International Journal of Environmental Research and Development.
ISSN 2249-3131 Volume 4, Number 1 (2014), pp. 33-36
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http://www.ripublication.com/ijerd.htm

Membrane Technique for Leachate Treatment- A Literature Review

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Abstract

Rapid increase in population and industrialization leads to huge generation of solid waste throughout the country with landfilling as the most common practice for management of these solid waste. It is estimated that out of 3267 MLD of sewage is generated in Delhi. Concentrations of COD, BOD_5, heavy metals, NH_4AN, low BOD_5/COD ratio and the lack of nutrients in the methanogenic phase have restricted the application of biological treatment processes like aerated lagoons, activated sludge, sequence batch reactors, trickling filter, rotational biological contactors, thereby membrane technology is now days being used. Membrane filtration can be defined as the separation of solid immiscible particles from a liquid or gaseous stream based primarily based on size difference. It includes processes such as reverse osmosis (RO), nanofiltration (NF), ultrafiltration(UF) and microfiltration (MF). MF cannot be use alone in leachate treatment, used as pre-treatment for other membrane processes e.g. UF, NF or RO. MF alone, the COD removal is between 25-35%. Using the UF step alone 50% of organic matter can be separated. Nanofiltration removes up to 60-70% COD as well as about 50% ammonia from leachates while its combination with physicochemical methods further improves leachate treatment bringing the COD removal (refractory COD inclusive) to a range of (70-80%). Reverse Osmosis process has been reported to be a very efficient and promising method for leachate treatment. RO membranes can remove more than 99% organic macromolecules and colloids from feed water and up to 99% of the inorganic ions. Due to high rejection ability, reverse osmosis membranes retain both organic and inorganic dissolved in water with rejection rates of 98 - 99% thus being useful for purifying of liquid

wastes, i.e. leachate. Permeate generated from the reverse osmosis unit is low in inorganic and organic contaminants which meet the discharge standards.

1. Introduction

Due to rapid urbanization and uncontrolled growth rate of population, Solid Waste Management (SWM) has become acute in India. The waste characteristics are expected to change due to urbanization, increased commercialization and standard of living. Waste disposal is one of the major problems being faced by all nations across the world. It is more than a menace in our country. In Indian cities the waste is generally not weighed. It is measured by volume to determine the quantity of waste disposed. Several studies conducted by National Environmental Engineering Research Institute (NEERI) and other consultants have shown that the waste generation rates are low in smaller towns whereas they are high in cities over 20 lac population. The range is between 200 gms / capita / day and 500 gms / capita / day. Leachate is the liquid waste which leaches out from solid waste. It varies widely in composition regarding the age of the landfill and the type of waste that it contains. It can usually contain both dissolved and suspended material. In a landfill that receives a mixture of municipal, commercial, and mixed industrial waste, but excludes significant amounts of concentrated specific chemical waste, landfill leachate may be characterized as a water-based solution of four groups of contaminants dissolved organic matter (alcohols, acids, aldehydes, short chain sugars etc.), inorganic macro components (common cations and anions including sulfate, chloride, Iron, aluminium, zinc and ammonia), heavy metals (Pb, Ni, Cu, Hg etc.), and xenobiotic organic compounds such as halogenated organics. The physical appearance of leachate when it emerges from a typical landfill site is a strongly odoured black, yellow or orange colored cloudy liquid. The smell is acidic and offensive and may be very pervasive because of hydrogen, nitrogen and sulfur rich organic species. Biologically refractory organic constituents, ammonia, and heavy metals in leachate are three principal issues with regard to treatment and disposal. The organic content in leachate is usually described by COD, 5-day BOD, or total organic carbon (TOC). Generally, high COD (3000–60,000), high BOD5/COD ratio (> 0.6), a high fraction of low-molecular organics characterize leachate from young landfills (1–2 years old). In contrast, moderate COD (100–500 mg/L), low BOD5/COD ratio (< 0.3), and a high fraction of high molecular-weight organics characterize mature leachate from old landfills (> 10 years old).

2. Materials and Methods

Microfiltration membrane size ranges between 0.02-10 μm and size range of ultrafiltration between 0.001-0.02 μm. Nanofiltration size range is from 0.0001-0.005 μm and for reverse osmosis it varies from 0.0001-0.003 μm.

3. Result and Discussion

Leachate consists of many different organic and inorganic compounds that are typically either dissolved or suspended in the wastewater. High concentrations of chemical oxygen demand (COD) associated, BOD, nitrogen, phenols, pesticides, solvents and heavy metals are common in these systems. Due to these characteristics leachate treatment technologies fall into these basic types biological and physicochemical and membrane process of treatment.

Biological treatment is firmly established as the standard method of waste treatment for some wastes. Biological purification processes can be aerobic type or anaerobic depending on whether or not the biological processing medium requires O_2 supply.The Moving Bed Biofilm Reactor (MBBR) is a highly effective biological treatment process that was developed on the basis of conventional activated sludge process and bio filter process. The most notable developments in anaerobic treatment process technology was the upflow anaerobic sludge blanket (UASB) reactor in the late l970s in the Nether-lands by Lettinga and his coworkers. Membrane filtration is used to remove particles that are too small for ordinary filters to remove. Most membrane filtration systems use cross flow filtration where the feed waste liquid flows across the membrane rather than through it, as in conventional filtration. The common membrane materials used for this process are Polysulfone (PSUF), Dynel, Cellulose acetate (CA). In nanofiltration process the membrane used also has Asymmetric micro porous structure. The size is in the range of 0.01–5nm. The driving force applied at pressure 5–50atm and sieving mechanism followed. The common membrane material used for this process is Polyvinylidene fluoride (PVDF).

The biological treatment processes including the aerobic and anaerobic treatment provide a good to average treatability for young to not so old leachates but are affected by excess biomass. The physio-chemical treatment processes have an average effect on the treatment of heavy metals and organic waste. The coagulation flocculation treatment process has average removal efficiency of heavy metals for medium to old leachates with high sludge production and consequent disposal. The chemical precipitation gives the same results for medium aged leachate. Adsorption gives a good result in removal of organic wastes from old leachates but with carbon fouling problem and is expensive too. The UASB technology needs constant monitoring when put into use to ensure that the sludge blanket is maintained, and not washed out (thereby losing the effect) UASB reactors, when they are submitted to high volumetric organic loading rate values, have exhibited higher performances compared to other kinds of anaerobic reactors. The membrane filtration processes provides an efficient removal technique for sulphate salts and ions, organic and inorganic compounds, but are costly. The nanofiltration process is effective in removing sulphate salts and ions, while reverse osmosis is good in removing of organic and inorganic compounds but require pretreatment. Activated sludge is not efficient for compounds with MW higher than 5000 and nutrients additions may be required. Trickling filter requires a clarifier for sloughed off solid and oxygen transfer is a Iimiting factor for BOD> 450 mg/l.

Activated carbon Adsorption necessitate regeneration of carbon or it is wasted with the sludge.

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