate feeding tanks at top and filter medium holding tank in mid. The collection tanks were set at ground. The frame was made of stainless steel racks and the tanks were of sterilized polyethylene vessels with capacities of 3 liters each. The plastic pipe and control valve was fixed to control the flow rate. The flow rates of greywater samples from feeding tanks to collection unit were 0.6 L/min.

2.3 Testing parameters

The greywater treatment unit was designed to determine the effect of burnt bricks, gravel and sawdust on greywater decontamination. The pH, temperature, TDS, EC, DO was determined by HQd Meters and IntelliCal ^{TM} Probe (HACH HQ40d Dual-input, Multi-Parameter Digital Meter).The turbidity was evaluated by absorptometric method (Modal HACH 2100, DR-2000, Hach Company, Loveland Colorado U.S) with stored program 750 set wavelengths at 450 nm and the sample cuvate (25ml) was used for greywater sample and blank samples. TSS was measured by followed the EPA method 160.2 and Standard Methods 2540D [EPA's 2013].According to that the glass filter was soaked in double distilled water, oven dried at 104^0C and weighted. Then put onto filtering flask-wrinkled side up and filtered. The deposited residue was oven dried at 105^0C and weighted.

The BOD was assessed by LDO Technology with LBOD Probe (HACH HQ40d Meter). The COD of samples were evaluated through COD Spectrometer COD VARIO Lovibond SN-09/14076 (Germany) with Reactor ET-108 Lovibond. The COD vials were of Merck (Germany) with ranges low (0-150 mg/L), medium (0-1500 mg/L) and high (0-15000 mg/L).

3. RESULTS AND DISCUSSION

The experiments were proceeds by collection the greywater samples and their pre and post treatment. The pH played prominent role in all reaction took place in water bodies. The greywater samples were acidic with pH 4.75-5.13 from its source. The samples were eluted separately and their mean pH was noted. The results showed sawdust increased the pH towards neutralization ranged from 6.3 to 7.3 and made it usable. However the burnt bricks and gravel exhibited very nearest results between pH 5.3-6.1, and 6.12-7.1 respectively. The results were satisfactory expect the lower range of burnt bricks and that was acidic.

The source temperature was higher than room temperature**.** The reason was the use of geezer in washing, bathing and hot weather of Jamshoro district. The allowable limit for safe aquatic life was 400C *(Charles E).* The average temperature at source was 430C it was immediately eluted from the greywater treatment unit temperature lower down to 24.3-17.90C, 29-200C, 15.2 - 13.6^0C by filter medium of burnt bricks, gravel and sawdust respectively. The sawdust lowers down the temperature effectively.

The study was revolved against the TSS and turbidity as well. The TSS was the insoluble particles that float and suspend but not settle down on bottom can

be seen by necked eyes without any instrumentation. The trapping mechanism directly influenced by particle size of filter medium and. On the contrast the turbidity was the content of micro solid particles which gave the turbid look. The burntbricks, gravel and sawdust provide the filter medium to trap the suspended particle. The mean TSS removal was as 43.99, 49.16 and 51.46% respectively **(Fig 1)**

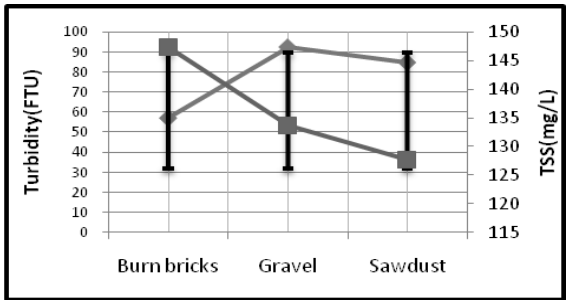


Fig 1. The mean turbidity removal (FTU) and TSS removal (mg/L) of greywater samples eluted from the filter medium of burntbricks, gravel and sawdust. The vertical lines showed error bars with standard deviation

The sawdust showed the comparatively better results because of its nodular, fibrous structure and non porous packing. This allowed the sample to flow down smoothly without blockage. As far as turbidity was concerned the filter medium of burntbricks, gravel and sawdust reduced the mean turbidity 52.09, 83.90 and 76.97% respectively. The gravel showed better results compared to other ones. This was because multidimensional shape of gravel particles. The quality of greywater can be upgraded by coagulation, adsorption on granular activated carbons and filtration. The laundry greywater coagulated with FeCl3 and $Al_2(SO_4)_3$ and exhibited the removal efficiency of 79% for TSS and 81% for COD *(Antonopoulou et al. 2013)*.The TDS and EC were the interrelated parameters mean TDS and EC during research period was in between 54-67 mg/L and110 - 134.2 µS/cm. The burntbricks filter medium was put the effect on TDS and EC as 51.2- 56.2mg/L and107.4-112.2 µS/cm. The gravel 57.8 -- 44.2 mg/L and 101.4-107.2µS/cm and sawdust 47-52.2mg/L and 99.34-104µS/cm (Fig 2)

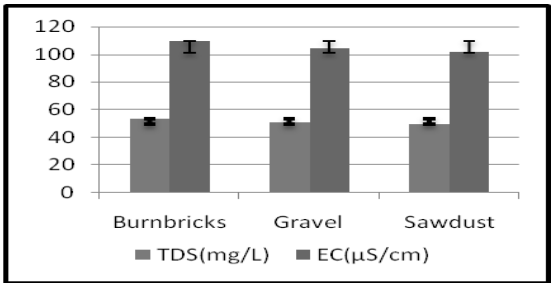


Fig 2. The mean TDS (mg/L) and mean EC (µS/cm) of greywater samples eluted from burnt bricks, gravel and sawdust. The vertical lines showed the error bars with standard deviation

The COD referred to dissolved recalcitrant and was readily oxidized in aerobic or anaerobic environment *(International Standards Organization 1989).* The samples were contaminated by multiple contaminants. The high inorganic load was the harmful to fauna and flora of receiving water. The common methods of COD load minimization were the biochemical, physiochemical and reed beds treatment methods. It was evident that biochemical treatment destroys the useful and beneficial microorganisms. On the contrary the unstable or non uniform composition of greywater the physiochemical method flops. The reed beds were comparatively feasible it allowed the grow properly *(Guodong et al. 2010).* The research samples exhibited the COD ranged between 96-156 mg/L in six months periods. The COD removal efficiency was the difference between the initial and eluted samples by initial COD value in terms of percentage.

The higher COD removal efficiency was obtained from gravel bed between 46.03-48.11mg/L. The burntbricks were seems to be non effective however sawdust was less effective. The DO was the important for aquatic life. When COD and BOD levels increased in water bodies ultimately the DO level decreased and environmental treats started up. Total dissolved gas concentrations in water should not be exceeding 110% otherwise dangerous to aquatic life. The excess levels cause the "gas bubble disease" in fishes and were rarely appeared. The bubbles or emboli block the flow of blood through blood vessels causing death. External bubbles (emphysema) can be seen on fins, on skin and on other tissue. Aquatic invertebrates were also affected by gas bubble disease but at levels higher than those lethal to fish. For good water quality the dissolved oxygen must be within the allowable ranged which promotes the aerobic life in water bodies. Below 5.0 mg/l causes the life under stress. The lower the concentration was the greater the stress Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills *(Mandal et al. 2011).* Mean DO of greywater source during research periods was 0.4mg/L. After elution the DO level was improved. The experimental study concluded that burn bricks and sawdust had same results while gravel improves the level twice than both mediums. The gravel bed was non compactable and possessed the small pores in bed that was why the oxygen in environment interact easily and taken part in level improvement. The presence of bacteria, pathogen, Protozoa, coli and e-coli, robin and other aquatic organisms indicated the BOD level of samples. The organic wastes, nitrates and phosphates in the water were also rise up the BOD level and decomposed by micro organisms. As water temperature increases, the rate of photosynthesis by algae and other plant life in the water also increases resulting the plants

grow and die faster. When the plants die, they fall to the bottom decomposed by bacteria. The bacteria require oxygen for this process so the BOD was high at that location. Their intake in human body caused the short term to terminal illness. The filter medium trapped the living organism as many as can and provide the shatter for their colonies. So it was necessary to change the filter medium after recommended time. The attempted was made to judge the effect of filter medium of burnt bricks, gravel and sawdust on BOD level of sample. It was concluded that BOD level reduced from 140.3-146mg/L, 53.4-59.2mg/L and 101.2-1072mg/L respectively**.** The mean initial BOD was noted 304.94mg/L.

4. CONCLUSION

This study was concluded that three filter medium burntbricks, gravel and sawdust were tested for decontamination of greywater. The beds of mediums were maintained and samples were eluted. The greywater testing parameters were pH, temperature, TSS, turbidity, TDS, EC, DO, BOD and COD. The study revealed that sawdust was effective in pH normalizing, temperature lowering down, TSS and turbidity elimination. The gravel was effective in BOD and COD reductions. It was improving the DO level as well. The entire filter medium showed almost same results in EC measures.

REFERENCE:

Antonopoulou G., A. Kirkou and S. A. Stasinakis (2013) Quantitative and qualitative greywater characterization in Greek households and investigation of their treatment using physicochemical methods Science of the Total Environment 454– 455.

Birks R.1., J. Colbourne S. Hills and R. Hobson (2004) Microbiological water quality in a large in-building, water recycling facility, Water Science Technology 50(2) 165-72.

Charles E. S., I. M. Donald, J. H. David R. G. John A. G. Chapman, and A. W. Brungs (2013) "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and their uses"U.S Environmental Protection agency, office of Research and Development, Environmental Research, Laboratories Duluth, Minnesota Narragansett, Rhode Island Corvallis, Oregon

Dixon A., D. Butler A. Fewkes M. Robinson, (2000) Measurement and modeling of quality changes in stored untreated grey water, Urban Water 1 (4) 293–306.

Eriksson, E., K. Auffarth, A. M. Eilersen, M. Henze, A.. Ledin, (2003) Household chemicals and personal care products as sources for xenobiotic organic compounds in grey wastewater, Water SA 29(2)135–146.

Friedler, E., (2004) Quality of individual domestic grey water streams and its implication for on-site treatment and reuse possibilities Environ. Technol. 25 (9) 997–1008.

Faruqui, N. and O. Al-Jayoussi (2002) Greywater Reuse in Urban Agriculture for Poverty Alleviation: A Case-Study in Jordan, Water International 27(3) 1-17

Guodong Ji, F. Zhai, R. Wang and Ni. Jinren (2010). Sludge granulation and performance of a low superficial gas velocity sequencing batch reactor in the treatment of prepared sanitary wastewater. Bioresour. Technol 101 (23): 9058-9064

Ghunmi L. A., G. Zeeman, M. Fayyad and B. V. J. Lier (2011) Grey Water Treatment Systems: A Review, Critical Reviews in Environmental Science and Technology,41(7) 657-698.

http://water.epa.gov/drink

Greenway M.(2005) The role of constructed wetlands in secondary effluent treatment and water reuse in subtropical and arid Australia, Ecology Engineering 25, 501–509

International Standards Organization. Water Quality—Determination of the Chemical Oxygen Demand. ISO 6060, 1989

Jefferson, B., A. Laine, S. Parsons, T. Stephenson, and S. Judd, (2000) ,Technologies for domestic wastewater recycling, Urban Water 1(4) 285–292.

March, J. G., M. Gual, and F. Orozco, (2004) Experiences on greywater re-use for toilet flushing in a hotel (Mallorca Island, Spain), Desalination 164 (3) 241–247

Mandal D., P. Labhasetwar S. Dhone A.S. Dubey G. Shinde and S. Wate (2011), Water conservation due to greywater treatment and reuse in urban setting with specific context to developing countries, Resources, Conservation and Recycling 55(3),356-361.

Pidou M., F.A. Memon T. Stephenson P. Jeffrey and B. Jefferson (2007) Greywater recycling: treatment options and applications. J. ICE Eng. Sustain. 160 (3) 119–131