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Evaluation of Leachate Discharge on Pond Water Quality Around the Benowo Surabaya Final Processing Site in 2025

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ABSTRACT

Background The Benowo landfill had the potential to contaminate the environment through leachate discharges containing organic and inorganic compounds. This contamination could affect the water quality of ponds located around the landfill and utilized by the community. **Research Objective:** The study aimed to evaluate the impact of leachate discharge on pond water quality around the Benowo landfill in Surabaya. **Research Method:** This study used a descriptive method with a qualitative approach and a cross-sectional design. The research object consisted of active ponds owned by residents located at a distance of 500, 1,000, and 1,500 meters from the landfill. Sampling occurred using a composite sampling technique and the samples were analyzed for pH, TDS, BOD, COD, and Fe parameters. Data was obtained from field observations and measurements, then presented in the form of tables and graphs. **Results:** The results showed that the water quality of ponds around Benowo landfill had decreased, on the parameters of BOD, COD, and Fe which exceeded the threshold of Class III quality standards according to PP No. 22 of 2021. The highest concentration was found at a distance of 500 meters from the landfill with BOD levels reaching 145 mg/L, COD 1042 mg/L, and Fe at 0.83 mg/L. The pH value ranged from 7.5-8.0 and TDS was still within the quality standard limit, which was <1,000 mg/L. These results indicated the potential for leachate contamination of active ponds used by the community for fish farming. **Conclusion:** The highest TDS and BOD values were found at 500 m, while COD and Fe fluctuated with a tendency to remain high up to 1500 m, influenced by water flow and surface runoff. The distribution of contaminants did not always decrease with distance, suggesting that leachate contamination is widespread and dynamic.

Keywords: Leachate, Water Quality, Benowo Landfill

BACKGROUND

Landfill (TPA), is a storage location for various types of waste, including liquid waste generated due to the entry of water from outside into the landfill or waste pile. The landfill serves to dissolve and rinse dissolved materials, including organic matter from the biological decomposition process known as leachate (Nurjanna & Ali, 2021). This leachate is formed in the landfill area, which is a place where residual waste is deposited, which is a major source of pollution if not managed properly (Pratama & Jawwad, 2023). Leachate contains many microorganisms, organic and inorganic materials, and heavy metals (Adriati et al., 2023). The pH concentration, temperature, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), total ammonia, nitrate, nitrite, Ferrum (Fe), sulfate, Chemical Oxygen

Demand (COD), and Biological Oxygen Demand (BOD) of leachate are all included in it (Parde et al., 2021). Waste management in landfills is crucial to prevent environmental pollution. If management is not optimal, then water pollution is one of the main impacts that can occur.

Water pollution is a decrease in water quality to a certain level that results in water not being able to function properly due to the entry of living things, energy, substances, and/or other components into water, as well as changes in water structure, both due to human activities and due to natural processes (Pratiwi, 2020). Groundwater and the environment can be contaminated by leachate or leachate, which can also come from decomposing waste debris (Walid et al., 2020). The arrival of the rainy season will cause problems such as in landfills in the city.

Landfill if it does not have a poor layer and will result in leachate leakage. In addition, leachate leakage can seep into the ground and pollute the environment, especially pond water around the landfill (Nurjanna & Ali, 2021). This pond water is included in the category of class three (3) water quality standards in PP No. 22 of 2021 concerning Water Quality Management and Water Pollution Control whose designation is used for freshwater fish farming, animal husbandry, water for irrigating crops, and or other designations that require the same water quality as these uses. Heavy metal pollution such as iron (Fe) is of particular concern because it can accumulate in the body, as research conducted by (Syukriah et al., 2024). Environmental quality, season, fish species, developmental stage, and age of maturation are some of the factors that influence metal content in fish tissue (Łuczyńska & Paszczyk, 2019).

From the observations carried out that the ponds around the Benowo landfill is still actively used as fresh fish farming water sourced from rainwater or irrigation waters and there are also ponds as salt production water sourced from rainwater. Previous research was conducted by taking three (3) samples on the west side at at the sampling point at different distances, point 1 or the closest distance is 500 meters, point 2 or medium distance is 900 meters, and point 3 or the farthest distance is 1200 meters.

The results of laboratory tests were compared to physical and chemical assessments using the Quality Standards of PP No. 22 of 2021 concerning Water Quality Management and Water Pollution Control, Republic of Indonesia. The parameters measured in this preliminary study are pH and TDS as physical parameters, BOD and COD as chemical parameters. The results of pH measurements at points 1, 2 and 3 are 7.36, 7.64, 8.22 where the results obtained are still at the quality standard threshold of 6-9. The results of TDS, BOD and COD measurements at points 1, 2, 3 were found that they were still far above the Quality Standard threshold. TDS results are 12070 mg/L, 7920 mg/L, 13560 mg/L while the established quality standard is 2000 mg/L. BOD results amounted to 145 mg/L, 116 mg/L, 112 mg/L while the established quality standard is 6 mg/L. The set standard is 40 mg/L, and the COD results are 1042 mg/L, 542 mg/L, and 1196 mg/L.

RESEARCH METHODS

This study is descriptive and uses a qualitative approach. This preliminary study aims to evaluate the impact of leachate discharge on the water quality of ponds around the Benowo Landfill, based on pH, TDS, BOD, COD, and Fe parameters. This study employed a descriptive qualitative approach using a cross-sectional design. This study aimed to identify the pond locations most impacted by the Benowo Landfill leachate discharge.

The sampling technique used several stages. The first stage was determining the distance between the pond water sampling points and the Benowo Landfill. The second stage was determining the sampling points within the Benowo Landfill. Water sampling was conducted at two locations on the west and east sides of the Benowo Landfill. The subjects of this study were ponds still actively used by the community around the Benowo Landfill in Surabaya.

The water sampling technique used a composite sample, using a mixture of water from several pond samples and then combining them into one sample. The water sampling was conducted at several sampling points during the day. Sample selection was conducted using purposive sampling, a sampling technique based on specific criteria. Six sampling points were selected, spread across both sides of the Benowo Landfill, as sampling locations. Sampling was replicated twice on different days. The first replication was conducted during the dry season, and the second during the rainy season.

The independent variable in this study was leachate generated from the waste decomposition process at the landfill, which pollutes the pond water. The dependent variable was pond water quality, measured using pH, TDS, BOD, and Fe. Data collection techniques included observation, documentation, field parameter measurements, and laboratory-scale measurements. The data were presented in tables and graphs. Analysis was carried out by grouping the data based on the distance of the pond water from the Benowo Landfill. The measurement results were compared with the quality standard, namely Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management.

RESULTS AND DISCUSSION

The Benowo landfill leachate discharge outlet showed that it has not met the requirements of the wastewater treatment regulation of East Java Governor Decree No. 45 of 2002 concerning Liquid Waste Quality Standards for Industry or other Business Activities, especially for five main parameters, namely TDS (12195 mg/L), COD (2000 mg/L), BOD (840 mg/L). This study was conducted to evaluate the extent of the influence of leachate discharge from Benowo landfill on the water quality of ponds located in the vicinity.

A. Measurement of pH, TDS, BOD, COD, and Fe Concentrations in Water from the West and East Sides of the Pond Based on Quality Standards PP No. 22 of 2021. *Potential of Hydrogen* (pH).

Table 1.

Results of pH Measurements on the West and East Side of the Pond in 2025

Distance (m)	West		East		Default Quality
	Replication				
	1	2	1	2	
500	8,22	8,38	7,98	7,77	6-9
1000	7,86	8,03	7,84	7,09	
1500	8,13	8,27	7,8	7,99	

Table 1 can be explained that the results on the west side of the pond at a distance of 500 meters in the first replication obtained a result of 8.22 and the second replication 8.38. At a distance of 1,000 meters in the first replication get results 7.86 and the second replication 8.03. At a distance of 1,500 meters in the first replication obtained a result of 8.13 and the second replication 8.27. Results on the east side of the pond at a distance of 500 meters in the first replication obtained a result of 7.98 and the second replication 7.77. At a distance of 1,000 meters in the first replication obtained a result of 7.84 and the second replication 7.09. At a distance of 1,500 meters in the f.

***Total Dissolved Solids* (TDS)**

Table 2.

Results of TDS Measurements on the West and East Side of the Pond in 2025

Distance (m)	West		East		Default Quality
	Replication				
	1	2	1	2	
500	1070	919	1723	2729	1000 mg/L
1000	950	860	1444	3027	
1500	996	961	1442	2890	

Based on Table 2 can be explained that the results on the west side of the pond at a distance of 500 meters in the first replication obtained results of 1070 and the second replication of 919. At a distance of 1,000 meters in the first replication get results 950 and the second replication 860. At a distance of 1,500 meters in the first replication get results 996 and the second measurement 961. Results on the east side of the pond at a distance of 500 meters in the first replication obtained a result of 1723 and the second replication 2729. At a distance of 1,000 meters in the first replication obtained a result of 1444 and the second replication of 3027. At a distance of 1,500 meters in the first replication, the results were 1442 and the second replication 2890.

***Biochemical Oxygen Demand* (BOD)**

Table 3.

Results of BOD Measurements on the West and East Side Ponds in Year 2025

Distance (m)	West		East		Default Quality
	Replication				
	1	2	1	2	
500	12,6	48	214	39	6 mg/L
1000	20,3	29	107	90	
1500	8,2	57	187	155	

Based on Table 3 can be explained that the results on the west side of the pond at a distance of 500 meters in the first replication get results 12.6 and the second replication 48. At a distance of 1,000 meters in the first replication get results 20.3 and the second replication 29. At a distance of 1,500 meters in the first replication get results 8.2 and the second replication 57 Results on the east side of the pond distance 500 meters in the first replication get results 214 and the second replication 39. At a distance of 1,000 meters in the first replication get results 107 and the second replication 90. At a distance of 1,500 meters in the first replication get results 187 and the second replication 155.

***Chemical Oxygen Demand* (COD)**

Table 4.

Results of COD Measurements on the West and East Side Ponds in 2025

Distance (m)	West		East		Default Quality
	Replication				
	1	2	1	2	
500	153	49	1240	237	40 mg/L
1000	117	86	1033	574	
1500	136	148	1025	1074	

Based on Table 4 can be explained that the results on the west side of the pond at a distance of 500 meters in the first replication get the results 153 and the second replication 49. At a distance of 1,000 meters in the first replication got a result of 11 and the second replication 86. At a distance of 1,500 meters in the first replication, the results were 136 and the second replication 148. 148. Results on the east side of the pond at a distance of 500 meters in the first replication obtained a result of 1240 and the second replication 237. At a distance of 1,000 meters in the first replication, the results were 1033 and the second replication 574. At a distance of 1,500 meters in the first replication, the results were 1025 and the second replication was 1074.

***Ferrum* (Fe)**

Table 5.

Results of Fe Measurements on the West and East Side Ponds in 2025

Distance (m)	West		East		Default Quality
	Replication				
	1	2	1	2	
500	2,37	2,52	0,61	1,57	0,03 mg/L
1000	1,79	2,05	1,07	0,48	
1500	2,89	0,9	0,14	0,4	

Based on Table 1. 5 can be explained that the results on the west side of the pond at a distance of 500 meters in the first replication obtained a result of 2.37 and the second replication of 2.52. At a distance of 1,000 meters in the first replication, the results were 1.79 and the second replication was 2.05. 2,05. At a distance of 1,500 meters in the first replication obtained a result of 2.89 and the second replication 0.9. Results on the east side of the pond at a distance of 500 meters in the first replication obtained a result of 0.61 and the second replication 1.57. At a distance of 1,000 meters in the first replication obtained a result of 1.07 and the second replication 0.48. At a distance of 1,500 meters in the first replication, the result was 0.14 and the second replication was 0.40.

B. Evaluation of the Impact of Liquid Waste Disposal on Pond Water Quality Based on pH, TDS, BOD, COD, and Fe Parameters

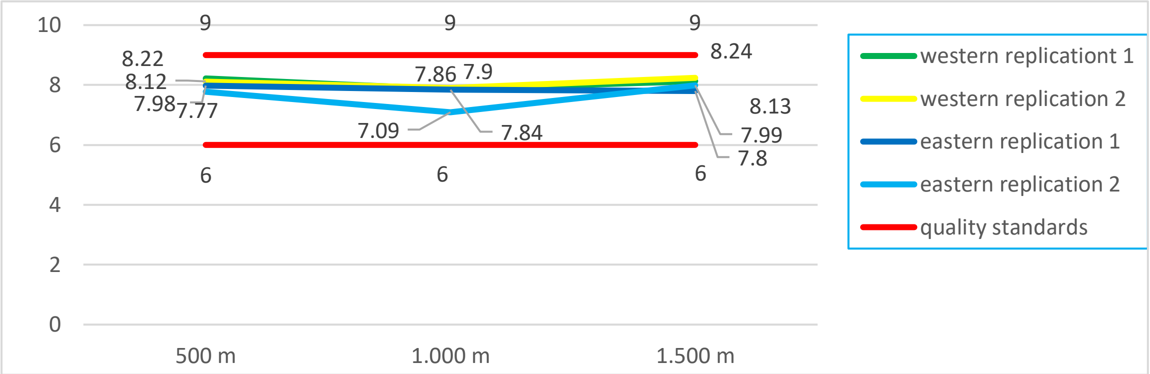

Figure 1. Results of pH Measurements on the West and East Side Pond in 2025

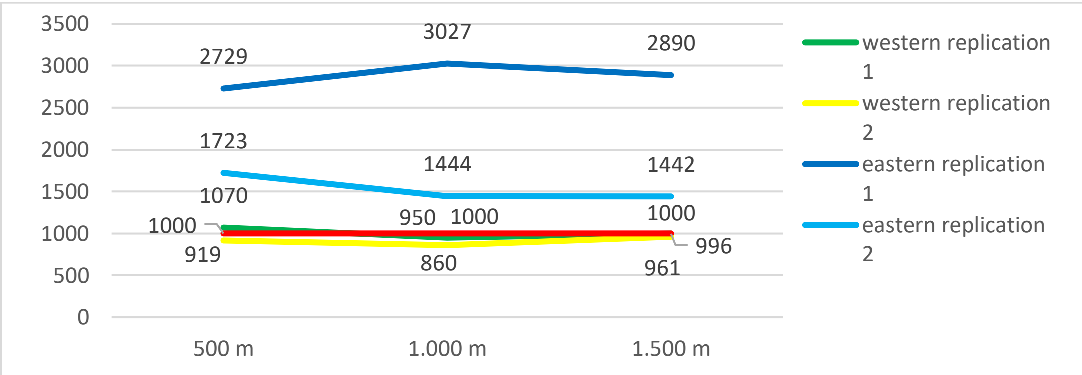

Figure 2. Results of TDS Measurements on the West and East Side Pond in 2025

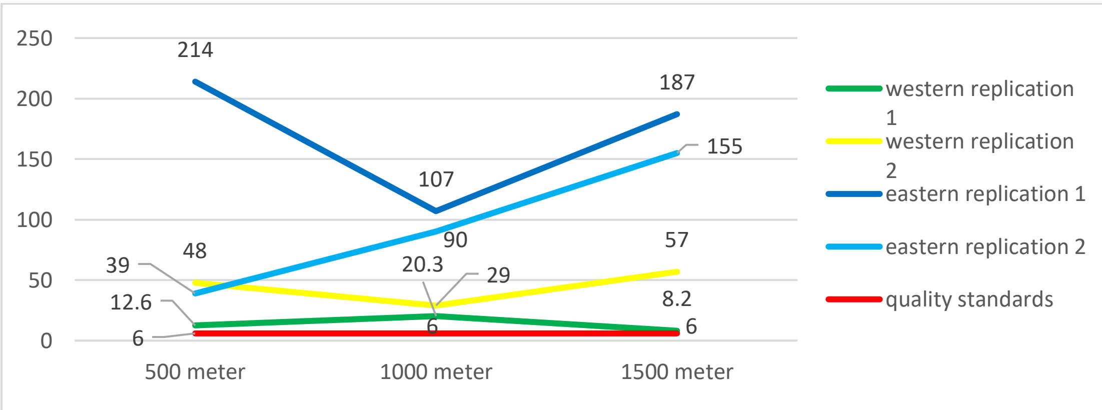

Figure 3. Results of BOD Measurements on the West and East Side Pond in 2025

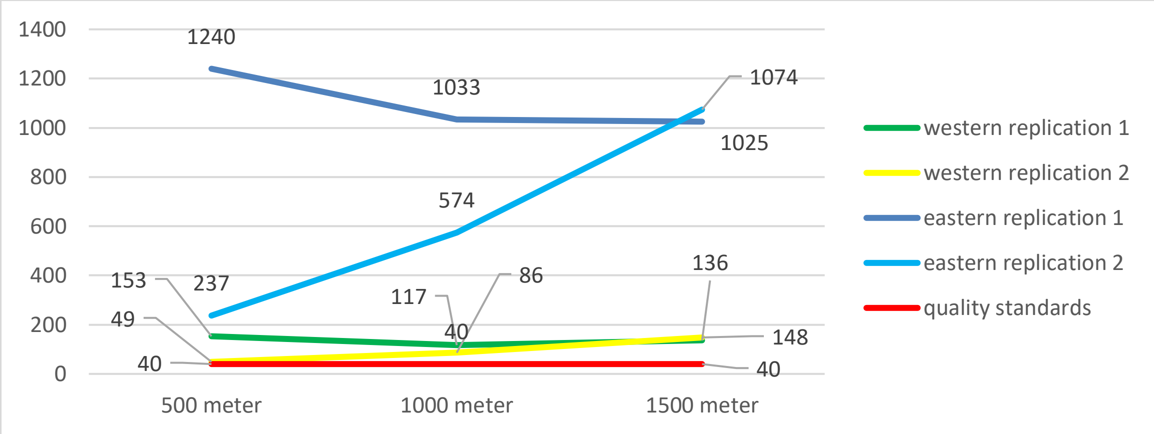

Figure 4. Results of COD Measurements on the West and East Side Pond in 2025

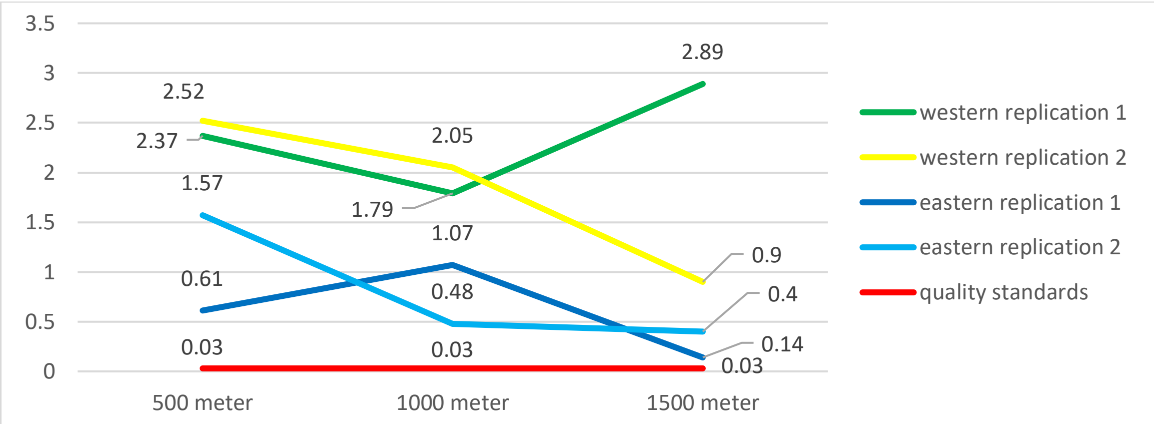

Figure 5. Results of Fe Measurements on the West and East Side Pond in 2025

***Potential of Hydrogen* (pH)**

All pH values at all three distances and both measurement points are in the range of 6 - 9, thus meeting the quality standards for water quality. There was a decrease in pH at a distance of 1000 meters and increased again at 1500 meters. The figure above shows that all measurements of pH values on the East Side, both for the first replication and the second replication, at all distance points (500 meters, 1,000 meters, and 1,500 meters) are within the specified quality standard range of 6-9.

***Total Dissolved Solids* (TDS)**

From the results of Figure 2, it can be explained that the TDS measurements on the West Side show that most of the sampling points are below the TDS quality standard threshold of 1000 mg/L, except for the first replication at a distance of 500 meters which exceeds the quality standard. This indicates that the water quality on the West Side generally meets the TDS standard, except at the closest point (500 meters) for the first replication. Based on the data presented, it can be concluded that all TDS concentration measurements on the East Side, both for the first replication and the second replication, at all distance points (500 meters, 1000 meters, and 1500 meters) were consistently well above the established quality standard of 1000 mg/L. This indicates that water quality on the East Side is generally not up to standard.

***Biochemical Oxygen Demand* (BOD)**

Based on Figure 3, both the first replication and the second replication show that BOD levels on the West Side at all measurement distances (500 meters, 1,000 meters, and 1,500 meters) are consistently above the standard. (1,500 meters) were consistently above the quality standard of 6 mg/L. The results of the figure above show that the BOD value on the East Side in the first replication shows a fluctuating pattern. At a distance of 500 meters, the highest value of 214 mg/L was recorded, then decreased dramatically to 107 mg/L at a distance of 1000 meters, and increased again to 187 mg/L at a distance of 1500 meters.

***Chemical Oxygen Demand* (COD)**

Figure 4 shows that all COD measurements on the west side for both the first replication and the second replication at all distance points (500 meters, 1,000 meters, and 1,500 meters) were above the specified quality standard of 40 mg/L. The first replication values showed a change from high, slightly decreasing, then slightly increasing again, but always well above the quality standard. The second replicate values showed a consistent increasing trend as the distance increased, from slightly above the quality standard to very far above the quality standard.

***Ferrum* (Fe)**

The figure shows that all Fe concentration measurements on the West Side, both for the first replication and the second replication, at all distance points (500 meters, 1,000 meters, and 1,500 meters) were well above the established quality standard of 0.03 mg/L. Both the first replication and the second replication showed high concentration changes above the safe threshold. The first replication tended to increase at the farthest distance, while the second replication showed a decrease but remained at a very high level compared to the quality standard. This indicates serious Fe pollution in the West Side region, with potential negative impacts on aquatic ecosystems and health.

DISCUSSION

A. Measurement of pH, TDS, BOD, COD, and Fe concentrations on the West Side and East Side based on Government Regulation No. 22 of 2021.

The results indicated that most pond water surrounding the Benowo landfill on both the west and east sides has been contaminated by leachate. Elevated concentrations of all parameters exceeded the quality standards, indicating organic matter pollution and inorganic contamination derived from landfill leachate.

***Potential of Hydrogen* (pH)**

The pH of pond water ranged from 7.09 to 8.38, which falls within the Class III water quality standards (6.0–9.0) specified in Government Regulation No. 22 of 2021. This stability suggests that the leachate influence did not significantly alter the acidity of pond water. The buffering capacity of pond water, attributed to carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions, neutralizes acidic or basic compounds from leachate. During the methanogenesis phase of leachate formation, the decomposition of organic material results in a neutral to slightly alkaline composition, maintaining pH equilibrium.

According to William and Mawantu (2023), leachate with high organic loads (BOD and COD) still exhibited a neutral–alkaline pH (8.10–8.20) due to intrinsic buffering systems within the landfill (William et al., 2023). Similarly, Alimby and Triajie (2021) confirmed that bicarbonate ions stabilize pH even under increasing COD and metal concentrations. Hence, the stable pH observed in this study demonstrates the self-buffering capacity of pond water that prevents drastic pH fluctuations despite leachate intrusion (Alimby & Triajie, 2021).

***Total Dissolved Solids* (TDS)**

In the first sampling, TDS values were highest at 500 m from the landfill, attributed to high evaporation rates, which concentrate solutes in the water column. In contrast, during the second sampling, TDS decreased at 500 m but increased at 1000–1500 m due to rainfall dilution at upstream sites and surface runoff introducing new solutes downstream. These fluctuations reflect seasonal dynamics affecting solute transport.

Taha et al. (2024) reported landfill leachate with TDS ranging from 9,684–16,128 mg/L, dominated by inorganic and organic solutes. Their findings similarly highlight the role of runoff and dilution in redistributing solutes around landfill-affected areas (Saed et al., 2024)

***Biochemical Oxygen Demand* (BOD)**

The highest BOD concentrations were detected on the east side at 500 m, suggesting significant organic pollution from leachate seepage. Seasonal variations strongly affected BOD levels. During dry conditions, evaporation and high temperature increased organic concentration and microbial activity, leading to higher oxygen demand. In contrast, during the rainy season, surface runoff from settlements and agriculture contributed to organic load, while turbidity reduced light penetration and photosynthetic oxygenation, exacerbating oxygen depletion.

Tanjungrejo et al. (2019) found similar seasonal BOD fluctuations around the Kudus landfill, while Jonah et al. (2025) reported that runoff during the rainy season in Nigeria's Qua Iboe River led to higher BOD at distant sites. These findings corroborate that rainfall-driven runoff disperses organic pollutants over large areas (Ramadhani et al., 2019) (Jonah et al., 2025).

***Chemical Oxygen Demand* (COD)**

COD showed similar fluctuation patterns, increasing during dry seasons due to concentration effects and remaining high during wet periods due to surface runoff introducing fresh organic materials. Elevated COD also indicates the presence of biodegradation-resistant compounds such as phenols, ammonia, and aromatic substances.

Research in Semarang by Syafrudin et al. (2024) revealed persistently high COD values (50.1–52.46 mg/L) in areas influenced by anthropogenic activities (Syafrudin et al., 2023). Likewise, Hidayati (2020) and Tanjungrejo Landfill studies found that COD consistently exceeded the permissible limits throughout the year, especially during rainy seasons when runoff was dominant (Karamina et al., 2021) (Meilasari et al., 2022).

***Ferrum* (Fe)**

The highest Fe concentrations occurred at 500 m on the east side, confirming direct leachate influence. In the first sampling, Fe decreased at 1000 m (likely due to precipitation as $Fe(OH)_3$ under neutral–alkaline pH) and rose again at 1500 m due to resuspension and flow accumulation. In the second sampling, Fe decreased across distances due to dilution and oxidation from heavy rainfall, which facilitated Fe precipitation.

Wang et al. (2024) emphasized the ecological risks of Fe bioaccumulation in aquatic organisms, leading to oxidative stress and metabolic disturbances that degrade fish health and quality (Wang et al., 2024).

B. Evaluation of leachate discharge on pond water quality in terns of pH, TDS, BOD, COD dan Fe

Sampling from both the west and east sides of Benowo landfill provides an overview of leachate dispersion patterns and the environmental impact on surrounding pond ecosystems. The results serve as a basis for improving waste management and pollution control strategies at the landfill.

***Potential of Hydrogen* (pH)**

Despite proximity to leachate sources, pH values remained stable from neutral to slightly alkaline. This suggests that distance from contamination sources does not significantly affect pH, unlike other parameters such as COD, BOD, and Fe. Ningsih et al. (2020) observed similar stability in pH at the Antang Landfill, where mineral composition and water volume had stronger effects than distance from the source. Likewise, the Supit Urang Landfill study (2021) highlighted the buffering role of water mixing in maintaining pH stability (Ningsih et al., 2020).

***Total Dissolved Solids* (TDS)**

The effect of distance on TDS values is very visible from the distribution pattern of measurement results that vary at each point. At a distance of 500 meters on both the west and east sides, the TDS tended to have the highest value in the first replication. This is due to the proximity of the point to the source of pollution, the Benowo landfill. Leachate seepage that has not been properly handled has great potential to flow directly or seep into nearby ponds, causing accumulation of solutes in pond water.

At a distance of 1000 meters, the first replication of TDS values began to decrease. This decrease occurs due to the adsorption process by soil particles along the water flow path and the sedimentation process, where solutes begin to settle or stick to the surface of sediment particles. At a distance of 1500 meters, the first replication results showed relatively low TDS values, but increased again in the second replication. This suggests the pond is still receiving surface runoff from the surrounding area that brings in new contaminants. The process of solute diffusion and groundwater flow from upstream to downstream can also cause dissolved compounds to move to this point, especially when heavy rainfall increases the mobility of compounds in water.

Findings by Environmental Technology et al. (2025) along the Sepaku River align with this pattern, where high TDS (≈6,700 mg/L) persisted downstream due to runoff and anthropogenic influence (Dewa et al., 2025). These results reinforce the findings at Benowo landfill that TDS distribution depends not only on distance, but also on seasonal conditions, topography, water flow direction, and soil structure.

***Biochemical Oxygen Demand* (BOD)**

BOD values demonstrated non-linear trends with distance. The highest concentrations occurred near the landfill (500 m), decreased at 1000 m, and rose again at 1500 m. This pattern reflects secondary pollution sources such as domestic drainage and agricultural runoff. Seasonal variations also influenced results, with high rainfall increasing organic inflow and oxygen depletion.

According to Astuti et al., (2023) found the value of BOD and other pollutant parameters in the surface water of the river around the Piyungan landfill that exceeded the quality standards. Fluctuations in BOD values are also influenced by distance from landfill sources and rainy season activities that increase surface runoff (Astuti et al., 2023). Research by Sahani et al., (2024) found a significant decrease in BOD but BOD levels are still far above the quality standard threshold, confirming that organic pollutants in landfill leachate water remain high and evenly distributed to the surrounding environment (Sahani et al., 2025).

Chemical Oxygen Demand (COD)

The COD fluctuation pattern shows that the value remains high even at the 1500 meter point, both on the west and east sides. For example, from the initial value of 1240 mg/L at 500 m, it only dropped to about 1025 mg/L at 1500 m, which means a decrease of only about 17%. This could be due to the direction of pond water flow carrying leachate from the landfill downstream, increasing the accumulation of pollutants at distant points.

The slow rate of degradation of organic compounds, especially chemical compounds from leachate that are difficult to biodegrade, such as detergents, aromatic compounds and heavy metals. The role of distance is not dominant due to the strong influence of surface runoff and groundwater flow, which continue to carry contaminants from various directions to the pond. In addition, the presence of uncovered irrigation channels and nearby settlements can also be secondary sources of contaminants, resulting in high COD values despite the distance from the landfill.

Desmaizal Syahdo'a's study (2025) found leachate water COD levels of more than 1000 mg/L, exceeding quality standards, indicating high organic pollutants that are difficult to degrade biologically, similar to the character of high COD in Benowo landfill (Syahdoa'a et al., 2025). This is also reinforced by findings in Jatibarang landfill and Tanjungrejo landfill which state that high COD values occur not only upstream but also downstream, due to the structure of the water flow and weak pollution control (Revansyah et al., 2022).

Ferrum (Fe)

Fe levels at point 500 meters generally have the highest levels, because it is the location closest to the source of lindhujani discharge from Benowo landfill. At the 1000 meter point, there was a decrease in Fe levels. This decrease is thought to be due to the natural sedimentation process of heavy metals, especially if supported by neutral pH and sufficient dissolved oxygen. Fe will precipitate in the form of $Fe(OH)_3$ and stick to the sediment, so the concentration in surface water decreases.

At the 1500 meter point, the Fe level increases again. This shows that the influence of contamination still reaches the farthest point, either through surface flow, groundwater flow, or due to resuspension of Fe-containing sediments. The relatively flat and closed contours of the ponds, as well as the poor drainage system, led to the accumulation of heavy metals downstream.

A study in a landfill area in Malaysia by Pysarenko et al. (2022) found high Fe levels near the waste source and significant accumulation downstream after the rainy season. Rainfall causes increased heavy metal runoff, carrying Fe away from the initial source (Pysarenko et al., 2022).

INTERPRETATION OF RESULTS

The research results indicate that despite significant leachate contamination around the Benowo landfill, the pH of pond water remains stable within class III quality standards. This stability suggests that natural buffering systems in the pond, mainly carbonate and bicarbonate ions, effectively mitigate pH fluctuations, supporting the hypothesis that biogeochemical processes can maintain ecosystem balance in polluted environments. This finding aligns with previous studies by William and Mawantu (2023) and Alimby & Triajie (2021), which highlight the buffering role of bicarbonate ions in maintaining pH stability despite high organic and heavy metal pollution.

The elevated levels of TDS, BOD, COD, and Fe illustrate ongoing and dispersed contamination from landfill leachate, confirming the hypothesis that leachate significantly deteriorates pond water quality. The interplay between evaporation, rainfall, surface runoff, and poor drainage creates dynamic pollutant concentrations, emphasizing the complex hydrological and seasonal influences on contamination spread. These interpretations support the findings by Taha et al. (2024), Syafrudin et al. (2024), and Jonah et al. (2025), who showed that both natural processes and anthropogenic activities contribute to the persistence and distribution of organic and inorganic pollutants in aquatic environments near landfills.

Notably, the non-linear distribution patterns of BOD and Fe concentrations upstream and downstream emphasize that pollutant load does not simply dilute with distance but accumulates due to pond morphology, flow dynamics, and secondary pollution sources. This insight reflects the work of researchers like Tanjungrejo et al. (2019) and Pysarenko et al. (2022), illustrating that environmental conditions such as slow water flow and poor drainage exacerbate contamination downstream.

Overall, the study underscores the importance of managing leachate discharge and controlling runoff to prevent widespread degradation of pond ecosystems. The consistency of pH despite other parameter fluctuations highlights natural resilience, but the persistent high levels of pollutants indicate that without intervention, ecological and health risks associated with heavy metals and organic contaminants will worsen. These interpretations suggest that further improvements in landfill management and surrounding land use practices are crucial to mitigating long-term environmental impacts.

RESEARCH IMPLICATIONS

1. Discuss the practical and theoretical implications of the research findings.
2. Explain how the research results can be used in public health practice or policy.

CONCLUSIONS

Based on the results of research and discussion regarding the evaluation of leachate discharge on pond water quality around Benowo landfill that the pH and TDS values of pond water samples on the west and east sides still meet the quality standards of class III according to PP No. 22 of 2021. Concentrations of BOD, COD and Fe at all sampling points on both sides exceed the quality standards of class III BOD more than 6 mg/L, COD more than 40 mg/L Fe 0.3 mg/L.

At distances of 500 m, 1000 m and 1500 m, there is an impact of leachate discharge on pond water quality, especially in the parameters of TDS, BOD, COD and Fe, especially at the 500 meter point. Distance to the source of contamination has a significant effect on the distribution of pollutant parameters. Distance does not always show a linear pattern due to topographic factors, flow direction, season, and anthropogenic activities around the pond.

REFERENCES

Adriati, A., Muhardi, M., Sutanto, Y., Putra, Y. S., & Perdhanan, R. (2023). Sebaran Lindi di Sekitar TPA Batu Layang Pontianak Berdasarkan Nilai Self-Potential. Agustus, 8(3), 104–108. https://doi.org/https://doi.org/10.22437/jop.v8i3.27087

Alimby, W. V. A., & Triajie, H. (2021). Tingkat Keasaman Pesisir Perairan Kamal Kabupaten Bangkalan Madura Pada Musim Peralihan. Jurnal Ilmiah Kelautan Dan Perikanan, 2(3), 186–

201. https://doi.org/https://doi.org/10.21107/juvenil.v2i3.11767

Astuti, F. A., Syafrudin, S., & Susilowati, I. (2023). Kajian Status Mutu Air Sungai Akibat Buangan Air Lindi TPA Piyungan Di Kabupaten Bantul. Jurnal Ilmu Lingkungan, 21(4), 881–887. https://doi.org/doi:10.14710/jil.21.4.881-887

Dewa, R. P., Aryantie, M. H., Amru, K., Anjani, R., & Plamonia, N. (2025). Analisis Kualitas Sumber Air Baku untuk Pemenuhan Kebutuhan Air Minum di Ibu Kota Nusantara. Jurnal Teknologi Lingkungan, 26(1). https://doi.org/https://doi.org/10.55981/jtl.2025.4037

Diartika, E. I. A. (2021). Studi Kasus Pencemaran Sampah dan Pengelolaan Sampah di TPA Supit Urang Malang. Jurnal Pembangunan Wilayah Dan Kota, 17(1), 70–82. https://doi.org/https://doi.org/10.14710/pwk.v17i1.33366

Jonah, U. E., Akpan, I. I., & Umoh, E. S. (2025). Investigating The Influence Of Surface Runoff And Human Activities On The Seasonal Characterization Of Physicochemical Properties Of The Upper Segment Of Qua Iboe River Water, Niger Delta, Nigeria. Journal Of Applied Sciences And Environmental Management, 29(1), 137–145. https://doi.org/https://dx.doi.org/10.4314/jasem.v29i1.18

Karamina, H., Murti, A. T., & Mujoko, T. (2021). Kandungan Logam Berat Fe, Cu, Zn, Pb, Co, Br, Pada Air Lindi di Tiga Lokasi Tempat Pembuangan Akhir (TPA) Dadaprejo, Kota Batu, Dau dan Supit Urang, Kabupaten Malang. Jurnal Ilmiah Hijau Cendekia, 6(2), 51–57. https://doi.org/https://doi.org/10.32503/hijau.v6i2.1984

Łuczyńska, J., & Paszczyk, B. (2019). Health Risk Assessment Of Heavy Metals And Lipid Quality Indexes In Freshwater Fish From Lakes Of Warmia And Mazury Region, Poland. Int J Environ Res Public Health, 16(19). https://doi.org/https://doi.org/10.3390/ijerph16193780

Meilasari, F., Sutrisno, H., & Purwoko, B. (2022). Analisis Sebaran Lindi di Sekitar Kawasan TPA Batu LayangBerdasarkanNilai Resistivitas. Jurnal Teknologi Lingkungan, 24(1).

Ningsih, R. O., Leo, M. N. Z., & Maru, R. (2020). Indeks Kualitas Air Tanah Disekitar Tempat Pembuangan Akhir (TPA) Antang Kota Makassar. Jurnal Environmental Science, 2(2).

Nurjanna, A., & Ali, M. (2021). Persebaran Air Lindi TPA Benowo Terhadap Kualitas Air Tambak. Envirous, 2(1), 74–80. https://doi.org/https://doi.org/10.33005/envirous.v2i1.77

Parde, D., Patwa, A., Shukla, A., Vijay, R., Killedar, D. J., & Kumar, R. (2021). A Review Of Constructed Wetland On Type, Treatment and Technology of Wastewater. Environmental Technology & Innovation, 21. https://doi.org/https://doi.org/10.1016/j.eti.2020.101261

Pratama, B. O., & Jawwad, M. A. S. (2023). Evaluasi dan Rekomendasi Unit Instalasi Pengolahan Air Lindi di TPA Tegalasri Kabupaten Blitar. Nusantara Hasana Journal, 2(8), 263–269.

Pratiwi, D. Y. (2020). Dampak Pencemaran Logam Berat Terhadap Sumber Daya Perikanan dan Kesehatan Manusia. Jurnal Akuatek, 1(10), 59–65.

Pysarenko, P., Samojlik, M., Taranenko, A., Tsova, Y., Horobets, M., & Filonenko, S. (2022). Monitoring Of Municipal Solid Waste Landfill Impact On Environment In Poltava Region, Ukraine. Ecological Engineering And Environmental Technology, 23(5), 54–60.

https://doi.org/https://Doi.Org/10.12912/27197050/151630

Ramadhani, J., Asrifah, R. D., & Widiarti, I. W. (2019). Pengolahan Air Lindi Menggunakan Metode Constructed Wetland Di TPA Sampah Tanjungrejo, Desa Tanjungrejo, Kecamatan Jekulo, Kabupaten Kudus. Jurnal Ilmiah Lingkungan Kebumian, 1(2), 1–8. https://doi.org/https://doi.org/10.31315/jilk.v1i2.3280

Revansyah, M., Puspaningrum, P, M., P, N., K, L., S, L., S, N., & A, A. (2022). Indonesia 2 Program Studi Biologi, Fakultas Matematika Dan Ilmu Pengetahuan Alam. Jurnal Material Dan Energi Indonesia, 12(2), 43–49.

Saed, T. R., Jaffar Y.M., A., Omar M.L, A., Nahla A, B., Amer, S., & Al-Shawabkeh, J. D. (2024). Characterization Of Landfill Leachate And Their Toxic Effects On Germination And Seedling Growth Of Various Plant Species – A Case Study. Journal Of Ecological Engineering, 25(11), 335–353. https://doi.org/10.12911/22998993/193481.

Sahani, W., Kasim, K. P., & Syarif, A. M. (2025). Efektivitas Fitoremediasi Menggunakan Eceng Gondok (Eichhornia crassipes) dalam Mengurangi Kadar BOD dan COD pada Air Lindi TPA Tamangapa, Kota Makassar. Jurnal Sulolipu: Media Komunikasi Sivitas Akademika Dan Masyarakat, 25(1), 139–145. https://doi.org/https://doi.org/10.32382/sulo.v25i1.1389

Syafrudin, Sarminingsih, A., Juliani, H., Arief, B. M., Sila, P. A., & Arlin, M. S. A. (2023). Water Quality Monitoring System For Temperature, Ph, Turbidity, DO, BOD, And COD Parameters Based On Internet Of Things In The Garang Watershed. Ecological Engineering And Environmental Technology, 25(2), 1–16. https://doi.org/https://doi.org/10.12912/27197050/174412

Syahdoa'a, D., Khair, A., Haris, A., & Arifin, A. (2025). Pengaruh Jenis Pasir Terhadap Kadar BOD Dan COD Pada Air Lindi Di Kecamatan Pulau Sebuku Kabupaten Kotabaru. Jurnal Penelitian Multidisplin Bangsa, 1(11), 1970–1983. https://doi.org/https://doi.org/10.59837/jpnmb.v1i11.391

Syukriah, S., Fauziansyah, H., & Amira, S. (2024). Studi Kandungan Logam Berat Besi (Fe) Pada Air dan Ikan di Tambak Medan Belawan Sumatera Utara. Bioma, 26(1), 16–26. https://doi.org/https://doi.org/10.14710/bioma.2024.58929

Walid, A., Kusumah, R. G. T., Putra, E. P., Suciarti, P., & Herlina, W. (2020). Pengaruh Keberadaan Tpa Terhadap Kualitas Air Bersih Diwilayah Pemukiman Warga Sekitar: Studi Literatur. Jurnal Ilmiah Universitas Batanghari Jambi, 20(3), 1075–1078. https://doi.org/10.33087/Jiubj.V20i3.1025.

Wang, Y., Noman, A., Zhang, C., Al-Bukhaiti, W. Q., & Abed, S. M. (2024). Effect Of Fish-Heavy Metals Contamination On The Generation Of Reactive Oxygen Species And Its Implications On Human Health: A Review. Frontiers. https://doi.org/10.3389/Fmars.2024.1500870.

William, M., Riogilang, H., & Supit, C. J. (2023). Analisis Kapasitas Air Lindi dan Rancangan Instalasi Pengolahan Lindi Pada TPA Kulo. *TEKNO*, *21*(85), 1580–1588.