Drawer Compacted Sand Filter: A new and innovative design for on-site wastewater treatment

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ABSTRACT: In this paper, results of new intermittent sand filter design was presented. Drawer Compacted Sand Filter DCSF is a modified design for sand filter, in which sand layer is broken down into several layers (10 cm each) and placed in a movable drawers separated by 5 cm space each. Lab-scale DCSF was designed and operated in Surrey University's lab for 49 days and fed by synthetic greywater. 30 cm of sand media was placed in three drawers, 10 cm each. 8 cm gravel was placed in the first drawer at the top of the chest. The effective size of sand media and gravel were 0.2 mm, 3 mm, respectively. The organic load was 42780 mg/m^2.day and hydraulic load was 50L/m^2.day. Significant reduction in BOD_5 and TSS was noticed between drawers 1 and 2, whereas no significant reduction was observed by passing water through all drawers. The study concluded that accommodating sand media in movable drawers and distribute hydraulic load between drawers would minimize the maintenance and space requirements for sand filter. However, this research is a preliminary study and further investigation is currently being done to optimize the system.

Key words: Drawer Compacted Sand Filter; Intermittent Sand Filter; Clogging.

INTRODUCTION

Intermittent Sand Filter has been used successfully in water and wastewater treatment for more than a century. It is used to describe multi-layer series of beds filled with particular medium i.e. washed graded sands, gravel, crushed glass and peat (EPA guidelines, 2002). The water percolates through the filtering media after being dosed onto the upper surface of sand. The distribution of wastewater usually occurs by using well-designed manifold lines placed over the upper sand surface. However, all scientific evidences have proved that treatment in Intermittent Sand Filter is mainly Aerobic i.e. biofilm develops on the sand particles which, in turns, absorb soluble organic matter as it percolates over the sand surface (Torrens et al., 2009; Leverenze et al., 2009, EPA guidelines, 2002, Metcalf & Eddy, 1991). Aerobic conditions are likely to be achieved by dissolved oxygen already found in applied water, gas diffusion between doses, and during rest periods (Torrens et al., 2009). However, maintaining aerobic conditions in sand filter is considered one of the crucial factor to achieve high treatment efficiency, which according to Leverenz (2009) could be maintained through unsaturated conditions and aeration between doses. Nevertheless, physical treatment as sedimentation and straining in addition to chemical adsorption treatment are also involved in sand filter (EPA guidelines, 2002). However, clogging in sand filter is considered the main concern for designers and operators. Clogging involves two main phenomena: reduction of pore space by suspended solid and reduction of pore space by bacterial growth (Leverenze et al, 2009). Many scientific research proved that accumulation of organic matter at the upper surface of sand layer, i.e. 0-1 cm below the course sand surface, is the responsible for clogging phenomena (Seigrist, 1987, Rodgers et al., 2004, McCray et al.2005, Torrens et al.,2009; EPA, 2002). However, giving resting periods between doses to allow attached bacteria for getting decayed endogenously is recommended to avoid or delay clogging (Leverenze et al, 2009).

MATERIALS AND METHODS

The goal of this paper is to suggest a new approach for sand filter design. Drawer Compacted Sand Filter DCSF is a modified design for sand filter, in which sand layer is broken down into several layers (10 cm each) and placed in a movable drawers separated by 5 cm space each (figure 1). This research hypothesize that placing treatment media in a separated movable drawers is a significant to facilitate the oxygen movement between layers, to avoid the occurrence of saturation condition, and to easing the maintenance requirements. Additionally, This research hypothesize that no significant water treatment is likely to occur after 10 cm percolation through the sand layer.

To examine that, A laboratory DCSF was designed and operated in Surrey University's lab for 49 days and fed by synthetic greywater. 30 cm of sand media was placed in three drawers, 10 cm each. 8 cm gravel was placed in the first drawer at the top of the chest (Figure 5.1). The effective size of sand media and gravel were 0.2 mm, 3 mm, respectively. The organic load was 42780 mg/m^2.day and hydraulic load was $50L/m^2$. Siphon pump was used to feed each drawer intermittently 4 times a day. Sampling tap was fixed at the corner of each drawer to evaluate the performance separately. Greywater was dosed and distributed evenly onto the upper surface of drawers by using well-designed manifold lines. The effluent from the first gravel drawer was dosed to the second sand drawer, the water from the second sand drawer was dosed to the third sand drawer and the water which came out from the third sand drawer was distributed onto the upper surface of the fourth drawer. However, after 10 days of operation, the hydraulic load was distributed evenly between drawers to evaluate the effectiveness of each drawer.

RESULTS AND DISCUSSION

The results showed a significant reduction in BOD_5 and TSS between the influent and the effluent greywater from the first drawer. Significant reduction of BOD_5 and TSS was also noticed between the first drawer and the second drawer. No significant reduction in BOD_5, and TSS was found between the second drawer and the third drawer. likewise, there was no significant removal between the third drawer and the fourth one (Figures 2,3,4). However, 2 logs of E.coli count were removed after passing the greywater through the four drawers. This

E.coli removal reduced to 1 log during the last week of operation. By distributing the load between drawers, each drawer had produced almost the same quality as if the water have passed through the all drawers, whereas the e.coli had significantly reduced by percolating the water through all drawers.

It is worth mentioning here that pilot DCSF has recently been designed and installed depending on the lab-scale DCSF. The pilot DCSF for greywater treatment has been in operation in Jordan since August 2011 (Figure 5.2). This pilot unit is still under evaluation and no water analysis has been done so far.

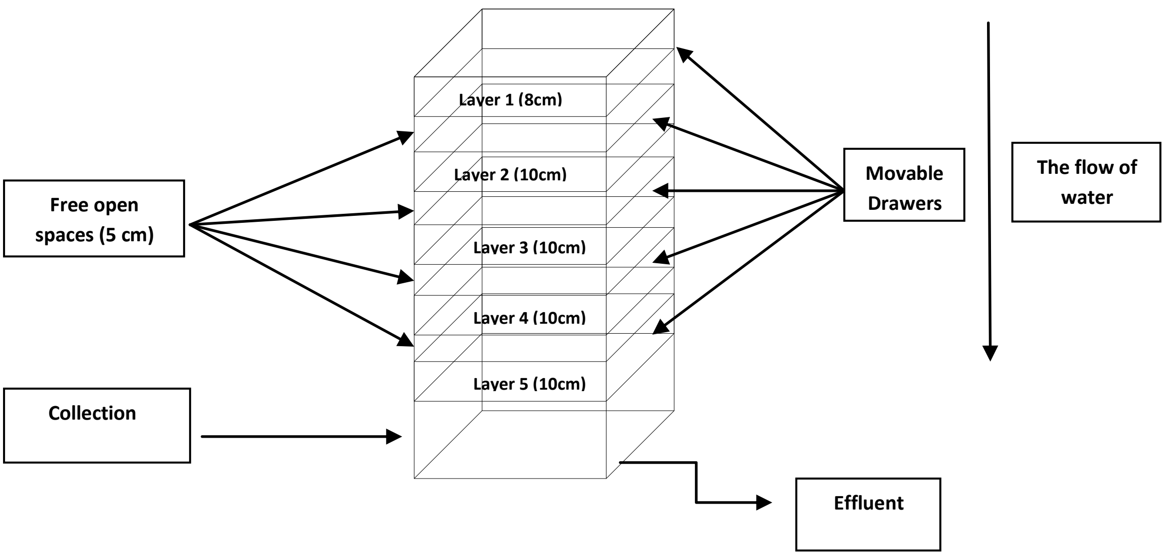

Figure.1 Schematic sketch for Drawer Compacted Sand Filter

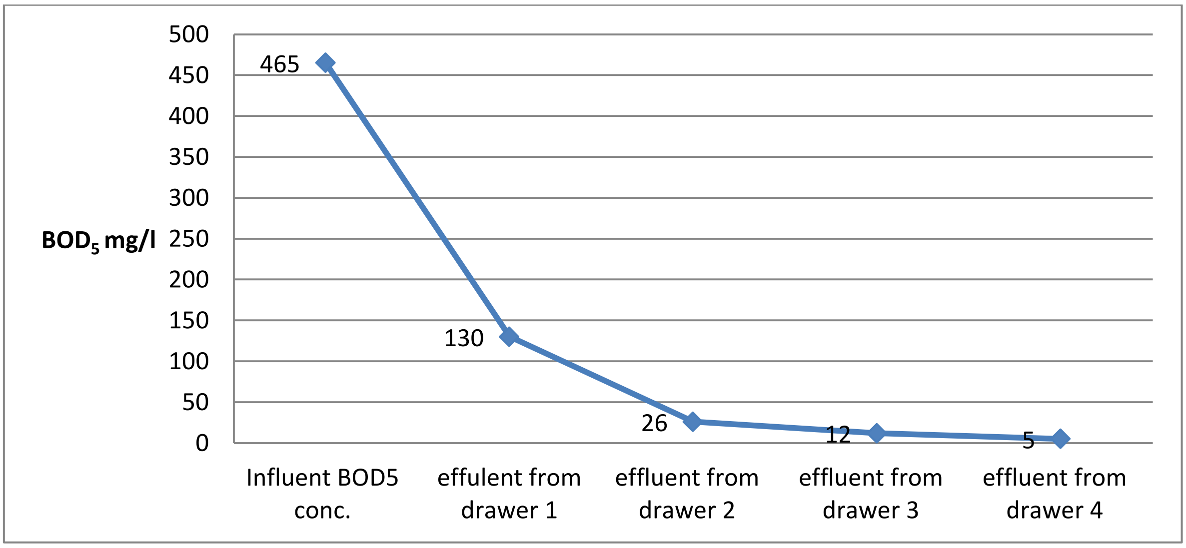

Figure 2. Average BOD_5 reduction by percolating through all drawers

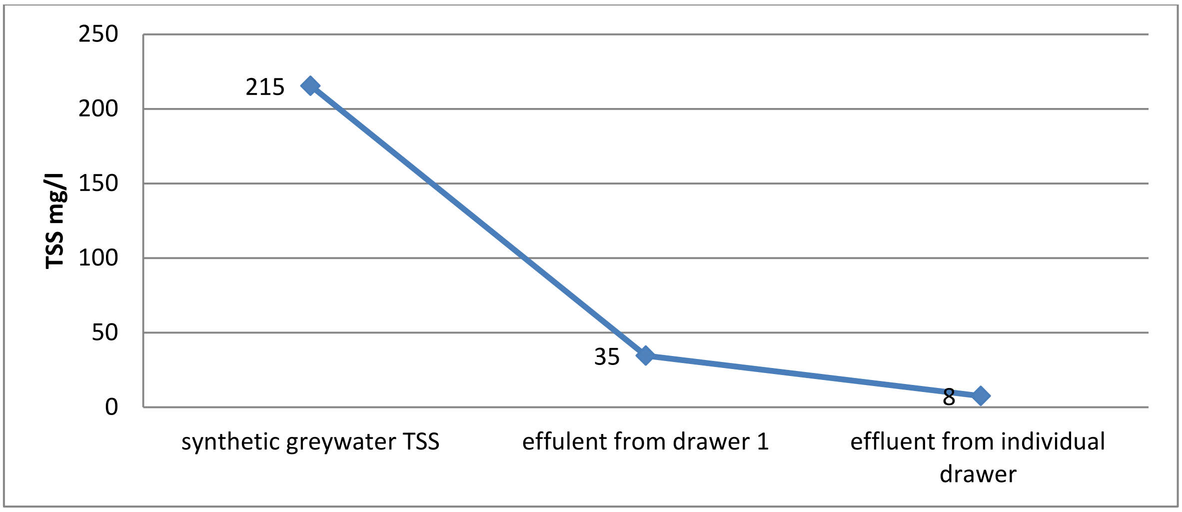

Figure 3. Average TSS reduction by percolating through the first gravel drawer and one sand drawer

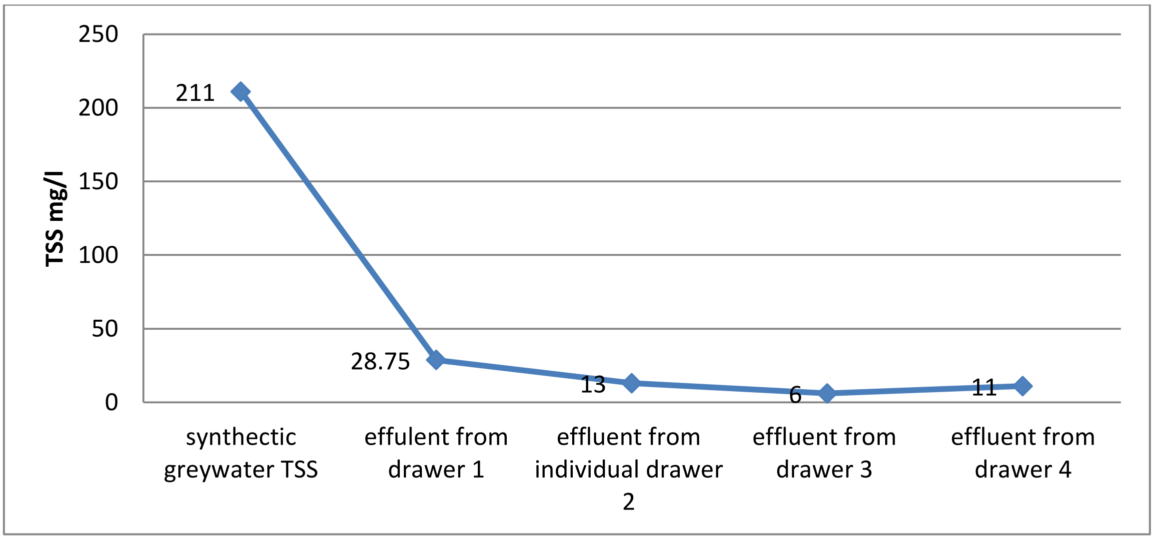

Figure 4. Average TSS reduction by percolating through all drawers

Figure 5.1 Lab-scale Drawer Compacted Sand Filter (Based in Surrey University, UK)

Figure 5.2 Pilot-scale Drawer Compacted Sand Filter (Based in Jordan at the roof top of one NGO)

CONCLUSION

The experiment concluded that intermittent sand filter could be designed in a smaller size than the current design guidelines with minimal maintenance requirements and without sacrificing treatment performance. According to aforementioned results, accommodating the infiltrative media in a movable drawers, distributing the organic and hydraulic load of wastewater between drawers, and adding more drawers for disinfection to get rid of e.coli are the main features for the intermittent sand filter new design.

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