Treatment of Leachate by Phytoremediation technique using Marigold and Colocasia Plants

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Abstract. Treatment of leachate is an important aspect in solid waste management and treatment system. A sustainable and economical method called phytoremediation makes use of plants to remove, degrade, or stabilize contaminants from polluted wastewater. In this work, the phytoextraction of zinc and copper from landfill leachate by Marigold and Colocasia plant is carried out. The efficiency of Marigold and Colocasia in the treatment of leachate is examined in this study. The findings demonstrated that plants greatly lowered the level of heavy metals in the landfill leachate. Marigold and Colocasia plants have a removal effectiveness of more than 95% for zinc in landfill leachate, with copper having the highest value at 44%. Both the chemical and biological oxygen demands (COD and BOD) are reduced by 87% and 67%, respectively. The average removal of pollutants is found to be 64%, 95% and 33% for total hardness, turbidity and pH for Marigold plant and 65%, 98% and 29% for total hardness, turbidity and pH for Colocasia plant.

Keywords: *Colocasia, Leachate, Marigold, Phytoextraction, Phytoremediation, Solid Waste Management.*

1 Introduction

Due to rising populations, increased industrialization, and changing consumer habits, solid waste production has skyrocketed in recent decades [1]. Because of this, proper waste management in urban areas is very crucial [2]. Municipal solid waste (MSW) management at a reasonable cost presents a number of options, making it difficult to choose the best one. Landfilling is the most often used method of waste disposal in developing countries. Since landfilling is technically viable, has minimal operating costs, needs little control, and is relatively straightforward, it is the most chosen alternative for the management of Municipal Solid Waste [4]. The matrix of landfill soil and solid waste undergoes physicochemical processes that lead to trash degradation. Landfill leachate is able to enter the solid waste matrix thanks to rainwater, biological, physical, and chemical processes. Weather, landfill age, precipitation, and the amount and kind of solid waste component all have an impact on leachate quality and quantity [5]. When water drains through a rubbish pile, it picks up impurities like metals and chemicals [6]. Fluorescent lights, electronic trash, dyes, and pesticides are the primary contributors to dangerous metals in leachate [7].

Heavy metal solubility and mobility are greatly influenced by factors such as landfill age, pH, and the ratio of organic to inorganic components [8]. Acid formation at low pH [9] is assumed to be the deliberate phase that enhances the occurrence of significant quantities of hazardous metals in landfill leachate. Heavy metals are a major environmental pollutant [10] because to their detrimental effects, ability to accumulate in the water system, and nonbiodegradable nature.

Since landfill leachate pollutes the surrounding region and has a negative impact on the local biota, groundwater, and aquatic systems, it is widely recognised as a serious environmental danger [5]. Leachate from landfills also contains complicated organic characteristics as BOD, COD, and pH. Since these organics are less biodegradable and selectively detrimental to biological systems, higher concentrations provide larger challenges [11]. The proper treatment of landfill leachate prior to its discharge into any water body is essential for preventing environmental degradation. Conventional heavy metals clean-up techniques, including as ion exchange, filtration, and adsorption, are inefficient, expensive, and may impair aquatic ecosystems [12]. The employment of plants in the purification process, or phytoremediation, has gained popularity as a potential strategy for the treatment of landfill leachate [6, 13]. Phytoremediation is an alternate treatment for heavy metals that is both cost-effective and self-sustaining [14]. With the discovery of hyperaccumulator plants, which can store huge quantities of heavy metals in their aerial parts, phytoremediation has taken great strides forward in the previous two decades [15, 16]. Plants used for phytoremediation should be able to tolerate extreme conditions, generate a lot of biomass, and soak up large amounts of contaminants. Each form of pollution degrades differently depending on the type of individual contaminants and the selected phytoremediation technique [17]. Plants provide a home for endophytic bacteria by acting as a source of nutrition and a barrier against the physical environment. These mutualistic associations improve plant growth and resistance to environmental stresses including lack of nutrients or exposure to toxic substances [18].

In this paper firstly, discussed overview of Sustainable Development and Industrial Ecology then different wastewater treatments. In this research used Phytoremediation technique by using Marigold and Colocasia plant. Finally, the analysis of result obtained from the Phytoremediation technique for leachate treatment using both the plants.

2 Sustainable Development and Industrial Ecology

Humanity's current practises cannot be maintained since they deplete the environment of vital resources—including food, water, fuel, minerals, and other raw materials—for human survival, before discarding their unwanted by-products. Humans see nature as a bottomless pit from which to extract resources and dump their waste. Waste discharged back into the environment contaminates untapped resources because the environment's natural capacity for waste removal is no longer sufficient to handle human waste, making the environment unsustainable over time.

2.1 Wastewater Treatment

Almost all industrial processes include the use of fresh water in some way, and the wastewater that results from these interactions typically contains dissolved hazardous metals that must be disposed of safely. According to the quality criteria established by the

World Health Organisation (World Health Organisation [WHO], 1984), cadmium, chromium, cobalt, copper, iron, lead, nickel, mercury, and zinc are the metals of most immediate concern. Humans are negatively impacted by ingesting these heavy metals since they are carcinogenic and readily bio-accumulate in marine creatures, the vast majority of which are ingested as food. They also hinder or damage cellular growth and metabolism. The most up-to-date technique for removing these metals from wastewater involves precipitating them out as hydroxides using lime or caustic at their pH of lowest solubility. This method might be costly because of the reagent used. These precipitates still need to be disposed of, however, and often undergo concentration and containment inside barrels before being land-filled or incinerated. This means that the problem of pollution has not been addressed, but rather relocated from one environmental medium (water) to another (land). Therefore, this is not a viable option for dealing with the wastewater problem in the long run.

2.2 Phytoremediation using Marigold and Colocasia plants

Human activity, however, has provided these nutrients, leading to fast growth of water hyacinth. Natural limiting factors for water hyacinth development include insufficient minerals, especially phosphate. Phosphate-rich sewage effluent from nearby cities and industries flows into the Lagos lagoon in Lagos, Nigeria. There are far too many water hyacinths on most Lagos water bodies during most of the year, especially during the rainy season. The water hyacinth is the most productive photosynthetic plant, with only ten plants producing 600,000 more over the course of an eight-month growth season and completely encircling 0.4 hectares (1 acre) of a natural freshwater surface. Although water hyacinths pose a significant problem in rivers owing to their rapid growth, this trait might really be used to your advantage in a sewage treatment facility.

3 Methodology

In preparation for this investigation, two laboratory size models of phytoremediation were built. Models of phytoremediation include four different levels. The bottom layer consists of gravel with a size of 20 millimetres and a height of 40 millimetres. Gravels measuring 10 millimetres in width and 30 millimetres in height make up the second layer from the bottom. In addition to that, IS sieves of 2.36 millimetres in thickness have been employed with a height of 30 millimetres. The soil and the first two plants in each model are located in the uppermost layer. The first plant is a marigold plant, and the second plant is a Colocasia plant. It has been decided to apply the dilution factor to the leachate. For the purpose of this specific investigation, a dilution factor of 5 was used.

Fig. 1. Experimental Setup of Marigold and Colocasia Plants

4 Result and Discussion

When water comes into touch with garbage at a landfill, a liquid called leachate is produced. It is a highly polluted and extremely dangerous liquid that, if not handled correctly, might do serious damage to the surrounding environment. Leachate from landfills normally consists of both organic and inorganic components, however this might vary depending on the kinds of trash that are being disposed of.

Some of the potential constituents found in landfill leachate include:

1. Organic compounds: Leachate may contain various organic compounds such as volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), phenols, and pesticides. These compounds can be toxic and pose a risk to aquatic life and human health if they enter water bodies.

2. Inorganic compounds: Leachate can contain heavy metals like lead, mercury, cadmium and arsenic, which are typically found in electronic waste and other industrial waste materials. These metals are persistent and can accumulate in the environment, causing long-term contamination.

3. Nutrients: Leachate is rich in nutrients such as nitrogen and phosphorus, which can promote excessive algal growth and eutrophication if they enter nearby surface waters. This can lead to oxygen depletion and harm aquatic ecosystems.

4. Pathogens: Leachate may contain various disease-causing microorganisms, including bacteria, viruses, and parasites. If leachate contaminates drinking water sources or comes into contact with humans or animals, it can lead to the spread of diseases.

5. Salts and heavy metals: Landfill leachate often has high concentrations of salts and dissolved solids, which can adversely affect soil and water quality. The presence

of heavy metals in leachate can also contaminate groundwater resources and pose a risk to human health.

6. Proper management and treatment of landfill leachate are essential to minimize its environmental impact. Most modern landfills have leachate collection systems in place, which capture the leachate and direct it to treatment facilities. The treatment processes involve various steps, such as physical, chemical, and biological treatments, to remove contaminants and reduce the environmental risks associated with leachate.

It's important to note that the specific composition and characteristics of landfill leachate can vary depending on the landfill site, waste composition, and other factors. Therefore, the exact results of landfill leachate analysis would depend on the specific testing conducted on the leachate from a particular landfill.

The analysis of raw leachate is carried out in the laboratory. The parameters like BOD, COD, Total hardness, pH and heavy metals (zinc and copper) are analysed and the results of these test are shown in the Table 1 below.

Table 1. Analysis of raw Leachate

Sr. No.	Test	Unit	Result
1	BOD	Mg/l	1350
2	COD	Mg/l	5220.8
3	Total Hardness	Mg/l	956.8
4	Turbidity	NTU	154
5	Zinc	Mg/l	0.495
6	Copper	Mg/l	0.145
7	pH		10

The dilution factor is adopted as 10 for further study. The initial result before treatment is shown in the Table 2 for same parameters. The final results after the treatment using phytoremediation technique with the help of Marigold plant and Colocasia plant is shown in the Table 3 and Table 4 respectively. The removal efficiency of parameters we considered for this study is carried out and listed in the Table 5 below.

Table 2. Results of Leachate Before Treatment

Sr. No.	Test	Unit	Result
1	BOD	Mg/l	360
2	COD	Mg/l	1335
3	Total Hardness	Mg/l	740.8
4	Turbidity	NTU	48.6
5	Zinc	Mg/l	1.14
6	Copper	Mg/l	0.09
7	pH		9

Table 3. Results of Leachate After Treatment Using Marigold Plant

Sr. No.	Test	Unit	Result
1	BOD	Mg/l	120
2	COD	Mg/l	180
3	Total Hardness	Mg/l	263.68
4	Turbidity	NTU	2.2
5	Zinc	Mg/l	0.06
6	Copper	Mg/l	0.06
7	pH		6

Table 4. Results of Leachate After Treatment Using Colocasia Plant

Sr. No.	Test	Unit	Result
1	BOD	Mg/l	100
2	COD	Mg/l	150
3	Total Hardness	Mg/l	261.62
4	Turbidity	NTU	1.1
5	Zinc	Mg/l	0.01
6	Copper	Mg/l	0.05
7	pH		6.4

The findings of the phytoremediation method utilizing Colocasia and marigold plants show considerable reductions in the BOD and COD contents in the landfill leachate. Following the phytoremediation procedure, the BOD levels dropped by 67% (for marigold) and 72% (for Colocasia) respectively, indicating a significant improvement in the decomposition of organic waste. Similar to how the COD levels decreased, the leachate's complex organic components were successfully broken down, with reductions of 87% for marigold and 89% for Colocasia. Through the phytoremediation procedure, the concentrations of zinc and copper, two heavy metals often present in landfill leachate, were also markedly decreased. Marigold and Colocasia reduced zinc concentrations by 95% and 99%, respectively, while copper concentrations dropped by 33% and 44%, respectively.

Table 5. Removal Efficiency of plants

Sr. No.	Parameters	Unit	Initial	Using Marigold Plant	Removal Efficiency (%)	Using Colocasia Plant	Removal Efficiency (%)
1	BOD	Mg/l	360	120	67%	100	72
2	COD	Mg/l	1335	180	87	150	89
3	Total Hardness	Mg/l	740.8	263.68	64	261.62	65
4	Turbidity	NTU	48.6	2.2	95	1.1	98
5	Zinc	Mg/l	1.14	0.06	95	0.01	99
6	Copper	Mg/l	0.09	0.06	33	0.05	44
7	pH		9	6	33	6.4	29

5 Conclusion

Leachate treatment is a crucial component of the solid waste management and treatment process, and phytoremediation is a promising approach. Both the Marigold and Colocasia plant shown outstanding resistance to leachate irrigation, however the Colocasia plant performed more efficiently than the marigold plant. Overall, the findings show that employing Colocasia and marigold plants to phytoremediation of landfill leachate is a viable strategy. Significant reductions in BOD, COD, total hardness, turbidity, pH, zinc and copper concentrations are shown by both plant species. These results support the use of phytoremediation as a viable and affordable approach to treating landfill leachate, helping to safeguard the local ecology and water supplies.

Following are some findings of the phytoremediation method utilizing Colocasia and marigold plants show considerable reductions in the BOD and COD contents in the landfill leachate.

- BOD levels dropped by 67% (for marigold) and 72% (for Colocasia) respectively, indicating a significant improvement in the decomposition of organic waste.

- COD levels decreased, the leachate's complex organic components were successfully broken down, with reductions of 87% for marigold and 89% for Colocasia.

- Marigold and Colocasia reduced zinc concentrations by 95% and 99%, respectively.

- Copper concentrations dropped by 33% and 44% for Marigold and Colocasia plant respectively.

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