Closed landfill as an Anaerobic digester for treating young landfill leachate: Laboratory study

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Introduction

Landfilling is the most common disposal practice of municipal solid waste (MSW) in developing countries. The quantity of leachate produced during the initial stages of landfilling is high compared to the closed landfills due to the absence of cover during monsoon seasons and high moisture content in the fresh waste. The young landfill leachate(LL) will be highly biodegradable, whereas biodegradability and quantity will decrease over time. Thus, designing a leachate treatment system is always a challenge. Recirculating active leachate in the closed landfill site would be a solution to this problem. Bioreactor landfilling is a popular technique used to enhance the degradation process by recirculating the leachate within the landfill. The potential of recirculating active LL into closed landfill is not much explored. The current focus of the study is treating active LL using a closed landfill as an anaerobic digestor.

The objective of the study is i)to treat active LL by recirculating in a solid-state stratified bed reactor made using MSW collected from a closed landfill site, ii) to study the effect of recirculation by measuring gas production, settlement, and the characteristics of the recirculated leachate.

Materials and methods

The MSW used in the study was collected from the closed landfill site in Bellahalli, Bangalore, Karnataka. The leachate was collected from the active landfill site in Mittinahalli, Bangalore, Karnataka. The MSW collected were shredded into 10-20 mm size and packed in a cylindrical reactor of 1000 mm height and 170 mm diameter with a packing density of 620 ± 15 kg/m^3. The initial height of the MSW layer was 650 mm. The reactor contained three valves, two at the top and one at the bottom. The top valves were used to collect the gas generated and recirculate the leachate, whereas the bottom valve was used to leachate from the reactor. A temperature(K-type thermocouple) and moisture sensor(Terros 10) were placed in the middle of the MSW sample to monitor temperature and moisture content. The gas composition was measured using a Biogas analyzer (GA 5000), and gas quantity was measured using the water displacement method. All analyses were performed in accordance with standard methods for the examination of water and wastewater. The leachate recirculation was carried out in three cycles; each cycle was 30 days. Two reactors were studied for 200 days with similar configurations at room temperature to understand the variability. The flow chart of the methodology is given in Fig. 1.

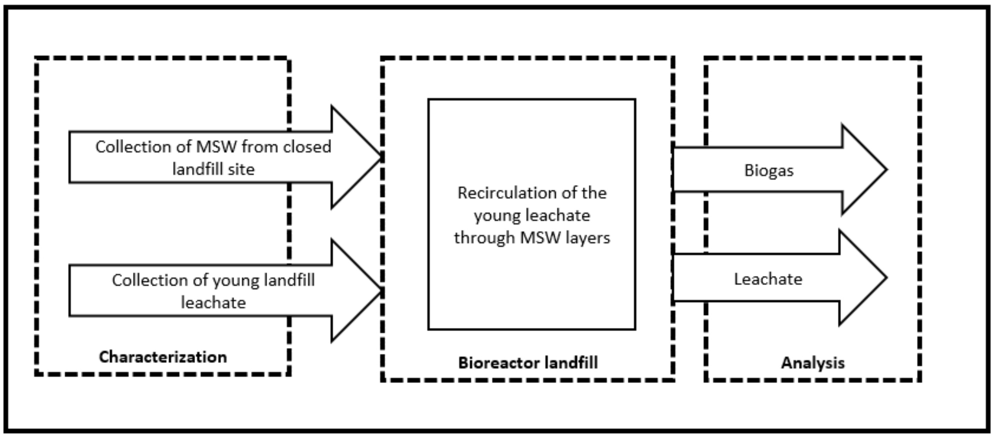

Fig. 1 Flow chart of research methodology

Results and discussion

Table 1 gives the physical composition of the MSW used in the reactors which are collected from the closed landfill site. The leachate characteristics of the closed and active landfill are given in Table 2. During the first cycle, the reactors were in the acclimatization stage. Therefore, the leachate characteristics were not accounted for reactor's efficiency calculations. The leachate recirculation cycle was completed in 90 days, and the reactors were observed for 200 days. The leachate characteristics of reactor 1(R1) and reactor 2(R2) after recirculation are given in table 2.

Table 1 Physical composition of the MSW used in the study collected from the closed landfill site

Waste component	Biodegradable fraction	Plastic	Paper	Textile	Glass	Metal	Other*
Fraction in sample (% w/w)	64.78 ± 0.18	11.45 ± 0.15	10.77 ± 0.51	4.19 ± 0.14	1.56 ± 0.06	0.04 ± 0.01	7.22 ± 0.03

* Rubber, coconut shells, bones, stone

The COD removal efficiency was 87.9 % in R1, and 71.42 % in R2, whereas R1 and R2 showed a BOD reduction of 88.9 % and 52.1 %, respectively. The decreased removal efficiency in R2 was due to the short-circuiting of the leachate. The moisture variation observed in the R2 validates the results. The alkaline nature of the recirculated leachate and the decrease in other chemical characteristics indicate biological activity. A settlement of 11.54 % and 8 % was observed in R1 and R2, respectively. A reduction in heavy metal concentration was observed in both reactors and quantity of the leachate at the end of each cycle was reduced by almost 70%.

Table 2 Physio-chemical characteristics of leachate collected from the active and closed landfill site

Parameters	Closed LL	Active LL	R1*	R2*
pH	7.69	5.85	8.53	8.23
Electrical Conductivity µS/cm	17400.00	37346.67	10605	17660
Total Dissolved solids mg/l	12800.00	23280.00	7000	11600
Biochemical oxygen demand mg/l	7200.00	10450.00	1150	5800
Chemical Oxygen Demand mg/l	16000.00	31500.00	3800	9000
Sulphate as SO_4, mg/l	165.80	1427.17	49.75	92.5
Chloride as Cl, mg/l	1949.75	3072.33	1058.35	3509.05
Calcium as Ca mg/l	32.10	3353.30	109	29
Total Alkalinity as $CaCO_3$, mg/l	7800.00	12833.33	340	490
Sodium as Na, mg/l	718.00	3828.33	<0.1	<0.1
Potassium as K, mg/l	659.00	2943.33	243.65	489.5
Nitrate as NO_3, mg/l	1376.00	1809.17	180	347
Total phosphorous as P, mg/l	20.14	59.00	310	625
Magnesium as Mg, mg/l	41.32	599.70	24.15	46.6
Ammoniacal nitrogen as N, mg/l	509.20	43.03	168.04	190.36
Total Kjeldahl nitrogen as N, mg/l	1273.00	1152.79	15.95	15.7
Nitrite as NO_2, mg/l	<0.1	<0.1	56.81	187.37
Iron as Fe, mg/l	0.31	146.67	0.29	0.33
Copper as Cu, mg/l	<0.05	0.25	<0.05	<0.05
Silver as Ag, mg/l	<0.1	<0.1	<0.10	<0.10
Chromium as Cr, mg/l	<0.05	0.72	<0.11	<0.05
Cadmium as Cd, mg/l	<0.03	0.27	<0.10	<0.03
Lead as Pb, mg/l	0.31	0.29	<0.13	<0.12
Zinc as Zn, mg/l	0.26	4.61	<0.14	<0.10
Nickel as Ni, mg/l	<0.1	<0.1	<0.10	<0.01

*after recirculation at the end of 30-day; an average of two cycles

Conclusion

Recirculating active LL in a closed landfill site is a promising solution to eliminate the leachate generated during the initial landfill period. The quantity of the leachate was reduced, and extensive reduction in BOD, COD, total dissolved solids and heavy metals was observed in recirculated leachate. Additional benefits from recirculating the young leachate include increased gas production and settlement of the closed landfill. There seems to be a distinct advantage in using closed landfills as anaerobic digesters to treat active LL in terms of landfill gas generated and can be considered clean energy.