International Journal of Environmental Engineering and Management.
ISSN 2231-1319, Volume 4, Number 5 (2013), pp. 439-444

http://www.ripublication.com/ ijeem.htm

# Leachate Treatment Technologies

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**Abstract**

Leachate is highly complex and polluted waste water that is produced by the introduction of percolation water through the body of landfill treatment. Leachate treatment is essential as it could threaten the surrounding ecosystem when discharge as it is and when it mixes with groundwater. This paper is a review of landfill leachate treatment methods. Advantages and drawbacks of various treatments are discussed. Various leachate treatment technologies like coagulation-flocculation, adsorption by activated carbon, biological treatment and reverse osmosis are reviewed and there treatment efficiency depending on operating condition of India is discussed. Finally due to an increase in strict rules and regulations leachate treatment plants do not reach the required specifications. The kind of leachate treatment technology should be chosen on the basis of specific situation.

**Keywords**: Leachate treatment, landfill, adsorption, coagulation, reverse osmosis, filtration.

## 1. Introduction

Landfills are dump yards without top and bottom impermeable layers. All types of wastes viz., Hazardous, Industrial and even biomedical waste are dumped in these yards whereas Leachate is any liquid that, in passing through matter, extracts solutes, suspended solids or any other component of the material through which it has passed, generally through the landfills. In India, the leachate is disposed of on open lands or is allowed to mix with some water body thus leading to a drastic increase in pollution level of the surrounding. The high value of COD of 6000-20000 mg/l, total solids of 24000-50000mg/l and high concentration of heavy metals in leachate of India raise

concern over its proper disposal and treatment system employed. This study is based on the currently used leachate treatment processes like biological treatment which involve treatment through aerobic and anaerobic bacteria, adsorption process on activated carbon, reverse osmosis and coagulation method with some modifications and their adaptability to Indian conditions.

## 2. Biological Treatment

Biological treatment is worldwide the most common practice for leachate treatment. Biological systems can be divided in anaerobic and aerobic treatment processes. Both can be realized by using different plant concepts.

In the following some of them are presented:

Anaerobic biological treatment: - Parts of the landfill body used as a reactor, anaerobic filter and anaerobic sludge bed reactor (UASB)

Aerobic biological treatment:-Aerated lagoons, activated sludge plants, rotating biological contactors (RBC), trickling filter sequential batch plant and co-treatment with sewage. [1]

Suitability under Indian criterion

- The main advantage of the anaerobic treatment processes the low energy requirement, because no oxygen has to be supplied [2]. Technical anaerobic processes need adequate temperatures of 35° C resp. 55° C. Since India has dry climate so basically useful under Indian criterion.[3]
- Aerated lagoons are a relatively simple leachate treatment system. The basic idea is that the retention time of the leachate is long enough so that as many bacteria can develop per time as the number that has been transported out of the lagoon with the effluent. Long retention times are also necessary in order to oxidize ammonia nitrification especially during low temperatures [4]. As India has high temp so here it requires less retention time.
- The detention time in activated sludge plants can be considerably shorter than in aerated lagoons. The reason is that the sludge content (amount of bacteria) can be controlled which is several times higher than in aerated lagoons [5]. It also requires a hot and humid climate which is their in India.

## 3. Treatment by Reverse Osmosis Method

High concentration of COD,BOD5,heavy metals,NH4---N, low BOD5/COD ratio and the lack of nutrients in the methanogenic phase have restricted the application of biological treatment processes according to the nature of leachate. Due to the development of organic and inorganic contaminants high rejection rate and the properly designed membrane either as a main step in a landfill leachate treatment chain or as single Post---treatment step has shown to be an indispensible means of landfill leachate treatment. The high rejection reverse osmosis can retain dissolved solids and metals to a widespread rang and the elimination rates can sometimes reach to 99%.Due

to the development of high rejection rate and the properly designed membrane modules, the use of reverse osmosis membrane either as a main step in a landfill leachate treatment chain or as single post treatment step has shown to be an indispensible means of landfill leachate treatment.

Suitability under Indian criterion

- Although reverse osmosis technology has superior removal for both dissolved organic and inorganic substances, the high level of suspended solids, colloids, dissolved organic and inorganic substances, the high level of suspended solids, colloids, dissolved organic matters (Humicsubstances, Fulvic acid—like materials), metal oxides, bacteria and their metabolites in landfill leachate can inevitable lead to the fouling of membrane after certain period of operation. Membrane fouling can even be cause the decline of permeate flux and increase of Trans membrane pressure. So making it a expensive method according to Indian criterion.[7]
- When salts concentration exceed their solubility (scaling) on the reverse osmosis feed side, precipitation of salts on the reverse osmosis membrane surface happens, which leads to the decline of permeate flux, the increase of trans-membrane pressure and demands frequent chemical membrane cleaning. Which require a lot of dewy technology which stubborn the situation of membrane which is not so effective in India. [8]

## 4. Adsorption Through Activated Carbon

Granular activated carbon (GAC) in combination with biological pretreatment is the leading technology for the treatment of landfill leachate for the removal of COD, absorbable organic halogens (AOX) and other toxic substances. Adsorption is the process by which molecules with particular characteristics of size and polarity are attracted and held to the adsorbing surface.[17] Advantages and disadvantages of this process are discussed below:

- However, activated carbon proves disadvantageous for large quantities without sustainable high COD removal efficiencies. Further, the effectiveness of carbon adsorption on the removal efficiency of COD and TOC in young leachate containing high volatile fatty acid content is dependent on the magnitude and proportion of the high and low molecular weight free volatile acid fractions in the leachate.[14]
- This method has several advantages – it doesn’t require precipitation and sedimentation steps; the activated carbon in granulated form could be further reused after thermal regeneration. The advantage of this process is the avoidance of the flocculation precipitation step in order to remove the powdered activated carbon, which in general also results in an increase in the salt content. It is use to reduce the concentration of hydrophobic substances which are difficult to remove by other methods.

- Activated carbon couldn't be used for residual phosphorous removal from the leachate, as phosphorous is poorly adsorbed on it. The treatment with adsorption process permits a suitable effluent for directly discharge, but high operating costs are significant issue that must be considered seriously.[18][19]

This method is not very suitable for Indian conditions as leachate quality of Indian landfills is very toxic thus resulting in lot of consumption of activated carbon making it an expensive affair.

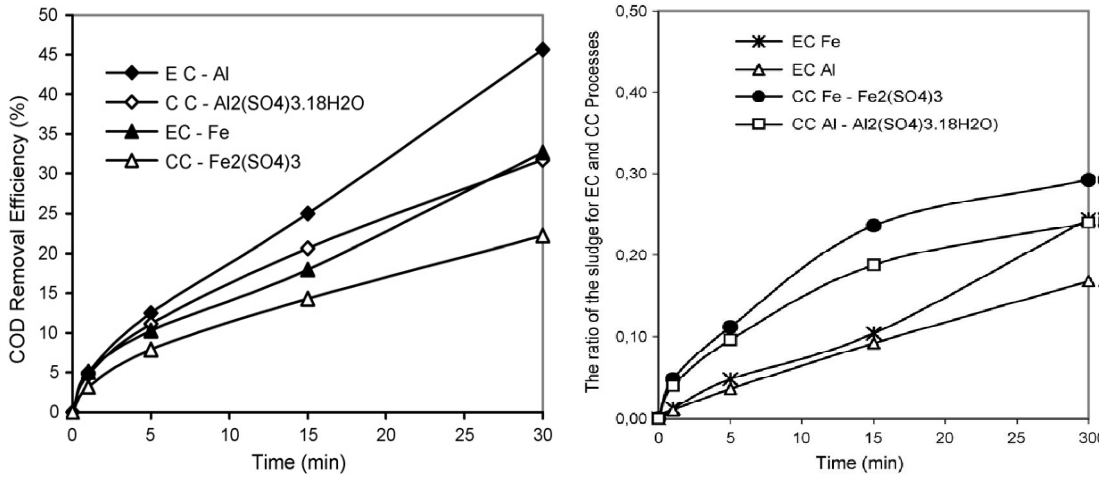
## 5. Coagulation and Flocculation

Coagulation-flocculation technique treats stabilized stage and old age leachate. The main objective of this process is the removal of organic compounds from the leachate. During coagulation process, sludge is produced depending upon the characteristics of the leachate and the pollutant removal efficiency. The removal mechanism of this process mainly consists of charge neutralization of negatively charged colloids by cationic hydrolysis products, followed by incorporation of impurities in an amorphous hydroxide precipitate through flocculation. [12] Following are the various coagulation methods:

1) The experimental study shows that coagulation with calcium hydroxide and alum can remove up to 69% and 54% COD and 99.9% and 94% turbidity from the leachate. Calcium hydroxide gave more removal of COD and turbidly. Ferric chloride and ferric sulfate are also used as coagulants now days.[10]
2) Hydrolyzing metal salt coagulants namely polyaluminum chloride (PACl) has higher coagulant efficiency and relative low cost compared to the conventional coagulants. Besides, PACI poses a good structure and higher charge density which leads to decrease in dosage requirements and hence lesser sludge production. The application of PACl as a coagulant for the removal of color, COD and ammonia from water and wastewater has been established. [9]
3) This technique, which is characterized by its simple equipment, easy operation, and decreased amount of sludge, the coagulant is generated by electrolytic oxidation of an appropriate anode material that leads, at an appropriate pH, to the insoluble metal hydroxide which is able to remove a large variety of pollutants These metal hydroxide species neutralize the electrostatic charges on suspended solids and oil droplets to facilitate agglomeration or coagulation and resultant separation from the aqueous phase.[11]

This graph shows the comparison between electro-coagulation metals and chemical coagulation compounds depicting the efficiency of electro coagulation.

PAC is a group of highly effective coagulants in water treatment that have replaced a large part of traditional aluminous coagulants because of low dosage, high efficiency, low cost and convenient usage. This process is very much suitable for Indian conditions due to high toxicity of waste in India and economically feasibility. Another advantage of this method is that it requires no pre-treatment of the leachate. [16]




## 6. Rotating Biological Contractor (RBC)

In the first phase of the aerobic system study, a cyclic-batch RBC system was used to select perforated acetate discs among three different acetate discs. These discs were selected on the basis of high COD removal (65%) and biological stability. In the second phase, the RBC's (using four stages) was operated continuously at different hydraulic retention times (HRT), at different rotational speeds, and with varying organic concentrations of the influent leachate (2500-9000mgL (-1)). 40% of the total surface area of each perforated disc was submerged in the leachate. A COD removal of about 52% is obtained at an HRT of 24h and a rotational speed of 6rpm. For the anaerobic system, the reactor was evaluated with a volumetric organic load of 3273g-COD m (-3) day (-1) at an HRT of 54, 44, 39, 24 and 17h. At these conditions, the system reached COD removal efficiencies of 62%, 61%, 59%, 44% and 24%.

It results in a removal up to 62% of COD. Even it is cheaper in operating it, so it is suitable for a developing country like India. However it requires infinitesimal amount of energy for running the operation. [20]

## 7. Conclusion

The risks of leachate generation can be mitigated by properly designed and engineered landfill sites, such as sites that are constructed on geologically impermeable materials or sites that use impermeable liners made of geomembranes or engineered clay. The use of linings is now mandatory in US and European countries. However despite much stricter statutory controls leachate from modern sites are found to contain a range of contaminants that may either be associated with some level of illegal activity or may reflect the ubiquitous use of a range of difficult materials in household and domestic products which enter the waste stream legally. We had emphasized on the treatment technologies that are suitable under Indian Criterion. And have finally come to a result

that India being a developing country those technologies which are cheaper and capable of treating the highly toxic waste. So from our study the most worthy technologies according to Indian standards are Coagulation and Flocculation, Biological treatment, Rotating Biological Contactor (RBC).

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