2011 International Conference on Environment and Industrial Innovation
IPCBEE vol.12 (2011) © (2011) IACSIT Press, Singapore

DEVELOPMENT OF HYBRID ANAEROBIC DIGESTION AND MEMBRANE SEPARATION TECHNIQUE

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Abstract. The treatment method of landfill leachate was optimize to improve the efficiency using integrated anaerobic digestion and membrane process. As the landfill leachate is difficult to treat due to is refractory contaminants and volume along with its changing characteristic with time the treatment becomes difficult, studies on anaerobic digestion of the leachate were carried out along with methane gas generation in order to enhance treatment efficiency membrane technology was coupled with anaerobic digestion. Fresh leachate were generated and characterized which is then feed to anaerobic reactor. Effluent from the anaerobic reactor was tested and was found to remove COD up to 80% and reduction in total solids, sodium, sulphate, phosphate, nitrate and heavy metals. (like Zn, Pb, Cd, Ni, Co, Mn, Fe, Cr, Cu etc.)However the efficiency after anaerobic digestion was not meeting the Environmental Standards. Hence it was subjected to ultrafiltration. (UF) The permeate of UF was feed to reverse osmosis (RO) membrane and permeate of RO was characterized. It is found that quality of permeate of RO meets the standard limits set by Government of India. The developed anaerobic digestion and membrane separation technique method was optimize for various operating parameters and performing parameters.

Keywords: COD- Chemical Oxygen Demand, TDS- Total Dissolved Solids, UF- Ultrafiltration, RO- Reverse Osmosis, NEERI- National Environmental Engineering Research Institute, LPM- lit/m^2/hr

1. Introduction

Current Population of India in 2010 is around 1,150,000,000 (1.15 billion) people. Currently, India is second largest country in the world after China in terms of population. By 2030, the population of India will be largest in the world estimated to be around 1.53 billion. There has been rapid increase in Indian population in the last 60 years. Population of India at the time of Independence was only 350 million. So Indian Population has increased more than three times India, with 1,190,000,000 (1.19 billion) people. The figures show that India represents almost 17.31% of the world's population, which means one out of six people on this planet live in India. Although, the crown of the world's most populous country is on China's head for decades, India is all set to take the numerous Uno position by 2030. With the population growth rate at 1.58%, India is predicted to have more than 1.53 billion people by the end of 2030.

A rapidly growing population puts enormous stress on existing infrastructure, and continually requires more resources to maintain the same standards. Municipal solid waste management was generally a neglected issue in the country until the unicipal Solid Waste (Management and Handling Rules) 2000 were promulgated. Hence as per direction given by MSW-2000 Rules leachate collection and treatment is necessary before disposed it to Environment.

Treatment of municipal landfill leachates presents unique problems from engineering point of view mainly because of high chemical oxygen demand (COD) (6000–15,000 mg/L), also due to the presence of toxic compounds such as metal ions. Landfill leachate management has been given significant attention in recent years especially for municipal areas. Composition of the landfill leachates present variations

depending on the nature of the landfilled solid wastes, the active microbial flora, characteristics of the soil, the rainfall patterns and the age of the landfill. Usually young landfill leachates are treated more easily as compared to the old ones. Therefore, the leachate should be characterized before a suitable treatment strategy was developed. Hence anaerobic and membrane treatment is decided to trate leachate.

2. MATERIALS AND METHODOLOGY

2.1. Treatment Options of Leachate

1. Anaerobic Treatment followed by Membrane Separation Treatment

In Membrane Separation Treatment Following treatments were given

1. Ultra filtration (UF)
2. Reverse Osmosis (RO)

The experimental set up was established in Solid and Hazardous Waste Management Division of National Environmental Engineering Research Institute Nagpur, India.

2.2. Anaerobic Digestion of Leachate

For anaerobic digestion of leachate 175 liters capacity reactor is using. This reactor has three compartments for primary, secondary and tertiary treatment. The shape of each compartment is tapering at bottom at outlet is given for collecting sample. In between primary and secondary unit circular and semicircular rings are provided for growth of anaerobic culture. In second unit hollow circular inclined (inclined at 60^0) tubes are provided. The effluent is collected from bottom of third compartment. The methane gas collection pipe is provided on top of reactor.

Anaerobic digestion is a series of processes in which microorganisms break down biodegradable material in the absence of oxygen, used for industrial or domestic purposes to manage waste and/or to release energy.Ideally in anaerobic digestion the production of methane and carbon dioxide can be calculated using the following

$$CaHbOcNd + (4a–b–2c+3d / 4)\ H_2O \rightarrow (4a+b–2c–3d / 8)\ CH_4 + (4a–b–2c+3d / 4)\ CO_2 + dNH_3$$

2.3. Membrane Treatment of Leachate

A membrane can be described as a material through which one type of substance can pass more readily than others, thus presenting the basis of a separation process. For many processes membranes act to reject pollutants, which may be suspended or dissolved and allow purified water through it, or transfer gas to the wastewater, as in the bubble-less oxygenation.

Ultrafiltration is a variety of membrane filtration in which hydrostatic pressure forces a liquid against a semipermeable membrane. Suspended solids and solutes of high molecular weight are retained, while water and low molecular weight solutes pass through the membrane. Spiral wound membrane module is consists of large consecutive layers of membrane and support material rolled up around a tube. It has maximizes surface area and less expensive. The type of membrane used is polyethylene sulphate and having opening size is 0.05 micron.

Reverseosmosis (RO) is a filtration method that removes many types of large molecules and ions from solutions by applying pressure to the solution when it is on one side of a selective membrane.. Spiral wound membrane module is consists of large consecutive layers of membrane and support material rolled up around a tube. It has maximizes surface area and less expensive. The type of membrane used is polyamide and having opening size is 0.001 micron.

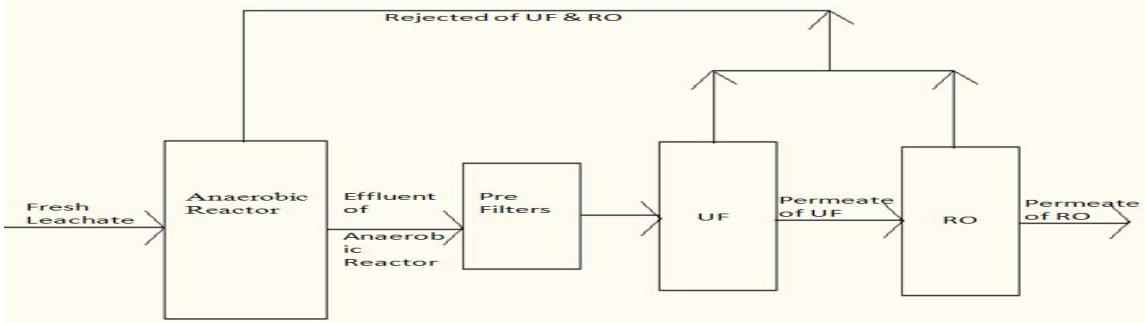

Fig 2.1- Flow Diagram of Experimental Work

3. RESULT AND DISCUSSION

Fresh leachate was feed through influent to primary chamber of anaerobic reactor. The anaerobic treatment was carried out in the reactor with 5 days HRT in reactor. The methane gas was collected from top of reactor. Then effluent of reactor were treated by membrane separation (UF and RO).

3.1. Characteristic of Leachate in anaerobic reactor

Table 3.1- Characteristic of Leachate in anaerobic reactor

Parameters	Fresh Leachate (Influent)	Effluent of Reactor
COD(mg/L)	16000	2700
TS(mg/L)	6070	4680
TDS(mg/L)	2730	4350
Sodium(mg/L)	2137	1842
Sulphate(mg/L)	2.95	2.95
Phosphate(mg/L)	3	2.7
Nitrate(mg/L)	19.1	15.6
pH	6.9	7.4

3.2. Characteristic of Leachate after Membrane Separation Technique

The effluent of anaerobic reactor was filtered through muslin cloth to remove suspended impurities. After that filtered leachate feed in the feed tank of membrane separation unit. Using high pressure pump the leachate feed to pre filter which are made by ceramic materials. After filtered through pre filter leachate feed to ultrafiltration unit under pressure. The permeate of UF unit was collected in collection tank and rejected was collected in feed tank.

The rejected of UF unit was removed from feed tank and clean it. The permeate of UF unit was collected from collection tank and feed into the feed tank for Reverse Osmosis (RO) treatment. Again using high pressure pump the leachate feed to pre filter which are made by ceramic materials. After filtered through pre filter leachate feed to RO unit under pressure. The permeate of RO unit was collected in collection tank and rejected was collected in feed tank. The rejected of UF and RO were again feed to anaerobic reactor for further treatment. The membrane inlet pressure and membrane outlet pressure for UF and RO is increased gradually while treating leachate and sample of permeate were collected at various trance membrane pressures and study of removal of COD were carried out as shown in graphs. Parameters other then COD were analyzed at final trance membrane pressures only as shown in below tables.

Treatment by Ultrafiltration (UF)

1.Flow Rate (at pressure 7 kg/cm^2)- Rejected = 14.5 LPM, Permeate = 3.4 LPM

2.Volume of Leachate- Feed = 28000 ml, Rejected = 1500 ml, Permeate = 23500 ml

Treatment by Reverse Osmosis (RO)

1.Flow Rate (at pressure 9 kg/cm^2)- Rejected = 12.5 LPM, Permeate = 1.1 LPM

2.Volume of Leachate- Feed = 23500 ml, Rejected = 3000 ml, Permeate = 18800ml

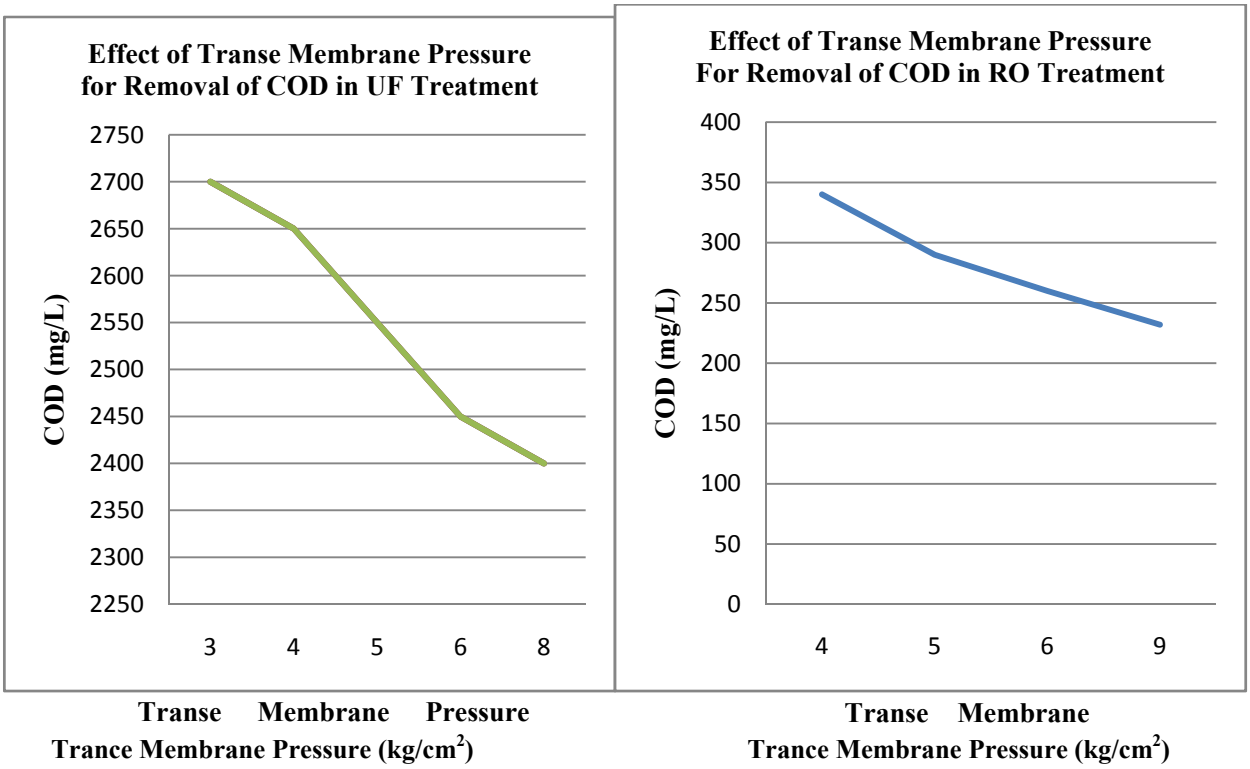

Table 3.2- Results of Membrane Separation Unit.

Parameters	Influent of Anaerobic Reactor	Effluent of Anaerobic Reactor (Feed to UF)	Permeate of UF	Rejected of UF	Permeate of RO
TS (mg/L)	6070	4710	2210	1220	1060
TDS (mg/L)	4010	3490	2210	1220	1060
Sodium (mg/L)	2137	2137	1020	1051	52
Phosphate (mg/L)	3.0	2.7	2.1	0.5	0.85
Nitrate (mg/L)	19.1	15.6	9.8	5.2	0.07
pH	6.8	6.89	7.17	7.23	7.02
Potassium (mg/L)	380	350	290	49	21.5

Table 3.3- Heavy Metals

Heavy Metals (mg/L)	Fresh Leachate (Influent)	Permeate of RO
Zn	1.36	0
Pb	1.64	0.103
Cd	1.82	0.114
Ni	1.70	0.110
Co	0.381	0.141
Mn	2.34	0.240
Fe	9.58	0.370
Cr	0.512	0.128
Cu	0.579	0.064

4. Conclusion

The various parameters as mentioned in tables above were studied at different levels of leachate treatment. From results it is concluded that after anaerobic treatment some parameters was not meeting disposal standards of leachate given by MSW 2000 Rules given by Ministry of Environment and Forest, Govt. of India, India. Eg- the disposal limit of COD is 250 mg/L as per MSW-2000 Rules but after anaerobic

treatment it reduces from 16000mg/L to 2700 mg/L. Hence membrane treatment were given after anaerobic treatment. The effluent of RO meeting all parameters below permissible limits of disposal standards of leachat. RO membrane also provide good efficiency to remove heavy metals from leachate. The anaerobic treatment generate methane gas which can be used for energy generation purpose and it is also use for earning carbon credits. As methane gas is used for energy generation purpose it reduces the green house gas emission generated from MSW landfill site.

5. Referances

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