Locally available low-cost packing media for anaerobic filters to treat Landfill Leachate

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Abstract— *Solid waste generated in urban centres is disposed into sanitary landfills or dumping sites. The generated leachate at dumping sites causes many problems leading to various environmental impacts. Hence, it is decided to conduct this research to find out an economical solution that suits to the country for proper treatment of leachate generated at dump sites. As the major portion of municipal solid waste is biodegradable, anaerobic filters well suit to the leachate treatment. As the packing media used for this treatment is highly expensive, finding readily and locally available, low-cost and efficient packing media is a timely need. Therefore, the performances of locally available and low-cost organic and inorganic packing media in treating landfill leachate were studied using a laboratory scale experimental set-up consisting of four packed-bed down-flow anaerobic filter columns. The height and diameter of the cylindrical shaped packed bed were 75 cm and 10 cm, respectively. The first three columns were filled with quartz, saw chips and quarry dust. The fourth column filled by using 25cm height layers of quartz, saw chips and quarry dust respectively. Each column was loaded with landfill leachate. Overall, quarry dust and mixed filter gave higher removal efficiencies than the other media for COD (Chemical Oxygen Demand) and BOD (Biochemical Oxygen Demand). The removal efficiency of turbidity remained around 90% for a long period of the experimental series in quarry dust filter. Mixed and saw chips filters showed higher turbidity removal percentages initially but decreased with the time. According to the experimental results, it was found that quarry dust and mixed filter can be used to treat landfill leachate effectively.*

Keywords— **Leachate, Down flow anaerobic filters, COD/ BOD/ Turbidity removal**

I. INTRODUCTION

With the growth of population, the need and wants of the people are increasing day by day. Due to this reason, the solid waste generation has increased throughout the country. Hence, solid waste management is an inevitable term of sustainable development. “Landfill” becomes the most viable and economical method which is used widely in modern world. Leachate is the liquid that generates when degenerating waste of solids in landfills contact with moisture. This causes a serious environmental issues due to substantial amount of organic and inorganic substances in leachate. It has the potential to pollute ground and surface water. Therefore, the leachate should be treated properly.

The main contributor to the generation of landfill leachate is rainfall. The precipitation percolates through the waste and gains dissolved and suspended components from the biodegrading waste due to several physical and chemical reactions. Groundwater inflow, surface water runoff and biological decomposition are the other contributors to leachate generation.

The environmental risks of leachate generation arise from it escaping into the environment around landfills, particularly to watercourses and ground water. These risks can be reduced by treating leachate. Leachate treatment technologies fall in to two basic types, biological and physical/ chemical. Attached growth technologies, which come under biochemical treatment, have successfully been used for landfill leachate treatment. There are many advantages of attached growth processes over suspended growth processes are lower energy requirements, simpler operation, no bulking problems, less maintenance and better recovery from shock loads. The removal of BOD, COD and turbidity are affected by attached growth process in waste water treatment. One of the most commonly applied attached growth processes to treat landfill leachate is known as anaerobic filters. However, the application of anaerobic filters has become very expensive due to expensive packing media. Therefore, the study focuses on the attached growth anaerobic down-flow treatment method. A challenge which is ongoing in environmental researchers is to find suitable materials, methods and modifications in the context of low cost landfill leachate treatment.

The aim of this study was to find out the efficiency of several low-cost, locally and readily available materials as packing media in down-flow anaerobic filter columns in treating landfill leachate. The selected materials are quarry dust, quartz and saw chips. The objective of this study is to compare the treatment efficiencies of different materials and to obtain the most efficient packing materials in treating organic and nitrogenous compounds in landfill leachate.

II. METHODOLOGY

The experimental setup include four anaerobic filter columns, each column have 101 cm height and 10 cm diameter. A sieve and gravel layer (8 cm) placed at the bottom of each column. First three columns were filled with 75 cm height layers of quartz, saw chips and quarry dust respectively. Fourth column was filled by using 25 cm height layers of quartz, saw chips and quarry dust. All the packing media were washed and dried before filling in columns and all the columns were flushed by tap water to remove all readily flushable contaminants from the media. The leachate collected from Karadiyana dumpsite which is the largest dumpsite in Colombo. This collected leachate was used as the influent for all experiments. Same influent flow rate was supplied for each column by using an overhead tank as shown in figure 1.

Figure 1. Experimental model

Table 1 shows the influent characteristics. The duration of experiment series is 25 days. During this experimental series, influent and effluent were characterized using Biochemical Oxygen Demand, Chemical Oxygen Demand, Turbidity and pH parameters.

Table 1. Influent Characteristics

Characteristics of the influent	Down-flow system
BOD_5 (mg/l)	8.6
COD (mg/l)	1880
Turbidity (NTU)	144
pH	8.01

The removal efficiency of a certain characteristic was calculated by using the following equation

$$\text{Removal Efficiency (\%)} = \left(\frac{I - E}{I}\right) * 100\%$$

I - Influent Characteristic
E - Effluent Characteristic

III. RESULTS AND DISCUSSION

A. Removal Efficiency of BOD

The efficiency of removing BOD by each packing media was determined by measuring BOD of the influent and effluent. BOD reduced while flowing through quarry dust and mixed filter columns. Figure 2 shows the variation of the removal efficiency of BOD with time for four different packing media. The removal efficiency of quarry dust and mixed filter were greater than 50% on average, whereas the highest efficiency was shown by the quarry dust filter. It varied between 55.81% and 86.04%. The removal efficiencies of both saw chips and quartz filters were not in a satisfactory state due to higher BOD value in the effluent. According to Coony (1999), adsorption is a very important method for removing contaminants, particularly organic contaminants from wastewater streams. Therefore, adsorption can also be considered as potential removal mechanism of organic materials in the columns with organic packing media. According to test results, it was found that quarry dust and mixed filters can be used to treat BOD in landfill leachate.

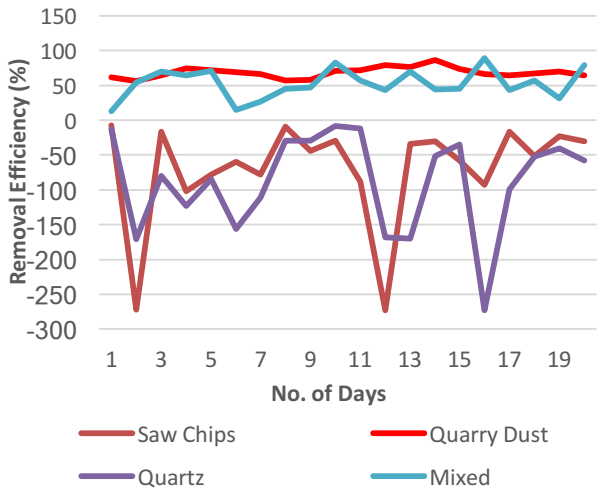

Figure 2. Variation of BOD removal efficiency

B. Removal Efficiency of COD

The efficiency of removing organic matter by each packing media was determined by measuring COD of influent and effluent of landfill leachate. Figure 3 shows the variation of COD removal efficiency. The average removal efficiency of quarry dust and mixed filters were 72.9% and 63.7% respectively, whereas the highest efficiency (94.68%) was shown by quarry dust filter column. This could have been caused due to adsorption. The removal efficiencies of both saw chips and quartz filters were not in a satisfactory level. Mixed filter showed improvement in removing COD in first three days, which could be due to adsorption. After three days, the removal efficiency of mixed filter decreased, which could have been caused by the exhaustion of the

vacant sites for adsorption. The removal efficiency of COD in quarry dust filter increased up to 8 day but from then onwards it decreased. Hence, adsorption and aerobic digestion could contribute the treatment of organic matter in terms of COD in landfill leachate. According to test results, it was found that quarry dust and mixed filters can be used to treat COD in landfill leachate. According to Bagchi (2004), the surfaces of organic matter provide some adsorption sites, in addition they may serve as energy source for microorganisms. Hence, the adsorption could contribute the treatment of organic matter in terms of COD in landfill leachate.

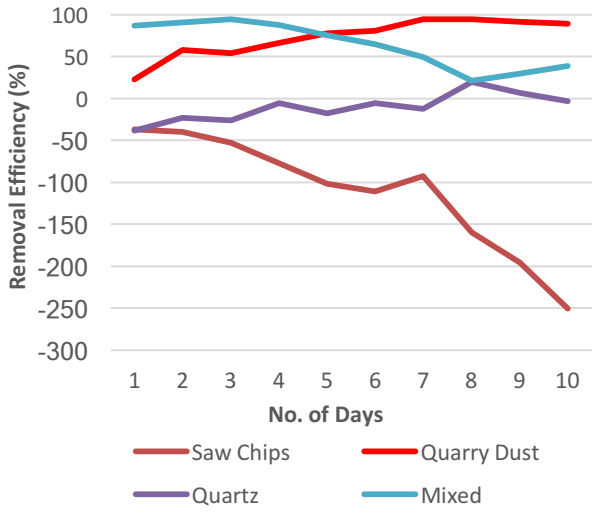

Figure 3. Variation of COD removal efficiency

C. *Removal Efficiency of Turbidity*

Figure 4 shows the variation of Turbidity removal efficiency in four different filter media. The average maximum removal efficiency (95.12%) showed in quarry dust filter column. Mixed and saw chips filters showed an average removal efficiency around 60%. Both mixed and saw chips filters showed a reduction after 11 days and 6 days respectively. The removal efficiency of Turbidity in quartz filter was not satisfied. From the experimental results, it was determined that all filters except quartz filter can be used to treat turbidity in landfill leachate.

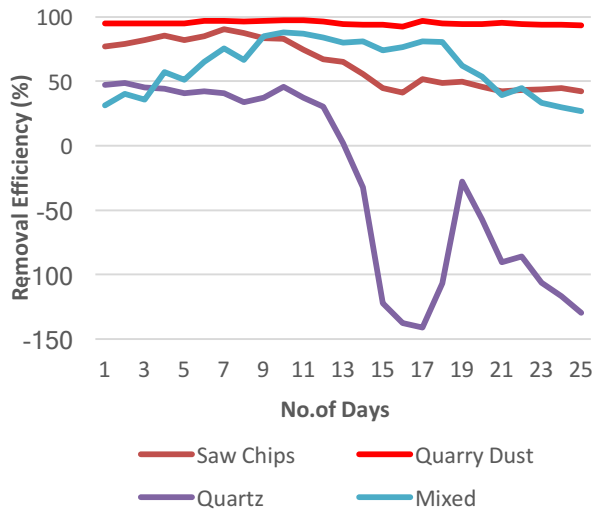

Figure 4. Variation of Turbidity removal efficiency

D. *pH values*

General pH range of surface water is 6.5 to 8.5. All effluent water samples were within the range of 6.5 to 8.5 for quarry dust, quartz and mixed filters. Average pH values of quarry dust, quartz and mixed filters are 7.35, 7.31 and 7.14 respectively. Few effluent water samples in the saw chips filter were out of range. But the average pH value was inside the range. The average pH value for saw chips filter was found as 6.73.

IV. CONCLUSION

From the analysis of test results, it was found that both quarry dust and mixed filter can be used to treat BOD and COD in landfill leachate. Out of that quarry dust is the most suitable packing media to treat landfill leachate. All the filters except quartz filter can be used to treat turbidity in landfill leachate. All four filter media can be used to treat pH values in landfill leachate. For biodegradable organic materials, the principal treatment mechanisms could be adsorption and anaerobic decomposition. The study shows the necessity of carrying out these experiments for longer durations to achieve better results because it would provide sufficient time and optimum requirements for anaerobic microorganisms to reproduce and grow. Table 2 shows effluent characteristics for all four filter media types. According to results, it was found that both quarry dust and mixed filters are suitable to treat landfill leachate.

Table 2. Effluent Characteristics

Packing Media	Average efficiency/ value of the Effluent			
	BOD (%)	COD (%)	Turbidity (%)	pH
Quarry Dust	68.37	72.9	95.12	7.35
Quartz	0	0	0	7.31
Saw Chips	0	0	63.75	6.73
Mixture	52.38	63.7	61.13	7.14

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