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Research Article

Performance of Anaerobic Baffled Reactor/Gravel Bed Filter Towards Domestic Wastewater Treatment

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Abstract

The goal of this research is to examine the potential use of anaerobic baffled reactor (ABR) followed by a gravel bed filter (GBF) towards domestic wastewater treatment and to observe the effect of this coupling on the water quality. The efficiency of the system was evaluated through testing the wastewater that is generated from the nearby primary schools (Yaffa and Al- Esteklal). This study illustrated that the use of both the ABR and GBF could be promising in conducting a sustainable onsite wastewater treatment. During the period of the study, samples were taken biweekly and analyzed for BOD, COD, TOC, TP and TN. After 3 months of operation the system stabilized showing high organic pollutants removal efficiencies. According to our recent study the average removal efficiencies of the system is 69% BOD, 77% COD, 60% TOC and 47% P. The microbial analysis indicated a high reduction of total Coliform and Fecal Coliform.

Keywords: *Anaerobic Baffled Reactor; Gravel Bed Filter*

Introduction

Proper wastewater management is one of the most important issues in developing countries. Collection and treatment of wastewater have a huge impact on both environment and economy at local and global level [1]. The two main historical objectives of wastewater management systems are to protect and promote human health and to provide water quality and ecosystem protection [2]. Due to the lack of water resources in Palestine which classified as a semi-arid area, wastewater treatment could form an alternative resource of water that could be used for agricultural and industrial purposes [3]. In general, the main component of domestic wastewater management consists of collection, treatment and disposal [4]. Depending on wastewater magnitude required to be treated, wastewater treatment systems could be divided into two main categories: centralized and decentralized systems [5].

Decentralized wastewater treatment systems are used to treat and dispose relatively small volumes of wastewater originating from single households or groups of dwellings not served by central sewer system, but connected with regional wastewater treatment plants [2].

From the operational point of view, using decentralized wastewater treatment systems decreases the operational cost since there is no necessity to use pumps, long and big pipes because wastewater collection, treatment and reuse will be performed at close vicinity to its source [6]. Eventually, this treated water will contribute in decreasing freshwater consumption for agricultural activities and serve the final goal in achieving wise water resources management. Among treatment technologies that belongs to decentralized wastewater treatment systems, anaerobic baffled reactor technology (ABR) was found to be the most promising and effective solution in domestic wastewater treatment.

A typical ABR is an improved septic tank that is suitable for influents with a high percentage of non-settleable suspended solids and a narrow COD/BOD ratio. It consists of a series of vertical, hanging and standing baffles that form several equal volume compartments. In order to direct the wastewater up and down the baffles through each compartment as it flows from the inlet to the outlet of the reactor [7].

In addition, the up and down flow of the liquid tends to reduce bacteria washout, which enhance the ability of the ABR to retain active biological mass without the use of any fixed media. The bacteria within the reactor tend to rise and settle with gas production in each compartment, but they move down the reactor horizontally at a relatively slow rate. As a result of the slow horizontal movement the contact time between the wastewater and sludge (active biomass) increased. As a result, the treatment is improved [8].

In this research, the performance of Al-Ubeidiya wastewater treatment plant will be monitored during one year by collecting samples taken at determined intervals and analyzed for physical, chemical, and biological parameters assessment.

Experimental

Materials and Equipments

ABR/GBF Treatment Plant Description: Al-Ubeidiya wastewater treatment plant consists of two main stages: the first stage was conducted using anaerobic baffled reactor (ABR) followed by the second stage which consists of a gravel bed filter (GBF) (Figure 1).

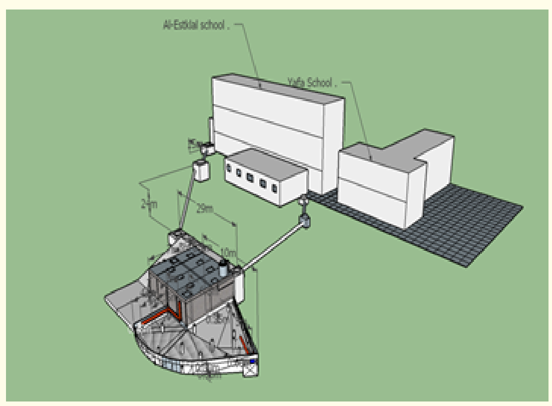

Figure 1: *Illustration of the setup of ABR/GBF.*

The ABR (Length: 9.0m, Width: 7.0m, Height: 2.5m) with 86m^3 net volume, consists of equally nine chambers that are separated using vertical standing baffles. It starts with a settling chamber followed by a series of up-flow chambers. The first chamber is responsible for settling of larger solids and impurities and most of the sludge is accumulated in this zone.

In this process the wastewater enters the chambers through the inlet at the upper part of the chamber and passes through the sludge in order to move up to the next chamber. As the wastewater passes through the sludge, intensive contact between the active biomass in the resident sludge and newly incoming wastewater occurs. The vertical baffles in the tank force the pre-settled wastewater to flow under and over the baffles guaranteeing contact between wastewater and resident sludge which allowing an enhanced anaerobic digestion of suspended and dissolved solids. The formed biogas during the anaerobic digestion is to be released through valves located at the sides of the reactor.

The second stage consists of GBF with a surface area of 100m2, depth of 0.6m and a volume capacity of ±60m3. The main working principle of the GBF that the liquid from the ninth chamber of the ABB is transported through pipes which carry and distribute the effluent continuously and horizontally through the filter bed. The organic matter and suspended solids are removed by filtration and microbiological degradation in anaerobic conditions. At the end of the process, the obtained effluent is collected through a tank for reuse.

Wastewater sampling and analysis

The efficiency of the ABR/GBF system was evaluated through collecting samples biweekly from specific points in the treatment plant (Figure 2).

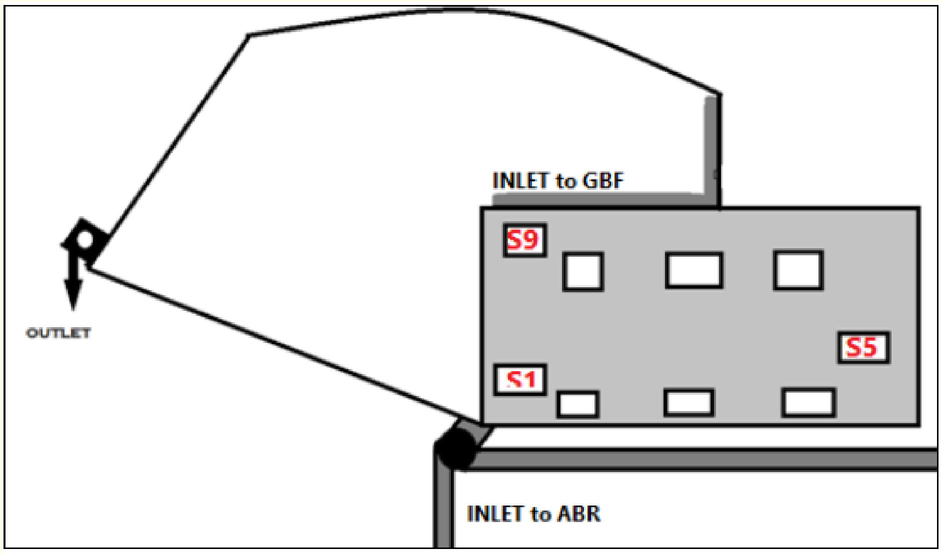

Figure 2: *Illustration of sampling points in ABR/GBF system. Four sampling points in the ARB/GBF system including the following locations: chamber one (W/ABR/S1), chamber five (W/ABR/S5), chamber nine (W/ABR/S9) and the outlet of the GBF (W/GBF/Out).*

Samples were collected in glass bottles (600 ml) and adjusted for different analysis in Soil and Hydrology Research Laboratory/Al-Quds University.

The samples were analyzed for physical, chemical, and biological parameters. All analysis was carried out as recommended by the standard operating procedures (SOPs).

Results and Discussion

The results of pH, EC (μS/cm) and turbidity (NTU) for the four sampling points are discussed (S1, S5, S9 and outlet). pH values were found to be in an acceptable range for wastewater effluent (pH values of 6 - 9). It was also observed that no significant changes in pH values during the treatment process were noted compared with raw wastewater, pH values, indicating a good buffering capacity of the wastewater (Figure 3) [9].

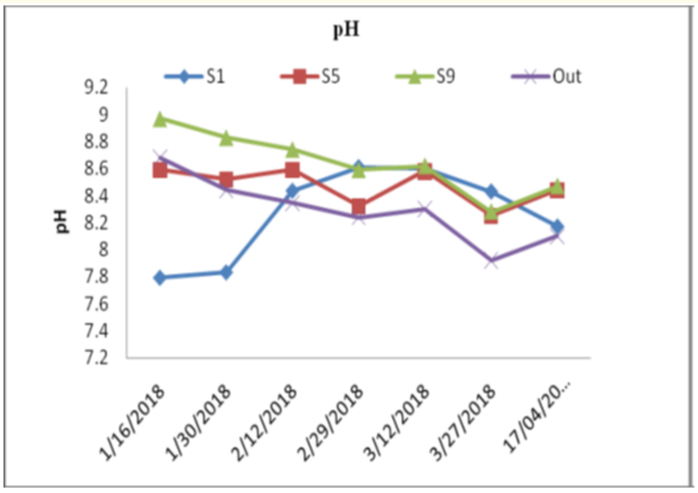

Figure 3: *pH values for sampling points vs sampling period.*

The turbidity results show that the treatment system was able to reduce the turbidity from 45.3 to 1.63 NTU, suggesting that the gravel substrate plays a significant role for the 60% removal of TOC via of the developed biofilm.

One of the main objectives of this study was to evaluate the capacity of the system to reduce the organic loading. Accordingly, ABR/GBF was monitored for COD and BOD removal. Figures 4 and 5 shows the results of BOD5 and COD concentrations for ABR/GBF system under a hydraulic loading rate of 2.8 m^3/d over the entire investigation period. It is clearly observed that treatment system was able to significantly reduce carbonaceous content of wastewater (BOD5 and COD) to a an acceptable level. The results showed that BOD5 and COD were reduced up to 69% and 77% respectively.

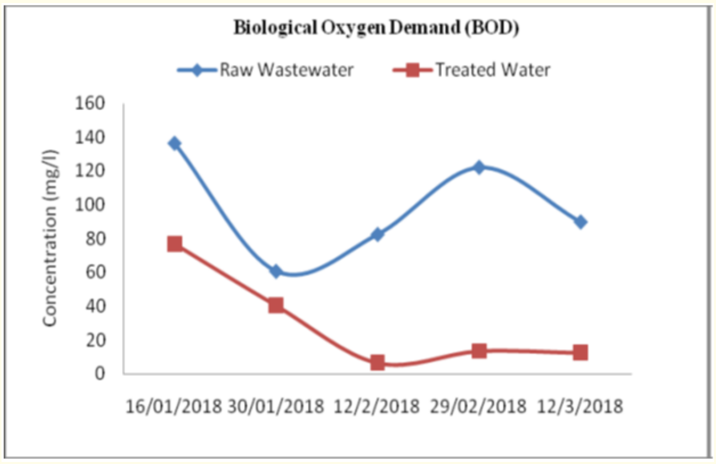

Figure 4: *BOD5 differences between raw wastewater and treated water.*

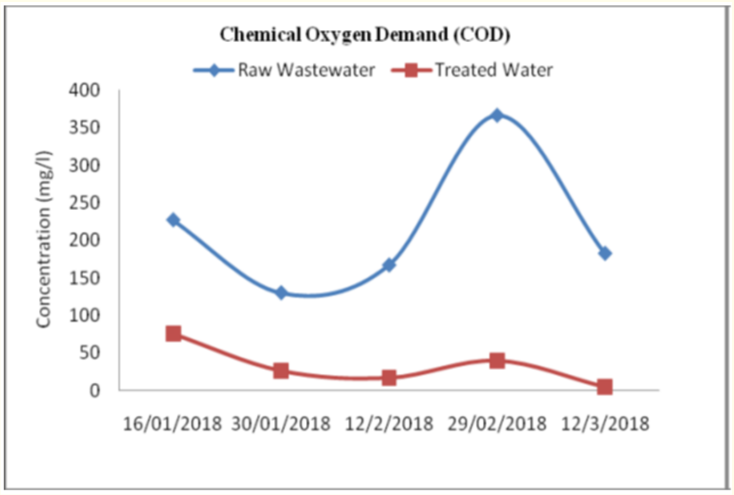

Figure 5: *COD differences between raw wastewater and treated water.*

Regarding nutrient concentrations in wastewater effluents, the monitoring included both nitrogen and phosphorus constituents. The ABR/GBF proved to remove more than 47% of the TP. The low Nitrate concentration in the influent wastewater is expected in domestic wastewater as most of the nitrogen compounds are present as organic compounds or ammonia, which is clearly reflected in the results of ammonia in figure 6.

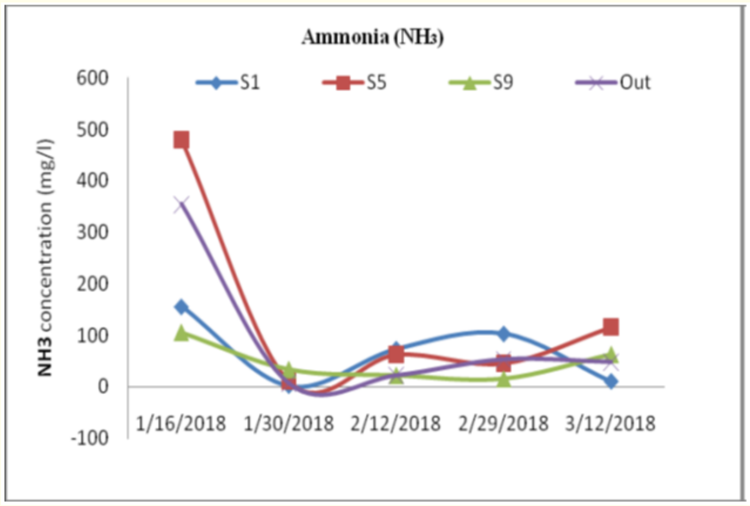

Figure 6: *Ammonia removal for ABR reactor/GBF system.*

Bacteriological load in the form of Fecal Coliforms (F.C) was another parameter used to evaluate the performance of the system. The results show clearly that (ABR/GBF) was able to significantly decrease the F.C concentration from 4.0 * 10^6 CFU/100 ml to < 1 CFU/100 ml.

Conclusion

The anaerobic baffled reactor (ABR) and gravel bed filter (GBF) combined system was monitored and investigated, the primary results revealed that the treatment system was able to reduce the major parameters to a ranges meeting the reuse standards, as well, these results could be the first step toward more development in the off grid treatment system.

The percentage of removal of the BOD and COD as well as the Bacteriological load is a positive indicator to develop the low ABR/GBF technology. The treated water can be reused for flashing twilights or in recreational activity.

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