Water Quality Analysis of Kalidami River Surabaya City Using Biomonitoring Method

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Abstract. Kalidami River in Surabaya is under heavy pollution pressure due to domestic and industrial activities, so a biomonitoring-based water quality assessment is needed. This study aims to analyze the condition of the river ecosystem through physical, chemical, and biological parameters. Water and sediment sampling was conducted in three river segments in April 2025. Physical-chemical parameters including BOD, COD, pH, temperature, TDS, and turbidity were measured using standard tools, while biological analysis focused on macroinvertebrates as bioindicators using the Shannon-Wiener Diversity Index (H') method. Results showed BOD (9.08-11.02 mg/L) and COD (61.3-82.6 mg/L) values exceeded the class 3 quality standard of PP No. 22 of 2021, indicating high organic pollution from domestic and industrial effluents. Although pH (7.53-7.55), temperature (29.9°C), and TDS (337-511 mg/L) met the standards, turbidity in Segment 1 reached 24.39 NTU. Macroinvertebrate diversity was low (H'=0.3768-0.6759) with pollution-tolerant species such as *Tubificidae* and *Gambusia affinis* dominating. This condition reflects the heavy ecological pressure due to waste accumulation, slow flow, and massive anthropogenic activities around the river. The study concluded that the degradation of the Kalidami River ecosystem requires immediate intervention, including structured waste management, community education, and periodic biomonitoring-based monitoring for sustainable restoration.

Keywords: Biomonitoring, kalidami river, *macrozoobenthos*, organic pollution, water quality.

1. Introduction

Rivers provide water that is beneficial for human life, including for agricultural activities, industry, and daily activities (households). In addition, rivers also provide benefits for organisms that live in river waters. The increase in population density accompanied by low economic conditions forces the population to live along the watershed. Most of the people who live along the watershed utilize river water for their daily lives. Environmental quality is an important indicator of environmental health, describing the physical, chemical and biological condition of water. River water quality decreases due to domestic, industrial, agricultural waste, and several human activities that affect river flow. The impact of such waste can damage ecosystems, human health problems, and decrease the function of rivers as a source of clean water. The existence of various sources of pollutants that enter the Kalibokor Channel will have an impact on the organisms that live in it (Ni'am *et al.*, 2022).

Kalidami River Surabaya is one of the channels used as drainage and sewerage that accommodates the East Surabaya area from Pakuwon City (Salsabila Dwi Ramadhani, 2024). The pollution of Kalidami River is caused by the discharge of domestic waste directly into the river without any management and is characterized by excessive foam on the surface of the river water. Kalidami River is polluted with relative pH fluctuations. The high use of detergents by the surrounding community causes foam to appear on the surface of the river, especially when the water discharge is low in the dry season. In addition, organic and inorganic waste that accumulates along the river flow also exacerbates pollution conditions, causing the water to become cloudy, black in color, and smells bad. These conditions have a negative impact on the health of the surrounding community and disrupt daily activities, including culinary businesses along the riverbanks. The results of water quality testing showed that parameters such as pH, temperature, dissolved oxygen, and Total Dissolved Solids (TDS).

Biomonitoring is the biological monitoring of water quality by looking at the presence of groups of indicator organisms that live in the water (Joko Widiyanto, 2016)(Ummuzzahra *et al.*, 2022). In river bodies, biomonitoring is usually done by identifying the presence and diversity of macroinvertebrates - small organisms such as aquatic insects, shrimps, snails, and worms that live on the bottom or banks of the river. These organisms are sensitive to changes in water quality and pollution levels, so their presence or absence can provide a comprehensive picture of the condition of the river ecosystem. For example, the presence of pollution-sensitive macroinvertebrates indicates good water quality and a healthy ecosystem, while the dominance of pollution-tolerant organisms indicates the presence of disturbance or pollution in the river. The function of biomonitoring in river bodies is very important because this method not only provides direct water quality data, but is also able to integrate the accumulative and long-term effects of pollution, which may not be detected by chemical or physical measurements alone.

2. Materials and Methods

2.1 Tools and Materials

The tools used in this study are; (1) bottle, (2) filter, (3) hand shovel, (4) bucket, (5) plastic jar, (6) BOD meter, (7) COD with open reflux method, (8) pH meter, (9) turbiditimeter. Meanwhile, the materials used in this study are macroinvertebrates found in sediments in the dami river and water obtained from the river body in the dami river. Appropriate sampling techniques are also required for sample collection, (1) Select sampling points that represent the characteristics of the water at that location. Consider the location of the water source, water flow, and potential sources of pollution. (2) Sample bottles must be washed before use. This is to ensure no contamination that could affect the measurement results of the parameters. (3) Collect water

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samples with a minimum volume of 1000 ml, avoiding the formation of air bubbles when transferring the sample into the bottle. (4) Seal the sample bottle tightly and store it in a cool condition. Water sampling was conducted at three points, twice at each point, between 8:00 and 9:00 a.m. and between 4:00 and 5:00 p.m. (R.Puty Ranijintan, A. M.Fadhil Hayat and St. Raodhah, 2016).

2.2 Location

Fig. 1 Map Of Each Segment
Source: Surabaya city detailed spatial plan map

The research location is located at coordinates 7°16'36.93 "S, 112°45'53.37 "E. The sampling location has three segments conducted on Thursday, April 24, 2025 at 12:00 - 14:00.

The sampling locations are divided into three segments with different surrounding land uses:

- Segment 1 is located in a densely populated urban residential area, with land use in the surrounding area dominated by residential areas and commercial activities.
- Segment 2 is located in an area with mixed land use consisting of residential areas, educational institutions, and light industry. Land use around this segment can contribute to variations in pollutant loads.
- Meanwhile, segment 3 is also located in a densely populated urban residential area, with land use that includes commercial activities and temporary waste disposal sites (TPS).

2.3 Biotic Observations in River Water Quality

Biotic components, especially macroinvertebrates, play an important role in biomonitoring studies because they can be used as bioindicators to assess the quality of an aquatic environment, especially in terms of pollution. Macroinvertebrates are organisms that live on the bottom of the water and are large enough to be observed without the aid of a microscope, such as aquatic insects, worms, snails, and small crustaceans. The presence and diversity of macroinvertebrate species are very sensitive to changes in environmental conditions, such as dissolved oxygen levels, acidity, and the content of other pollutants in water.

2.4 Physical Condition of The Kalidami River

To determine the physical condition of the river and the presence of organisms around it, the first step is to determine the location and sampling points that will be the object of research. The determination of this location is based on the results of field surveys and initial hypotheses about the condition of the river. After the location was determined, observations were made of various physical aspects of the river, such as sediment deposits collected from each point, vegetation growing around the river flow, and environmental conditions along the river path, where the condition of the river water in Kalidami River is very murky, has an unpleasant odor, and contains suspended organic matter. All findings from these observations were recorded in detail according to the actual situation in the field.

2.5 The Parameters of The Kalidami River

To determine the quality of river water, an examination of the water content is carried out. Prior to this examination, the process of taking water samples from the river is carried out. In this study, sampling was conducted at three different locations along the river. The purpose of this division of points is so that the water quality at each location can be analyzed individually, as well as to determine the factors that distinguish water quality between points. Water taken from the five points was stored in separate jerry cans that had been labeled to avoid misidentification. All samples were then taken to the Environmental Engineering Laboratory, Department of Environmental Engineering, Institut Teknologi Adhi Tama Surabaya for testing. Parameters tested to assess water quality include pH, TDS, BOD, and DO. Tests were carried out using their respective tools, namely pH meter, TDS meter, BOD meter, and DO meter. The measurement results of each parameter were recorded and analyzed for each sampling point.

3. Result and Analysis

3.1 Physical Analysis

The physical and environmental conditions of rivers are critical factors that influence the distribution and abundance of bioindicator organisms. In this study, biomonitoring sampling was conducted in three segments representing a variety of river characteristics. The physical parameters observed included the presence of organisms or plants living around the water body. From the observation results, the river water at all sampling points showed a level of water turbidity and river water odor.

Table 1
Differences in physical characteristics of kalidami river in three segments

Documentation	Physical Characteristics
	Segment 1 shows that the water body in the river looks murky, smelly, and there is scum, and there are macroinvertebrates in the form of *gambusia affinis* and *tubificidae*.
	Segment 2 shows that the water body in the river looks murky, smelly, and there is scum, and there are macroinvertebrates in the form of *tubificidae* and *gambusia affinis*.
	Segment 3 shows that the water body looks murky, smelly, and there is scum, and there are macroinvertebrates in the form of *gambusia affinis* and *tubificidae*.

3.2 Chemical Parameter Analysis

Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) describes the quantity of oxygen required to chemically oxidize organic and inorganic substances. This parameter is used to assess the level of water pollution by oxidizable substances, both organic (e.g. domestic, agricultural waste) and inorganic (e.g. ammonia, sulfide, or metals). COD levels in wastewater decrease as the concentration of organic matter contained in wastewater decreases (Muhammad Ridwan Harahap, 2020). In this study, the COD value of the three segments was obtained, in segment 1 it was 82.6 mg/L, in segment 2 it decreased to 66.6 mg/L, in segment 3 it decreased further to 61.3 mg/L. Based on PP No. 22 of 2021 concerning the implementation of environmental protection and management, the quality standard for COD concentration is 40 mg/L, which means that the COD concentration in the three segments has exceeded the quality standard.

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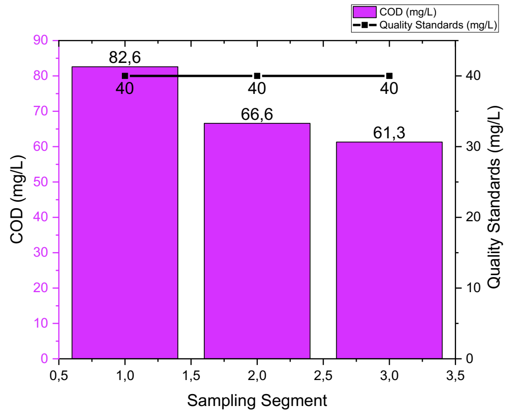

Fig. 12 COD Content Graph

High COD content in river water indicates the presence of pollutant sources such as industrial waste, pesticides, or fertilizers that can disturb the balance of the river ecosystem, this is in accordance with the statement (Thomson Napitupulu *et al.*, 2024). The COD concentration of segments 1, 2, and 3 has decreased because in segment 1 the water flow speed is slower than segments 2 and 3, this is in accordance with the statement (Tang *et al.*, 2019).

Biological Oxygen Demand (BOD)

Biological Oxygen Demand (BOD) is the quantity of dissolved oxygen needed to break down organic matter contained in water completely using the size of biological and chemical processes that occur in waters. BOD or Biochemical Oxygen Demand is one of the important parameters in water quality analysis used to measure the amount of dissolved oxygen needed by aerobic microorganisms in the process of decomposing organic matter contained in water. This measurement is usually carried out for five days at 20°C and is often referred to as BOD_5. The higher the BOD value, the more organic matter is contained in the water, indicating that the water is polluted.

In this study, the BOD value of segment 1 was found to be very high at 11.02 mg/L compared to segment 2 at 9.18 mg/L and segment 3 at 9.08 mg/L. The decrease in BOD value in waters indicates that the amount of organic matter that can be decomposed by microorganisms is getting less. One of the main causes is that the Food and Beverage (FnB) industry and residential areas have great potential to increase BOD (Biochemical Oxygen Demand) levels in river bodies. This is due to the waste generated from both sources, which generally contains high organic matter. The high concentration of BOD indicates the behavior of disposing of organic waste such as food and vegetable waste in the river (Haryono, Soesilo and Agustina, 2024). According to PP No. 2 of 2021 concerning the implementation of environmental protection and management, the river BOD quality standard is 6 mg/L, so the BOD results from the three river segments do not meet the quality standard.

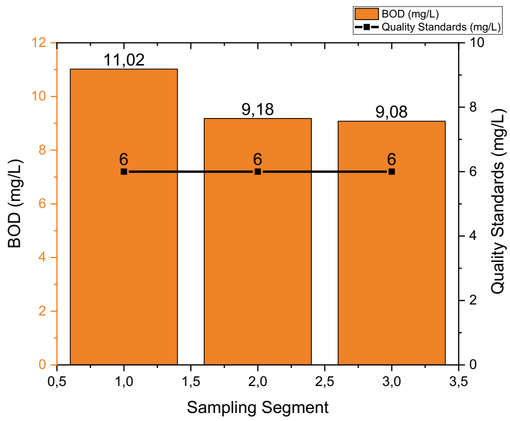

Fig. 3 BOD Content Graph

pH dan Temperatur

The pH of river bodies is an important indicator in assessing water quality and the health of aquatic ecosystems. The pH value indicates the acidity or basicity of the water, which is measured on a scale of 0 to 14. Some of the factors that affect river pH include industrial and domestic waste inputs, organic matter decomposition processes, photosynthetic activity of aquatic plants, and geological and soil characteristics around the river. Extreme changes in pH can cause major disruptions in aquatic ecosystems. Too low pH values can dissolve heavy metals from bottom sediments, which then become toxic to aquatic organisms. Conversely, high pH can also disrupt physiological processes such as osmoregulation in fish. Therefore, regular pH monitoring is an important part of river water quality management.

In the research that has been obtained, the pH value of each point is 7.55 in segment 1, segment 2 has the same value as segment 1, namely 7.55, and segment 3 is 7.53. According to PP No. 2 of 2021 concerning the implementation of environmental protection and management, the quality standard for river pH is 6-9, so from the research results the three segments meet the quality standards.

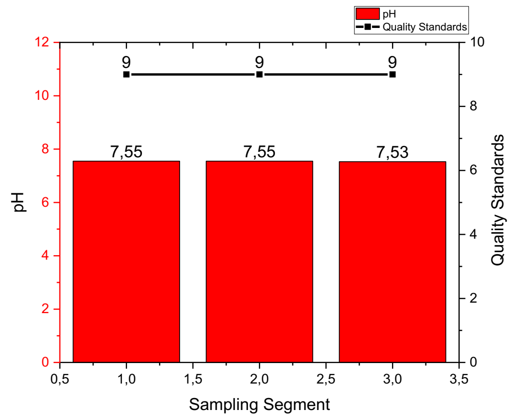

Fig. 4 pH Content Graph

Water temperature has an important role in river bodies because it affects various physical, chemical and biological aspects in the river ecosystem. According to (Damayanti Nainggolan *et al.*, 2024), water temperature is influenced by the intensity of the sun reaching the water, the measurement location is an open location so that sunlight directly reaches the water surface and the condition of the surrounding vegetation, so that water temperatures tend to be lower upstream and increase downstream. This temperature regulates the solubility of oxygen and chemical compounds in water; for example, high temperatures can reduce dissolved oxygen levels that are needed by aquatic organisms. After testing the temperature of the three segments, they got the same temperature value of 29,9℃.

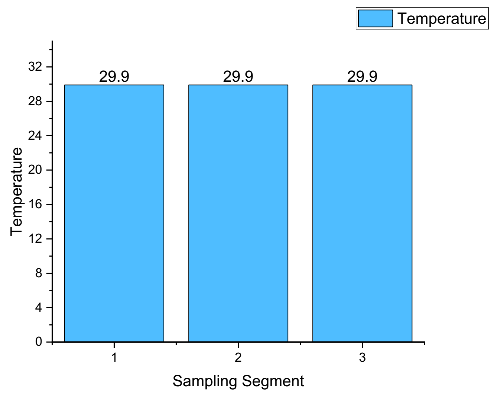

Fig. 5 Temprature Content Graph

Turbidity

Turbidity is a measure of the degree of cloudiness of water or the degree to which suspended particles (such as silt, clay, microorganisms, or organic matter) impede the penetration of light into it. A high turbidity level indicates that the water is more turbid and a low turbidity level indicates that the water is clearer. Turbidity is a general indicator of the presence of solid particles in water and not the size of a particular substance. In this study, the turbidity value of the three segments was obtained, in segment 1 it was 24,39 NTU, in segment 2 it was 1,35 NTU, in segment 3 it was 4,11 NTU. The turbidity at the first point is higher than at the other points because the environment contains more vegetation, which causes more organic matter to be released and leads to turbidity in the river water.

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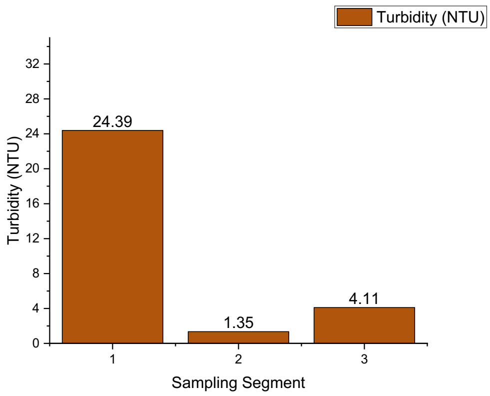

Fig. 6 Turbidity Content Graph

Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) is a measure of the total amount of inorganic and organic solids dissolved in water, including ions, minerals, metals, salts, and certain organic compounds. TDS is expressed in milligrams per liter (mg/L) or parts per million (ppm). These substances are not visually visible because they are completely dissolved in water. TDS levels correlate with the viscosity of the liquid, the higher the TDS levels, the more viscous the liquid is (Ode Arsyanti Wida Malesi & Jaya Putra, 2024).

In this study, the TDS value in segment 1 was 511 mg/L, in segment 2 it was 358 mg/L, in segment 3 it was 337 mg/L. Based on PP No. 22 of 2021 concerning the implementation of environmental protection and management, the quality standard for the TDS parameter is 1000 mg/L, so the results of the TDS parameter concentration in river water bodies in the three segments have met the quality standard.

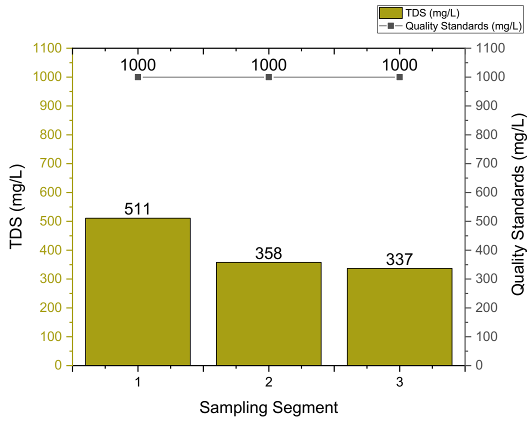

Fig. 7 TDS Content Graph

Quality Standard

Based on the results of research tests on each parameter compared with quality standards in order to determine whether or not it meets the quality standards. In this research, the quality standard used is the Government Regulation of the Republic of Indonesia No. 22 of 2021 Appendix VI, concerning the Implementation of Environmental Protection and Management using third-class quality standards.

Table 2 water quality parameter values of Surabaya city's Kalidami river

Parameter	Unit	Sampling Point			Qualiy Sandards
		Segment 1	Segment 2	Segment 3	Kelas 3
BOD	mg/L	9,08	9,18	11,02	6
COD	mg/L	82,6	66,6	61,3	40
pH	-	7,55	7,55	7,53	6-9
Temperature	°C	29,9	29,9	29,9	Dev 3
Turbidity	NTU	24,39	1,35	4,11	-

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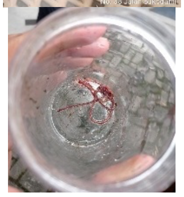
Parameter	Unit	Sampling Point			Qualiy Sandards
		Segment 1	Segment 2	Segment 3	Kelas 3
TDS	mg/L	511	358	337	1000 mg/L

Biological Parameter

Macrozoobenthos are large animal organisms that live on the bottom of waters such as rivers, lakes or swamps, which play an important role as indicators of aquatic environmental quality. The abundance and diversity of macrozoobenthos reflect the condition of aquatic ecosystems, as they are sensitive to physical and chemical changes in water, including pollution levels. Therefore, macrozoobenthos analysis is often used in biomonitoring to biologically assess the health and quality of river bodies. The study of these biological parameters provides important information in water resources management and conservation efforts.

Table 3 The number of macrozoobenthos in the Kalidami river of Surabaya city

Famili	Documentation	The number of *makrozoobentos*		
		Segmen 1	Segmen 2	Segmen 3
Gambusia Affinis		14	16	20
Tubificidae		2	11	4
Total at each point		14	27	20

Shannon Wiener Diversity Index (H')

It is a quantitative method to analyze the diversity of species in a community, by considering the number of species with their evenness. In this study, the index was used to determine the response of *macrozoobenthos* to changes in water quality in the kalidami river.

Table 4 Shannon Wiener diversity index (H')

Kalidami river Kota Surabaya					
Family	**ni**	**ni/N (Pi)**	**Ln(Pi)**	**Pi.Ln(Pi)**	**H'**
Sampling Segment 1 Kalidami River					
Tubificidae	2	0,1250	-2,0794	-0,2599	
Gambusia affinis	14	0,8750	-0,1335	-0,1168	
Total	**16**	**1**	**-2,2130**	**-0,3768**	**0,3768**
Sampling Segment 2 Kalidami River					
Tubificidae	11	0,4074	-0,8979	-0,3658	
Gambusia affinis	16	0,5926	-0,5232	-0,3101	
Total	**27**	**1**	**-1,4212**	**-0,6759**	**0,6759**
Sampling Segment 3 Kalidami River					
Tubificidae	4	0,1667	-1,7918	-0,2986	
Gambusia affinis	20	0,8333	-0,1823	-0,1519	
Total	**24**	**1**	**-1,9741**	**-0,4506**	**0,4506**

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In the diversity index, a high value (H') indicates a healthy environment, high diversity of biota, while a low value indicates a polluted environment. Based on the calculation of Shannon Wiener diversity results (H'), Kalidami segment 1 is 0,3768, then in segment 2 is 0,6759, and in segment 3 is 0,4506. These results show that the three segments have low biota diversity, unstable ecosystem conditions, very low productivity, and heavy ecological pressure. This is evidenced by the environment of each segment.

In segment one where the environmental conditions are many dense settlements and many food and beverage industries as well as slow water flow and have a very dense turbidity so that you cannot see the riverbed and there is a lot of organic waste. Then in segment 2 the environmental conditions are dense settlements where the river water flow moves slowly and there are many water hyacinths. In segment 3 there is a TPS on the side of the river and densely populated, the river conditions have a lot of garbage and foam and the river water flow is slightly swift.

6. Conclusion

Based on the results of biomonitoring research on water quality of Kalidami River, Surabaya City, it can be concluded that the condition of the river ecosystem has been significantly degraded in all three segments. This is indicated by the BOD (9.08-11.02 mg/L) and COD (61.3-82.6 mg/L) values that exceed the class 3 quality standards according to Appendix VI of PP No. 22 of 2021, indicating high organic pollutant loads from domestic and industrial waste. Although physical parameters such as pH (7.53-7.55), temperature (29.9°C) and TDS (337-511 mg/L) still met the standards, the turbidity of the water in segment 1 (24.39 NTU) and the dominance of pollution-tolerant macroinvertebrates such as *Tubificidae* throughout the segment reinforced the findings of heavy pollution. Shannon-Wiener Diversity Index (H') analysis showed low values in all segments, namely segment 1 (H' = 0.3768), segment 2 (H' = 0.6759), and segment 3 (H' = 0.4506). This value reflects high ecological pressure due to waste accumulation, slow water flow, and massive anthropogenic activities around the river, such as dense settlements and food and beverage industries.

The dominance of *Gambusia affinis* and *Tubificidae* as pollution-tolerant bioindicators, as well as the low diversity of biota, confirm the negative impacts of direct sewage discharge, accumulation of organic-inorganic waste, and lack of environmental management. Thus, pollution control interventions and ecosystem restoration are needed to restore the function of Kalidami River as a sustainable water resource. This research proposes the need for structured and systematic implementation of waste use, the need for public education on environmental awareness and management, and regular monitoring such as biomonitoring to maintain the Kalidami river ecosystem in Surabaya city in a sustainable manner.

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