Using Geotextile Filter as Biofilm Media in Anaerobic Landfill Bioreactor

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A lab-scale anaerobic reactor with leachate recirculation equipment was designed to increase the efficiency of landfill bioreactor technology. A porous geotextile fabric was placed into the drainage layer of the reactor as biofilm media to maintain a good environment for anaerobic bacteria. Leachate quality and biogas productions was investigated throughout the study. Removal efficiency of COD in leachate was determined as 96% and 1191 liters of biogas was produced in total. Rapid formation of methanogenic conditions was remarkable.

Introduction

A great amount of leachate containing highly concentrated pollutants, is produced in landfill areas. These hazardous leachate waste water needed to be managed well to avoid its potential hazards for the environment. Conventional end of pipe treatment techniques, bring many operational and economic problems to the local authorities which are in charge of municipal solid waste disposal.

Considering landfills as bioreactor is a new and promising strategy. Landfill bioreactors aim to accelerate the decomposition of solid wastes. Many techniques were experienced for this purpose such as leachate recirculation, supplemental water addition, waste compaction, alkalinity addition, and co-disposal of sewage sludge. Leachate recirculation is considered as a proven method for acceleration of waste decomposition, which has been tested in many cases both in scientific studies and real case applications. However, there is much less interest on how leachate recirculation in landfill bioreactors can be used as in-situ treatment of leachate. In addition, from this perspective there are some potential techniques which may be very effective on this. One of the promising in-situ leachate treatment materials that can be used in the drainage layers of landfills is geotextile fabric. There have been some studies which were indicated that highly porous geotextile filter can be a great alternative media for attached-growth waste water treatment systems (Korkut et.al., 2006; Yaman et.al., 2006; Alimahmoodi et.al., 2012). In this study, a porous geotextile material was placed in a lab-scale leachate recirculated anaerobic landfill bioreactor for enhancing the decomposition of solid wastes and improving leachate quality.

Material and Methods

In this study, a lab-scale PVC reactor at 1 m height and 30 cm diameter was used to simulate anaerobic landfill bioreactors. Reactor was equipped with several ports for collection and distribution of leachate and biogas. The leachate produced from the waste body in the reactors was collected after passing through a specifically designed drainage layer where a geotextile fabric was replaced.

Reactor was filled with 30.8 kg of MSW which were taken from a compost recycling plant in Istanbul, Turkey where MSWs are used for producing compost. Solid wastes were used in this study, was consisting of 62% organic wastes, 16% paper, 8% plastic etc. and physical properties of MSW are listed in Table 1. After reactors were filled and compacted to 700 kg/m^3 with municipal solid wastes, 1 liter of anaerobic seed sludge was injected to the waste body. The simulated landfill bioreactor with geotextile layer was operated under mesophilic conditions (33-37 ºC) and 5.5 liters of pure water were added to the reactor during first month of operation to stimulate leachate formation.

All produced leachates were periodically recirculated to the waste body by pumps during operation. Leachate quality were investigated in terms of pH, total dissolved solids (TDS), chemical oxygen demand (COD) and sulfate ion (SO_4^{2-}) periodically by following standard methods.

Table 1. Properties of the feed municipal solid wastes.

Parameters	Value (%)
Water Content	62
Total Solids	38
Volatile Solids	71
Fixed Solids	29

Results and Discussion

Leachate pH is a parameter which highly effect the efficiency of organic removal in the system. Optimum pH range is known to be in neutral area for methanogenic bacteria which converts organic compounds mainly to methane and carbon dioxide. However, at the early stages of anaerobic biodegradation such as fermentation phase, organic acids are accumulating in the system which causes low pH values that continues until the methanogenesis. Figure 1, shows that pH was reached the neural area within two months of operation. TDS which mainly indicates dissolved solid concentrations in the leachate, was decreased to 10,080 mg/L from 12,510 mg/L (max value) in 7 months (Figure 2).

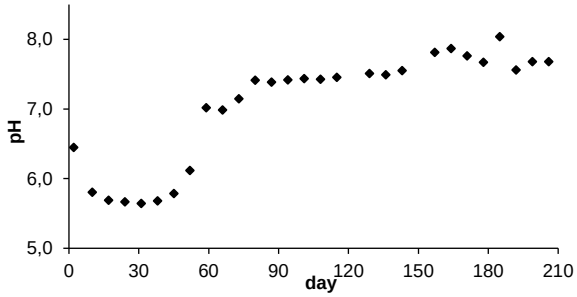

Figure 1. Change of leachate pH over time.

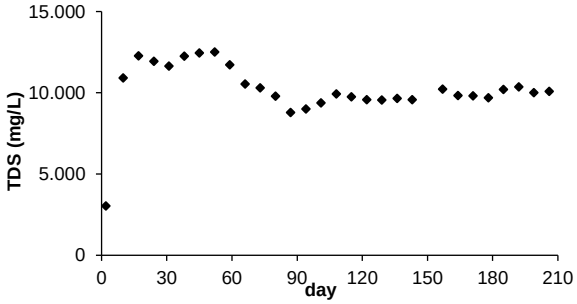

Figure 2. Change of leachate TDS over time.

Sulfate reduction under anaerobic conditions is a well-known phenomenon which may inhibit to methanogenic bacteria in some extent. Figure 3 shows the rapid reduction of sulfate by anaerobic bacteria in the geotextile enhanced landfill bioreactor. COD is a typical parameter that is used for determining the organic pollution strength of leachate, which is known as its high organic content. In this case, maximum and minimum COD values were detected as 52,400 and 2,192 mg/L respectively, which means that 96% of total organic pollution was removed by the geotextile enhanced landfill bioreactor. In addition to this epic removal efficiency, the rapid decrease trend in COD trend was remarkable as compared to similar studies (Erses et.al., 2008; Yaman et.al., 2016).

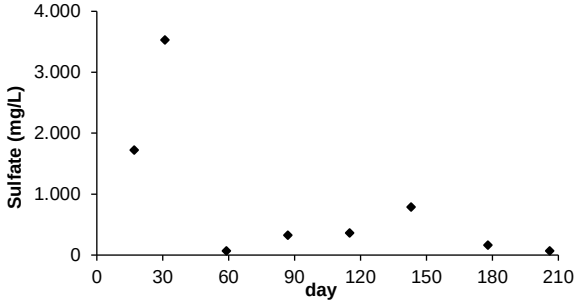

Figure 3. Change of leachate Sulfate over time.

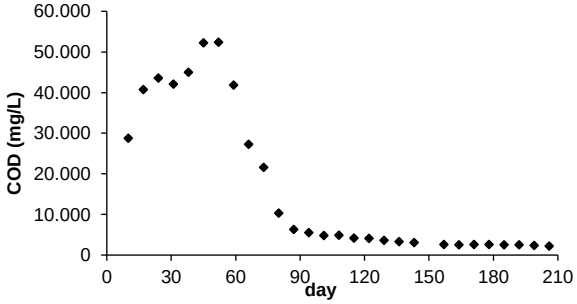

Figure 4. Change of leachate COD over time.

The geotextile enhanced landfill bioreactor was produced 1191 liters of biogas as a result of biodegradation of organics by methanogenic bacterial community in 210 days of operation. Cumulative biogas production data shows that after methanogenic conditions were occurred in the system, a sharp increasing trend was observed (Figure 5). Methane (CH_4) and carbon dioxide (CO_2) are the main components of biogas which is produced by anaerobic waste degradation. In this study, maximum methane percentage was detected as %55 on the day of 73.

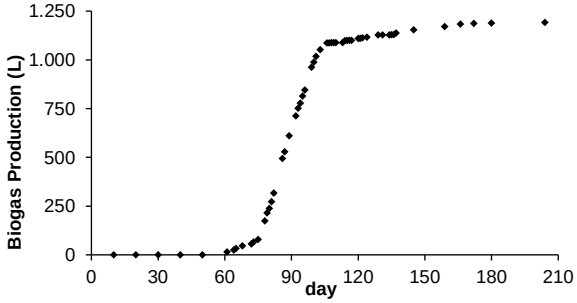

Figure 5. Cumulative Biogas production over time.

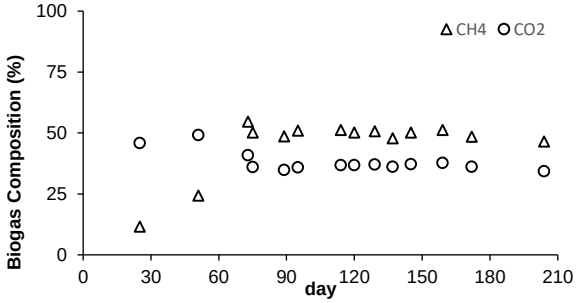

Figure 6. Biogas composition over time.

Conclusions

Results of this study has been showed that there is a high potential of using geotextile as a biofilter in leachate recirculated landfill bioreactors for in-situ treatment of leachate and rapid decomposition of solid wastes.

References

A.S. Erses, T.T. Onay, O. Yenigun, Comparison of aerobic and anaerobic degradation of municipal solid waste in bioreactor landfills, Bioresour Technol, 99 (2008) 5418-5426.

E.N. Korkut, J.P. Martin, C. Yaman, Wastewater treatment with biomass attached to porous geotextile baffles, Journal of Environmental Engineering, 132 (2006) 284-288.

M. Alimahmoodi, L. Yerushalmi, C.N. Mulligan, Development of biofilm on geotextile in a new multi-zone wastewater treatment system for simultaneous removal of COD, nitrogen and phosphorus, Bioresour Technol, 107 (2012) 78-86.

C. Yaman, J. Martin, E. Korkut, Effects of wastewater filtration on geotextile permeability, Geosynthetics International, 13 (2006) 87-97.

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