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Biological Remediation of the Municipal Solid Waste Leachate - A Case Study of Hyderabad Integrated MSW Limited

Konda Durga Sindhu Sree*, Surya Narayan Dash* and Anagani Leelavathi†**
*Department of Chemical Engineering, GMR Institute of Technology, Rajam-532 127, India
**Environment Protection Training and Research Institute, Gachibowli, Hyderabad-500 032, India
†Corresponding author: Anagani Leelavathi

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ABSTRACT

A prominent issue associated with the handling of municipal solid waste is the generation of a highly toxic semi-solid matter namely, leachate. The consequences of mishandling the aforementioned are widespread. Hence, the present study tried to take an initiative to remediate the same in an eco-friendly way. The research included a detailed investigation of the existing conditions in terms of quality, quantity, climatic condition, etc. The entire study primarily focused on the biodegradability of the toxic pollutants with the help of EM.1 solution procured from Pragati Enterprises and bringing down the pollution level during the treatment tenure. The major three parameters of interest include chemical oxygen demand (COD), biochemical oxygen demand (BOD), and total dissolved solids (TDS). A pilot pond of 7.5 kL capacity was prepared at the east corner of Hyderabad Integrated MSW facility to facilitate the practical studies. Four major remediates, i.e. coir pith powder, Bokashi balls, EM culture, and Bokashi powder were added weighing 34 MT, 560 kg, 10.5 kL, and 75 kg respectively, over the due course of 4 months and successive reduction in pollution levels were noted. Depletion in the level of all the prior-mentioned parameters was observed ranging 42.6%, 45.4%, and 37.8% respectively for COD, BOD and TDS. Furthermore, a notable reduction in obnoxious odour was observed around the pilot plant after the 15th day of the initiation of the operation. It signifies the feasibility of the experimented technology towards the treatment of municipal solid waste leachate (MSWL), and hence the study recommends the usage of the same as a potential pre-treatment before the tertiary purification units.

INTRODUCTION

Despite a considerable amount of effort has been made to extend realistic solutions for the MSWL treatment, an ultimate wholesome treatment is still unachieved. Treating leachate and bringing down the pollution level to the disposal limits or reuse is not an easy task. It requires a series of operations. Otherwise, it may cause serious environmental concern such as groundwater contamination, odour formation etc. Furthermore, an ancillary headache associated with advanced treatment is the disposal of secondary pollutants (Heng et al. 2012). In most of the cases the process reject goes for the forced evaporation and finally, the salts land up in the secured land filling. In the majority of the cases due to the absence of any pertinent pre-treatment method, direct pollution load gets subjected to the tertiary unit, resulting in fouling of the membrane and other complicated and expensive issues. Thus, a simple, scalable, and inexpensive pre-treatment technology is the need of the hour. A diverse range of secondary treatment techniques have been already investigated and demonstrated by several researchers (Choudhury et al. 2019, Er et al. 2018, Jeyapriya & Saseetharan 2007), but most of it lags in terms of up-scalability and affordability. Moreover, utilizing the external researches and products in Indian conditions is again questionable due to the contradictory climatic and native conditions (Gupta et al. 1998, Jampala et al. 2016, Jeyapriya & Saseetharan 2007, Krishna et al. 2015, Ramesh et al. 2009). Therefore, it's highly recommended to check the adaptability of certain products and its functionality. Based on the aforementioned, it's advisable to go for the mixed consortium of organisms instead of indigenous culture, moreover the usage of native species is utterly recommended (Choudhury et al. 2018a, Choudhury et al. 2018b, Tighiri & Erkurt 2019, Snehlata et al. 2015). Zhang et al. (2016) have also investigated on the effectiveness of native species of organisms towards the removal of substances such as volatile fatty acids, micro-scale xenobiotic organic chemicals, and refractory aquatic humic substances and stated that the native organisms remove the pollution load more proficiently when compared to externally introduced indigenous species. Ultimately, the superiority of biological process towards the stabilization of organic pollutants is a well-established fact and Kurniawan et al. (2010) have reviewed a wide range of biological applications based on the target pollutants.

Finally, it was concluded by them that the bio-aerobic treatment units are most useful in terms of pollution removal if energy recovery is not possible.

The objective of the present research was to understand the behavioural characteristics and the functionality of certain organisms towards the bioremediation of the RO reject of MSWL and also to demonstrate a realistic secondary treatment mechanism to be utilized as the pre-treatment technique prior to advanced treatment units.

MATERIALS AND METHODS

The present study was conducted within the premises of Hyderabad Integrated MSW processing and disposal facility (HIMSW), which handles approx. 5000-6000 tons of MSW on a regular basis. The facility is located at Jawahar Nagar Gram Panchayat area, at the outskirts of Hyderabad city and operating in Public-Private Partnership (PPP) mode. The work has been carried out as a joint venture between HIMSW and Environment Protection Training and Research Institute (EPTRI). Further details are delineated below.

Preparation of Pilot Pond

The study involved the formation of an open circular pond of 7.5 kL capacity. The same was prepared with the help of JCB by digging up the soil at the east corner of the facility at a coordinate value of approx 78°35'39.51" E and 17°31'32.94" N. The dimensions of the pond include 2 m of radius and 0.6 m of depth. The depth was kept minimal to maximise the surface area and thus the evaporation. The pond was protected with the help of high-density polyethylene liner to arrest the downward leachate movement, garland drains to avoid the risk of any sort of spillage, and protective barriers to mitigate human and animal interference.

Leachate Source Selection

Due to the intrusion of leachate into the rainwater ponds (i.e. Malkaram Pond) located at the North-East side of the facility, approx. 6.5 lakh m^3 of fresh surface water was previously transformed into diluted leachate, locally termed as legacy leachate. At present, the same is getting treated with the help of reverse osmosis (RO) technique by Rochem Separation Systems India Pvt Ltd. The present research work incorporated remediation for the RO reject generated by the aforementioned and used the same as influent.

Characterization

The leachate sample was collected following the BIS standard method and analysed during the different periods of the research tenure. The primary parameters taken into consideration include pH, Electrical conductivity (EC), TDS, BOD, COD, and NH_3-N. Additionally, monitoring parameters included temperature and precipitation. The onsite parameters such as pH, TDS, temperature etc. were analysed using the portable mobile probes of EZDO PH5011A and TDS5031 and MEXTECH multi-thermometer, respectively. Whereas, the gas generation in and around the area was strictly monitored with multi-gas analyser of INSTRUKART (i.e., CO, CO_2, H_2S, CH_4, NH_3). The frequency of analysis was optimized as once a day.

Factors of Interest

As the study aimed to constitute a comparison between the pre and post-monsoon data, therefore, it was necessary to undertake two parameters for the primary comparisons namely, temperature and precipitation. The total research tenure so far is 4 months (Feb' 19-May'19) and the rain has been observed on 12th of April. Based on that, the entire period was divided into two parts, pre and post-monsoon period. The pre-monsoon study was carried out over a period of February to March 2019 whereas, post-monsoon studies were undertaken after 20th April to 31st of May 2019.

Introduction of the Conversion Agents

The study inculcated inclusion of four major conversion cum stabilization agents, which are EM.1 solution, Bokashi balls, Bokashi powder, and coir pith powder. Blower with suitable piping & diffusers were utilized to spray the EM culture after the successive intervals. While other solid products were manually mixed and stirred with the help of Noble NPEAG281450 MI High-Speed Stirrer. The set of operation performed alongside the sequence are showcased in Table 1.

Therefore, a total amount of 34MT of coir pith powder, 560 kg of Bokashi balls, 10.5 kL of EM culture, and 75 kg of Bokashi powder were added during the treatment tenure.

RESULTS

The remediation system was prepared and operated under the open atmospheric condition and hence atmospheric agents and seasonal variation found to play a significant role in the performance of it. The culture utilized for the study was majorly mesospheric to minimise the impact of temperature and can be easily found in the open environment. The natural habitats for all the three primary organisms include lactose substrate for lactobacillus, bread and such similar products for yeast, and roots of the plants/trees for certain essential prototroph. Other crucial information is depicted below.

Reduction of Pollution Load

Generally, RO reject constitutes elevated TDS concentration thus safe handling of the same possesses a major challenge.

Table 1: Set of operations.

Days	Date	Particulars	
		Product	Quantity added
DAY -1	20/02/2019	Bokashi balls	60.0 kg
		EM culture (Raw)	3.0 L
		Bokashi powder	15 kg
DAY -4	23/02/2019	Bokashi balls	60 kg
		EM culture (Raw)	3.0 L
		Bokashi powder	15.0 kg
DAY -11	01/03/2019	Bokashi balls	60.0 kg
		EM culture (Raw)	3.0 L
		Bokashi powder	15.0 kg
DAY -13	03/03/2019	Coir pith powder	14.0 MT*
DAY -19	09/03/2019	Bokashi powder	25.0 kg
		Bokashi balls	200.0 kg
DAY -29	19/03/2019	Coir pith powder	10.0 MT
DAY -56	17/04/2019	Maida	100.0 kg
		Bokashi balls	200.0 kg
		Coir pith powder	10.0 MT

*MT stands for Metric ton

Table 2: Reduction in leachate quantity.

Days	Date	Height Reduction (inch)	Volume Reduction* (m^3)
DAY -1	20/02/2019	N.A.	N.A.
DAY -4	23/02/2019	3.0	0.96
DAY -11	01/03/2019	6.0	1.91
DAY -13	03/03/2019	6.5	2.07
DAY -19	09/03/2019	8.0	2.55
DAY -29	19/03/2019	10.2	3.25
DAY-56	17/04/2019	22.0	7.02

*Values are subjected to local conditions

Initially, up to the first 30 days, the treatment rate was moderately lower. Possibly due to the activation and the acclimatization to the local conditions, but a steep growth in performance was observed after the initiation period. The observation on the reduction of leachate volume over the treatment tenure is portrayed in Table 2.

Reduction in Concentration

The target liquid was the reject of the RO process and hence it is obvious that the same should be highly concentrated and toxic in nature. Therefore regular monitoring was performed for the operating parameters. Onsite parameters were tested on a regular basis, which includes pH, temperature and precipitation. The range of pH found to be varying between 8.77 and 6.54. Though high pH value such as 8.70 or above was observed during the initial phase, the same got lowered to up to 6.50 during the treatment process. Probably, due to the inhibition of the anoxic activities during the later stage of the study. Whereas, the day and night temperature also increased between February to April 2019. The max and min temperature of Feb was recorded as 19°C and 39°C respectively. On the other hand, a much high min temperature of 25°C was observed during April'19, which facilitated higher rates of evaporation. Precipitation was only observed during the middle half of April, ranging approx. 62 mm with a maximum value of 37 mm on 12th of the month, which had

Table 3: Variation in treatment efficiency during pre and post monsoon period.

Sl. No.	Name of the Parameter	Units	Method	Raw*	Pre-monsoon	Post-monsoon
1	pH	---	APHA 4500 H^+ B	8.73@25°C	7.78@25°C	6.77@25°C
2	Electrical Conductivity	μSm^{-1}	APHA 2150 B	85800	64521 ± 1000	53890 ± 1000
3	COD	mg/L	APHA 5220 B	10524	7240 ± 00	6041 ± 200
4	Chlorides	mg/L	APHA 4500 Cl B	18802	14516 ± 200	11845 ± 200
5	Total Solids	mg/L	APHA 2540 B	44350	32473 ± 1000	29710 ± 1000
6	Total Dissolved Solids	mg/L	APHA 2540 C	43960	33985 ± 1000	27695 ± 1000
7	BOD (3days @27°C)	mg/L	IS: 3025	1020	740 ± 50	557 ± 25
8	Ammoniacal Nitrogen (NH_3-N)	mg/L	APHA 4500 NH_3-C	68	47 ± 5	32 ± 5

*All the heavy metal values were below detection limit

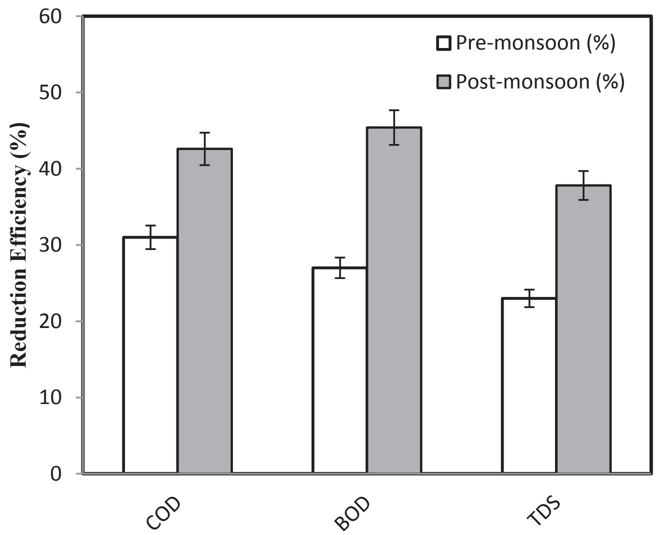

Fig. 1: Pre and post monsoon performance evaluation.

little to no effect on the study. The characteristics of the raw influent and treated effluent over the different time frame are depicted in Table 3.

Further the DO content of the influent was tested with the help of the Winkler method (APHA 2005) and found to be nil. Due to the prior mentioned condition, the influent liquid can be considered as septic and caused a possible delay in the activation of the externally introduced organisms. Later the same was elevated up to 5 mg/L, because of the mixing of atmospheric oxygen as a natural phenomenon, though the re-oxygenation process was considerably slow due to the lack of turbulence of static body. Therefore, it is recommended to install air diffusers if budget is available. It can optimise the treatment period by minimising the activation period. The overall efficiency during the pre and post monsoon period in term of percentage is shown in Fig. 1.

Both COD and TDS showed a clear pattern of reduced concentration and better treatment efficiency from post to pre-monsoon session, ranging approx. 42 and 38% respectively over the values of 31 and 23%. But though the concentration of BOD got reduced between both the sessions, a higher depletion rate was noted during the post-monsoon from 27% to 45.4%, recording an elevation of 68% enhancement in the treatment efficiency. The value is significantly almost two times the efficiency increment value of COD, which is 37.42% and the possible reason behind the same is the activation of the dormant organisms. Certainly, the boom in the ultimate removal efficiency was also dependant on a few more factors worked positively towards the treatment, includes a mesophilic range of temperature, minimal precipitation etc.

DISCUSSION

The ultimate treatment efficacy is a local phenomenon and its dependant on the various factors such as the effectivity of the organism, climatic condition, influent characteristics etc. (Choudhury & Dandapani 2018, Reddy & Reddy 2018a, Reddy & Reddy 2018b). Reddy & Nandini (2011) have reported a much lower concentration of the MSWL which clearly strengthen the factor of local influence. Moreover, Er et al. (2018) have reported much superior efficacy of micro-organic treatment towards the purification of leachate, raging approx. 75-80%. The higher rate of efficiency is probably due to the introduction of additional air diffusers and a combination of the variety of organisms utilized. Contrarily, Raghab et al. (2013) explicitly claimed the superiority of the chemical treatment over the biological mechanism and reported a much-depleted efficacy of approx. 15-20% on the overall reduction. Based on the characteristics showcased for the influent leachate for the prior mentioned study, the particular sample carried mostly inorganic pollutants and therefore biological treatment found to be quite ineffective (Sarala & Babu 2012).

CONCLUSION

The treatment depicted an explicit fact that through biological treatment units are significantly slower and moderately vulnerable to the external factors, it can yield good results if properly maintained. The present system produced a considerably acceptable treatment efficacy of 42.6%, 45.4%, and 37.8% respectively for COD, BOD, and TDS over a period of approx. 55 days. Furthermore, a notable reduction in obnoxious odour was also observed around the pilot plant after the 15^{th} day of the beginning of the operation. It signifies the feasibility of the experimented technology towards the treatment of MSWL and thus the study recommends the usage of the same as a potential pre-treatment before the tertiary purification units.

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