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ANALYSIS OF THE INFLUENCE OF TAMBAKRIGAGADUNG LANDFILL LEACHATE CHARACTERISTICS ON WATER QUALITY AND HEAVY METAL CONTAMINATION OF RESERVOIRS, TIKUNG DISTRICT, LAMONGAN REGENCY

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ABSTRACT

Analysis of the Influence of Tambakrigagadung Landfill Leachate Characteristics on Water Quality and Heavy Metal Contamination of Reservoirs, Tikung District, Lamongan Regency. The Final Disposal Site (TPA) of Tambakrigadung Village, Lamongan Regency, implements a semi-sanitary landfill system in which waste processing still piles up piles of waste with soil for a certain period, causing a foul odor due to the leachate that collects. Leachate that is not managed correctly is feared to flow into reservoirs as irrigation and productive land that is used by local communities for rice fields or ponds around the Tambakrigadung TPA so that it can disrupt workers, reduce the quality and yield of rice fields, and affect the development of pond fish around the Tambakrigadung landfill. This research aims to test the quality of reservoir water, which refers to the leachate water quality standards of PermenLHK RI No. P.59 Tahun 2016. It analyzes the influence of leachate on reservoir water around Tambakrigadung. The method used in this research is grab sampling. Analysis of pH, BOD, COD, and TSS parameters using simple linear regression quantitative analysis. Quantitative parameter analysis shows that TPA Tambakrigadung leachate influences the pH and TSS parameters of reservoir water in Tikung District, Lamongan Regency, which is indicated by a significance value of <0.05. The analysis of heavy metal parameters shows that the leachate does not meet quality standards, with a total N of 187.7 ppm and cadmium of 0.15 ppm. The mercury parameter meets quality standards, namely 0.00065 ppm. Meanwhile, heavy metal parameters in reservoir water have met quality standards based on PP No. 22 of 2021.

INTRODUCTION

Waste is an important problem that needs to be addressed because the pile of garbage that is increasing along with the amount of waste produced from all human activities can be a source of disease (1). The amount of waste generated in Lamongan Regency in 2022 is around ±228 tons/day or 80,240 tons/year (2). This amount exceeds the number of city waste piles in Blitar City, which is 74 tons per day (3). The landfill is a final disposal site and waste management on a household scale and community shops, while waste that pollutes the highway is transported by the Lamongan Regency Regional Environment Agency to the landfill (Final Processing

Site). According to Law No. 18 of 2008, Landfill is a place where waste reaches the last stage in its management so as not to cause disturbances to the surrounding environment. Organic and inorganic waste needs to be managed because it has the potential to disrupt the environment, especially through leachate contamination of the soil and rivers which can pollute ponds, rivers and surrounding groundwater [(4)]. In addition, it can also have a negative impact on health and as a breeding ground for various diseases [(5)].

The purpose of landfill waste is reviewed from its use, namely as a waste disposal site and as a lowland reclamation [(6)]. The process of decomposing waste both chemically and biochemically produces a secretion liquid with a high solids content and oxygen requirement called leachate. Leachate is a black liquid that smells bad and has a high content of organic and inorganic substances [(7)]. The organic matter contained in leachate is inorganic and organic chlorinated salts that can contaminate the soil, surface water, as well as groundwater, water bodies, and downstream water [(8–11)]. The content of leachate consists of several heavy metals such as Zn, Cu, Mn, Hg, Cd, Pb, Cr, and other heavy metals [(12)]. Leachate can penetrate through the bottom layer of the landfill. Chemical elements and biological materials that are carried will be filtered through the absorption process and the filtration process from the soil layer [(6)]. Therefore, the leachate has the potential to contaminate surface water and groundwater [(12)]. Moreover, Leachate can increase nitrate levels in the soil that can be absorbed by food crops, causing human health problems [(13)]. Leachate can also alter the physicochemical conditions of the waters leading to a decrease in the diversity and abundance of plankton [(14)].

Rainwater acts as a solvent that carries pollutants from the decomposition of waste flowing into the leachate reservoir. However, if in high concentrations, the substances contained in leachate absorbed into the soil cannot decompose properly so that it pollutes the surrounding environment, including polluting the soil, groundwater, and surface water around the location [(15)].

The Tambakrigadung Waste Landfill is the largest landfill in Lamongan City located in Tambakrigadung Village, Tikung District. The landfill is surrounded by rice fields, ponds, and housing that are not far from the landfill location. The final handling of waste at the Tambakrigadung Village Waste Landfill uses a semi- sanitary landfill or piling up garbage with soil in a certain period [(16)]. The system produces by-products, namely gas and leachate, causing an unpleasant odor [(17–19)]. Leachate can also contaminate drinking water sources at a distance of 100 meters from the source of pollution [(20)]. The landfill, which is only 1 km from the residential location, has the potential to pollute water and soil.

The condition of leachate in the Tambakrigadung Landfill that is monitored to be poorly controlled can cause pollution. Reservoir water for rice field irrigation around the landfill has become smelly and is feared to contain pollutants from leachate. The landfill is also located on productive land used by the surrounding community, namely freshwater fishponds. This landfill can disturb pond workers and is feared to reduce the quality and yield of rice fields and can affect the development of fish in ponds.

The purpose of this study is to find out and identify the possibility of pollution due to leachate leakage which results in the pollution of reservoir water quality as agricultural irrigation water around the Tambakrigadung Landfill reviewed from chemical and heavy metal pollution parameters. The leachate character data can show the level of pollution based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.59/Menlhk/Setjen/Kum.1/7/2016 concerning leachate quality standards for businesses and/or activities where waste is finally processed [(21)]. The character of leachate can be used as a consideration to evaluate the waste treatment system and leachate treatment at the Tambakrigadung Waste Landfill, Lamongan Regency and identify the possibility of pollution due to leachate leakage which results in the pollution of reservoir water quality as agricultural irrigation water around the landfill from chemical and physical pollution parameters. In addition, the results of the research are expected to be used as a reference in development planning in other landfills.

MATERIALS AND RESEARCH METHODS

The research was conducted from February to May 2023. Sampling was carried out at three points, at the location of the Tambakrigadung Landfill, Lamongan Regency (red star) and at the reservoir (yellow star). The distance from the location of the Tambakrigadung landfill to the reservoir is approximately 400 m as shown in Figure 1. This study uses quantitative descriptive analysis. This analysis was used to describe the condition of leachate in the Tambakrigadung Waste Landfill, Lamongan Regency.

Figure 1. Sampling point

The tools used in this study include mobile phones with Android RAM specifications of 4GB (Global Positioning System (GPS) and documentation tools), HDPE bottles, and stationery (notebooks, pens, labels). The leachate sampling method is carried out directly using the grab sampling in accordance with SNI 6989.59:2008 concerning the method of sampling leachate using the grab sampling method, which is a method of sampling water characteristics that is carried out only at that time [22]. Water samples are taken using a water sampler based on SNI 6989.59:2008. The parameters measured are pH, BOD (Biologycal Oxygen Demand), COD (Chemical Oxygen Demand) than TSS, (Total Suspended Solid). This parameter is the main parameter for determining organic substances in the waste. pH measurements are carried out at the location of leachate collection. BOD, COD, and TSS measurements were carried out at the Environmental Health Laboratory, Lamongan Islamic University. The determination of parameters and examination methods is in accordance with the SNI Laboratory standards shown in Table 1. The analysis of leachate at the Tambakrigadung Waste Landfill in Lamongan Regency according to the leachate criteria refers to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.59/Menlhk/Setjen/Kum.1/7/2016 concerning leachate quality standards for businesses and/or activities where the final waste is processed.

The heavy metals analyzed in reservoir water and leachate samples are Cadmium (Cd) and Mercury (Hg) which are non-essential metals for the biological systems of living things. A number of samples were deconstructed in the fume hood by heating the test sample that had been added with concentrated HNO3 until the volume was ±10 ml until it was clear. According to the Indonesia National Standard (SNI 13-6974-2003) and [23] Heavy metals in a sample can be analyzed by the Atomic Absorption Spectrophotometry (SSA) method of the flame system. The analysis was carried out at the Pharmacy Laboratory, Universitas Airlangga Surabaya with the help of local laboratories.

Table 1. Analysis method for leachate water parameters from Tambakrigadung Waste Landfill, Lamongan Regency

No.	Parameter	Unit	Test Method	Reference
1.	pH	-	QI/LKA/08 (Electrometry)	SNI 6989.11:2019
2.	BOD	mg/L	APHA. 5210 B-1998	SNI 6989.72:2009
3.	COD	mg/ L	QI/LKA/19 (Electrophotometry)	SNI 6989.2:2009
4.	TSS	mg/ L	APHA. 2540 D-2005	SNI 06-6989.3:2004

RESEARCH RESULTS AND DISCUSSION

Leacheate Water Quality at TPA Tambakrigadung, Lamongan Regency

The leachate used in the study was water from the last pool. Leachate management at the Tambakrigadung Landfill, Lamongan Regency is still using the semi sanitary landfill and leachate treatment has not been carried out properly. So far, leachate has been stored in the reservoir and then allowed to decompose naturally or with facultative anaerobic principles (24).

Based on observations at the time of sampling, the leachate from the Tambakrigadung Landfill, Lamongan Regency was brownish-yellow and smelled bad or smelly typical of garbage. The smell is due to the decomposition process of organic matter that produces odorous compounds, namely ammonia (25).

Table 2. Leachate Water Quality Parameters compared with Leachate Water Quality Standard Criteria

No.	Parameter	Unit	Results	Quality Standards*)
1.	pH	-	6.85	6-9
2.	BOD	mg/L	139	150
3.	COD	mg/L	110	300
4.	TSS	mg/L	35	100

*) Quality Standards are in accordance with Regulation of The Minister Of Environment And Forestry Of The Republic Of Indonesia Number P.59/Menlhk/Setjen/Kum.1/7/2016 Concerning Quality Standards For Leachate For Businesses And/or Activities Of Final Waste Processing Place

Leachate is liquid waste that arises from external water that enters the garbage pile, dissolves and rinses dissolved matter, including biologically decomposed organic matter (12). The quantity and quality of leachate varies and fluctuates, depending on the ingress of water which mostly comes from rain and is influenced by several factors such as surface, soil slope, and climatic conditions (26)

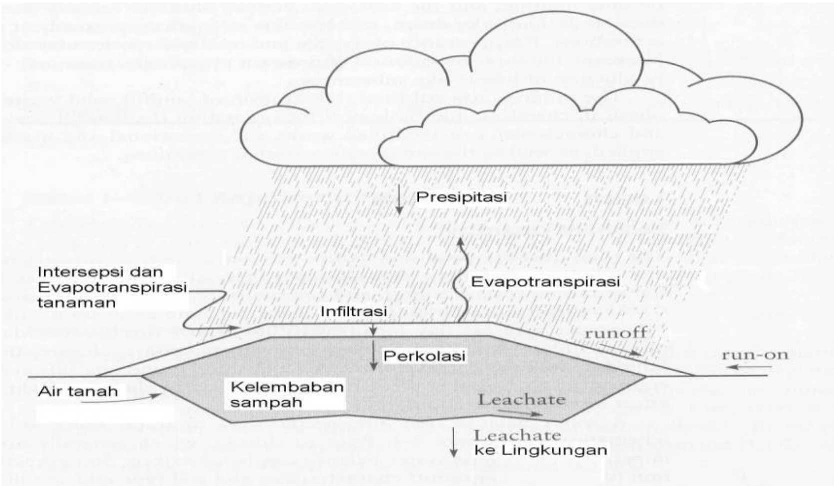

Figure 2. Process of leachate formation(27).

Leachate production is sustainable with the balance of water in the landfill. The amount of water that enters will be equal to the amount of water consumed for the waste decomposition process biologically and chemically and the amount of water left that seeps out. Water from the outside enters through seepage from overburden that comes from rainwater and other surface water. The amount of water that enters will be more than in the dry season (28). The composition and characteristics of leachate vary because it is influenced by the characteristics of waste (organic-inorganic), decomposition process (soluble-insolvable), state of the waste pile (temperature, pH, humidity, age), characteristics of water sources (quantity and quality of water affected by water affected by climate and hydrogeology), availability of nutrients and microbes, and the presence of inhibitors [(29)].

Reservoir Water Quality around Tambakrigadung Landfill, Lamongan Regency.
The location of the reservoir water where the water was taken as a sample is very close to the location of the Tambakrigadung Landfill, Lamongan Regency. Reservoir water sampling was taken at 4 different points, namely river water, at approximately 50 m, 100 m, 150 m, and 200 m downstream from the landfill location. Based on the results of field observations during sampling, reservoir water tends to be dark brown and smelly.

Table 3. Leachate Water Quality Parameters compared with Leachate Water Quality Standard Criteria compared with Leachate Water Quality Standard Criteria

No.	Parameter	Unit	Reservoir water collection point				Quality Standards*)
			1	2	3	4	
1.	pH	-	7.30	7.05	6.88	6.64	6-9
2.	BOD	mg/L	135	69	145	112	150
3.	COD	mg/L	40	22	18	24	300
4.	TSS	mg/L	33	24	22	15	100

*)Quality Standards are in accordance with REGULATION OF THE MINISTER OF ENVIRONMENT AND FORESTRY OF THE REPUBLIC OF INDONESIA NUMBER P.59/Menlhk/Setjen/Kum.1/7/2016 CONCERNING QUALITY STANDARDS FOR LEACHATE FOR BUSINESSES AND/OR ACTIVITIES OF FINAL WASTE PROCESSING PLACE

The results of a comparative destructive analysis with leachate quality standards according to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.59/Menlhk/Setjen/Kum.1/7/2016 concerning leachate for businesses and/or activities where waste is finally processed in table 3 shows that the pH, BOD, COD, and TSS values are still within the quality standards.

The pH parameter is the degree of acidity used to indicate the activity of hydrogen ions in water [(30)]. pH measurements are important to know the type of reaction and how fast organic and inorganic matter reacts in water [(31)]. The pH of leachate at the Tambakrigadung Landfill, Lamongan Regency is still in the range of the standard value of muku. The pH value of leachate compared to the pH of reservoir water taken from several location points did not show a significant difference. The difference in pH value in reservoir water at each point indicates that there are stages of degradation of the garbage pile. Higher pH values indicate a decrease in degraded organic matter, which leads to a decrease in the concentration of organic acids. A decrease in pH can occur because the landfill is in acidic condition [(32)]. This indicates that there is activity of microorganisms that break down organic matter, such as carbohydrates that are broken down into glucose and glucose which is then broken down into organic acids, thus producing carbon dioxide (CO2) and water (H2O) [(33)]. The pH value that is at the neutral point indicates that the degradation process is going well and optimally [(31)].

pH correlates with sampling distance (R = -0.539). If the pH is high, then the sample distance is getting closer, and vice versa. The ideal waters to support fish life and aquatic organisms as fish food are waters that have a pH ranging from 6.5 to 8.5. So based on the research and quality standards that have been set, reservoir waters are classified as ideal waters that support the life of fish and other aquatic organisms as fish food [33, 34].

In Table 1 and Table 3, BOD levels are still below the environmental standards set by the Minister of Environment and Forestry No.59 of 2016 concerning Waste Standards for Businesses and/or Activities at Waste Final Processing Sites. It was stated that the standard threshold for BOD quality that is safe to dispose of into water bodies is 150 mg/L. Low BOD values are influenced by general characteristics for old waste classified as methanogenesis phase [17] [36]. In this phase, there is a decrease in BOD because there is a good degradation process by microbes so that it can degrade the organic matter contained in the column landfill. In addition, the influence of leachate quality affects the concentration of BOD. The BOD value in aged leachate ranges from 100 mg/L (37).

COD is used to measure the content of organic matter and the amount of oxygen required to chemically oxidize organic matter. Leachate from old landfills is almost neutral, i.e. it has relatively low levels of organic carbon and minerals. The COD level for wastewater (Table 1 and Table 3) was 110 mg/L, while the COD of water in the reservoir at each measurement point showed a lower value than the wastewater quality standard of 300 mg/L. The low concentration of COD was caused by the properties of the influence of the age of the waste or waste that had entered the phase methagenic where the leachate produced has matured or contains nitrogen [38]. COD correlates with sampling distance ($R = -0.797$) which means that the distance between the well and the landfill to the COD level of well water has a very close and negative and significant relationship. The farther the sampling distance, the lower the COD value. The high concentration of COD indicates the amount of organic matter contained in the landfill column. This shows that microorganisms grow and begin to degrade organic matter in the substrate that takes place in the acidogenesis. The difference in sampling distance points shows that COD concentration tends to decrease [39]. The decline occurred due to the reduction of available organic contaminants due to degradation and the decay of available contaminants due to degradation in landfill [6].

Total Suspended Solid (TSS) is the sum of all types of solid particles in a total filterable solid with a maximum size of 2.0 μm and can be deposited (15). It can be seen from Table 1 and Table 3 that the TSS content in the leachate outlet pool is between 15-35 mg/l. According to environmental quality standards, it is stated that the maximum limit of TSS that is safe to dispose of in rivers is 100 mg/L. This figure shows that the number of solid substances put into waste treatment is very minimal. TSS correlates with sampling distance ($R = -0.980$) which means the relationship is close or strong. If the sampling distance increases or increases, the TSS value is lower. The low TSS value can also be caused by the flow of water from the reservoir at the observation site and the influence of the season. In addition, the level of soil surface erosion (densely populated settlements) can also be a trigger for high and low TSS values in reservoirs. High TSS can block the entry of sunlight into the water, thus disrupting the photosynthesis process and causing a decrease in dissolved oxygen released into the water [40].

The total content in the leachate water and reservoir water around TPA Tambakrigadung is unclear.

The following data presents the results of testing the total N content in the leachate from Tambakrigagadung landfill:

Table 4. Test results for Total N content in TPA Tambakrigadung leachate and reservoir water

Sample Name	Results	Minister of Environment and Forestry Regulation 59 of 2016 Standards for Landfill Leachate Quality	
Leachate	187.7 ppm	60 mg/L	
Sample Name	**Results**	**Lake Water Quality Standards (PP 22 of 2021)**	
		Grade 3	4th grade
Reservoir water	0.80 ppm	1.90	-

The total N-value contained in leachate is 187.7 ppm. Based on the environmental quality standards set by the Minister of Environment and Forestry No.59 of 2016 concerning Leachate Quality Standards for Businesses and/or Activities of Final Waste Processing Sites, the threshold for the N Total quality standard that is safe to be disposed of into water bodies is 60 mg/L. The high total N value is influenced by the organic waste contained in the Tambakrigadung Landfill and the leachate treatment pond which is less effective (13).
The total N-content in a waste comes from domestic waste which contains 40-60% protein. Protein in domestic waste in waters is one of the sources of organic nitrogen content in addition to urea, which is then converted into ammonia. If it has enough oxygen content, it turns into nitrite and nitrate at the oxidation stage.
The results of the analysis of the leachate quality of the Tambakrigadung Landfill, Lamongan Regency on the water quality around the landfill showed that all parameters did not exceed the standard quality standard threshold. Waste that decomposes and produces leachate is then washed away by rainwater into river water and also enters the ground, not polluting the reservoir water around the location of the Tambakrigadung Landfill, Lamongan Regency.

Mercury Content in Leachate and Reservoir Water around the Tambakrigadung Landfill

The following data represents the results of testing the mercury content in the leachate of TPA Tambakrigadung:

Table 5. Test results for mercury content in landfill leachate and reservoir water around the landfill

Sample Name	**Results**	**Minister of Environment and Forestry Regulation 59 of 2016 Quality Standards for Landfill Leachate Water**	
Leachate	0.00065 ppm	0.1 mg/L	
Sample Name	**Results**	**Lake Water Quality Standards (PP 22 of 2021)**	
		Grade 3	4th grade
Reservoir water	0.0005 ppm	1.90	-

Mercury is an essential compound where its appearance in certain amounts is needed by living organisms, but in excessive amounts it causes toxic effects [41]. Heavy metals are difficult to degrade, so they are very easy to accumulate in the environment and their natural presence is difficult to remove [42]. In this study, the mercury level in the leachate landfill column was detected at 0.00065 mg/L while based on the quality standard according to the Minister of Environment and Forestry Regulation 59 of 2016 was 0.1 mg/L. Meanwhile, the results of the analysis of reservoir water samples in this study showed that the mercury content in the reservoir was 0.0005 mg/L while based on the quality standard according to PP 22 of 2021 in class 3 was 1.90 mg/L, which means that the reservoir water has a low mercury content. This is because sampling of reservoir water at points 1, 2, 3, and far away is carried out Composit, so that the cadmium content in the reservoir water sample is low [13,14].

CONCLUSIONS AND RECOMMENDATIONS

The results of the parameter analysis showed that the leachate in the Tambakrigadung Landfill, Lamongan Regency did not exceed the standard quality threshold so that it did not affect the quality of the reservoir water around the Tambakrigadung Landfill. The author provides recommendations for heavy metal testing in leachate and reservoir water around the Tambakrigadung Landfill.

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