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Contamination Levels of Pb Heavy Metals and Availability of Phytoremediation Plants in the Gampong Jawa Landfill Area, Banda Aceh City

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Abstract: Heavy metal contamination is a major problem that occurs in landfill areas and contamination will continue to increase over time. This condition has a real impact on the increase in the accumulation of various kinds of materials which will have an impact on the occurrence of hazardous material accumulation such as the heavy metal lead (Pb). The purpose of this study was to determine the levels of heavy metal contamination of Pb found in the Gampong Jawa landfill area and the availability of phytoremediation plants as a mechanism to contain pollutant levels in the soil. The method of data collection was carried out by measuring the levels of lead accumulation (Pb) in groundwater in the TPA Gampong Jawa Kota Banda Aceh using the Atomic Absorption Spectrophotometry (AAS) method and for the availability of phytoremediation plants using an observational approach with a descriptive method. under the peacock (0.5648 ppm), under the neem (0.3031 ppm), under the orange garden (0.4438 ppm). The phytoremediation plants found included *Samanea saman* L, *Leucaena leucocephala* L, *Cymbopogon citratus*, *Imperata cylindrica* L, *Desmodium ovalifolium*, *Azadirachta indica*.

Keywords: AAS; Contamination; Heavy metal; Lead; phytoremediation.

Introduction

Health and the environment are inseparable factors, especially in the use of heavy metals which can be either used or misused in food and cosmetic products. Several heavy metals such as mercury, lead, cadmium, arsenic, and copper often exceed the threshold for human health. Typical heavy metals such as lead (Pb), cadmium (Cd) and mercury (Hg) are toxic and bio-accumulative with the potential to cause multiple organ damage, even at very small levels. The use of products with excessive heavy metal content in the long term can cause accumulation in the skin and organs, which has a negative impact on our health and is also supported by vehicle emissions.

Heavy metals are a real threat to the environment and have an impact on plants and animals. Heavy metals can have a real harmful impact on animals, plants and the environment (Ning et al., 2021).Every plant and animal has a tolerance level to heavy metals with different amounts of accumulation. The presence of heavy metals in the soil is evidence of the first step for metal accumulation in plants (Rajeshkumar et al., 2020).

The highly toxic and mobile heavy metals with great potential for bioaccumulation and biomagnification that can be transferred into the food chain, pose a significant threat to food safety and human health (Gu et al., 2020). Reducing levels can be accomplished by washing the soil which is a quick and cost-effective procedure that not only reduces the volume of soil that needs to be treated but takes a long time and a small area to manage (Ohlbaum et al., 2018). Heavy metal contamination is a condition of dissolving heavy metal elements into the environment caused by various supporting factors such as rainwater, wind, soil pH, soil texture and other human activities which accumulate in the sludge (Mulyani, 2023). One of these environmental pollution is soil pollution as a

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characteristic of soil damage caused by the proximity of synthetic xenobiotic substances (man-made) or other changes in ordinary soil conditions. Heavy metal contamination lead found on the soil surface can cause poisoning in plants and organisms that live in the area and can cause accumulation in animals and humans (Elfiza, 2023). The accumulation effect is very dangerous depending on the level of toxicity found in the soil. The non-biodegradability and toxicity of heavy metals have serious ecological consequences (Chitraprabha and Sathyavathi 2018).

Another effect on the environment is that heavy metal elements can precipitate in the long term so that it will cause soil to become toxic and will be harmful to plants and animals (Mutiah, 2022). Heavy metal reduction can be done by conventional remediation such as physical, thermal and chemical treatments which are very expensive and may require excavation of land and is very expensive (Madanan et al., 2021). There are other, cheaper methods to reduce these effects by initiating the phytoremediation mechanism. Phytoremediation with high yielding plants can be an alternative for recovery of metal polluted soils (Cano-Ruiz et al., 2020). Plants take in metals through their roots and store them in the harvestable parts in a process known as phytoremediation (Chitraprabha and Sathyavathi 2018). Phytoremediation itself is a remediation technique by utilizing plants as reducing agents for heavy metal elements in the soil. Plants used in phytoremediation are selected based on their ability to absorb and accumulate certain pollutants from the environment. Once the contaminants are concentrated in the plant tissue, the plant can be harvested and treated separately from the environment. Phytoremediation can be a more environmentally friendly and inexpensive alternative to conventional waste treatment technologies such as incineration or landfilling. Soil contamination from heavy metals poses serious risks to the environment and public health (Jekti, 2017). Phytoremediation is an alternative that is environmentally friendly and cheaper than chemical-physical techniques (Cristaldi et al. 2020).

This type of phytoremediation plant has its own characteristics such as being resistant to contaminants, being able to absorb, accumulate and metabolize heavy metal elements with a fast process so that the accumulation process can take place quickly. This is economically advantageous through exploiting the capacity of plants to accumulate heavy metals in polluted habitats (Elshamy et al., 2019). One of the areas in Banda Aceh that is a place for collecting various materials, be it garbage or other waste, is the Gampong Jawa TPA, Banda Aceh City. The Gampong Jawa Tpa is one of the garbage and waste disposal sites in the city of Banda Aceh and every year it continues to increase and has a direct impact on the community around the Final Disposal Site (Syamsuddin et al., 2012). There are two main sources of heavy metals in the soil, namely natural or anthropogenic (Eltaher et al., 2019)The level of accumulation of heavy metals in the soil has a great impact on environmental health, this needs to be considered in detail because it will contaminate it for a long time. Other impacts on the aquatic environment and animals can be seen with a number of further tests which will have a significant impact on the bodies of both animals and the environment. To find out more about these conditions, it is necessary to study the environment first. Accumulation in the environment, especially soil and water that will settle, will have an impact on the plants and animals that are in the area.

Method

This research was conducted in the Gampong Jawa Final Disposal Site (TPA) area, Banda Aceh, which is a waste processing location in the region. The soil samples used in this study were collected from the land within the TPA area designated for waste processing. The Gampong Jawa TPA is divided into several processing sections, including the organic waste treatment unit, inorganic waste treatment unit, and leachate treatment unit.

The integration of these processing units is an integral part of the waste management process at the Gampong Jawa TPA. The organic waste treatment unit aims to decompose organic waste, while the inorganic waste treatment unit handles non-organic waste (Dewi, 2022). The leachate treatment unit, on the other hand, plays a crucial role in treating leachate generated from the decomposition process (Agustikawati, 2022).

The main focus of this research was to analyze the soil samples taken from the waste processing area within the Gampong Jawa TPA. The objective of this study is to provide a deeper understanding of the environmental impacts resulting from waste processing activities at this location. Furthermore, the research findings are expected to offer valuable insights into the development of more efficient and sustainable waste management methods in the future.

By comprehending the soil composition around the waste processing area of the Gampong Jawa TPA, this research aims to help understand the interaction between waste and the environment and to take appropriate actions to preserve the sustainability of the surrounding environment. The results of this research are anticipated to make a positive contribution to environmental preservation efforts and improve waste management processes at this site. The map of the research locations is seen in Figure 1.

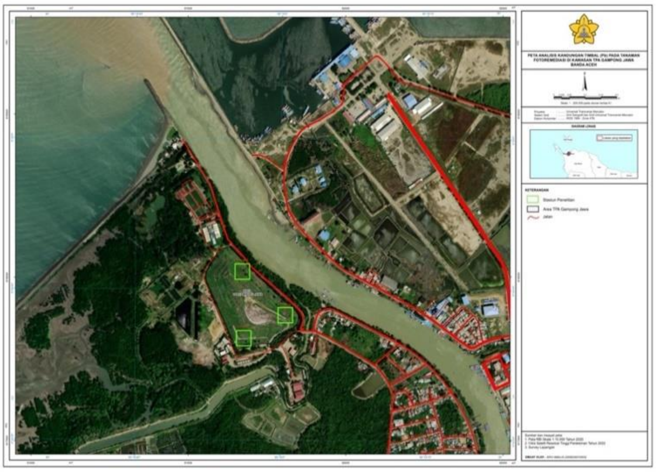

Figure 1. Location of Sampling

The study area is divided into 3 locations based on the presence of vegetation and areas that have water deposits during the rainy season. The precipitate will become a collection point for various kinds of heavy metal elements, especially Pb, which will accumulate to the bottom of the precipitate.

Sample collection and processing

The research sample was taken in the TPA Gampong Jawa, Banda Aceh City. The sample used in this research is a sample taken directly from the TPA Gampong Jawa area. Samples are taken by determining the location randomly *purposive* where the samples taken are based on other supporting factors such as the presence of vegetation. This is done to see the spreading power and settling power of the pb material.

Tools and materials

The tools used in this study were Atomic Absorption Spectrophotometry (AAS), Microwave, Fume hood, volume pipette, analytical balance, vixal tube, stative, funnel, test tube, flacon bottle, rubber bulb, beaker, measuring cup, meter, fume hood, hot plate, spatula, plastic shovel, plastic spoon, Erlenmeyer, Uv-Vis spectrophotometry, microscope, object glass, cover glass, 100 ml volumetric flask, 100 ml measuring cup, 250 ml beaker, cuvet, mortal, pestle, filter paper, funnel, pipette, scissors, label and stationery.

The materials used in this study were filter paper, aquadest, concentrated nitric acid (HNO3), 70% perchloric acid (HCLO4) solution, distilled water, clear nail polish, 96% alcohol, sterile plastic, tissue, soil and leaves taken in the landfill area.

Object of research

The research object studied in this study is the land around the Gampong Jawa landfill area of Banda Aceh City. The land is under various kinds of phytoremediation plants around the TPA area. Sampling of the soil is to ensure the level of pb content around the vegetation in the TPA Gampong Jawa, Banda Aceh City.

Data analysis

Analysis of the Lead (Pb) content of soil and plants using Atomic Absorption spectrophotometry (AAS) will be carried out at the Agricultural Laboratory of the Faculty of Agriculture, Syiah Kuala University. Besides that, the condition of the area will be analyzed descriptively.

Result and Discussion

Heavy Metal Content in Gampong Jawa TPA

Soil naturally contains various types of heavy metals. Metals are toxic chemical elements present in waters and soil that pose a major threat to humans and other organisms (De Souza et al., 2019). The content of heavy metals in the soil will continue to increase along with the increase in the amount of accumulation and addition of other materials that will settle on that location. This pollutant present in several forms in the sludge remains very dangerous (Sharma et al., 2021). It poses a major threat to human health, food safety and the environment (Kurnia et al. 2023). The content of heavy metals in the soil will not disappear on its own if it is not broken down by plants or other micro-organisms (Purba, 2023). The interaction between metals and plants is facilitated by root exudates, such as amino acids, organic acids or other compounds that can accumulate metals and transport them to other plant parts. The following is Figure 2 which is the amount of heavy metal accumulation found in the Gampong Jawa landfill area of Banda Aceh City. The Acumulated of Pb can see in Figure 2.

The accumulation and mobility of Pb to agricultural soils means that food crops grown on these soils can be a major source of Pb toxicity for humans and grazing animals. Acumulation of Pb have variation (Khairuddin, 2021). High concentrations of toxic Pb inhibit seed germination, root elongation, chlorosis and wilting of leaves, release of plant biomass and plant death (Hamdayani, 2016). This can be reduced through the physiochemical properties of rhizosphere soil, enzyme activity, and rhizosphere-related microbial communities which are very important for modulating phytoremediation in soils contaminated with heavy metals (Lin et al. 2021). Biosorption-based technology has been proposed to remove radionuclides from radioactive wastewater containing organic compounds through the potential for phytoremediation (Astuti, 2023).

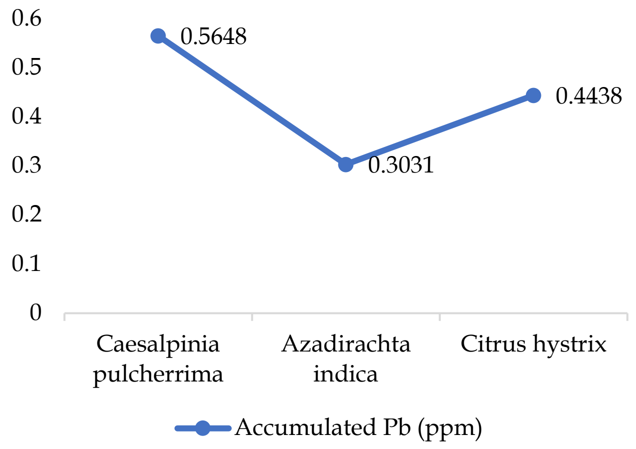

Figure 2. Accumulation of Pb found in soil solids under several tree stands.

Types of Phytoremediation Vegetation in Gampong Jawa TPA

The existence of vegetation in areas containing heavy metal contamination is an important factor to ensure that the presence of contamination can be degraded naturally. The one polutan can impact with toxic is alloy (Syafira, 2023). The reduction in pollutant content can be broken down by various factors, especially biological factors through the process of phytoremediation.The root system plays an important role in phytoremediation because it is where the initial contact with contaminants occurs (Chua et al., 2019). Phytoremediation itself occurs when plants are able to grow quickly in toxic environmental conditions, are able to consume large amounts of water in a short time, are able to remediate more than one pollutant and have a high level of resistance to pollutants. The following are the Habitus of phytoremediation species found in the Gampong Jawa landfill area. The following is Figure 3. Which is the habitus of phytoremediation plants found in the Gampong Jawa landfill area, Banda Aceh City.

From the results of observations it was found that there were 3 vegetation habitus found in the Gampong Jawa landfill area of Banda Aceh City. All these habitus consist of Herbs 13.04%, Shrubs 17.39%, Trees 69.57%. The percentage of habitus shows that the landfill area is more dominated by tree habitus than other habitus and this shows that trees are more resistant to heavy metal (Pb) contaminated areas than other areas. Pb is a problem in many areas of the world (Pires-Lira et al. 2020). The presence of toxic metals can be maintained in non-metabolic parts of plants such as cell walls and vacuoles, thereby reducing or preventing toxic effects on plant growth and metabolism. However, the growth-inhibitory response to exposure to high doses of metals can be ascribed to deficiencies in nutrient uptake, limitations in cell development resulting from metabolic activity of roots and lignification of cell walls (The following is a table of types of vegetation and types of phytoremediation that can be carried out by these vegetation.

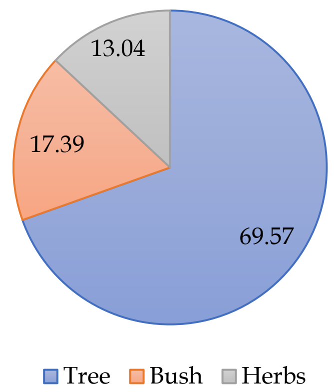

Figure 3. Percentage of vegetation habitus that becomes Pb accumulator.

The existence of vegetation found in the Gampong Jawa area consists of 6 species from the fabacean family and 1 species from the Anacardinacea family and 1 species of asteracea and 2 species of poaceae. The vegetation found in the Gampong Jawa TPA area has a high ability in phytoremediation. Phytoremediation provides a low cost and sustainable remediation for the removal of very heavy metal contaminants in water (Alikasturi et al. 2019). It was found that 2 species had the ability of Phytoextraction and Phytostabilization and the other 8 species had only Phytostabilization. Phytoextraction, also called phytoaccumulation, refers to the uptake and translocation of metal contaminants in the soil by plant roots. The main limitation of phytoextraction is the long time for remediation; during this period the cultivated land remains unproductive (Chauhan et al., 2020). Phytoextraction is mainly used for the treatment of soil contaminated with heavy metals while Phytostabilization is a plant process in attracting certain contaminants to the roots of plants because they cannot be passed on to other parts of the plant. Phytoextraction is an effective tool for heavy metal removal (Alaboudi et al., 2018). Each remediation method has its drawbacks in large-scale practice, including low efficiency, high expenditure and production of secondary pollution (Chen et al., 2020).

Conclusion

The level of Pb heavy metal contamination found in the Gampong Jawa landfill ranges under the peacock (0.5648 ppm), under the neem (0.3031 ppm), under the orange garden (0.4438 ppm). The presence of heavy metals in soil and water is a very dangerous factor and will have a direct impact on the ecosystem and the availability of phytoremediation plants in the Gampong Jawa landfill area of Banda Aceh City consists of 6 species from the fabacean family and 1 species from the Anacardinacea family and 1 species asteracea and 2 species of Poaceae. The vegetation found in the Gampong Jawa TPA area has a high ability in phytoremediation.

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Arvi Amalia; Drafting the article, Zumaidar; Critical revision and Data interprestation, Amalia; Conception and data collection.

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The authors declare no conflict of interest.

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