International Journal of Civil Engineering and Geo-Environmental

Journal homepage: http://ijceg.ump.edu.my
ISSN:21802742

Application of Biofilter System for Domestic Wastewater Treatment

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ARTICLE INFO

Keywords:
Filtering system,
Natural occurring materials,
Mudball,
Activated Carbon,
Water quality
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ABSTRACT

Nowadays, clean water resources are reduced due to water pollution problems. Pollution carried by the domestic wastewater is considered as one of the contributors to water pollution problems. One of the ways to treat wastewater is by constructing a biofilter system at the point sources to treat the polluted water before being discharged into rivers. This study emphasizes on the utilization of a filtering system using natural occurring materials such as empty fruit bunch (EFB) from oil palm fibre, mudball from effective microorganism (EM), activated carbon from coconut shell, charcoal, sand, and gravel as the filtering materials. Experiment was conducted at Universiti Malaysia Pahang (UMP), where a site scale filtering system was set up to observe the potential of the system in removing pollutants. The results were analyzed by evaluating the water quality parameters such as pH, SS, BOD, COD, and AN in term of their percentages of removal and comparison to Standard A and Standard B of Environmental Quality Act (1974). For overall, the biofilter system was found to be capable in removing pollutants in domestic wastewater where the maximum percentages of removal for parameters SS, COD, BOD, and AN are as high as 83.08%, 51.60%, 72.42%, and 85.71% respectively. The study also indicated that the performance of the biofilter system in improving parameters SS, COD, BOD, and AN increased as the quantity of filtering materials applied increased.

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1. Introduction

Conventional wastewater treatment method maybe used to remove unwanted nutrient and dissolved heavy metal ions from wastewaters. Other method that was available but costly is chemical oxidation and reduction, ion exchange, electrochemical and treatment. However, these high-technology processes have significant disadvantages, including incomplete metal removal, requirements, such as expensive equipment and monitoring systems, high reagent, energy and generation of toxic sludge or other waste products that require disposal (CWA, 1987). In the other hand, implementing a centralized waste water treatment system would be costly due to construction and maintenance. Considerately, biological method is considered as an economical solution in terms of construction, operation, maintenance, and pollution. Thus, this biofiltration system may be the answer to cleaner and cheaper water source in the near future.

The technique of biofiltration has been successfully used in water and wastewater treatment for over a century. The biofiltration process used in tertiary treatment before the early 1980s for application to water pollution and reuse, however, were focused on the design, parameters and operations (Viotti *et al.*, 2002), and the biomass and microbial activity did not receive enough attention. Biomass and microbial activity in a biofilter are two critical parameters, which determine the performance in water treatment (Liu *et al.*, 2001), and have become the focus of interest in the scientific community due to the development of modern analytical techniques.

2. Materials and Method

2.1 Location of Study

The study is conducted at an open drainage system which is located at Student Residential College (KK3), Universiti Malaysia Pahang (UMP) for the purpose to evaluate the effectiveness of biofilter system in removing pollutants. The catchment area consists of hostel and cafeteria which has effluent discharge that is polluted due to poor wastewater management. This leads to dirty water discharged into Sungai Belat. Figure 1 shows the location of study area at UMP.

Figure 1: Location of Study Area

2.2 Experimental Set-up

The experimental system was set up at UMP with the drainage system near Students Residential College (KK3), UMP was chosen as the location of site study. Figure 2 and 3 show the compartmentalized biofilter and filtration materials in the biofilter respectively.

Figure 2: Biofilter System

Figure 3: Arrangement of Filtering Materials

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The compartmentalized biofilter was made of acrylic material with dimensions of 800 mm × 900 mm × 650 mm. 10mm acrylic used to separate in to 6 compartments in order to facilitate the movement of treated water. An inlet pipe was installed to enable an incoming water to be treated water and will finally being discharge through outlet pipe. Both inlet and outlet pipes are 2" in size.

2.3 Mechanism and Sampling Point

The biofilter design used the basic concept of water filter where it uses a closed system. Water intake will first run through sponge which filters large materials, then filtered with coarse gravel and sand to improve turbidity, followed by mud ball to remove sludge and color, then undergo chemical reactions by activated carbon, further filtered subsequently by charcoal to eliminate odor, and lastly run through Empty Fruit Bunch (EFB) for final filtration before output to water body. Diagram of the biofilter with the influent and effluent sampling point is shown in Figure 4. Domestic wastewater has been used as wastewater sample for this study.

The wastewater samples for the experiment were taken from a drainage system near Students Residential College (KK2), UMP. The catchment area consists of students' hostel and cafeterias. More than 50% of the waste contains food waste, rubbish, and oil. During the experiments, wastewater samples were taken from two points; influent (at the inlet) and effluent (at the outlet) as illustrated in Figure 4.

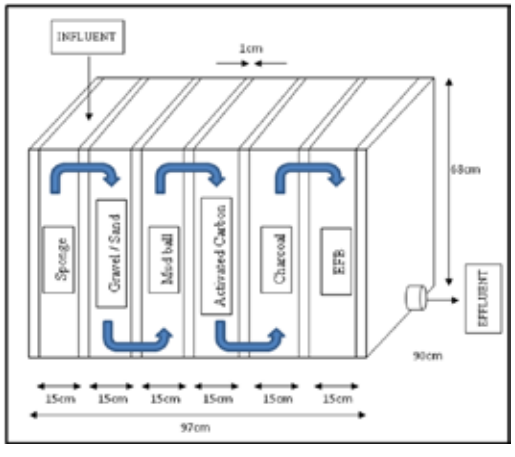


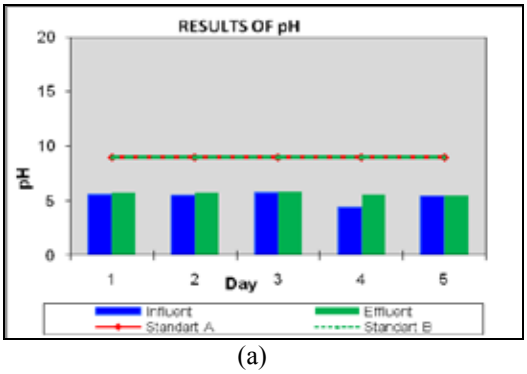
Figure 4: Illustration of mechanism of biofilter system

3. Results and Discussions

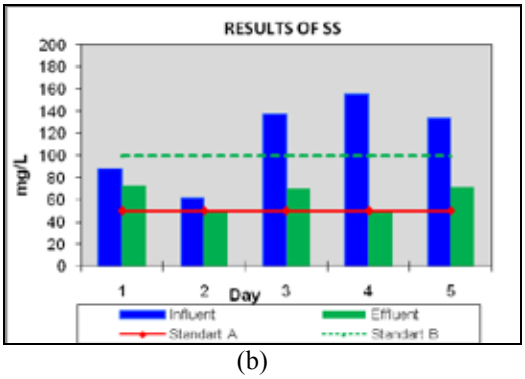
The performance of the biofilter system is evaluated in terms of comparison with Standard A and Standard B of Environmental Quality Act (1974) and percentages of removal. A total of five days data collection was taken starting 4th October 2010 until 14th October 2010 for the evaluation of the biofilter system.

3.1 Comparison with Standard A and Standard B of Environmental Quality Act (1974)

The results of pH in Figure 5(a) show that the pH values are ranging from 5.5 to 5.8 after the treatments which are in the limit of Standard B (5.5-9.0). For Suspended Solid (SS) parameters, all the effluents of discharge water are complying with parameter limit as stated in Standard B, Environmental Quality Act (1974). The concentrations of SS effluent however are not complying with Standard A. It can be seen from Figure 5(b) that the concentration of influent samples before treatment are high, which in the range 62 mg/L to 156 mg/L.



(a)



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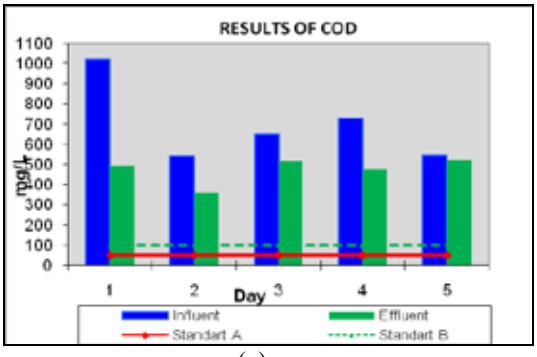

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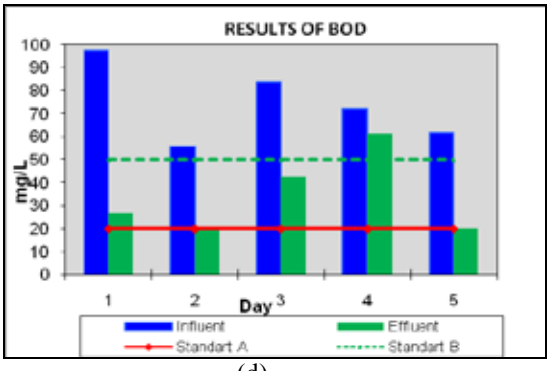

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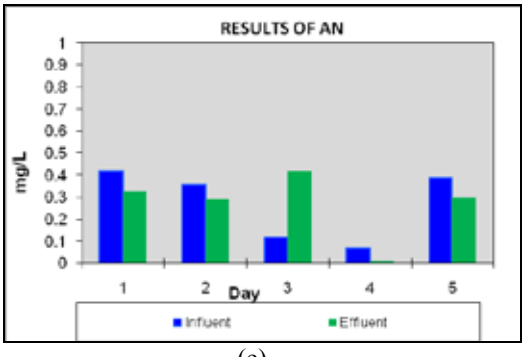


(e)

Figure 5: Water Quality Results for Parameters (a)pH, (b)SS, (c)COD, (d)BOD and (e)AN

From Figure 5(b), it can be noticed that there are reduction in the concentration of COD after the treatment. This may be implied from less suspended solid, as the COD is also an indicator of organic contents in water. Despite of the excellent performance of COD removal, all the effluents of discharge water are not complying Standard A and B due to the high concentration of influents as shown in Figure 5(c). The results of BOD follows the same trend as SS when compared to Standard A and B where all the effluents of discharge water are complying Standard B only (Figure 8(e)). AN also shows an improvement in terms of concentration removal.

3.2 Percentages of Removal

Instead of poor performances shown in the comparison with Standard A and Standard B of Environmental Quality Act (1974), the biofilter recorded encouraging results in terms of percentages of removal. The results of the removal efficiency for parameters SS, COD, BOD, and AN are illustrated in Table 1.

Date of Experiment		Day 1	Day 2	Day 3	Day 4	Day 5
Parameter	Unit	% of Removal				
SS	mg/L	17.05	20.97	49.28	67.31	83.08
COD	mg/L	51.60	33.31	19.91	34.25	4.70
BOD	mg/L	72.42	64.35	49.13	15.09	67.59
AN	mg/L	21.43	19.44	0.00	85.71	23.08

Table 1: Percentages of Removal Results

The results of SS removal ranging from 17.05% up to 83.08% which showed that the biofilter is capable to reduce the amount of suspended solid by adsorbed pollutants contained in the water. COD removal increase from 4.70% to 51.60%, the reduction in COD value may be implied from less suspended solid as the COD is also an indicator of organic contents in water. On the other hand, the BOD removal ranging from 15.09% to 72.42%, the removal shows that the oxygen consumption in water is reduced due to less contaminant contained in the treated water. AN also shows an encouraging results in terms of percentages of removal where the values ranging from 19.44% up to 85.71% except for Day 3 where no removal was recorded.

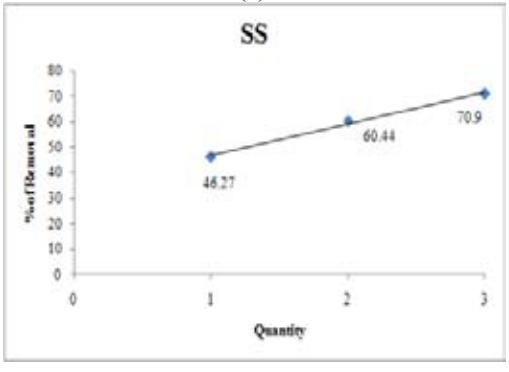
3.3 Performance over Increasing Quantity of Materials Used

An attempt has been made to test the capability of biofilter system with different quantity of filtering materials used. The test has been done on 15th October 2010 using the three different quantities of filtering materials shown in Table 2.

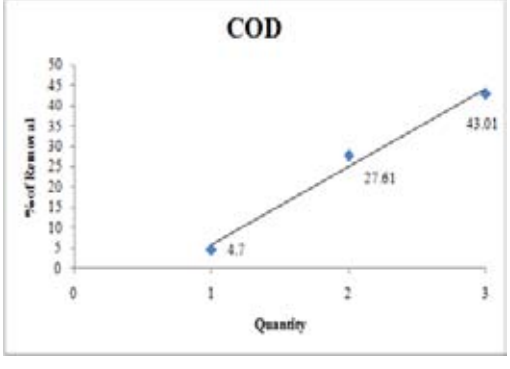
Table 2: Quantity Variables on Filtering Materials

Quantity	Quantities					
	Sponge (Packet)	Sand & Granite (kg)	EM Mudball (Pieces)	Activated Carbon (kg)	Charcoal (kg)	EFB (kg)
1	3	10: 5	40	10	5	3
2	6	20: 10	80	20	10	6
3	9	30: 15	120	30	15	9

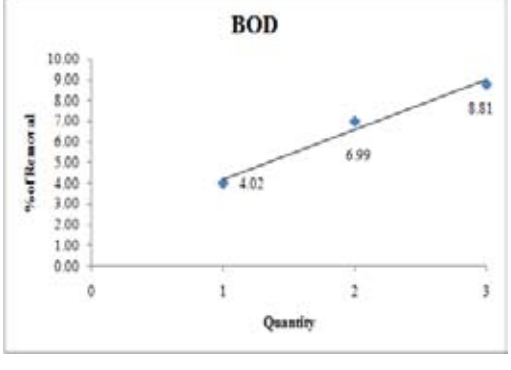
(a)



(b)



(c)



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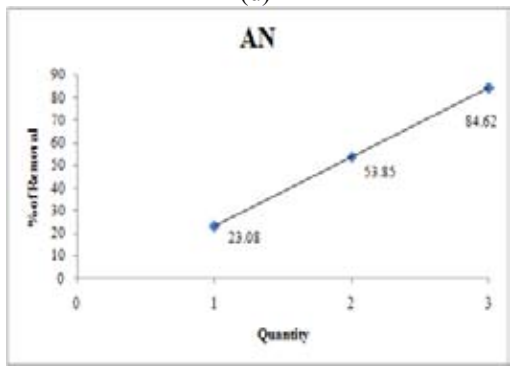

Figure 6: Percentages of Removal versus Different Quantity Used for Parameters (a) SS, (b) COD, (c)BOD and (d)AN

The percentages of removal of SS were recorded as 46.27% when Quantity 1 was applied. The percentages were increased to 60.44% and 70.9% for Quantity 2 and Quantity 3 respectively as shown in Figure 6(a). The results for COD is represented by Figure 6(b) where it can be seen that the percentages of removal is only 4.7% when Quantity 1 was used but the value increased to 27.61% with Quantity 2 and 43.01% with Quantity 3 used. The same trend can be observed on parameters BOD and AN where the removal efficiency for the biofilter increase with the increasing quantity of filtering materials applied.

4. Conclusion

In the present study, an attempt has been made to evaluate and investigate the performance of biofilter system in improving water quality for open channel flow. The water quality assessment for domestic wastewater has been performed for the purpose of achieving the study objectives.

For overall, it can be concluded that the filtration system is effective in removing pollutants where the results indicated a SS removal within the range of 17.05% - 83.08%, COD within 19.91 – 51.60%, BOD removal in the range of 15.09% - 72.42% and AN with 19.44% to 81.71% removal. However, most all the effluent of discharge water of the filtration system are not comply with parameter limit as stated in Standard A and Standard B of Environmental Quality Act (1974). The effluent discharges were not

capable to comply the Standard A and Standard B limit due to the high concentration values of influent enters the system. The study also indicated that the performance of the biofilter system increase with the increase quantity of filtering materials used for parameters SS, COD, BOD, and AN.

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