https://dx.doi.org/10.24001/ijaems.3.4.13 ISSN: 2454-1311

Treatment of Pretreated Landfill Leachate by Membrane Bioreactor Process

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Abstract— *Landfill leachate is a liquid that is mainly produced by the rain which falls on the solid waste. The leachate usually contains high concentrations of ammonium, organic matter, toxic compounds and heavy metals, which makes it unsuitable for discharge in natural bodies without any prior treatment. The formation of leachate threatens the groundwater, soil and environment. Land filling is the one of the least expensive method for disposal of municipal solid waste (MSW). In this study, landfill leachate is treated by coagulation and Membrane Bioreactor (MBR) process by using ultrafiltration (UF). The original sample has BOD/COD ratio as 0.603. Coagulation was used as a pretreatment prior to the biological treatment. . It was done by using alum as an coagulant at an optimum dosage of 160 mg/L. Coagulation has proven effective as a pretreatment. But the effluent quality did not meet the general standards for discharge of environmental pollutants. So the effluent after coagulation process was treated by MBR process. In this study, after MBR treatment all the parameters except BOD have met the relevant Indian Standards for discharge as irrigation water.*

Keywords* – *Coagulation, Leachate, Membrane Bioreactor Process, Municipal Solid Waste, Ultrafiltration.

I. INTRODUCTION

Waste is material that is no longer useful or valuable for society. Looking back in time, the waste management first became a problem in densely populated areas, such as villages and towns. A poor waste management leads to sanitary and aesthetical issues. One commonly used waste management method is to dispose the waste in a landfill. There are environmental downsides of disposing waste in a landfill, even if it is constructed with modern practice. The waste in the landfill is degraded during the production of greenhouse gases, such as methane.

Percolation of precipitation and groundwater flowing into the landfill create leachate, contaminated water.

Sanitary Landfill is considered to be the most common way of disposing urban solid wastes. An important problem associated with sanitary landfills is the production of leachate. Leachate is generally formed when rain water percolates through dumped waste and takes up the organic and inorganic products by both physical extraction and hydrolytic and fermentation processes. Generally, leachate contains high concentrations of soluble organic matter and inorganic ions. Due to its high strength and its impact on environment, direct discharge of leachate into the environment is not recommended.

Presently in India, little attention is made to landfill leachate treatment and even less attention to treat the produced sludge while treating leachate. Leachate Channeling (Combined treatment with domestic sewage, Recycling and lagooning), Biological Processes (Aerobic and Anaerobic) and Chemical/ Physical Treatment (Chemical precipitation, Chemical oxidation, Adsorption, membrane technology and stripping of NH_3) are some of the leachate treatment methods.

This study consists of two methods, namely physicochemical treatment and biological treatment. In the lab scale, the general treatment is simulated by Membrane bioreactor (MBR). MBR, though not widely used as a general treatment technique at present in developing countries, has future prospects of wide application as the cost of membranes are coming down.

II. MATERIALS AND METHODS

2.1 Leachate

The landfill leachate sample was collected from Municipal Solid Waste Disposal Facility at Brahmapuram, Kochi. The landfill leachate samples from the sites were collected in sterile bottles. The bottles were labeled with the date and time of sampling. Samples were immediately transferred to the laboratory and stored at 4°C. Their main physicochemical characteristics are analyzed.

Table.1: Landfill leachate characteristics

Sl.No.	Parameters	Unit	Value
1.	Ph	-	5.0
2.	BOD	mg/L	30800
3.	COD	mg/L	51060
4.	TSS	mg/L	8635
5.	TDS	mg/L	18590
6.	Turbidity	NTU	1230
7.	Chloride	mg/L	4551.7

https://dx.doi.org/10.24001/ijaems.3.4.13 ISSN: 2454-1311

8.	Ammonia nitrogen	mg/L	3800
9.	Phosphate	mg/L	720
10.	Sulphate	mg/L	5600
11.	Sulphide	mg/L	415
12.	Potassium	mg/L	3625

2.2 Preparation of Synthetic Wastewater

Synthetic leachate was prepared based on the data obtained from previous studies. The composition of synthetic sample was prepared by trial and error method so that reasonable match with the sample could be obtained.

Table .2: Composition of synthetic sample (Anisha Suresh et al., 2016)

Chemicals Required	Quantity in grams/ litre
Ammonium chloride	3.2
Sodium sulphide	2.2
Sodium chloride	3.2
Calcium carbonate	0.38
Dipotassium hydrogen ortho phosphate	0.8
Ferrous sulphate	0.24
Magnesium sulphate	0.24
D- Glucose	28

2.3 Jar Test

Coagulation experiments were performed by using a conventional jar-test apparatus equipped with five 1,000-ml beakers at room temperature. Alum was used as coagulant in this study. Coagulant dosage was optimized by performing the experiments at varying coagulant dosage at optimum pH. The beakers were labeled and kept in jar apparatus and stirred at 200 rpm for 3 min and at 60 rpm for 20 min, and is, then, allowed to settle for 30 min. The first run was done by adding different doses of Alum as 100, 120, 140, 160, 180 mg/l to the samples. To evaluate the efficiency of Coagulation, turbidity of leachate were measured before and after the treatment.

Fig.1 : Jar Test Apparatus with Leachate Samples

2.4 Process in MBR

An acrylic container of 8L capacity was used as the bioreactor. The size of the reactor was 20cm x 16cm x 25cm. The reactor was supplied with oxygen by aerator. Aeration rate of 3litre/min was provided. The membrane arrangement consist of membrane module having pore size of 0.5µm, pump of capacity 1.5 lpm and DC adapter connected in series.

Bio sludge collected from a secondary sedimentation tank from a dairy plant was acclimatized with leachate for 1 month. The reactor was operated in batch mode which was filled with 1L sludge and 3L leachate in order to maintain the MLSS concentration in the range 18 g/L. After the reaction time, mixed liquor was allowed to settle for 30 minutes. The supernatant from the bioreactor was passed through the hollow fibre membrane module using a pump of capacity 1.5 lpm. The treated effluent was collected and analyzed.

Fig.2 : Experimental setup of MBR

III. RESULTS AND DISCUSSIONS

3.1 Determination of Optimum Coagulant Dosage and Hydraulic Retention Time (HRT)

Coagulation is used as the pretreatment method for the leachate and alum was used as the coagulant. Coagulation test was carried out using jar test. By chemical treatment using alum with different doses the best removal efficiency of 94.9% has been achieved at an alum dose of 160 mg/L. This alum concentration has been used as the optimum coagulant dosage for the treatment of leachate.

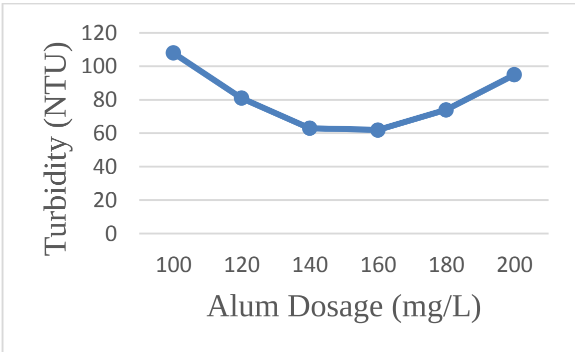

Fig. 3: Determination of Optimum Coagulant Dosage

The synthetic wastewater was subjected to activated sludge process at neutral pH in the bioreactor. The

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optimum HRT was obtained by analyzing the COD removal efficiency in each day.

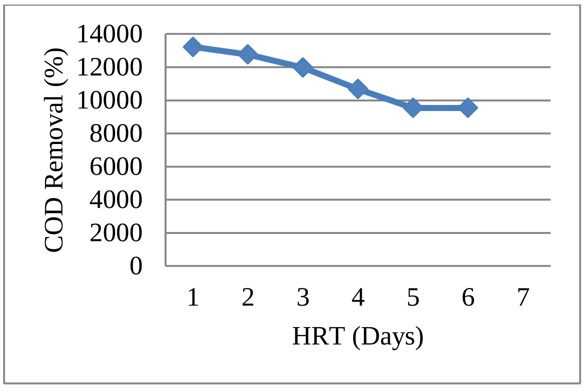

Fig.4: COD removal at different HRTs

So the leachate sample was treated by coagulation process with an optimum coagulant dosage of 160 mg/l and MBR with an optimum HRT of 5 days.

3.2 Pretreatment of Leachate by Coagulation

Leachate was pretreated by coagulation process with an optimum coagulant dosage of 160 mg/l and at neutral pH. The removals of various parameters by coagulation process were studied.

Table.3: Percentage removal of pollutants after pretreatment (coagulation)

Parameters (mg/L)	Concentration of Parameters before pretreatment	Concentration of Parameters after pretreatment	% Removel
BOD	30800	8008	74
COD	51060	11743.8	77
TSS	8635	1554.3	82
TDS	18590	3532.1	81
Turbidity (NTU)	1230	86.1	93
Chloride	4551.7	773.78	83
Ammonia nitrogen	3800	532	86
Phosphate	720	151.2	79
Sulphate	5600	1008	82
Sulphide	415	124.5	70
Potassium	3625	906.25	75

From the above Table 3 it is clear that coagulation as a pretreatment is efficient to operate. The percentage removals of BOD, COD, TSS, TDS, turbidity, chloride, ammonia nitrogen, phosphate, sulphate, sulphide and potassium were 74%, 77%, 82%, 81%, 93%, 83%, 86%, 79%, 82%, 70% and 75% respectively.

3.3 Treatment of Leachate by MBR Process

The pretreated leachate sample was passed through MBR process for the secondary treatment at an optimum HRT of 5 days. The removals of various parameters by MBR process were studied.

Table.4 : Percentage removal of pollutants after MBR

Parameters (mg/L)	Conc. of Parameters before MBR	Conc. of Parameters after MBR	% Removel
BOD	8008	960.9	87
COD	11743.8	1761.6	85
TSS	1554.3	139.9	91
TDS	3532.1	353.2	90
Turbidity (NTU)	86.1	5.2	94
Chloride	773.78	85.1	89
Ammonia nitrogen	532	37.2	93
Phosphate	151.2	6	96
Sulphate	1008	100.8	90
Sulphide	124.5	13.7	89
Potassium	906.25	326.3	91

The membrane can capture most of the suspended solids in the reactor because of its fine pore size. Therefore, non-biodegradable organic compounds are removed through filtration of particulates and discharge sludge. The percentage removal increases after MBR process. The percentage removals of BOD, COD, TSS, TDS, turbidity, chloride, ammonia nitrogen, phosphate, sulphate, sulphide and potassium were 87%, 85%, 91%, 90%, 94%, 89%, 93%, 96%, 90%, 89% and 91% respectively.

Table.5: Evaluation of performance of MBR process after pretreatment in leachate based on relevant Indian Standards

Parameters (mg/L)	Final Effluent Characteristics	General standards for discharge of environmental pollutants as per The Environment (Protection) Rules, 1986, Govt. of India	
		Into surface water	To land for irrigation
BOD	960.9	<30	<100
COD	1761.6	<250	-----
TSS	139.9	<100	<200
TDS	353.2	<1500	----
Turbidity (NTU)	5.2	<40	----
Chloride	85.1	<1000	<600

Ammonia nitrogen	37.2	<50	-----
Phosphate	6	<2	----
Sulphate	100.8	<1000	<1000
Sulphide	13.7	<2	-----
Potassium	326.3	<30	----

The Table 5 summarizes the result of all treatment done using original leachate. The table shows the performance of coagulation and membrane bioreactor process based on the relevant Indian Standards. These standards are inserted by the Govt. of India by Rule 2(d) of the Environment (Protection) Second Amendment Rules, 1993 notified vide G.S.R. 422(E) dated 19.05.1993, published in the Gazette No. 174 dated 19.05.1993.The table shows that final treated effluent have not met all the relevant standards. The value of BOD, COD, phosphate, TSS and sulphide is not within the limit and has not met the standards of discharge into surface water. So the effluent could not be discharged into surface water. After all treatments, all the parameters of the effluent except BOD have met the standards of discharge as irrigation water.

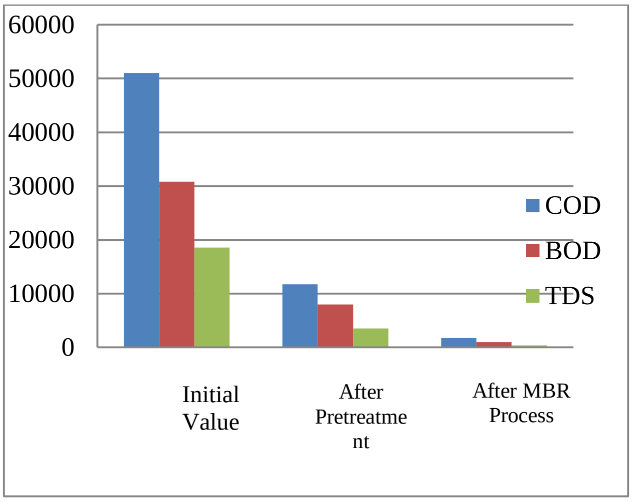

Fig.5: Comparison of effeciency of treatment process for COD, BOD and TDS removal

After pretreatment the removal percentages were 77%, 74% and 81% for COD, BOD and TDS respectively. The removal ratios has increased to 85%, 87% and 90% for those parameters after MBR process.

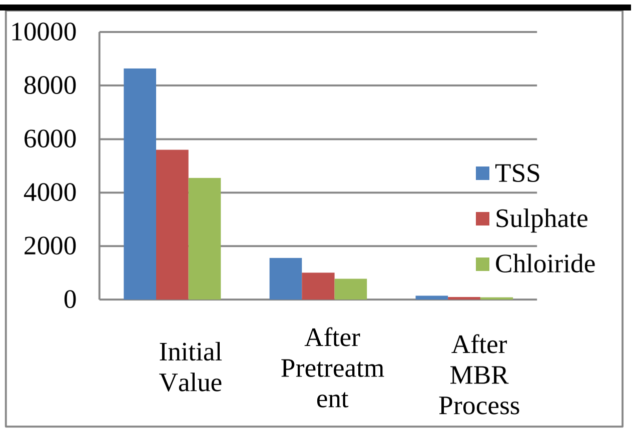

Fig. 6 : Comparison of treatment process for TSS, Sulphate and Chloride removal

The removal ratios of TSS, sulphate and chloride has increased from 82%, 82% and 83% to 91%, 90% and 89% after MBR process.

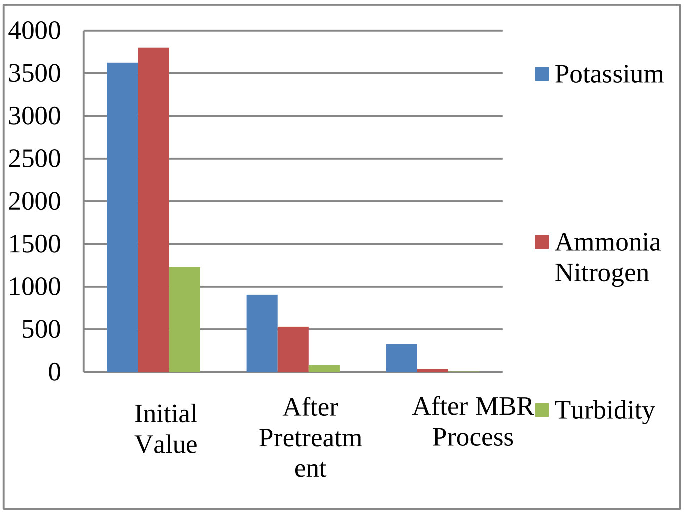

Fig. 6 : Comparison of treatment process for Potassium, Ammonia Nitrogen and Turbidity removal

After pretreatment the removal percentages were 75%, 86% and 93% for potassium, ammonia nitrogen and turbidity respectively. After MBR process, 91%, 93% and 94% removal ratios were obtained.

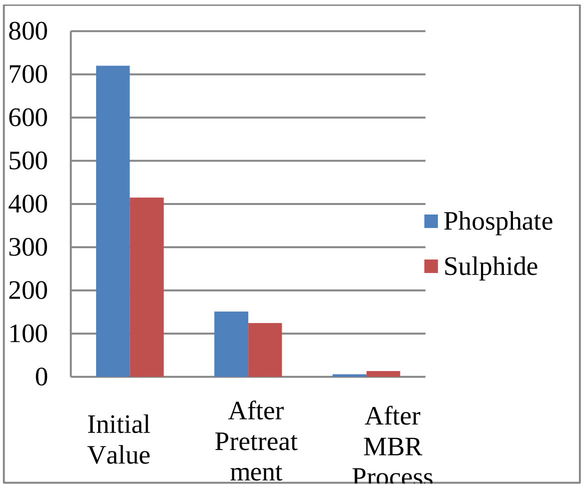

Fig. 7 : Comparison of treatment process for Phosphate and sulphide removal

The removal ratios of phosphate and sulphide has increased from 79%, and 70% to 96%, and 89% after MBR process.

IV. CONCLUSIONS

In this study, landfill leachate was treated by coagulation as a pretreatment and MBR process in order to meet the effluent discharge standards.

The sample was pretreated by coagulation with an Optimum coagulant dosage of 160 mg/L. In case of MBR process the sample was treated with an optimum HRT of 5 days and at neutral pH in batch mode. After coagulation process the percentage removal obtained for BOD, COD, TSS, TDS, turbidity, chloride, ammonia nitrogen, phosphate, sulphate, sulphide and potassium were 74%, 77%, 82%, 81%, 93%, 83%, 86%, 79%, 82%, 70%, and 75% respectively. The percentage removal obtained for BOD, COD, TSS, TDS, turbidity, chloride, ammonia nitrogen, phosphate, sulphate, sulphide and potassium after MBR treatment were 96.9%, 96.5%, 98%, 98%, 99.5%, 98%, 99%, 99%, 98%, 96.7% and 91% respectively. From the result it can be seen that percentage removal of pollutants increased after MBR treatment. But final treated effluent has not met all the relevant Indian Standards for discharge in to surface water. But for discharging as irrigation water all the parameters except BOD has met the relevant Indian Standards. So the final treated effluent can be used as irrigation water after doing a post treatment. So it can be concluded that coagulation process can be used as a pretreatment of MBR system. It gives high percentage removal of pollutants.

ACKNOWLEDGEMENTS

This research was supported by Malabar College of Engineering and Technology, Thrissur, Kerala.

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