STUDY OF HEAVY METALS CONCENTRATIONS IN LEACHATE AND GROUNDWATERS NEARBY LANDFILL

Gunawan Lanjahi¹, Anwar Mallongi², Hasnawati Amqam³, Hasanuddin Ishak⁴, Suriah⁵, Muh Hatta⁶
¹,²,³,⁴ Environmental Health Department, Faculty of Public Health, Hasanuddin University, Indonesia
⁵ Health Promotion and Behavioral Sciences Department, Faculty of Public Health, Hasanuddin University, Indonesia
⁶ Marine Science Department, Faculty of Marine Sciences and Fisheries, Hasanuddin University, Indonesia
¹ Email: g.lanjahi@yahoo.com

ABSTRACT

Leachate generation is a major problem for municipal solid waste landfills and causes significant threat to surface water and groundwaters. This study is determined to examine the concentration of heavy metals in leachate and groundwaters nearby Talumelito Landfills. This research was an analytical descriptive with cross sectional design. The study involved a sample of leachate and 12 samples of groundwater to analyze the heavy metals of Cd, Cr, Pb, and Zn using Atomic Absorption Spectrometry (AAS). The result of observation that heavy metal concentration in the leachate are as follows: Cd: >0,500 mg/l, Cr: 2,72 mg/l, Pb: >5.00 mg/l, and Zn: 5,20 mg/l. Meanwhile, the groundwaters nearby the landfill contained Cd: 0,0405 mg/l, Cr: 0,3508 mg/l, Pb: 0,515 mg/l, and Zn: 3,95 mg/l. The identified concentration of heavy metal on leachate was high exceed the standard value of Indonesian Environment and Forestry Ministry Regulation. The identified concentration of Cd, Cr and Pb in groundwater exceed the standard value of Indonesian Health Ministry Regulation while Zn within safe limits. The leachate produced by TPA Talumelito can cause pollution to groundwater in surrounding settlements, therefore require repairment in terms of landfill leachate processing and water treatment technology development.

Keywords: Heavy Metals, Leachate, Groundwaters, Landfills

I. INTRODUCTION

The problem of waste in Indonesia is still very big. Indonesia has a population of 327 million people, which is directly proportional to the production of waste every day. The Ministry of Environment and Forestry conveyed that the national waste generation in 2019 was 175,000 tons per day or the equivalent of 64 million tons per year [1]. In Gorontalo Province in 2018 the waste generation reached around 520,709 tons per day or 190,058.79 tons per year. The biggest contributor of waste from Gorontalo Regency is 149.969 tons per day and Gorontalo City is 137,239 tons per day [2].

Landfilling is the oldest, most widely used and cheapest solid waste disposal technique [3; 4]. At the landfill site rainwater seeps and dissolves various organic and inorganic substances present in the solid waste, leading to the production of leachate [5]. Leachate contains large amounts of organic contaminants such as Biochemical Oxygen Demand (BOD5), Chemical Oxygen Demand (COD), ammonia and high concentrations of heavy metals [6]. Leachate from landfill has the potential to contain several heavy metals such as cadmium (Cd), lead (Pb), copper (Cu), chromium (Cr) and zinc (Zn) [7] and Mercury (Hg), Iron (Fe), Manganese (Mn), Nitrate, and Nitrite [8].

Runoff, underground runoff, infiltration from rainfall carry toxins from landfill waste to groundwater and soil around residential areas. The constituents, toxicity and risk level of landfill leachate depend on the components of the waste material and the availability of an impermeable undercoat and leachate collection system. Chemical compounds in leachate pose serious risks to ecosystems and human health when they migrate to surface water,
groundwater or accumulate in food sources such as vegetables or fish [9]. Contamination of groundwater by landfills, affects overall water quality and renders water unfit for use [10].

TPA Talumelito is one of the landfills in Gorontalo Province with an average amount of waste processing 30,000 tons/year originating from 3 regencies/cities namely Gorontalo City, Gorontalo Regency and Bone Bolango Regency. This TPA applies a Sanitary landfill and composting operating system with leachate treatment at the TPA using the help of a stabilization pond. The large volume of leachate exceeds the storage capacity in the rainy season, and the wetland tub has a leak which causes leachate to come out of the reservoir. The high rainfall in Gorontalo allows leachate to be carried by rainwater and seep into the soil layer and into permeable rocks resulting in subsurface water pollution.

In this study, the impact of leachate migration on heavy metal concentrations in groundwater around the Talumelito Final Disposal Site (TPA) is estimated. Several heavy metals such as cadmium (Cd), Chromium (Cr), lead (Pb) and zinc (Zn) in leachate and groundwater were examined to determine the possible relationship of heavy metal contamination in groundwater.

II. METHODS

Study Area
TPA Talumelito is a Regional TPA of Gorontalo Province with an area of ±15 ha located in Telaga Biru District, Gorontalo Regency. Administratively, the Talumelito TPA is directly adjacent to Talumelito Village and East Pentadio Village. The topography of the TPA Talumelito area and its surroundings is mostly flat, low hills and highlands, spread at an altitude of 0 – 80 mdpl. Meanwhile, the topography is dominated by a slope of 15 – 40º (45 – 46%) with soil types that are prone to erosion. The main geological conditions and structures are faults that have the potential to cause tectonic movements so that the area is prone to natural disasters such as earthquakes, soil movements, erosion, and floods. Lithologically, this area is included in limestone with a geological age of the Quaternary era with the type of ancient lake sediment material. The morphological aspects of this area are mostly plains on the east, south and west sides and partly hills on the north side.

Sampling and Analysis

One sample of leachate was taken in the final reservoir (wetland basin) before the leachate was discharged into the environment, while 12 wells of groundwater samples were selected based on the direction of groundwater flow which is estimated to have a significant effect on groundwater conditions in residential areas. Around the landfill with a radius of 1000 meters (1 km) from the landfill (Figure 1). Analysis of Cadmium (Cd), Chromium (Cr) Lead (Pb), and Zinc (Zn) in leachate and groundwater samples was carried out in the laboratory using the Atomic Absorption Spectrophotometer (AAS) referring to the Indonesian National Standard (SNI) method based on the type of heavy metal.

The results of laboratory tests regarding the concentration of heavy metals Cd, Cr, Pb and Zn in leachate are presented descriptively and compared with the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.59/Menhk/Setjen/Kum.1/7.2016 and Regulation of the Minister of Environment of the Republic of Indonesia Number 5 2004 regarding leachate water quality standards and wastewater quality standards, while the results of testing concentrations of heavy metals Cd, Cr, Pb and Zn in groundwater are presented descriptively and compared with the Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements.
III. RESULTS

Heavy Metals in Leachate

The leachate in TPA Talumelito contains quite high heavy metals, especially heavy metals Cd, Cr and Pb when compared to the required standard values (Table 2). Metal concentration of Cd > 0.500 mg/l does not meet the standard, it has exceeded the standard value required by the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia in 2016 concerning leachate quality standards. Meanwhile, metal concentrations of Cr 2.72 mg/l, Pb > 5.00 mg/l and Zn 5.20 mg/l did not meet the standard, exceeding the standard value of wastewater required by the Regulation of the Minister of the Environment of the Republic of Indonesia Number 5 2004 of the wastewater quality standard.

<table>
<thead>
<tr>
<th>Heavy Metals</th>
<th>Up to (mg/l)</th>
<th>Quality Standard (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium (Cd)</td>
<td>&gt; 0.500</td>
<td>0.1</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>2.72</td>
<td>0.5</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>&gt; 5.00</td>
<td>0.1</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>5.20</td>
<td>5.0</td>
</tr>
</tbody>
</table>

*Note: Limit of detection (LOD) Cd 0.002 mg/l, Cr 0.010 mg/l, Pb 0.010 mg/l and Zn 0.2 mg/l.

Heavy Metals in Groundwater

The concentration of cadmium in groundwater around TPA Talumelito ranged from 0.00 – 0.098 mg/l with an average value (mean) of 0.0405 mg/l. The concentration of chromium (Cr) ranged from 0.08 to 1.26 mg/l with an average value (mean) of 0.3508 mg/L. The concentration of lead (Pb) ranged from 0.32 to 1.34 mg/l with a median value of 0.455 mg/l. While the concentration of Zn metal ranged from 0.81 to 5.46 mg/l with an average (mean) of 3.95 mg/l. The concentration of Cd, Cr and Pb metals exceeds the quality standards required by the Minister of Health of the Republic of Indonesia No. 32 of 2017, while the concentration of Zn is still within safe limits.

<table>
<thead>
<tr>
<th>Heavy Metals</th>
<th>Min</th>
<th>Max</th>
<th>Median/Mean*</th>
<th>Quality Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd (mg/l)</td>
<td>0.00</td>
<td>0.098</td>
<td>0.0405</td>
<td>0.005</td>
</tr>
<tr>
<td>Cr (mg/l)</td>
<td>0.08</td>
<td>1.26</td>
<td>0.3508</td>
<td>0.05</td>
</tr>
<tr>
<td>Pb (mg/l)</td>
<td>0.32</td>
<td>1.34</td>
<td>0.455*</td>
<td>0.05</td>
</tr>
<tr>
<td>Zn (mg/l)</td>
<td>0.81</td>
<td>5.46</td>
<td>3.95</td>
<td>15</td>
</tr>
</tbody>
</table>
All sampling points are in the area around the landfill with a distance of < 1000 m from the center of the landfill. Community wells were found at a distance of 489.26 m from the landfill to the farthest sampling point of 979.07 m from the landfill. According to the government regulation of the Republic of Indonesia Number 81 of 2012, this location distance does not meet the requirements where the landfill should be located more than 1 km from the settlement with consideration of leachate pollution. Heavy metal concentrations vary depending on the location of the groundwater. The highest heavy metals Cd and Pb are at the well point with a distance of 674.43 m from the landfill, the highest Cr metal is at the sampling point at a distance of 643.62 m from the landfill, while the highest Zn metal is at the well at a distance of 742.78 m from the landfill. Heavy metal concentrations were still detected quite large at several well points which were further away from the landfill, especially Cd and Zn metals. The distribution of Pb metal is fairly even at almost all well points. Cr metal tends to decrease in concentration as the distance between the well and the landfill increases (Figure 2).

Figure 2. Groundwater heavy metal concentrations based on the distance from the well location to the landfill around TPA Talumelito

IV. DISCUSSION

The Talumelito Final Disposal Site (TPA) is the final place for waste disposal in the Gorontalo Province of Indonesia with the sanitary landfill waste processing method, namely by piling up waste with soil which is carried out layer by layer. The waste decomposition process produces leachate which flows by gravity to the leachate collection tank. After undergoing the processing process in the facultative tanks, maturation tanks, aeration tanks and wetlands, they are then discharged into the river around the landfill.

All concentrations of heavy metals in the wetland basin were detected to be high enough to exceed the required standard values. The entry of Cd, Cr, Pb and Zn metals into the leachate is caused by the type of waste deposited in landfills. Data from the Talumelito TPA states that the processed waste is in the form of plastic bottles, plastic, food cans, rubber/leather, and others such as batteries and fluorescent lights. This domestic effluent contains metals Cd, Cr, Pb [11; 12]. Meanwhile, the presence of Zn in leachate indicates that landfills receive waste from fluorescent lamps, batteries and plastics [13]. No other natural sources of heavy metals were found around the leachate pond.

The quality of leachate depends on several factors such as the variation and proportion of waste components, rainfall and season, the age of the stockpile, operational patterns and the time of sampling [14]. The high concentration of heavy metals detected in the leachate samples examined was also caused by the leachate processing process in the reservoir that was not maximized, at the time of observation there were problems with electricity disturbances so that the process was not running optimally, the lack of filter media and vegetation in the wetland tub so that heavy metals were not absorbed properly, good. In addition, the sampling time entered the dry season so that there was no dilution by rainwater at the sampling location.
The concentrations of Cd, Cr, and Pb detected in groundwater around the Talumelito TPA are quite high, which have exceeded the quality standard according to the Regulation of the Minister of Health of the Republic of Indonesia Number 32 of 2017, while the average concentration of Zn is still within safe limits. The high content of heavy metals in groundwater around the Talumelito Final Disposal Site (TPA) is most likely due to leachate produced from landfills, leachate disposal into rivers around the landfill and the volume of leachate that often overflows and seeps into the surrounding soil, especially during the rainy season, resulting in contamination, on ground water. The high concentration of heavy metals Cd, Cr, Pb and Zn in the leachate at the Talumelito TPA can be one of the causes of the high metal concentration in the surrounding groundwater, namely Talumelito Village and East Pentadio Village. Leachate generation can pose a significant threat to surface and groundwater if not managed properly and discharged into the environment [15]. Areas near the landfill have a greater chance of water pollution due to the possibility of contamination of leachate sources from the landfill. Leachate leakage can cause contamination of groundwater and nearby surface water [16].

Heavy metal concentrations vary depending on the location of the groundwater. Metal concentrations of Cd, Pb and Zn were still detected quite large at several well points that were further away from the landfill, for example at points X and XI with a distance of almost 1 km from the landfill, while point V which was the closest point to the landfill, the concentration of heavy metals was quite low compared to point V. On the other hand, Cd metal is not even detected. Pb metal is spread fairly evenly at almost all points, Cr metal tends to decrease in concentration as the distance between the well and the landfill increases. This shows that most of the distribution of heavy metals in groundwater around the TPA talumelito does not depend on the distance from the groundwater source to the landfill. Several wells that are quite far apart but are located at a lower level have the potential to be more polluted due to the slope between locations which causes faster movement of water in the soil. The wells at the study site have different depths ranging from ± 20 m to 139 m. Some wells with high depth have less metal content. The greater the depth of groundwater, the rate of groundwater movement will be slower as the water temperature decreases which causes the toxicity of metals to decrease and vice versa [17].

Another source of heavy metal contribution in the study area is natural sources caused by physical factors such as erosion or erosion that occurs in mineral rocks because the topography of the study area is in the highlands and low hills, besides dust and particles in the air will be brought down by rainwater [18]. Unnaturally caused by intensive agricultural activities at the study site using inorganic fertilizers and pesticides such as Pb, Cd, Cr, Hg, Zn, As, Cu and Mn metals [19], and sourced from water pipes used in injection wells which are likely to contain heavy metals, especially lead (Pb) [11].

V. CONCLUSION

The leachate produced by the Talumelito landfill showed high concentrations of all heavy metals (Cd, Cr, Pb, Zn) examined, exceeding the standards required by the Minister of Environment and Forestry -RI. The concentration of Cd, Cr and Pb metals in most of the groundwater samples exceeded the quality standard of the Minister of Health of the Republic of Indonesia, while Zn was within safe limits. Heavy metals in groundwater are most likely caused by leachate produced from landfills through leachate disposal into rivers around the landfill and the volume of leachate that often overflows and seeps into the surrounding soil.

The leachate produced by the landfill can cause contamination of groundwater in surrounding settlements, therefore corrective actions are needed, including maximizing the constructed wetland method in terms of filter media and vegetation, repairing landfill leachate treatment tanks so that leachate does not seep into the surrounding area, and for the government to can develop water treatment technology in order to reduce the heavy metal content in groundwater used by the surrounding community.

Acknowledgements

The authors would like to thank the Directorate General of Higher Education of the Republic of Indonesia for supporting this research as part of the PasTi scholarship funding. The author expresses his deepest gratitude to the Regent of Gorontalo and the Head of TPA Talumelito who have given permission to conduct research in the area of Final Disposal (TPA) and its surroundings.

REFERENCES


Meirikayanti, H., Rahardja, B.S., Adriana, M. .. 2018. “Analysis of Heavy Metal Copper (Cu) Content on Mud Crab (Scylla Sp) at Wonorejo River, Surabaya.” Fisheries and Marine Scientific Journal 10(1):106–11
