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The potential and contamination of metals Pb and Zn on the soil around Tamangapa Antang landfill

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Abstract. A Study on the potential and contamination of Pb and Zn metal on the soil around Tamangapa Antang Landfill has been conducted. The study aims to analyze the potential and contamination of heavy metals of Pb and Zn on the soil around the landfill. The sample points are divided into 4 lines namely, line A, line B, line C and Line D, at the point of 5 m (laterally) with the depth of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm (vertically). The total soil samples whose heavy metal elements analyzed using *Atomic Absorption Spectroscopy* method are twelve samples. The concentrations of Pb and Zn metals in Tamangapa Antang Landfill soil have spread horizontally on the soil surface (top soil). The concentration of Pb for Line A has exceeded the threshold ($R_2 = 0.10714$) in every depth, while in Line B, Line C and Line D, the concentration is still below the threshold. Zn concentrations for Line A, Line B, Line C and Line D are above the threshold, except Line B at the depth of 20 to 30 cm is still below the threshold (67 ppm) which is allowed by the Government of Indonesia and The General of Drug and Food Control as a contaminant in the soil. Soils pH varies from 4.82 to 6 (acid) and the average abundance of heavy metal content in the soil samples at Tamangapa Antang Landfill site is $Zn > Pb$. Pollution of this heavy metal has been felt by local residents from a radius of 5 to 50 m. Where the Tamangapa Antang Landfill is in the middle of a settlement, so that it can affect the health of the population around the landfill, requiring residents who are still using dug wells. Request assistance from the local government to take immediate action to avoid problems with humans and the local environment.

1. Introduction

Landfill for Makassar citizens is an essential requirement to create a comfortable environment in a big city. When the waste in Makassar City is not transferred to the landfill in one day, then the city will be full of waste so it disturbs the public convenience. Tamangapa Antang Landfill in its operation uses Open Dumping in which the waste is dumped and left open daily with the soil [1]. Since its opening, Tamangapa Antang Landfill is estimated to have 1,240,000 tons of organic waste disposed [2]. If the landfill does not have proper management, it will produce solid waste which contains many toxic compounds such as heavy metals [3]. Uncontrolled Landfill is very harmful to health and can damage the environment [4,5]. Landfill is one of the main sources of the increased levels of metal in the soil.



The movement of contaminants from the landfill to the ecosystem is a complex process which involves a variety of geochemical activities [6].

Heavy metals are very harmful to the environment and organisms. This can be enriched through the food chain. Soil which is contaminated with heavy metals is difficult to managed [7]. In the past, soil contamination was not considered as important as the air and water pollution since soil contamination is more difficult to control than the air and water pollution [7]. But in the last years, soil pollution in developed countries such as in Indonesia, especially in South Sulawesi becomes serious. Thus, more attention is given and it also becomes a hot topic for environmental protection worldwide. The presence of high concentrations of metal elements in the soil is caused by natural and anthropogenic factors [6].

Soil surface is the recipient of various pollutants, especially heavy metals such as copper, nickel and zinc which can be used as indicators to determine the environmental quality [8]. In their activities, humans always interact with the soil. Soil is formed by the decomposition of rock and organic materials for years. The characteristics of Soil vary from one place to another place with different composition of bedrock, climate and other factors. Certain chemical elements occur naturally in soil as mineral components, but may be toxic at some concentration [9]. Most of the people around Tamangapa Antang Landfill Makassar City, using dug wells as a source of drinking water. If the soil is contaminated with heavy metals Pb and Zn then it can contaminate the well water. Consuming water contaminated with heavy metals, will settle in the body. Heavy metals such as Pb and Zn, if already absorbed into the human body will not be destroyed and can cause health effects for humans themselves depending on which part of the heavy metal can be bound in the body. If heavy metals are already bound in the human body will be poison [5].

Soil which is contaminated by heavy metals is potentially polluting the environment. Plants grown on soil contaminated with heavy metals such as Pb and Zn greatly disrupt human health. Soil which is contaminated by heavy metals is colorless and odorless, thus making it difficult to control. It inexplicitly damages the environment in a short time, but when it exceeds the environmental tolerance, the heavy metals in the soil will be active and cause ecological damage [7].

The location of Tamangapa Antang Landfill located in Bangkala Sub-District, Manggala District, Makassar City, South Sulawesi Province (see Figure 1), has been used since 1995 until now with the area of 18.8 hectare. According to the planing, Tamangapa Antang Landfill that was originally designed for the needs of 10 years, but in fact, until now the Landfill is still in use, it means that the age of the Landfill is 21 years, and cannot accommodate the volume of waste that is in Makassar City is reaching 800 tons or about 4,000 cubic per day. Based on the records of the Department of Hygiene and Environment, Makassar with an approximate total population of 1.3 million people, is producing about 3,800 m³ or equal to 300 tons of public waste every day. Whereas the maximum capacity of Tamangapa Antang Landfill is only about 2,800 m³ for accommodate public waste every day. Additional landfill is needed for the disposal of 1000 m³ of the over waste. About 87% of waste in Makassar City is organic waste and about 13% is inorganic waste, such as plastic and paper.

Considering these facts, it can be assumed that there is pollution in Tamangapa Antang Landfill of Makassar, such as environmental pollution, soil contamination and groundwater contamination which can affect or risk the environmental sanitation and cause air pollution. The movement of pollutants has spread to the northwest of the Southeast Sea of which the pollution is around 300 tom 450m from the waste of Tamangapa Antang Landfill [10]. The direction of the groundwater flow in Tamangapa Antang Landfill is in the same direction to the slope of rock layer that is Northwest-Southeast [11]. This greatly affects the shallow groundwater quality. The pollution of shallow groundwater caused by liquid waste infusion (Leachate) from the landfill's waste which can also contaminate the wells of the surrounding residences. This pollution has been felt by the residents around the landfill, especially for those who use the groundwater as a source of drinking water [11].

This research is triggered by the amount of pressure received by the soil due to the piles of waste from domestic activities. When a hazardous substance has polluted the soil surface, it can evaporate,

swept away by the rainwater into the soil then settled as a toxic chemical on the ground. This study aims to analyze the potential spread of heavy metals of Pb and Zn on the soil around Tamangapa Antang Landfill. The research is focused on how the impact of heavy metal metals can be spread on the soil around Tamangapa Antang Landfill of Makassar City to the life of the people around the landfill area, at the point of 5 m (laterally) with the depth of 0 to 10 cm, 10 to 20 cm [12] and 20 to 30 cm (vertically).

2. Research Methodology

2.1. Research Area

The location of this study is administratively included in the Bangkala Sub-District, Manggala District, and Makassar City, South Sulawesi Province, Indonesia. Geographically, Tamangapa Antang landfill is situated 119°29'10" to 119°29'40" East Longitude and 5°10'20" to 5°10'40" South Latitude. The location of the study area is shown in Figure 1.

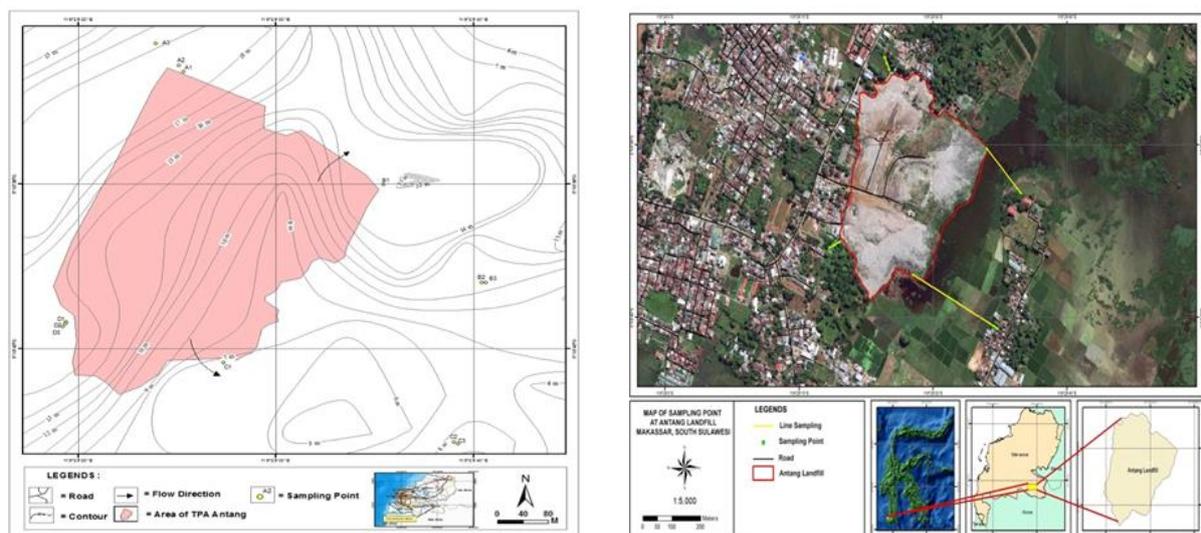


Figure 1. The map and Sampling Point for Line A, Line B, Line and Line D, at the point of 5 m with the depth of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm, on soil Tamangapa Antang Landfill of Makassar City, South Sulawesi Province, Indonesia.

2.2. Soil Sampling

The sample used in this study was top soil collected from the Tamangapa Antang Landfill area in Makassar City, South Sulawesi Province. Determination of soil sampling points by dividing 4 lines, lines in the direction of groundwater flow (Line A and Line C), lines perpendicular to groundwater flow (Line B and Line D), at 5 m laterally, while vertically consisting of dept variations, namely, Line A with a dept of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm, Line B with a dept of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm, Line C with a dept of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm and line C and Line D with a dept of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm [12]. The landfill are located about 10 m from the residential area (especially in the western and northern part of landfill area, see Figure 1). The total soil samples to be analyzed for heavy metal elements using Atomic Absorption Spectroscopy Method. Soil samples on every sampling points were taken 0.5 kg for analysis. Measurement of temperature is carried out directly on the field (landfill), while pH measurements are carried out in the laboratory. Sampling poits are shown in Figure 1 (marked by green points in line A, B, C, and D).

2.3. Soil Samples Testing

Before being tested, the soil was saved in the oven for 48 hours at 106°C [6,13,14] first to ease the filtering process so that the grains are not attached to each other. It was then crushed with wooden or

ceramic hammer [6], sieved using stainless steel of 2 mm sieves [6,15,12] and stored in the desiccator before being analyzed [14]. The soil sample that has been prepared was then brought to the laboratory for analysis.

3. Results

The measurement results of the total concentrations of metals Pb and Zn using *Atomic Absorption Spectroscopy* method for Line A, Line B, Line C and Line D at point 5 m (laterally) with the depth of 0 to 10 cm, 10 to 20 cm [12] and 20 to 30 cm (vertically). The analysis result of the heavy metals of Pb and Zn for Line A, at point 5 m with the depth of 0 to 10 cm, 10 to 20 cm, and 20 to 30 cm can be seen in (Figure 2).

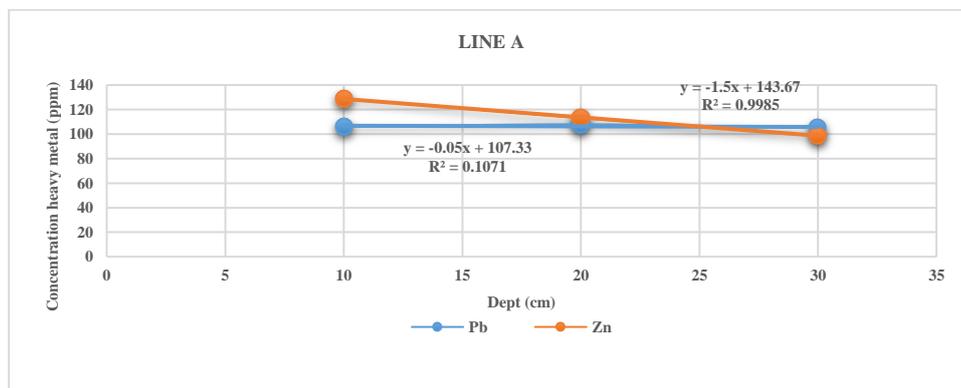


Figure 2. The analysis result of heavy metals Pb and Zn for Line A, at point 5 m with the depth of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm on soil Tamangapa Antang Landfill of Makassar City, South Sulawesi Province, Indonesia.

For Line A, the concentration of metal Pb at the depth of 0 to 10 cm ranges from 106 ppm, at the depth of 10 to 20 cm, it increases to 108 ppm and at the depth of 20 to 30 cm the concentration decreases to 105 ppm. Zn metal concentration at the depth of 0 to 10 cm is the highest level of 129 ppm, at the depth of 10 to 20 cm and 20 to 30 cm the concentration decreases to 113 ppm and 99 ppm respectively. The results of the analysis of the heavy metals Pb and Zn for Line B, at point 5 m with the depth of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm can be seen in Figure 3.

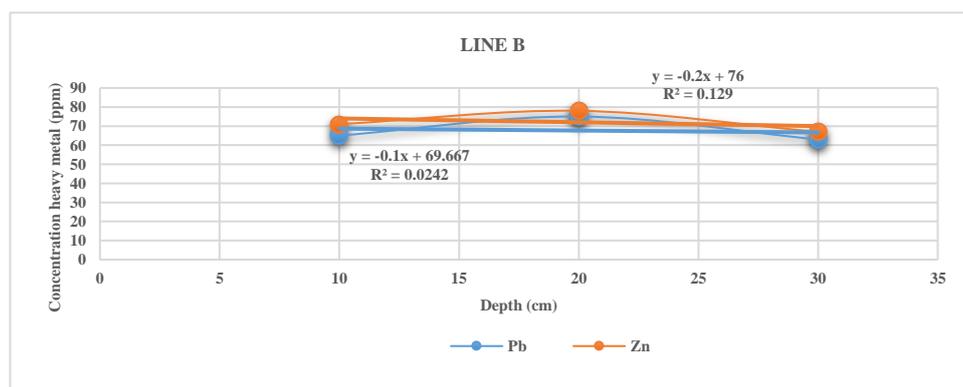


Figure 3. The analysis result of heavy metals Pb and Zn for Line B at point 5 m with the depth of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm on soil Tamangapa Antang Landfill of Makassar City, South Sulawesi Province, Indonesia.

For Line B, the concentration of metal Pb at the depth of 0 to 10 cm is about 65 ppm, at the depth of 10 to 20 cm, the concentration increases around 75 ppm, while at the depth of 20-30 cm the concentration decreases to around 63 ppm. The concentration of Zn metal at the depth of 0 to 10 cm is

about 71 ppm, at the depth of 10 to 20 cm, the concentration increases to around 78 ppm, while at the depth of 20 to 30 cm, the concentration decreases to 67 ppm. The analysis result of heavy metals of Pb and Zn for Line C, at point 5 m with the depth of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm can be seen in Figure 4.

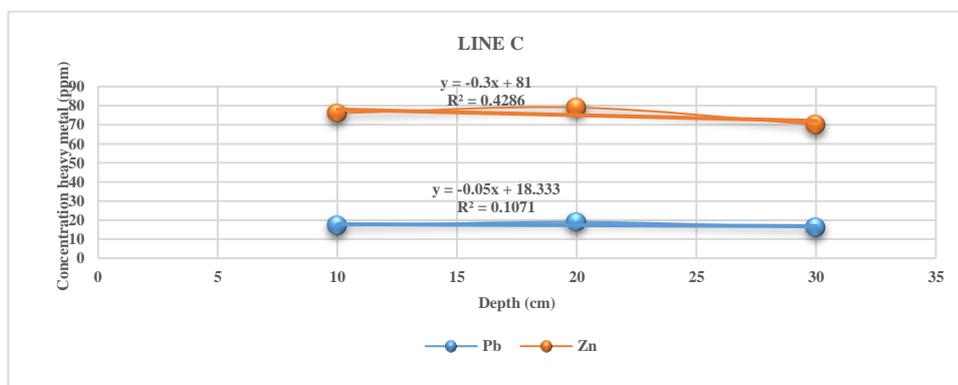


Figure 4. The analysis result of heavy metals Pb and Zn for Line C, at point 5 m with the depth of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm on soil Tamangapa Antang Landfill of Makassar City, South Sulawesi Province, Indonesia.

For Line C, Pb metal concentration at the depth of 0 to 10 cm ranges 17 ppm, at the depth of 10 to 20 cm, the concentration increases to 19 ppm, whereas at the depth of 20 to 30 cm, the concentration decreases to 16 ppm. Zn concentration at the depth of 0 to 10 cm concentration ranges from 76 ppm, at the depth of 10 to 20 cm, the concentration increases to 79 ppm, while at the depth of 20 to 30 cm, the concentration decreases to 70 ppm. The analysis result of heavy metals of Pb and Zn for Line C, at point 5 m with the depth of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm can be seen in Figure 5.

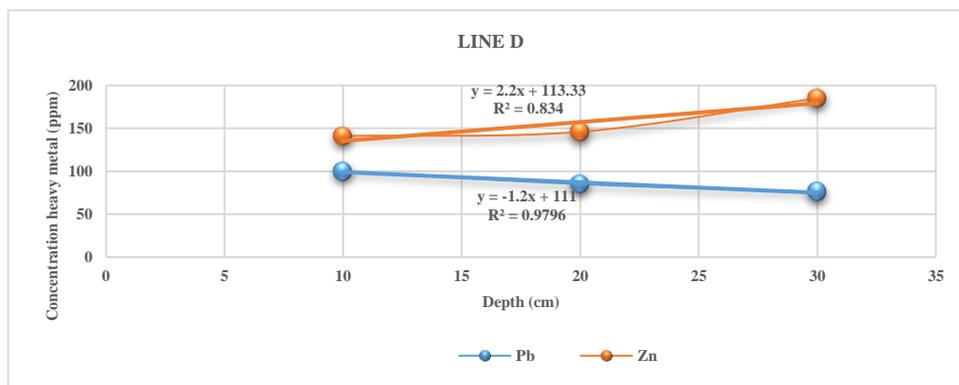


Figure 5. The analysis result of heavy metals Pb and Zn for Line D, at point 5 m with the depth of 0 to 10 cm, 10 to 20 cm and 20 to 30 cm on soil Tamangapa Antang Landfill of Makassar City, South Sulawesi Province, Indonesia.

For Line D, Pb metal concentration at the depth of 0 to 10 cm is the highest level which is around 100 ppm, while at the depth of 10 to 20 cm and 20 to 30 cm, the concentration decreases exponentially which is around 85 ppm and 76 ppm. The concentration of Zn metal at the depth of 0 to 10 cm is about 141 ppm, at the depth of 10 to 20 cm, the concentration increases to 146 ppm, while at the depth of 20 to 30 cm, the concentration increases exponentially to 185 ppm.

4. Discussion

The concentration of Pb and Zn heavy metals in the location of the Tamangapa Antang Landfill in Makassar City, South Sulawesi Province has spread both laterally and vertically. The concentration of the two metal elements are varied in each line and depth on the soil surface (top soil), with the level of

enrichment already exceeding the expected threshold value by the soil environment. This condition can cause cancer (carcinogen) especially for the community who live around the Tamangapa Antang Landfill, Makassar City, South Sulawesi Province, where the Tamangapa Antang Landfill is situated around the residential area.

The mean concentration of Pb metal in the soil of Tamangapa Antang landfill at Line A and Line D ranges from 76 to 108 ppm which are above the average threshold of each depth unless Line D at the depth of 10 to 20 cm and 20 to 30 cm which are still below the average threshold. Meanwhile, in Line B and Line C, the average concentration ranges between 16 to 75 ppm which is still below the average threshold. Pb metal in the soil is as the oxidant of Pb^{2+} . When the pH increases, the ion of Pb^{2+} ions are less soluble as the oxidant. At higher pH, it will form complexes in which the organic material will precipitate as carbonate, hydroxide and phosphate. The increase of concentration of lead (Pb) in Line A can be attributed to industrial, chemical and anthropogenic waste disposal and lead is positively correlated with other metals [6]. Pb metal is one of heavy metals which is very harmful to the living things because such metal is carcinogenic which can cause mutations and decomposes in a long time and its toxicity does not change [16].

The average concentration of Zn metal in the soil of Tamangapa Antang Landfill is between 67 to 185 ppm. For Line A, Line B, Line C and Line D, the concentration has exceeded the threshold for all depth. Except Line B which at the depth of 20 to 30 cm is about 67 ppm, thus it is still below the average threshold. The average pH ranges from 4.82 to 6. The oxidant of Zn metal in the soil is about Zn^{2+} which is under the acid oxidizing conditions. Zn^{2+} is one of the most heavily soluble and moving heavy metals in clays as well as hydrocarbon oxides and organic materials in which the solubility in the soil is very potential at acidic pH [6].

The average abundance of heavy metal content in soil samples at the Tamangapa Antang Landfill site is $Zn > Pb$. The maximum concentration of Zn metal is 67 to 185 ppm which is higher than the result obtained by [17] (80 ppm), but the result is lower than [18] (600 ppm). The result of Metal Pb (16 to 108 ppm) obtained is higher than [19] (5.67 ppm), but lower than [18] (280 ppm) and [20] (29 to 138 ppm). The enrichment of heavy metal elements of Pb and Zn on top soil surface around Tamangapa Antang landfill soil is still high accumulated. This is due to anthropogenic or human activity, Leachate and soil characteristics [21,22,23,24], supported by a very acidic pH ranging from 4.82 to 6. At heavy acidity, the mobility of heavy metals' pH in the soil is relatively high [25]. If there is a very high and continuous rainfall, it can result to permeation to the bottom of landfill of which the water seepage will come out into the river. The heavy metals are under Leachate and will settle in the soil, so heavy metals such as Pb, and Zn will continue to accumulate in the soil [7]. The heavy metals Pb and Zn will affect the quality of the soil and groundwater around the landfill, this greatly affects the lives of people around the Tamangapa Antang Landfill, because most people around the Tamangapa Antang Landfill still use dug wells as a source of drinking water. Pollution of Pb and Zn heavy metals has been felt by residents in Antang Tamangapa Landfill from a radius of 5 to 50 m.

The soil of Tamangapa Antang Landfill includes Utisol soil (a reddish soil contains a lot of clay), thus showing plasticity, encouraging flooding and surface water pollution [12]. The color of the soil is due to the metal content, especially the oxidized iron and aluminum (weathered soil). The soil pH analyzed at Tamangapa Antang Landfill of Makassar City ranges from 4.82 to 6 which is acidic with an average value of 4.84. The temperature of soil ranges from 25 to 31°C. pH plays an important role in the bioavailability of heavy metals and toxicity of the soils to the surrounding area [26][25]. pH affects the mobility of metals in the soil [12,26]. The low pH or acid pH will assist in the availability, mobility and redistribution of heavy metals of Pb and Zn in various fractions due to the increased solubility of ions in acidic soil environments [26].

The relatively acid soils have increased solubility and mobility of the micronutrients so that the concentrations of heavy metals in the soil increases [8,26]. If the soil solution is too acidic, the plant cannot take the advantage of N, P, K and other nutrients they need. In acid soil (low pH), the soil is dominated by Al, Fe and Mn ions. These ions will bind the nutrients need by plants especially P, K, S,

Mg so that the plants cannot absorb food well although the nutrient content in the soil is a lot. The heavy metals of Pb and Zn are very harmful to the health of the population [7], especially the residents who are living around the landfill area, because they can cause cancer and lung damage and the children will also have low IQ or low level of intelligence. Therefore, it becomes the threat for human beings because it can cause death [7,27,9,28,29].

5. Conclusion

The potential of metal content of Pb and Zn has spread horizontally above the soil surface (top soil). The metal concentration of Pb for Line A has exceeded the threshold ($R_2 = 0.10714$) in every depth, whereas in Line B, Line C and Line D the concentration is still below the threshold. The potential of metal content of Zn for Line A, Line B, Line C and Line D is above the threshold, while for Line B at the depth of 20 to 30 cm, it is still below the threshold (67 ppm) which is still allowed by the Government of the Republic of Indonesia and the General of Drugs and Foods Control as a contaminant in the soil. The soil pH varies from 4.82 to 6 which is acidic.

The metal concentration of Pb and Zn at Tamangapa Antang Landfill of Makassar City, South Sulawesi Province is influenced by the content of organic matter, temperature, texture and soils pH. The heavy metals of Pb and Zn still have high accumulation. If there is a continuous high rainfall, it can result to the permeation to the bottom of the landfill site, of which residents around Tamangapa Antang landfill still use dug wells. Therefore, the water leachate will affect the soil quality around the landfill and it is damage for the residents because the landfill is located in the residential area and has been operating for 21 years.

Authorized government must immediately take appropriate action by means of bioremediation, namely by purifying well water, to remove heavy metals Pb and Zn, using zeolite activated charcoal and chitosan.

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