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Leachate Characteristics and its Treatment Techniques - A Review

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Abstract. The issue of waste management has existed since the dawn of time. The remark discovered in Old Testimony is most likely the first written guideline on waste management. Municipal waste landfilling is a key problem in the waste management system. Before being discharged into the environment, the generated leachate must be properly treated. There are mainly two types of leachate treatment technologies: (i) Biological methods, (ii) physical and chemical methods. Here's a brief overview of the basic procedures for treating landfill leachates that are currently in use.

Keywords. Waste management; Leachate; Biological methods; Physical and chemical methods

1. Introduction

Our environment is deteriorating day by day as a result of fast industrialization and population growth. Sanitary landfill leachate is a polluted effluent that is extremely complicated. Its quality is determined by biological, chemical, and physical processes in landfills, as well as the waste composition and water regime in the landfill. Leachate treatment efforts rise in tandem with rising leachate effluent quality criteria. Liquid waste leachate is formed during the stabilization of a landfill by the dynamic breakdown of wastes and infiltration of water into the landfill, primarily through precipitation [1]. Leachate is a complicated effluent with a high potential for pollution, causing serious environmental issues such as soil and groundwater pollution, as well as human health threats [2].

1.1. Factor responsible for the Generation of leachate

Leachates from landfills are generated by a number of factors, such as:

- Infiltration of leachate into the ground (potential pollution of the groundwater may occur).
- Rainfall (precipitation).
- Infiltration of groundwater.
- Evaporation from the site.
- Water from the deposited waste, mainly due to the static pressure.

1.2. Effects of leachates on human health

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If local governments do not take the necessary efforts to line landfills and drain off leachates, residents living near landfills risk suffering a variety of health concerns. When water travels through inadequately placed waste and percolates to the ground, harmful compounds taken from the waste contaminate the groundwater.

1.3. Composition and Characteristics of leachate

Leachate typically contains substantial volumes of organic matter (biodegradable but refractory to biodegradation), as well as ammonia, nitrogen, heavy metals, chlorinated organic and inorganic salts, all of which pose a significant risk to the surrounding soil, groundwater, and even surface water. The pollutant components of leachate can be categorized into four categories. COD (chemical oxygen demand) and TOC (total organic carbon), as well as specific organic molecules, inorganic compounds, and heavy metals, are all examples of organic matter. The organic content of leachates, on the other hand, is frequently determined by a combination of metrics such as COD, BOD (biochemical oxygen demand), TOC, and dissolved organic carbon. All of these elements are taken into consideration using a simplified water balance equation, which allows designers to estimate the quantity of leachate that will be produced by the landfill. [3] created this equation in particular: $L = P - R - DUs - ET – DUw$. Where L is leachate production, P is precipitation, R is a surface run-off, Us is changing in soil moisture, ET is the actual evaporative losses from the bare-soil, *Uw* is the change in the moisture content of the refuse components.

Landfills are divided into three categories: young (less than five years), intermediate (5-10 years), and old or stabilized (more than 10 years). Table 1 shows the usual features of leachate based on landfill age. The typical chemical concentrations in young and old landfill leachates compared with sewage and groundwater are also shown in Table 2 adopted from [4].

Table 1. Characteristics of leachate at different ages of landfill

Parameter	Young	Intermediate	Old
Age (years)	< 5	5-10	>10
pH	6.5	6.5-7.5	>7.5
COD (mg/l)	> 10,000	4,000-10,000	<4,000
BOD5/COD	> 0.3	0.1-0.3	<0.1
Organic compounds	80% volatile fat acids (VFA)	5-30% VFA+ humic and fulvic acids	Humic and fulvic acids
Heavy metals	Low-medium	Low	Low
Biodegradability	Important	Medium	Low

Table 2. Typical concentrations in landfill leachate compared with sewage and groundwater

Parameters	Young leachate concentration	Old leachate concentration	Typical sewage concentration	Typical groundwater concentration
COD	20,000-40,000	500-3,000	350	20
BOD5	10,000-20,000	50-100	250	0
TOC	9,000-25,000	100-1,000	100	5
Volatile fatty acids	9,000-25,000	50-100	50	0

2. Methodology

2.1. Leachate control and Treatment

It is exceedingly expensive to clean up contaminated groundwater. The Department of Water Affairs

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and Forestry's Minimum Requirements for Waste Disposal by Landfill provides detailed information on landfill liner designs for various landfill types. Leachate collection systems are installed above the liner and usually consist of a piping system sloped to drain to a central collection point where a pump is located. Once the leachate has been collected and removed from the landfill, it must undergo some type of treatment and disposal [5].

Biological and physical/chemical leachate treatment processes are the most common. Landfill leachate can be mixed with incoming wastewater and treated biologically, physically, and chemically at a sewage treatment plant. Because the best overall treatment efficiencies are generally achieved by removing the inorganic constituents first, and then the organic constituents, biological treatment can be preceded by physical or chemical treatment of the organic constituents to make the liquid more acceptable for biological processing [6].

2.2. Biological treatment processes

Biological treatment involves maintaining the conditions required for optimal growth of the microorganisms involved, regardless of the kind of wastewater. Microorganisms transform colloidal, dissolved carbonaceous organic materials and inorganic elements like N, P, S, K, Ca, and Mg into cell tissue or/and gases. The standard treatment strategy for industrial effluents or leachate. Different process design and/or operational control factors must be considered depending on the wastewater and the standards that must be satisfied [7].

2.2.1. Anaerobic treatment

During the period of high organic concentrations in leachates from a landfill's acidogenic phase, an anaerobic treatment step could be used to reduce major quantities of degradable organics. The main benefit of the anaerobic treatment method is that it requires very little energy because no oxygen is required. Temperatures of 35 °C to 55 °C are required for technical anaerobic operations [8].

2.2.2. Aerated lagoons and activated sludge plants

Aerated lagoons are a simple solution for treating leachate. The underlying idea is that the leachate's detention period is long enough for as many bacteria to grow per unit of time as were transported out of the lagoon with the effluent. Long retention times are also required to oxidize ammonia nitrification, which is particularly important at low temperatures. The costs of maintenance and operation are low. The required detention periods are in the range of 50 to 100 days [3].

In activated sludge plants, the detention time is typically much shorter than in aerated lagoons. The reason for this is that the sludge content (amount of bacteria) can be managed, but in aerated lagoons, it is several times higher. Installing a settling tank behind the aeration tank and recirculating the sludge into the activated sludge tank accomplishes this [5].

2.2.3. Rotating biological contactors (RBC) and trickling filters

The bacteria are linked to the material of the spinning contractors or the fillers in the trickling filters, which distinguishes these plants from activated sludge plants. The rotating contactor is partially in the air and partly in the water. Air can be vented naturally or through a trickling filter. This kind of treatment uses a small quantity of energy. Treatment of high-organic-polluted leachates may result in blockage due to organic precipitates and/or biomass production. However, because to the high sludge age, nitrification processes are often more effective in fixed film reactors. As a result, these treatment approaches are better suited to treating leachate from existing landfills. RBCs are compact and usually coated, temperature impacts are easier to control [1].

2.3. Physico-chemical techniques

When the biological oxidation process is inhibited by the presence of bio-refractory materials, Physico-chemical techniques are employed in conjunction with biological methods to improve treatment efficiency.

2.3.1. Coagulation–flocculation

Several studies focused on coagulation-flocculation for the treatment of landfill leachates with the goal of improving performance, such as selecting the best coagulant, determining experimental settings, assessing the pH effect, and investigating flocculent addition. Coagulants such as aluminum sulfate, ferrous sulfate etc, are often employed, and adding flocculants to coagulants improves the floc-settling rate [1]. In addition, Adsorption and Membrane processes are some of the physio-chemical techniques that are also employed to improve the treatment efficiency.

3. Conclusion

The problem of leachate treatment has persisted in various countries for some time, but no uniform solution has been established. The following are the different types of leachate treatment technologies: (i) biological processes, (ii) chemical and physical processes. However, in order to achieve stringent quality standards for direct leachate discharge into surface water, integrated treatment systems, which include a combination of chemical, physical, and biological stages, must be developed.

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Conflict of Interest

The author declares that there is no conflicting interest in the paper.

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