Journals Pub

International Journal of
Water Resources Engineering

ISSN: 2456-1606
Volume 11, Issue 1, 2025
January–June
DOI (Journal): 10.37628/IJWRE

https://journalspub.com/journal/ijwre/

Case Study IJWRE

Treatment of Leachate by Using Solid Waste

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Abstract

Leachate, a hazardous liquid from landfill decomposition, is a significant environmental challenge worldwide. Traditional collection of solid waste: Gather the solid waste material you want to generate leachate from. This waste could include organic matter, plastics, paper, and other materials commonly found in municipal solid waste. Sorting and compressing: Depending on the initial state of the waste, you may need to shred or crush it to increase the surface area available for leaching. This step helps to expedite the leaching process. Placement in a leaching chamber or tank: Place the shredded waste material in a container specifically designed for leaching. This could be a leaching chamber, tank, or any other suitable vessel. The container should be equipped with a drainage system at the bottom to collect any leachate. However, certain methods often involve complex and expensive processes, making them unsustainable over time. Biochar, a carbon-rich material derived from biomass pyrolysis, has gained interest as a sustainable and cost-effective solution for leachate treatment. This paper reviews the current research on biochar's application in treating leachate, exploring its mechanisms for adsorption and filtration. Factors influencing biochar's efficiency include feedstock type, pyrolysis conditions, surface functional groups, and pH. The paper also addresses potential challenges and limitations, such as scale-up, regeneration, and disposal of spent biochar. Despite these, biochar shows promise as a sustainable solution for leachate treatment, offering advantages like low cost, abundant raw materials, and carbon sequestration potential. Future research should focus on optimizing biochar-based systems, improving understanding of mechanisms, and developing innovative large-scale implementation approaches. Biochar's versatility and eco-friendliness makes it a promising avenue for addressing environmental pollution and promoting sustainability in waste management practices.

Keywords: Environmental impact, solid waste, contamination, heavy metals, organic pollutants, nutrient compounds, water quality, soil contamination, traditional treatment methods, chemical coagulation, advanced oxidation processes, membrane filtration, biochar, pyrolysis, adsorption

INTRODUCTION

Leachate is a complex and highly contaminated liquid formed through the decomposition of organic materials in solid waste. It poses a significant environmental risk due to its ability to percolate into the surrounding soil and water bodies, carrying harmful substances, such as heavy metals, organic pollutants, and excessive nutrients.

These pollutants can cause the deterioration of water quality, contaminate soil, and result in negative ecological consequences.

Traditional methods for treating landfill leachate often involve energy-intensive and complicated techniques, such as chemical coagulation, advanced oxidation processes, or membrane filtration. While these approaches can be effective, they frequently come with challenges related to high operational costs, energy demands, and potential secondary pollution, making their long-term application less sustainable [1–3].

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Received Date: December 15, 2024
Accepted Date: January 26, 2025
Published Date: February 01, 2025

Citation: Bangal Akhil, Amaan Panwar, Rani Khengare. Treatment of Leachate by Using Solid Waste. International Journal of Water Resources Engineering 2025; 11(1): 43–49p.

In recent years, biochar has gained attention as a promising and eco-friendly alternative for leachate treatment. Derived from the pyrolysis of biomass under oxygen-limited conditions, the biochar possesses a highly porous structure with an extensive surface area, making it highly effective in absorbing a wide range of contaminants. These include heavy metals like lead and cadmium, organic pollutants, such as phenols, and nutrient compounds like ammonium and nitrate [4–7].

The advantages of biochar over conventional leachate treatment methods are manifold. It is derived from renewable and readily available raw materials, making it an affordable solution. Moreover, its production can contribute to carbon sequestration, as it locks carbon into a stable form that can remain in the environment for decades or even centuries. Additionally, biochar can be seamlessly integrated into existing waste management systems, providing a practical and scalable solution for addressing the environmental challenges associated with solid waste disposal.

LITERATURE SURVEY

To better understand the potential of biochar and other treatment methods for landfill leachate, a thorough review of existing literature was conducted.

Environmental implications of landfill leachate emphasize the critical need for effective treatment methods to mitigate its impact on ecosystems.

Various techniques for leachate treatment focus on ammonia removal and recovery, highlighting the potential for resource recovery from leachate while reducing its environmental footprint.

Comparative analysis of coagulation and electrocoagulation processes for treating landfill leachate offer insights into the efficiency and limitations of these conventional methods.

The application of microalgae for leachate treatment reveals its potential as a sustainable biological approach for pollutant removal.

Studies on the treatment of municipal solid waste landfill leachate provide data on the effectiveness of different treatment technologies.

Optimizing conventional Fenton and photo-Fenton processes for landfill leachate treatment highlights their applicability in improving the efficiency of leachate management.

Research on the effects of landfill leachate application on crop growth and pollution evaluation emphasizes the need for innovative and sustainable solutions.

Investigations into chemical variations in landfill leachate provide foundational knowledge on its composition and behavior over time.

By leveraging advanced materials like biochar and integrating them into waste management practices, societies can address the pressing issue of landfill leachate in a cost-effective and environmentally sustainable manner. This method promotes the long-term preservation of natural resources and minimizes the environmental impact of waste disposal practices.

PREPARATION OF LEACHATE

Collection of Solid Waste

Gather the solid waste material you want to generate leachate from. This waste could include organic matter, plastics, paper, and other materials commonly found in municipal solid waste.

Sorting and Compressing

Depending on the initial state of the waste, you may need to shred or crush it to increase the surface area available for leaching. This step helps to expedite the leaching process.

Placement in a Leaching Chamber or Tank

Place the shredded waste material in a container specifically designed for leaching. This could be a leaching chamber, tank, or any other suitable vessel.

The container should include a drainage system at the bottom to collect the leachate.

Water Application

Water should be added to the container with solid waste. The amount of water added depends on factors like the type and quantity of waste, as well as the desired leachate concentration. Generally, enough water should be added to saturate the waste material.

Agitation or Stirring (Optional)

If possible, agitate or stir the mixture to enhance the contact between the water and the solid waste. This helps in accelerating the leaching process by facilitating the transfer of contaminants from the waste to the water.

Allow Leaching to Occur

Let the mixture sit undisturbed to allow leaching to occur. The length of this step can vary based on factors like the composition of waste, temperature, and level of agitation.

Collection of Leachate

As water percolates through the waste material, it will dissolve and carry away various contaminants, forming leachate. Collect the leachate from the drainage system at the bottom of the container [9, 10].

PRE-TESTING ON LEACHATE

pH Testing on Leachate

Testing the pH of leachate is crucial for assessing its acidity or alkalinity. As the liquid that drains from landfills or waste disposal sites, leachate’s pH level can influence its environmental impact and safety. Here’s how pH testing on leachate is typically done.

Conductivity Test on Leachate

Conductivity testing is a valuable method for assessing the electrical conductivity of Leachate (Figure 1).

METHODOLOGY

The Chemical Oxygen Demand (COD) test is an important method for evaluating the organic content and pollution level in leachate. Leachate, which originates from landfills or waste disposal sites, contains various organic and inorganic compounds. Here is how the COD test is typically conducted.

Biochemical Oxygen Demand (BOD) Test on Leachate

The Biochemical Oxygen Demand (BOD) test is a crucial method for assessing the organic content and pollution level in leachate. Leachate, which originates from landfills or waste disposal sites, contains various organic and inorganic compounds. Here is how the BOD test is typically conducted.

Treatment of Leachate by Using Biochar

Leachate treatment was an essential process. In older landfills, or those without a membrane separating the waste from the underlying geology, leachate can escape from the waste and flow directly into the groundwater. As a result, high concentrations of leachate may contaminate the surrounding environment. Initially, leachate can be black, anoxic, and may even contain dissolved gases. Over time, as it becomes oxygenated, it changes to a brown or yellow color due to iron salts in suspension. It also fosters bacterial growth, often leading to the development of sewage fungus. To prevent these issues, leachate treatment methods have been developed. Many landfills now use “temporary capping geomembranes” to prevent precipitation and mitigate landfill gas odors. These temporary membranes are more cost-effective than traditional 40 or 60 mil products and help reduce precipitation from entering specific areas of the landfill.

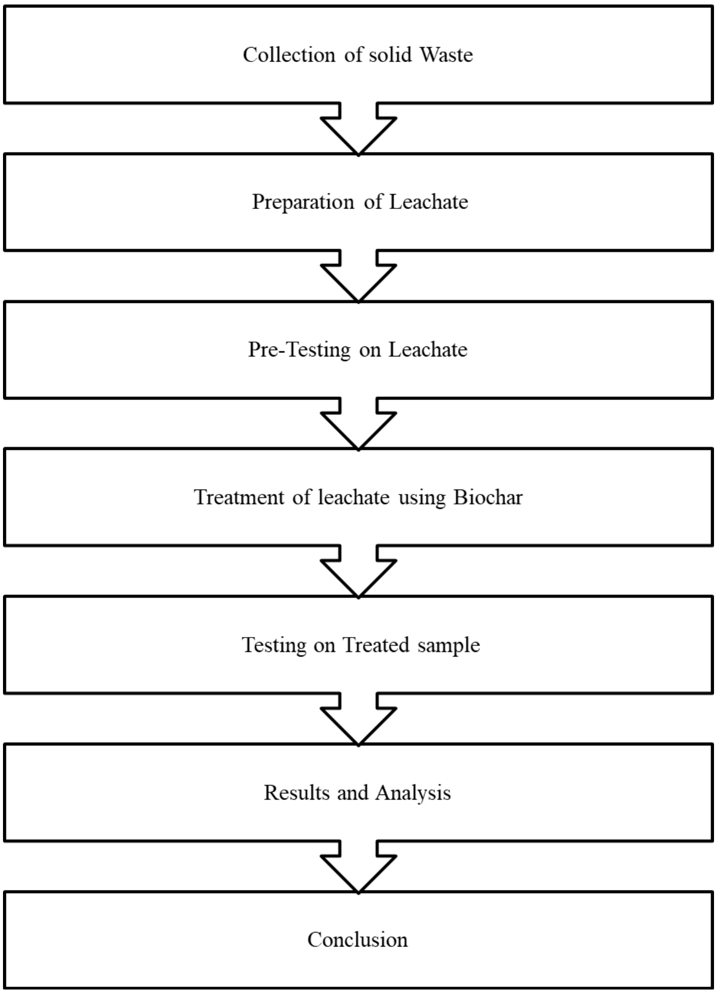

Figure 1. Methodology graph Chemical Oxygen Demand (COD) test on Leachate.

Method of Leachate Treatment

There are several methods for leachate treatment, including physical treatment, chemical treatment, and biological treatment.

Use of Biochar in Filtration

Biochar is a carbon-dense substance created by heating organic biomass in a low- or zero-oxygen environment, a process known as pyrolysis. It has unique properties and characteristics that make it valuable for various applications, including soil amendment, carbon sequestration, and environmental remediation. Here are some key properties and characteristics of biochar (Figures 2–9):

Construction of Filter

Filled the remaining volume with Leachate rate of filtration = 70 ml/hr.

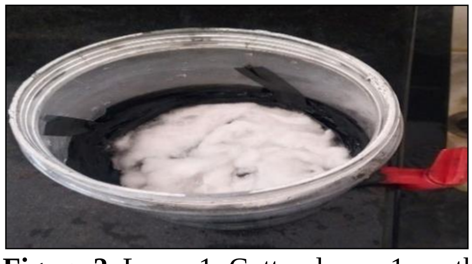

Figure 2. Layer 1: Cotton layer: 1 cm thick.

Figure 3. Layer 2: Sand layer: 2 cm thick (<4 mm).

Figure 4. Layer 3: Biochar layer: 3 cm thick (<4 mm).

Figure 5. Layer 4: 2 cm thick sand layer (<4 mm).

Figure 6. Layer 5: 4 cm thick biochar layer (4–10 mm).

Figure 7. Layer 6: Topmost layer of gravel size 10–20 mm.

Rate of filtration = 70 ml/hr.

Figure 8. Filtered sample from biochar filter Filled the remaining volume with Leachate.

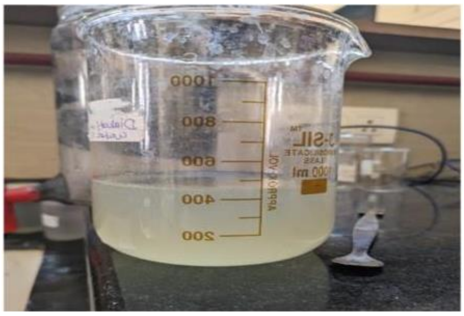

Figure 9. Filtered sample from biochar filter.

Results are shown in Tables 1 and 2.

Table 1. Observations before treatment.

S.N.	Name of Test	Observations	Unit	Range
1	pH	5	–	4.2–7.8
2	BOD	4548	mg/l	2000–68000
3	COD	9984	mg/l	2740–152000
4	Conductivity	7.5	µ/cm	5.8–52
5	BOD/COD	0.45	–	–
6	TDS	660	mg/l	500–50000
7	TSS	60	mg/l	10–5000
8	TS	720	mg/l	500–50000

Table 2. Observations after treatment.

S.N.	Name of Test	Observations	Unit	Permissible Limit
1	pH	6.8	–	6.5–8
2	BOD	36	mg/l	<50
3	COD	960	mg/l	<500
4	Conductivity	4	µ/c m	3.5–5.8
5	BOD/COD	0.03	–	–
6	TDS	180	mg/l	–
7	TSS	36	mg/l	–
8	TS	216	mg/l	–

CONCLUSIONS

- Concluding the project on the treatment of leachate using biochar, it is evident that biochar holds significant promise as a sustainable and effective solution for mitigating leachate pollution.

- Through comprehensive experimentation and analysis, its remarkable ability to adsorb contaminants were observed, thereby reducing the organic and inorganic load in leachate. The findings underscore the potential of biochar as a cost-effective, eco-friendly alternative to conventional treatment methods.
- Not only does it offer a means to address the environmental challenges posed by leachate, but it also presents opportunities for waste valorization by utilizing organic residues for biochar production.
- From the above results, it can be concluded that Biochar removes 80–100% of biological oxygen demand (BOD) and 80–100% of chemical oxygen demand (COD) which can be considered as most economical method of leachate treatment.
- The BOD/COD ratio of biochar is 0.03 with respect to the depth of 10 cm.
- It can be concluded that Biochar is a better material for the treatment of leachate to prevent harming ground water, soil and atmosphere for lining in a filter media.
- In conclusion, the application of biochar for leachate treatment holds tremendous potential for addressing environmental pollution while promoting sustainable resource management. By harnessing the inherent properties of biochar, we can strive towards a cleaner, healthier environment for the current and future generation.

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