ISSN-1996-918X

Pak. J. Anal. Environ. Chem. Vol. 17, No. 1 (2016) 87 – 92

doi: 10.21743/pjaec/2016.06.013

An Investigation on Indigenous Material as a Filter Medium for Decontamination of Greywater

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Received 04 May 2016, Revised 26 June 2016, Accepted 28 June 2016

Abstract

The laboratory scale greywater treatment unit was designed. The aim was to determine the effect of filter mediums on pH, temperature, total dissolved solids (TDS), electric conductivity (EC), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and turbidity of greywater. The indigenous materials such as burnt bricks (BB), sawdust (SD) and gravel of particle size 5mm were set at 1L/h flow rate. The results concluded that SD was effective to normalize the pH 10.2 to7.2 and eliminated the TSS up to 52.01%. It was effective in removal of TDS and decreasing EC. While gravel performed better for decreasing BOD, COD and increasing DO levels.

Keywords: Indigenous; Gravel; Treatment; Filter mediums; Results.

Introduction

The water pollution is a major concern regarding public health. The rapid growth in population, mismanagement of water resources and climate change are the key factors of water pollution [1]. The major cause of pollution is the discharge of untreated municipal and industrial wastewater in water bodies. The water borne and water related diseases are due to contaminated water that even percolates into soil layers and contaminates the ground water thereby making it unsafe for drinking [2]. The contamination of rivers, lakes channels, aquifers and all water bodies is called the water pollution. The pollutants degrade our environment, as fresh water reservoirs are limited on earth's curst therefore it is needed to balance the rate of fresh water withdrawal and replacement from aquifers in ecosystem. The wastewater treatment and recycling can reduce and mitigate this problem with recovery of useful products such as organic matter and water nutrients; furthermore it is needed to categorize the wastewater and treat the greywater and black water separately in order to make the system efficient and economical [3-5].

The municipal wastewater discharged from toilets and washrooms is known as greywater, generated by bathing, toilet flushing and laundering, due to usage of shampoo, tooth pastes, shaving creams, and laundry soaps.

Around 70% of total water consumed in any middle class family of 4-6 members gets converted into greywater [6] and is composed of 9-20% nutrients and 30% organic load [7,8]. The composition varies from population to pollution and is directly related to age groups; number of family members, gender and living standards, but generally it contains the soap precipitates, leather, detergent, hair, lint, cosmetics, softeners and textile chemicals etc. By composition it contains the salts of various types, fats, borax, sulfate, oils, grease,

waxes and nutrients. Its nature could be acidic or alkaline depending upon the consumption of products, however due to its non-neutral nature, grey water cannot be used for crop cultivation and irrigation [9] and efficiency of water treatment plants depends upon their performance of the contents of greywater from black water [10].

The researchers are engaged to design the efficient and economical greywater treatment methods to conserve the water, still in its infancy but hopeful that in future common men would get benefit of the outcome [10-11].

In contemporary world of research various greywater treatment methods and techniques are available such as; chemical, physicochemical and biological treatments and among them; coagulation [12], photo-catalyst [13] and electro-coagulation [14] are chemical methods of treatment. Literature survey suggests that electro-coagulation chemical method is popular amongst all due to its simplicity, cost effectiveness, efficiency, compactness and eco-friendly nature as it needs less maintenance with lower sludge production and hydraulic retention times [14, 15], even this method is effective in removing various pollutants from wastewater and is followed by sedimentation and flotation [16, 17]. In case of physicochemical methods various types of filters; rotating/ stationary are being used, besides the disinfectant systems merged to eliminate the microbes. The biological systems are composed of the aerated filters and bioreactors; on the other hand, reed-bed technology is considered as an effective advanced technology for treatment of greywaters, the ultra-fine membrane and reverse osmosis type biological methods proved to stop significant microbiological growth that is in practice at Thames Water recycling plant London, while the membrane gives better organic load separation than many sand filters [18,19].

The research studies suggest that toilet greywater carries pathogens and bacteria, hence BOD level is observed high therefore care should be taken during its safe disposal, because microbes under favorable conditions are multiplied quickly with respect to time. The water parameters; DO and BOD had inverse relation whereas; mathematical model of Dixon is fitted best for estimation of water parameters COD and DO [20]. The treated greywater can be reused in car cleaning, gardening, floor washing, toilet flushing, hydrants, fire sprinklers and irrigation; hence it could overcome the water shortage and safe disposal problems, even it could be used as coolant for cooling various industrial installments and boiler feedings [21].

Present research work on treatment of water was focused on decontamination of greywater using filter media designed locally in Chemical Engineering Department, MUET Jamshoro. The pre and post elution readings were noted.

Materials and Methods

Preparation of filter medium

The burnt bricks (BB), sawdust (SD) and small size gravel were taken as filter media for greywater treatment (Fig. 1). The BB was obtained from brick manufacturers in Sheikh Bhirkio. The SD was obtained from Hyderabad timber market of unseasoned wood and gravel from Mehran University boys' hostel [5]. The adhered dust, debris and unwanted foreign particles were eliminated by washing and sun-dried for three days (72 hours) to avoid bell formation during crushing. The materials were crushed in disc type pulverizer (Shanghai Manufacturing), screened in fractional vibratory sieve shakers available in Chemical Engineering Department MUET Jamshoro.

Figure 1. **The BB, SD and gravel as filter medium for decontamination of greywater**

Fabrication of greywater treatment unit

The portable locally fabricated floor mounted unit was designed (Fig. 2) that consisted

of stainless steel frame of three racks provided the stability against downward and horizontal load distribution. Each rack held three pre-washed polyethylene bottles of 3 liters capacity connected with PVC pipes, upper rack polyethylene bottles carried the greywater samples, the middle carried filter medium and the lower collected the eluted samples. For controlling the flow rate, a control valve was installed. The filter medium tank contained equally distributed bed of BB, SD and gravel of 1kg each having particle size of not more than 5mm.

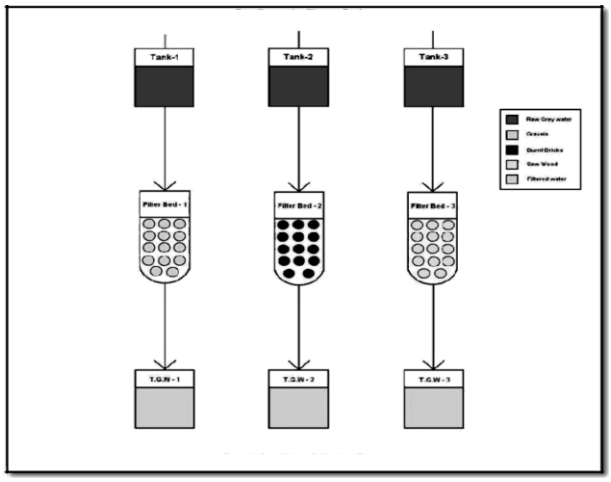

Figure 2. **The schematic diagram of greywater treatment unit**

Experimental parameters

The experimental parameters such as pH, temperature, TDS, EC, DO, BOD, COD, Turbidity and TSS were studied on locally fabricated units.

The initial five parameters were determined on dual point intake multi parameter digital unit (HACH- HQ40d, USA) having intelli Cal^{TM} probe. The BOD was assessed by LDO Technology with LBOD Probe (HACH HQ40d Meter).

The COD of samples was evaluated through COD Spectrometer model 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). The turbidity was evaluated by absorptiometric method (Model HACH 2100, USA) with stored programme 750 with set wavelength at 450 nm. The sample/blank cuvette was of 25ml.

The TSS was measured by following the EPA method 160.2 and Standard Methods 2540D.

Results and Discussion

The treatment of greywater was conducted with collection of water samples in pre washed sampling bottles from selected sampling points for six months and analyzed in triplicates with minimum delay.

After preliminary examination of above mentioned water parameters, the greywater samples were discharged into fabricated tanks of treatment unit with flow rates kept at 1L/ h. The samples slowly passed through filter media tanks as low flow rates provided greater contact times, the eluted samples once passed were collected in the lower racks and analyzed.

The pH is important quality parameter; hence collected samples showed alkaline pH ranged upto 10.2 during six month observations. The alkaline pH was due to usage of detergent, face wash, soap and shaving creams. The high alkaline nature of water is considered harmful therefore makes that water unsuitable for local consumption. However elution of greywater samples through filter media pushed the pH from alkaline to neutral (Fig. 3), as the results revealed that organic based wood SD lowered the pH (7.5) on average against other two media namely; gravel (9.05) and BB (9.67) average monthly values respectively.

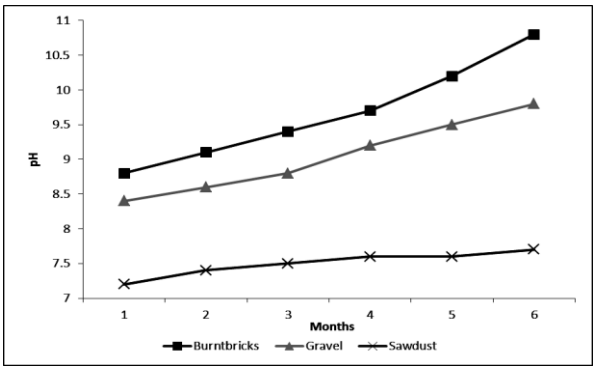

Figure 3. **The effect of BB gravel and SD as filter media on pH of greywater samples**

The temperature of greywater samples were noted by thermometer at the time of discharge as allowable temperature of wastewater in water bodies reported is 40°C [22]. The greywater samples discharge temperature was found between 23.5- 41.2°C, higher temperature was due to the use of house geysers possibly.

The TDS parameter mention the total solids dissolved in greywater and electric conductivity showed the conductivity of current from them. There was a strong relation of TDS and EC. The greywater samples showed mean high values of TDS 120 mg/L and EC 298 µS/cm respectively (Fig. 4). During present work it was observed that TDS and EC reduced to 85.7 mg/L and 149.7 µS/cm BB, SD 45.6 mg/L and 98.6 µS/cm and gavel 77.8 mg/L and 134.3 µS/cm respectively.

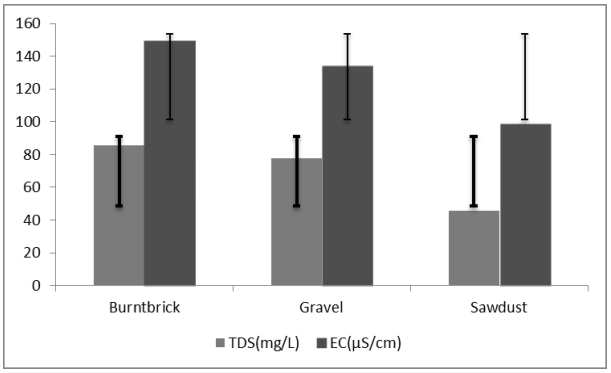

Figure 4. **The effect of TDS (mg/L) and EC (µS/cm) on BB, Gravel and SD as Filter Media**

The DO level of greywater was also evaluated. It was ranged between 0.7-1.0 mg/L, as DO is an important water quality parameter directly related to aquatic life and affects are visible on local flora and fauna. It is the fact that aquatic life falls in danger if the dissolved gas concentration becomes less than 110% and above this range the gas bubble disease symptoms appear on external parts as tissues, fins and skin of various fishes. This happens because bubbles block the blood circulation in veins which ultimately cause death and usually vertebrates and invertebrates are equally affected by this disease and lower limit of DO also causes heavy stress in fishes [23]. The samples showed mean DO level 0.4mg/L which helps the presence of microbes and organic matter in greywater. During present work DO and BOD levels in treated greywater was improved after elution through gravel based unit DO (2.0mg/L), BOD (58.5 mg/L) and in this case SD and BB were comparatively less effective than gravel possibly due to its porous medium structure facilitated aeration (Fig. 5). The presence of pathogens, bacteria, protozoa, coli and e-coli, robin and other aquatic organisms grow during presence of BOD parameter as indicated by presence of temperature, nitrates and phosphate contents favorable to microbe multiplication. Temperature increase accelerated metabolic activities with enhanced growth rates and increased the photosynthesis reaction in algae and other aquatic plants. The decomposition of living organisms by microbes decreased the DO and increased the BOD levels. As microbes consume dissolved oxygen during elution times the filter media trapped the microbes on their surface, where they made their large colonies, therefore it is recommended to change or recharge the filter media after certain period.

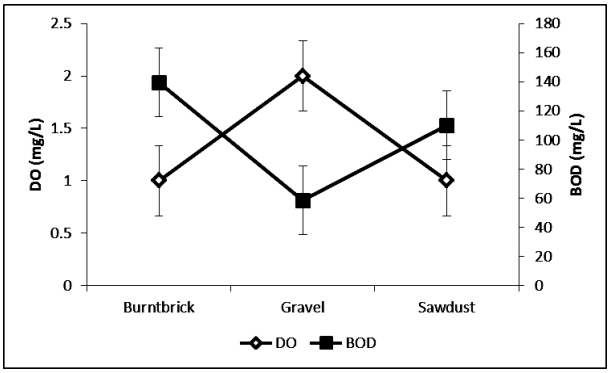

Figure 5. **The effect of BB gravel and SD as filter medium on DO (mg/L) and BOD (mg/L) of greywater samples**

The COD parameter is related with organic material of aerobic and anaerobic in nature which readily oxidized when introduced in water bodies [24]. The greywater samples were enriched by various organic degradable and inorganic non degradable contents retained for longer durations in environment. The biochemical, physiochemical and reed-bed methods were most practiced in various parts of the world that eliminate the beneficial microorganism and bacteria. The physical treatment methods gave uncertainty because treated greywater contained non uniform composition whereas reed-bed method

comparatively proven better and gave uniform and stable samples [25].

The COD of samples was noted in range of 96-164mg/L with mean COD during the study period was 97.4mg/L. After elution from filter media the recorded COD were 76.6 mg/L, 89.4mg/L and 45.1 mg/L from SD, BB and gravel respectively. It was noted that gravel was comparatively better than other filter media due to porous bed and space amongst particles work efficiently.

The suspended solids are the solids which float in samples and therefore cannot be dragged down by gravitational force. The TSS was eliminated from greywater samples as mean value of 42.81, 48.11 and 52.01% by BB, gravel and SD medium which in this case worked better than other media.

Conclusion

The treatment media of BB, SD and gravel was used as filter media for removing the contaminants from greywater with 1kg bed of particle size 5mm of each filter media set in locally fabricated unit connected with PVC pipes. It was concluded that greywater high contents of alkalinity when passed through filter media, the SD material was found effective in lowering down the pH from 10.2 to 7.2 with average of pH 7.5. The greywater temperature was within the allowable limits of ambient temperatures (below 40^{o}C), whereas TDS (45.6 mg/L), EC (98.6 µS/cm), TSS (52.01%) and turbidity levels effectively reduced. However DO (2.0mg/L), BOD (58.5 mg/L) and COD (45.1 mg/L) of greywater samples were reduced better by gravel contained filter media unit.

Acknowledgement

The authors are highly thankful to faculty of Chemical Engineering Department for their help and support. The authors acknowledge the scholars whose articles were cited and their references included in present research article.

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