COMBINED TREATMENT OF MSW LEACHATE

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ABSTRACT

In the recent past, the quantum of solid waste is growing at an alarming rate due to growing population, urbanization and industrialization. MSW is a non-homogeneous mixture of solids, which cannot be put back to any use without proper processing. MSW, if not managed properly, leads to serious and long term environmental consequences particularly ground water pollution, due to generation of leachates from dumping sites & Landfills. Treatment of MSW leachate is thought as important step since the inception of MSW 2000 rules. In coming years management of MSW and its leachate is going to be a major environmental issue. As there is no specific treatment methodology available for leachate treatment this research work was focused on developing a treatment methodology for MSW leachate so as to meet the requirements of Schedule IV of MSW 2000 rules for disposal of leachates(5). In this work an attempt has been made to study the feasibility of treatment of leachate by a novel anaerobic reactor treatment combined by post treatment of effluent from this reactor in membrane reactor.

KEYWORDS: *Leachate, Anaerobic Digestion, Inclined tube reactor, Membrane Treatment, Combined Treatment.*

I. INTRODUCTION

Leachate is a high-strength wastewater which is produced from landfills, the commonest method of solid waste disposal and has significant environmental impacts on air, water, and soil. However major potential environmental impact related to landfill leachate is pollution of groundwater and surface water. Since groundwater is the major source of drinking water in India, the risk of groundwater pollution due to seepage of leachate from landfills, has become one of the most important environmental concerns, particularly in developing countries like India, where most of the landfills have been built without any sound engineering design such as engineered liners and leachate interception and collection system. Therefore management of such a leachate in a difficult task and offers a wide scope for research.

II. REACTORS USED IN BIOLOGICAL (ANAEROBIC) TREATMENT OF LEACHATE

The Reactor Configurations used in Anaerobic Treatment Systems can be broadly Categorized into two types, principally on the basis of the way, they hold the microbial biomass viz. 1. Suspended Growth Reactor System (SGRS) 2. Attached Growth Reactor System(AGRS). In SGRS the biomass is available in the form of granules and/or sludge suspended in the reactor volume, whereas in AGRS it is available in the form of biofilm attached to the support media packed in the recator. The most widely used SGRS is Upflow Anaerobic Sludge Blanket Reactor (UASB). Although UASB exhibits high treatment efficiency, few drawbacks are associated with it viz clogging, pressure drop, AGRS are however are more stable in shock load conditions as compared to UASB . Looking into the drawbacks of these most widely accepted reactor technologies, non-conventional anaerobic reactor system has been developed which combines the advantageous features of these system while discarding their functional drawbacks and operational difficulties.

III. MATERIALS & METHODS

a. Reactor :

The anaerobic inclined tube reactor system used in this work was developed as a combination of suspended and attached growth system in which the biomass is available in the form of suspended granules as well as attached biofilms. This reactor also facilitates preliminary treatment such as primary sedimentation and secondary treatment, such as biomethanation in a single reactor vessel.The overall capacity of this reactor is 170 l.and has three chambers. The capacity of first, second and third chamber is 30 l, 110 l and 30 l respectively. The second chamber consist of circular tubes inclined at 60^{o} (100 cm length, 1.5 inch dia and 16 nos,) and corrugated plastic media outside the tubes.. The volume of plastic media (Raschig Rings) is approximately 40 l. The sludge disposal ports are provided at the bottom of the reactor. The upper part of the reactor is utilized for biogas collection whereas the hopper bottom of the reactor is utilized for sludge collection. The wastewater is fed through inlet to the chamber 1, which rises through inclined tubes available in the chamber 2. When the wastewater passes through the second chamber the suspended particulate matter is removed and the partially treated effluent passes through the media chamber. While passing through the second chamber the biodegradation of organic matter takes place converting organic matter to methane, CO_2, H_2S, etc. as per the theory of biomethanation. Sample can be fed using feed pump in first chamber. The details of the reactor are enlisted in **Table.1**. **Figure 1 and 2** shows the schematic and actual photograph of the experimental setup respectively.

I- Inlet of Reactor
O- Outlet of Reactor
F- Feed Tank
P- Feed Pump
S- Sludge Disposal Port
G- Biogas Collection Unit
1- First Chamber
2- Middle Chamber
3- Third Chamber

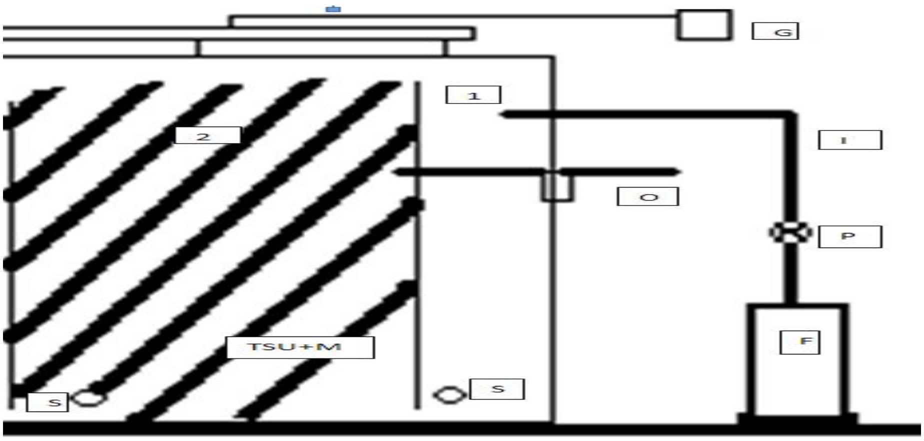

Fig 1: Sketch of Inclined Tube Reactor for Leachate Treatment

Fig 2. Inclined Tube Reactor for Leachate Treatment (Actual Set up)

Table 1: Physical Features of the Inclined Tube Reactor

Material of construction	Perspex
Reactor volume	170 l
Breadth of reactor	86 cm
Vertical height of reactor	100 cm
Width of reactor	28 cm
Type of media	Raschig Rings
Volume of rings	~ 40 l

b. Raw Material :

Leachate from MSW dumping site in Nagpur was used for the study. **Table** 2 shows the typical composition of leachate used.

Table 2: Characteristics of the Leachate

Parameter	**Value**
pH	6-6.9
Alkalinity	500-1000 mg/l
COD	12000-16000 mg/l
VFA	150-400 mg/l
Amm. Nitrogen	15-55 mg/l
Suspended solids	50-400 mg/l
Volatile suspended solids	40-350 mg/l
Heavy metals: (mg/l) Cadmium	0.0
Lead	0.01-0.83
Nickel	0-0.02
Iron	1.6-6.2
Chromium	0.05-0.07
Manganese	0.46-0.63
Zinc	0.20-0.52

IV. STEADY STATE OPERATION OF THE REACTOR SYSTEMS

The reactor used in this research work was evaluated in details for its performance under different operating conditions & Operating Parameters viz. Loading Rate, Hydraulic Retention Time, Influent Concentration These Operating parameters were used as lumped parameters, which indirectly represents the process parameters that are not directly measurable. The estimated kinetic constants in batch experiments (as usually done in laboratory) are directly applicable to the working anaerobic reactor system. Therefore, usually all bioreactor systems utilize these lumped parameters and actually used for scale up and operation of the actual reactor system.

The reactor was operated under various operating conditions. Temperature range 33-35ºC, pH range 6.5-7.5, influent COD concentration of 10,000-16000 mg/l and corresponding COD removal efficiencies were observed. Treatment efficiency of the reactor was determined on the basis of COD removal as COD is a parameter which represents total carbon present in the leachate and also because its analysis is more reliable and accurate. The data was collected and analysed for varied influent concentrations at constant detention time.

V. RESULT & DISCUSSION

Effect of Influent Concentration (Si) on Performance of Reactor

Reactor was operated at constant HRT of 3 days, with varying inlet COD concentration. Variation in efficiency with variation in inlet COD concentration is graphically shown in **Figure 3** which indicate that the influent COD which was in the range of 12000-18000 mg/l, the COD reduction around 88.5 – 90% could be achieved at HRT of 3 days.

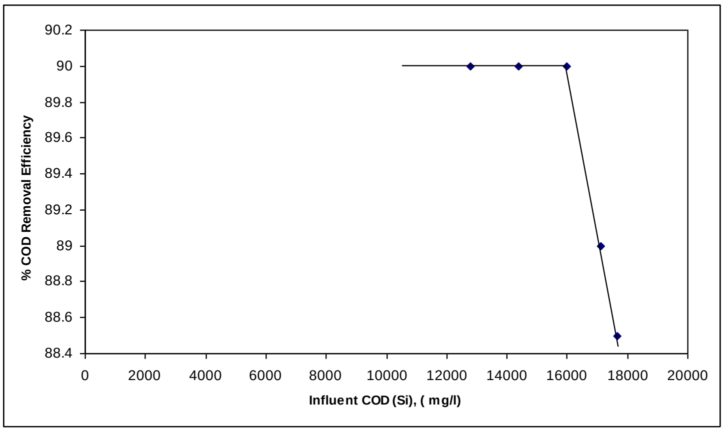

Figure 3 Effect of Influent COD on COD Removal Efficiency (HRT 3 days)

From the graph, it can inferred that this reactor system can take up maximum inlet COD concentration of about 16000 mg/l without significant loss of efficiency. Beyond this concentration, efficiency of the reactor dropped substantially. Three days HRT provided for these experiments was sufficient enough for anaerobic biochemical reactions to occur within the reactor. The limitations of the inlet concentration are due to the limitations on the diffusion of the organics into the biofilm. Normally, the higher input COD, shall result in diffusional limitations and toxicity to the microorganisms. Although, can not be measured directly, higher COD values would result in increased values of decay coefficient (kd), so much so that, microbial activity decreases substantially. Accordingly, every reactor system, especially fixed film system should exhibit a limiting input concentration beyond which the reactor cannot work efficiently. In this case, this concentration is estimated to be about 16000 mg/l.

Effect of Variation in HRT on Efficiency

Reactor was run at constant organic loading rate at different HRTs and COD removal efficiency at steady state were recorded. The graphical representation of variation of efficiency with HRT is shown in **Figure 4.** From the graph, it can be said that the overall removal efficiency increased with increase in HRT. Also the maximum removal efficiency is found to be 90% at influent COD concentr, increase in efficiency is marginal and therefore, inclined tube reactor should exhibit optimum efficiency at HRT's around three days. HRT is a parameter which takes care of time requirements for kinetically different reactions occurring in anaerobic digestion. The developed reactor system can be scaled up considering HRT around 3 days.

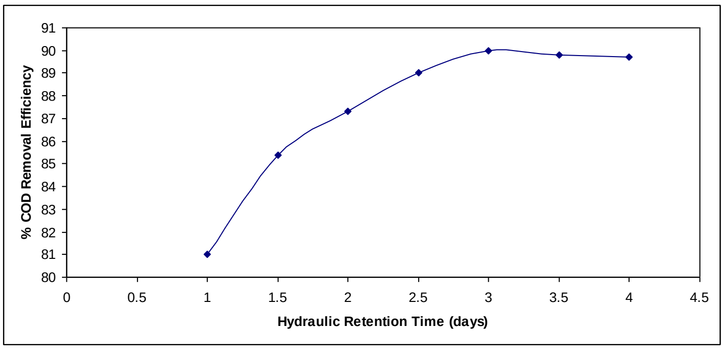

Figure 4 Effect of variation on COD Removal Efficiency at different HRTs

Variation of Efficiency with respect to Organic Loading Rate (OLR)

The values of maximum influent concentration and optimum HRT were used in the experiments carried out to assess the effect of OLR on COD removal efficiency. Graphical representation in fig **5, wherein** it can be observed that COD removal efficiency of the inclined reactor remains more or less constant with increasing OLR upto a certain value of OLR, beyond which, removal efficiency substantially drops. Normally OLR is a lumped parameter, which indirectly involves, kinetic parameters such as μ_{max}, K_s active biofilms thickness etc, which are not directly measurable. From the graph it can be inferred that COD removal efficiency is 90% at organic loading rate upto 5.07 kg COD/m^3/day. It is customary to operate such systems at 80% of the found values.

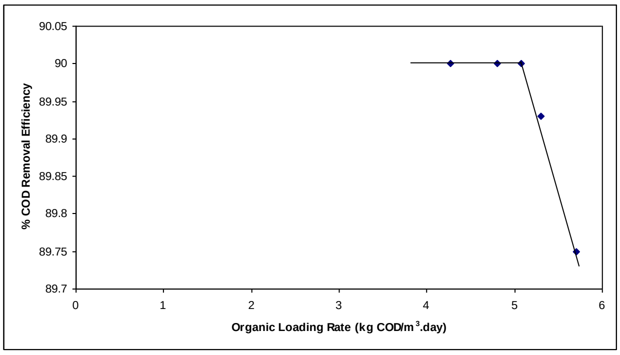

Figure 5 Variation on COD Removal Effluent with OLR (HRT 3 Days)

Membrane Studies

Although the anaerobic treatment reduced the COD concentration upto 90 %, The effluent from the reactor had very high values of COD, and were not as per the disposal limits set by MSW handling rules. So it was thought to conduct post treatment of this effluent by membrane studies. These studies have been conducted by using Reverse Osmosis (RO). Various experimental runs were conducted to study the COD removal efficiency at various trance membrane pressures. These studies were mainly conducted to examine the feasibility of membrane processes for the post treatment of anaerobically treated leachate so as to meet the standards of Schedule IV of MSW rules 2000. In these studies, characteristics of feed, permeate and concentrate were recorded. Polyamide based RO membrane was used and trance membrane pressures in the range of 3-7 kg/cm^2 were used. Summary of findings is shown in T**able 3, Table 4 & Table 5, and Fig 6. Fig 7 & Fig 8.**

Table 3: Removal of COD by RO (Run 1)

Initial value of COD (mg/l)	Trance Membrane Pressure (kg/cm^2)	COD of permeate of RO	Permeate Flow Rate (l/min)	% Removal of COD
2400	3	477.6	0.8	80.1
	4	409.2	0.42	82.95
	5	318	0.5	86.75
	6	261.6	0.7	89.1
	7	230.16	1.1	90.41

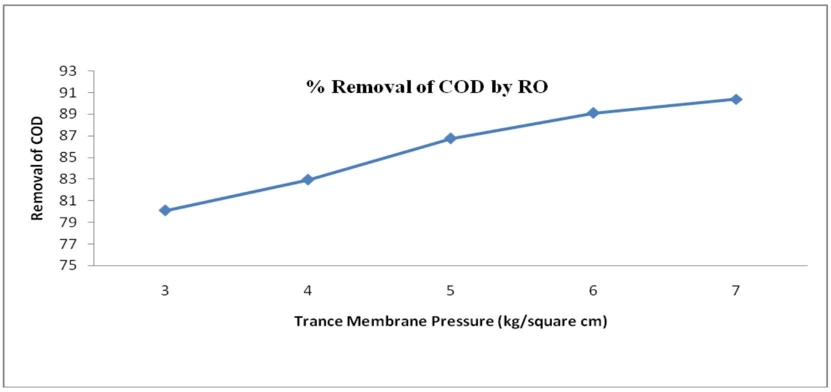

Figure 6: % Removal of COD by RO (Run 1)

Table 4: Removal of COD by RO (Run 2)

Initial value of COD (mg/l)	Trance Membrane Pressure (kg/cm^2)	COD of permeate of RO	Permeate Flow Rate (l/min)	% Removal of COD
2000	3	320	0.39	80.36
	4	290	0.42	82.2
	5	260	0.65	84.4
	6	250	0.75	84.66
	7	190	1.25	88.34

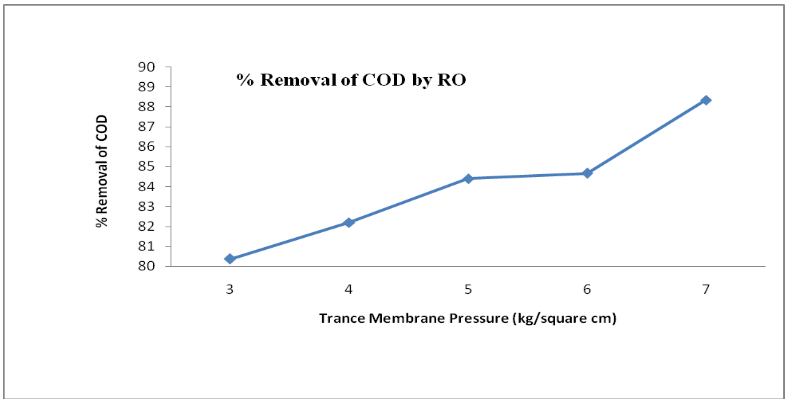

Figure 7: % Removal of COD by RO (Run 2)

Table5: Removal of COD by RO (Run 3)

Initial value of COD (mg/l)	Trance Membrane Pressure (kg/cm^2)	COD of permeate of RO	Permeate Flow Rate (l/min)	% Removal Of COD
1600	3	328	0.41	79.05
	4	313.6	0.5	80.4
	5	291.2	0.61	81.8
	6	259.2	0.85	83.78
	7	195.2	1.2	87.8

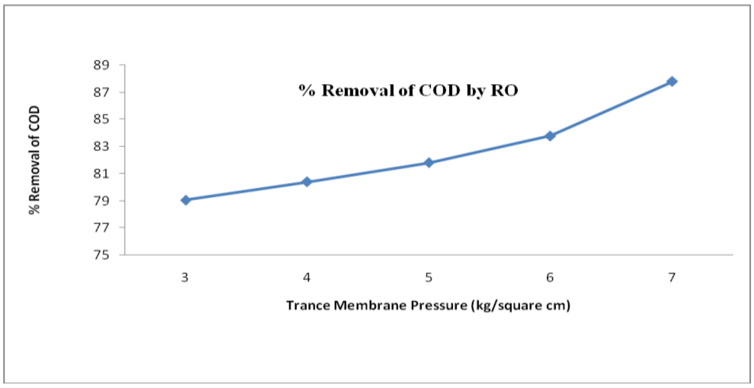

Figure 8: % Removal of COD by RO (Run 3)

From above experimental results it can be concluded that Membrane separation by reverse osmosis (RO) technique gives good COD removal efficiency and also reduces the concentration of heavy metals. The RO membrane gives removal efficiency of 80% to 90% as it is a tight membrane. As trance membrane pressure increases, the COD removal efficiency increases due to compaction of membrane. RO treatment reduces the concentration of all heavy metals below permissible disposal limit given by MSW-2000 Rules.

VI. CONCLUSION

Anaerobic inclined tube reactor for the treatment of MSW leachate was studied. The overall efficiency of reactor increases with increase in HRT and decreased with increase in loading rate. Also the maximum COD removal efficiency was found to be 90.5% at influent COD concentration of 16000 mg/l and HRT of 3 days. The reactor system can be loaded to maximum loading rate of 16 kg COD/m^3.d.Hence the study indicates that the treatment of MSW leachate in Anaerobic Inclined Tube Reactor is possible, but still does not agree with the disposal limits as mentioned in the MSW handling rules. Combination of anaerobic treatment of leachates followed by post treatment by reverse osmosis can be identified as a good treatment option for the leachates.

Future work: The work can be carried out at different operating parameters like various HRTs, Concentration, Also study can be carried out with different membranes .

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