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Advance Treatment of Leachate Generated from Solid Waste

Rahul Gupta[1], Farhin Khan[1*] and Dr. Sarita Sharma[2]

[1]*Assistant Professor, Department of Chemical Engineering, Indore Institute of Science and Technology, Indore*

[2]*Professor, Department of Chemical Engineering, Ujjain Engineering College, Ujjain*

Abstract

As we all know that several of tons municipal solid waste (MSW) is generated in India per year which is very difficult to handle and treat. Organic and inorganic waste, e-waste, used papers, wood, plastic glass, leather, rubber etc. comes under the municipal solid waste (MSW). For the treatment of the MSW we use landfill method which causes threat to the water bodies, eventually harming the environment, ecosystem as well as living beings. The most common and most focused studies observed in many technical papers related to this problem mostly deals with the management and treatment efficiency of solid waste leachate. This review paper aims to put forward an overview of solid waste leachate, it's characteristics, composition, contaminants to the ground water, effects on mankind and environment, current scenario of landfill technology in India, various treatment methods.

Keywords: Biogas; electricity; landfill; leachate; treatment; solid wastes.

1. Introduction

Excessive generation of Solid waste leachate and its handling and treatment is one of the most common problem arises during disposal for solid waste. It can be defined as a method of disposing of wastes on lands without creating bother or risk to health or safety of the people. The solid waste leachate can cause severe impacts on the environment as well as human health. These wastes include mainly biodegradable wastes, composite wastes such as clothing, electronic and electronic wastes such

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as wires and cells, medical wastes and hazardous wastes like paints, chemicals, sprays. The biodegradable wastes like garden waste and food waste contains a little amount of moisture in it. This moisture present in municipal solid waste leads to the generation of leachate, commonly known as "solid waste leachate." (Ayilara et al.; 2020). Other than this, it normally comes from rain water or melting of snow. Leachate is mostly formed through:

- Decaying of the organic matter, either aerobically or anaerobically.
- Oxidation of waste materials chemically.
- Emission of various gases from the landfills.
- Disintegrating and draining of organic and inorganic waste matter by water and leachate transporting through the land.
- The flow of disintegrated matters by osmosis and concentration gradients (Akram et al.; 2018).

Leachate is commonly considered as an extremely contaminating liquid because it is consisting of high concentration of suspended organic compounds, inorganic compounds, and heavy metals having high biological oxygen demand (BOD) and high chemical oxygen demand (COD) (Schiopu and Gavrilescu 2010). It contains a mixture of chemicals due to the diverse nature of the waste and is undoubtedly the worst contaminants to aquifers as if emitted, it can release a combination of pollutants to the groundwater through transportation of leachate, mostly for the unlined and no collection of leachates and destroying system landfills. The solid waste leachate pollutes the water bodies by three ways: (a) the seeping of leachate in land contaminates groundwater; (b) the outward flow results in leachate leaks out at the verge of the landfill that affects water sources at the surface; (c) polluted groundwater discharge to surface water (Fatta et al,;1999). Since solid waste management becomes an essential issue and the leachate is considered as very hazardous substance, this study is done to list out some efficient ways to minimize its effects on the environment.

1.1. Characteristics

The effect of environment in terms of the quality of water stored in different water sources depends on the characteristics of solid waste leachate. The calcium content and alkalinity of leachate from active landfills depends on the waste matter disposed, moisture content and its age. Ash monofill leachates generally have high calcium concentration while municipal solid waste leachate when combined with combustion residue are more alkaline. These leachates are more likely to form mineral precipitate as they have enough quantities of substances which can act as a co precipitate like calcium, iron, magnesium and sulphate (Levine et al.; 2005).

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1.2. Indian Scenario of Leachate Treatment Technology

Scientific strong waste landfills lessen the chances of waste leaching beneath the ground as the base layer is constructed of 90m of clay, consequently arresting any seepage or leakage in the landfill. On top of the bottom layer, a drainage layer fabricated from soil, measuring 15m in period and a vegetative layer of 45cm to decrease soil erosion. The life of these layers guarantee that the leachate is amassed before it leaches into the ground. Delhi, is considered one of India's biggest municipal stable waste turbines which have been reeling with the problem of landfills for years. The predominant problems in creation of clinical landfills across India is being accessibility of land, technical expertise and availability of money for established order. It's so unlucky that majority of personal agencies are not wanting to invest within the production of clinical landfills. Also, number of engineers with proper know-how of growing above noted base layers of scientific landfills are much less. Thinking about land required for the development of clinical landfills turned into undetermined until recently, the quantity of engineers or know-how with technical knowledge of improvement stays comparatively much less.

1.3. Composition of Leachate and their Negative Impact on the Environment

The composition of leachate depends on some factors, like properties of waste products, their location, seasons and climate conditions, age and structure of landfill, recollection time of waste at incineration plants, modes of operation of transfer stations, etc. Commonly, very low concentrations of heavy metals are observed in leachate. Comparatively, ammonia concentration does not decrease and often add up to a major long-term pollutant in the leachate (Jase et al.; 2014). MSW landfill leachate pollutants are classified into four different groups:

a) Dissolved organic matter, measured as COD/TOC, volatile fatty acids that are collected through the waste stabilization in acidic phase and various refractory compounds like fulvic and humic-like compounds.
b) Inorganic macro components: NH_4^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, Na^+, Cl^-, K^+, SO_4^{2-}, Mn^{2+} and HCO_3^-.
c) Heavy metals: Cd^{2+}, Zn^{2+}, Cr^{3+}, Ni^{2+}, Cu^{2+} and Pb^{2+}.
d) Xenobiotic organic compounds which are derived from homely or commercial chemical matter and are present in comparatively low concentrations. These compounds include among others a different variety of phenols, aromatic hydrocarbons, pesticides, chlorinated aliphatic and plasticizers (Kamaruddin et al.; 2017).

Other chemical compounds can be observed in leachate from landfills such as Co, BO_3^{3-}, Ba, SeO_4^{2-}, H_2S, Li and Hg. Commonly, they are found in little concentrations and are not the main concern.

In a well-managed landfill site with composite liners, the obstruction tends to get damaged with time, hence leachate possibly can get leaked and discharge through the soil. Inorganic cations and

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anions like Ca2+, Na+, Cl-, SO43-, etc. leach through the leachate and mix into the groundwater and soil. These inorganic compounds are not adapted by the type of the soil and remain as a contaminant of both the water and the soil (Guangyu 2011). Zinc, which is generally present in the upper layer of the soil and iron has the highest rate of separation. The exposure of leachate in soil decreases its hydraulic conductivity resulting in soil clogging and this can differ the properties of the soil such as water retention, field capacity, many more. The soil microbial community gets altered and the emergence of biofilms with metal precipitation may start occurring (Leuther *et al.;* 2019).

2. Description and Evaluation of Leachate Treatment Methods

Technologies that are meant for the treatment of leachate can be categorized as: 1. biological, 2. Physicochemical methods and 3. membrane technology.

2.1. Biological Treatment Methods-

(a) Rotating biological contactors- Rotating biological contactor, also known as rotating biological filter is an example of biological filter technology. It consists of a sequence of plastic disc parallel to each other mounted centrally on a common horizontal rotating shaft which is supported just above the surface of wastewater so that the discs are approximately half immersed. These discs are about 40% immersed in a tank consisting waste water and then they are slowly rotated by a mechanical or a compressed air drive. Microorganisms from the wastewater grow on the surface of the discs, within and rotation of the shaft brings them into contact with the liquid allowing the digestion of the organic matter. As the discs start to rotate out the waste water, the biofilm gets oxygenated as they get exposed to air, the pollutants are decomposed aerobically. When the discs reach a specific critical thickness and new microorganisms grow on it, some portion of that biofilm falls off from the disc. (Wiszniowski et al.; 2006).

(b) Aerobic activated sludge- In this method, a variety of microorganisms with organic matter and oxygen is regularly supplied in a reactor tank. This organic matter and oxygen are directly consumed by the microorganisms and transform it into a purified effluent (microbial biomass, CO2, minerals and water) with the help of aerobic metabolism. These microorganisms form particles that are clump together also known as flocks. These flocks slowly settle down in the tank and hence they are easily removed from the tank. The removed part of the sludge is again processed to provide biomass for the treatment of the new influent. This method is mostly used for the domestic wastewater treatment. Organic carbon, ammonia content, and nutrients can be effectively removed through this process (Wiszniowski et al.; 2006).

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2.2. Physicochemical Methods-

(a) Flotation- Flotation utilizes the capability of some compounds to float on the surface of the leachate by themselves or with the help of air bubbles from below. Floatation has been mostly used for removal of ions, colloids, fibers, microorganisms and macromolecules. However, recently an investigation has been carried out for the observation of outcome of this process for the removal of humic acid (non-biodegradable compounds) from landfill leachate after biological treatment. Which showed efficiency in treatment by reaching almost 99% of humic acid removal (Wiszniowski et al.; 2006).

(b) Coagulation Flocculation- In this process, the attraction between the particles is increased so that they can aggregate together forming heavy floc that can settle down in the tank. Compounds like ferrous sulphate, aluminum sulphate, ferric chloro-sulphate and ferric chloride are used as the coagulants in the process. This process may be successfully used in the treatment of stable and old landfill leachate. This process is basically a pre-treatment process. For COD removal from new or young leachate is about 25-38% effective while for aged or stable leachate with low concentration of COD/BOD, it is about 75% effective (Wiszniowski 2006).

2.3. Membrane Technology-

Membrane technology in the treatment of leachate is one of the applications of membrane materials used for physicochemical processes. The main objective of this process is to separate two solutions with variant concentrations by the help of a semipermeable membrane. The semipermeable membrane acts like a barrier between the two solutions where pressure is induced on the more concentrated liquid (leachate), this pressure forces the water to one of lower concentration while majority of the leachate compounds are reserved. The retention capacity depends on the membrane. Some of the examples of membrane treatment are: reverse osmosis (RO), micro-filtration (MF), ultra-filtration (UF), Nano-filtration (NF) (Eaux 2015).

3. Conclusion

MSW landfill is one of the significant problems for the municipal corporation of India. The leachate which is being generated through these landfills should be treated before exposed in the environment. Various treatment methods have been reviewed in this paper like physicochemical processes, biological processes as well as membrane technology. The paper has briefly reviewed a sustainable approach for treatment of landfill leachate which is, the generation of electricity in microbial fuel cell. Construction of scientific landfills is also an effective major for minimizing its effects on environment. In order to minimize its negative impacts on the environment, the proposal of optimal treatment methods is one of the biggest challenges. Landfill leachate composition varies according to the time and site. In order to overcome this, an easy and universally adaptable technique is required.

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