LenteraBio
Berkala Ilmiah Biologi

LenteraBio, 2025; Volume 14, Issue 2: 295-302

p-ISSN: 2252-3979 e-ISSN: 2685-7871
https://journal.unesa.ac.id/index.php/lenterabio/index

Macrozoobenthos as a Bioindicator for Kendedes River Water Quality in Malang, East Java

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Article History:
Received:
12-July-2024
Revised:
30-May-2025
Available online:
31-May-2025
Published regularly:
31-May-2025

Abstract
The Kendedes River is a river that supports the activities of residents on its banks, such as bathing, washing, and some also use it for fishing. This river plays a crucial role in the lives of local communities, serving both as a source of agricultural irrigation and a provider of clean water. This research aims to identify the types of macrozoobenthos, analyse the macrozoobenthos diversity index, and determine water quality in terms of physico-chemical parameters, adjusted according to the quality standards of Government Regulation of the Republic of Indonesia No. 22 of 2021 concerning the implementation of environmental protection and management. This type of research combines both quantitative and qualitative observational methods. In this study, six species from five genera were identified, including *Pilsbryoconcha exilis*, *Melanoides tuberculata*, *Melanoides maculata*, *Semyla riquetti*, *Pila ampullacea*, and *Sucospira testudinaria*. This diversity index is then calculated using the Shannon-Wiener (H') formula. The Kendedes River in Malang, East Java, has a macrozoobenthos diversity index of 1.07, which falls within the medium diversity index category. The Kendedes River has an average BOD (Biological Oxygen Demand) of 1.24 and an average COD (Chemical Oxygen Demand) of 10.28, as measured according to the quality standards outlined in Government Regulation of the Republic of Indonesia No. 22 of 2021, which concerns the implementation of environmental protection and management. The Kendedes River, Malang, East Java, still meets quality standards when viewed in terms of the macrozoobenthos diversity index classification. The water quality in the Kendedes River, Malang, East Java, is classified as moderately polluted waters.

Keywords: Aquatic ecosystem; ecological assessment; freshwater pollution

How to Cite: Angga ZBB, Kuntjoro S, 2025. Macrozoobenthos as a Bioindicator for Kendedes River Water Quality in Malang, East Java. LenteraBio; 14(2): 295-302.

DOI: https://doi.org/10.26740/lenterabio.v14n2.p295-302

INTRODUCTION

Water is essential to all forms of life on Earth. About 60-70% of the human body consists of water, and it is also necessary for all biochemical processes that support life. Water resources are also needed for the habitat of flora and fauna, for hydrological systems, and the chemical cycle (Kılıç, 2020). River waters are an important part of the ecosystem. The condition of river waters can indirectly indicate the quality of an environment. River utilisation is very beneficial for society; however, human unawareness can hurt the environment in river waters (Anh et al., 2023; Li et al., 2023).

Bioindicators are biotic components that are used as indicators. Bioindicators are also biotic indicators that can show time and place, natural conditions, and changes in environmental quality due to human activities. By using bioindicators, we can predict the natural state of a place or its level/extent of contamination (Sagova-Mareckova et al., 2021). Biological analysis can be used to determine water quality because it can provide better results using resident organisms.

Macrozoobenthos maintains nutritional balance in the aquatic environment and is very sensitive to environmental changes. Macrozoobenthos life is also influenced by biotic and abiotic factors (Zakiawati et al., 2021). In river ecosystems, macrozoobenthos functions as primary consumers (herbivores) and secondary consumers (carnivores), which are then eaten by top carnivores. Most of them are detritivores, macrophages and microphages. Their food includes phytoplankton, algae, periphyton, macrophytes, bacteria, organic compounds in mud, zooplankton, and other macrozoobenthos. Thus, macrozoobenthos influence the ecosystem because of their important role in the ecosystem (Bao, 2011; Upadhyay and Verma, 2025).

Previous research in the Juri River, Pasuruan, found that macrozoobenthos diversity is useful for detecting pollution levels. The results of the study found low macrozoobenthos diversity so that the river is classified as heavily polluted, while in terms of measurements of physical and chemical parameters such as COD, DO, pH and temperature still meet the established standards of class 3 river water based on Government Regulation No.22 of 2021, except for the results of BOD measurements found that it does not meet the quality standards (Ainii and Kuntjoro, 2024). Similar findings by other researchers have confirmed that macrozoobenthos composition and diversity are closely linked to water quality conditions, making them reliable indicators for monitoring ecosystem health (Arimoro and Ikomi, 2009; Maulana and Kuntjoro, 2023). Therefore, research on the Kendedes River using macrozoobenthos is necessary to evaluate its ecological status and to support sustainable river management efforts.

One of the rivers in Malang Regency, East Java, Indonesia, is the Kendedes River. This river has an important role in providing water for various purposes, including agricultural irrigation and the needs of local communities. According to Government Regulation Number 82 of 2001, the Kendedes River in Malang, East Java, is included in the class III river category, which means that its water can be used for purposes such as cultivating freshwater fish, animal husbandry, irrigating crops, or other purposes. In this research, macrozoobenthos is used as a bioindicator based on the number of organisms, diversity and ecological quantity of macrozoobenthos, such as abundance. This is closely related to aquatic environmental variables such as brightness, temperature, pH, DO, BOD, and COD.

MATERIALS AND METHODS

This research was conducted from October to December 2023 at the Kendedes River, Singosari Sub-district, Malang Regency, East Java (Figure 1). Station 1 was located at coordinates (7°52'54.10"S 112°39'39.50"E), station 2 is located at coordinates (7°52'56.30"S 112°39'38.80"E), station 3 is located at coordinates (7°52'59.20"S 112°39'38.60"E) The study employed a descriptive approach with purposive sampling. Sampling was carried out at three stations representing different environmental conditions along the river. At each station, macrozoobenthos and physico-chemical water parameters were measured.

Macrozoobenthos samples were collected using a hand scope from the riverbed substrate. Specimens were then sorted, documented, and identified morphologically using the *Fresh Water Biology* (2nd Edition) by W.T. Edmondson. The diversity and abundance of macrozoobenthos were analyzed using the Shannon-Wiener diversity index (H'). The diversity criteria were categorized as follows: H' < 1 = low, 1 < H' < 3 = moderate, H' > 3 = high (Odum, 1971).

$$H' = - \sum pi \ln pi$$

Water quality was evaluated through physico-chemical parameters including temperature, pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), and brightness. Temperature was measured using a glass thermometer immersed directly in the river. pH was measured using a calibrated digital pH meter. DO was measured in situ using a DO meter following the Winkler method. BOD was determined by measuring the DO content at initial time (DO_0) and after 5 days of incubation (DO_5), then calculating the difference. COD samples were collected in 500 mL glass bottles and analyzed in a certified water quality laboratory (PDAM Ngagel Surabaya). Brightness was assessed using a Secchi disk.

All water quality parameters were compared to the Class III water quality standards based on Government Regulation Number 22 of 2021. The research applied both quantitative and qualitative observational approaches, with data analyzed descriptively and inferentially.

RESULTS

The macrozoobenthos found in the Kendedes River, Malang, East Java consists of four families and six species, namely, *Pilsbryoconcha exilis*, *Melanoides tubercula*, *Melanoides maculata*, *Semyla riquetti*, *Pila ampullacea*, *Sucospira testudinaria* (Table 1). The highest macrozoobenthos diversity index calculation results were at station 2, which was 1.26, which was included in the medium category, and the lowest diversity index was at station 3, which was 1.21, which was also included in the medium category. The results of the calculation of the highest macrozoobenthos relative abundance value were 51.10% for the *Sucospira testudinaria* species and the lowest was 1.10% for the *Pila ampullacea* species.

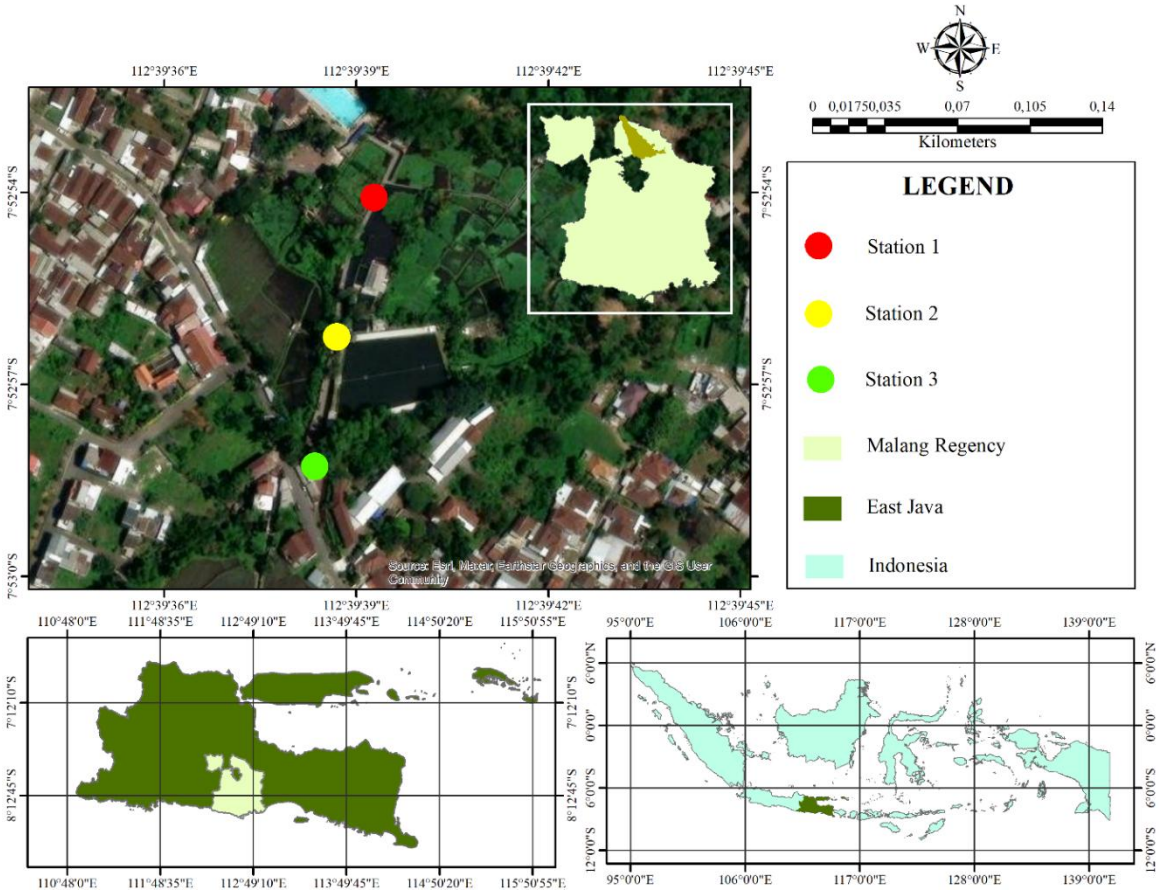

Figure 1. Map of sampling site

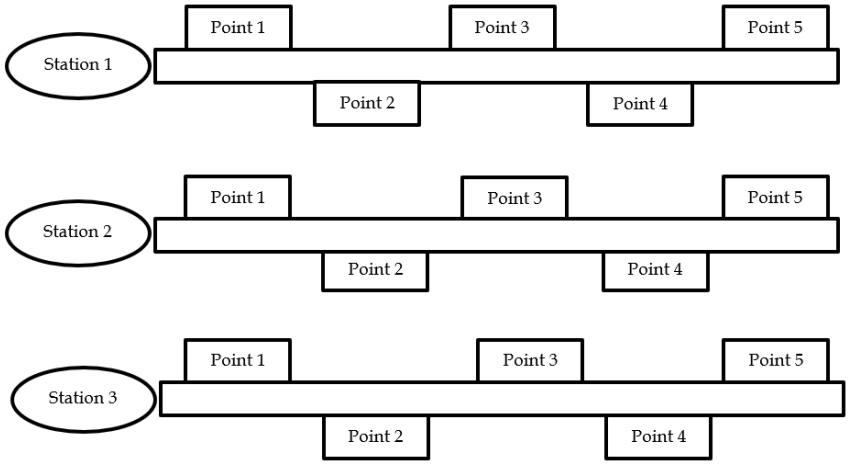

Figure 2. Station point sampling plan

Table 1. Index of diversity and abundance of macrozoobenthos in the Kendedes River, Malang, East Java

Spesies type	Number of individuals per station			Amount individual	Abudance relatively (%)
	1	2	3		
Pilsbryoconcha exilis	6	11	4	21	2.56
Melanoides tubercula	63	124	54	241	29.39
Melanoides maculata	20	32	14	66	8.05
Semyla riquet	20	28	16	64	7.80
Pila ampullacea	4	4	1	9	1.10
Sucospira testudinaria	134	187	98	419	51.10
Total	**247**	**386**	**187**	**820**	
Diversity Index	**1.24**	**1.26**	**1.21**	**1.07**	

Water quality measurements using physical parameters include temperature and brightness parameters of river water. The highest temperature measurement results were at station 2, namely 28.68 °C, while the lowest temperature was at station 3, namely 25.56 °C. The overall temperature of the station on the Kendedes River in Malang, East Java, is 27.26. According to Republic of Indonesia Government Regulation number 22 of 2021, the temperature in the waters of the Kendedes River in Malang, East Java still meets quality standards. The highest brightness measurement results were at station 1, namely 75.8 cm. Meanwhile, the lowest brightness was at station 2, namely 34.2 cm. The average brightness at all stations on the Kendedes River, Malang, East Java is 49 cm.

Table 2. Results of physical parameter measurements in the Kendedes River, Malang, East Java.

Station	Repetition	Parameter fisika	
		Temperature °C	Brightness
1	1	27.6	78
	2	27.6	76
	3	27.4	79
	4	27.6	74
	5	27.5	72
	Average	**27.54 °C**	**75.8 cm**
2	1	28.5	38
	2	28.1	37
	3	28.4	35
	4	29.3	31
	5	29.1	30
	Average	**28.68 °C**	**34.2 cm**
3	1	25.7	39
	2	25.2	41
	3	25.5	37
	4	25.6	35
	5	25.8	33
	Average	**25.56** °C	**37 cm**
Total average		**27.26**	**49 cm**
Quality standard		**22-28**	**-**
Criteria		**Complies with the standard**	**-**

The highest DO (Dissolved Oxygen) measurement results were at station 1, namely 7.44 (mg/I). Meanwhile, the lowest was at station 2, namely 5.85 (mg/I). The average DO value at all stations on the Kendedes River, Malang, East Java, is 6.64 (mg/I). According to Republic of Indonesia Government Regulation number 22 of 2021, DO (Dissolved Oxygen) found in the Kali Kendedes River in Malang, East Java does not meet quality standards.

The highest BOD Biological Oxygen Demand) measurement results were at station 1, namely

1.96 (mg/I), while the lowest results were at station 2, namely 0.78 (mg/I). The overall average value of BOD Biological Oxygen Demand) at Kendedes River Station, Malang, East Java, is 1.24 (mg/I). Where according to Republic of Indonesia Government Regulation number 22 of 2021, the BOD Biological Ocygen Demand) levels found in the waters of the Kendedes River, Malang, East Java still meet quality standards.

The highest pH measurement results were at station 1, namely 6.87. Meanwhile, the lowest was at station 2, namely 6.76. The average pH value for the entire station is 6.82. Where these results, according to Republic of Indonesia Government Regulation number 22 of 202, still meet quality standards.The highest COD measurement results at station 3 were 13.72 while the lowest were at station 2 at 8.76. The average COD value for all stations is 10.58 where these results, according to Republic of Indonesia Government Regulation number 22 of 202, still meet quality standards.

Table 3. Results of chemical parameter measurements in the Kendedes River, Malang, East Java.

Station	Chemical parameters				
	Repetition	**DO(mg/I)**	**BOD(mg/I)**	**COD(mg/I)**	**pH**
1	1	8.29	3.11	10.3	6.93
	2	8.33	2.8	11.9	6.88

Station	Chemical parameters				
	Repetition	**DO(mg/l)**	**BOD(mg/l)**	**COD(mg/l)**	**pH**
	3	7.27	2.08	6.9	6.9
	4	7.01	1.45	11.9	6.77
	5	6.28	0.34	5.3	6.86
	Average	**7.44**	**1.96**	**9.26**	**6.87**
2	1	7.36	0.59	12.5	6.8
	2	5.7	1.66	13.6	6.83
	3	5.9	0.81	0	6.77
	4	5.4	0.7	10.8	6.71
	5	4.9	0.14	6.9	6.67
	Average	**5.85**	**0.78**	**8.76**	**6.76**
3	1	7.62	1.61	13.1	6.9
	2	6.8	1.02	30.8	6.88
	3	6.56	0.98	9.2	6.84
	4	6.48	1.05	0	6.79
	5	5.63	0.33	15.5	6.8
	Average	**6.62**	**1.00**	**13.72**	**6.84**
Total average		**6.64**	**1.24**	**10.58**	**6.82**
Quality standard		**4 mg/l**	**3 mg/l**	**25 mg/l**	**6-9**
Criteria		**Does not comply with the standard**	**Complies with the standard**	**Complies with the standard**	**Complies with the standard**

DISCUSSION

Results of macrozoobenthos identification from three stations showed that sulcospira testudinaria was the most common and frequently found species. This gastropod species belongs to the Pachychilidae family. Gastropods live in lakes, rivers or waterfalls with calm or fast currents, according to the speed of the water flow at the station, which falls into the moderate to fast current category. The habitat of gastropods is lakes, rivers or waterfalls with calm or fast currents (Linares et al., 2022).

Another identification at 3 stations on the Kendedes River, another species was found which also belonged to the genus *Melanoides*, namely *Melanoides Maculata*. The melanoides genus is the organism with the greatest abundance because it can survive in polluted environmental conditions or waters and also in conditions of low dissolved oxygen values. (Prabandini et al., 2021). Other identification results also found pila ampulacea, this species belongs to the Ampullaridae family and is a type of freshwater snail that is easily found in rivers, swamps and rice fields. This species is found in shallow rivers and is usually overgrown with water grass (Sil et al., 2020). Some species of snail snails, such as *Ampullaridae*, have become invasive in some areas due to their ability to reproduce rapidly and have negative impacts on native ecosystems. However, in general, snails have significant ecological and aesthetic value in freshwater ecosystems. The Ampullaridae family also has a strong dispersal ability to survive for a long time. Apart from that, this family is included in the invasive gastropod group because it is able to adapt to polluted environments. This species has high adaptation to tides or uncertain conditions so it can live in various habitats (Greufe et al., 2024).

Based on the data obtained, it shows that station 1 had a total number of individuals found of 247 with a diversity index of 1.24. At station 2 the total number of individuals found was 386 with a diversity index value of 1.26. At station 3 the total number of individuals found was 187 with a diversity index of 1.21. Then the total number of individuals found in the Kendedes River, Malang, East Java was 820 individuals with a diversity index of 1.07.

The results of this research show that the 3 research stations carried out on the Kendedes River, Malang, East Java have calculation results that are not too far off, but these 3 stations are included in the medium diversity index, these results are based on calculations using the diversity index formula Shanoon Wiener namely H <3.00. This difference in diversity index can also be influenced by the high level of nutrient availability and also the quality of the environment at each station. One of the main factors influencing macrozoobenthos diversity is water quality. The source of nutrition for aquatic biota which can influence the growth and density of aquatic biota, especially macrozoobenthos, is dissolved organic matter (Arfiati, 2019).

Station 2 has a higher diversity index compared to stations 1 and 3, and the dominant species found at this location is from the gastropod class, even though station 2 is often used by local people for bathing and activities, this place has a lot of substrate. makes it easier for Gastropods to stick and

survive, such as rocks (Wahdaniar, 2016). Gastropods theoretically prefer muddy places, and many species attach to plants on riverbanks. However, the diversity index of this station is slightly higher than other stations because to survive, they attach their bodies to the bottom of the substrate by crawling. In addition to their ability to survive, gastropods excel in endurance and adaptation to the environment. Gastropods can adapt to their environment, even though the environment around them is polluted.

The results of temperature measurements in the Kendedes River, Malang, East Java were around 27.26 °C. This shows that the temperature in the Kendedes River, Malang, East Java meets quality standards, the highest temperature value is at station 2, namely 28.68 °C, while the lowest temperature is at station 3, namely 25.56 °C. The dominant macrozoobenthos identification was found to be from the gastropod class, this is because the gastropod class has a high temperature tolerance range. In general, the appropriate temperature range is 25-32 °C (Ernawati et al., 2024).

The brightness values in this study ranged between 25 and 100 cm, and the highest brightness value reached 75.8 cm at station 1. and this is a good brightness value. Rainfall increases water discharge, reducing the clarity of waters. In addition, brightness is significantly influenced by currents and particles dissolved in the environment. Brightness also affects macrozoobenthos visibility and can inhibit light penetration into the water (Patty et al., 2020). The DO value in this study was around 6.64 mg/l, the highest DO level obtained in this study was at station 1, namely 7.44 mg/l, and the lowest DO level was at station 2, namely 5.85 mg/l. , this shows that the DO levels at 3 research stations on the Kendees River, Malang, East Java meet quality standards

Decomposition of organic matter, nitrogen cycling, and nutrient balance are some of the biochemical processes carried out by oxygen in aquatic ecosystems. Low DO levels can disrupt these processes and change the general dynamics of waters. If macrozoobenthos wants to live in water, the BOD value in this study is around 1.24 mg/l. The highest BOD value is at station 1 at 1.96 mg/l and the lowest BOD level is at station 2, namely 0.78 mg/l. l. In this way, the BOD value still meets quality standards. BOD (Biochemical Oxygen Demand) levels are a measure of how much oxygen is needed by microorganisms to convert organic matter in a water sample within a certain time. BOD levels are an important measure that shows the level of organic pollution in waters; BOD levels are also influenced by domestic and industrial waste activities that enter water bodies (Vigiak, 2019), they must maintain low oxygen concentrations. According to Persulessy and Arini (2019), however, the ideal DO for aquatic biota is 10 mg/L or less.

The pH value at 3 stations is around 6.82, the highest pH level is at station 3, namely 6.84. while the lowest pH level was at station 2, namely 6.76. The pH range at the 3 stations is still allowed and is still included in the category according to quality standards. One of the most important factors for monitoring water quality is water pH (Chapman, 1996). For optimal survival, aquatic organisms require a tolerable pH range. If the condition persists, extreme changes in pH can cause stress and even death. Macrozoobenthos life usually has a pH range of 7–8 (Clesceri et al., 2017).

The COD value in this research was around 10.58 mg/l, where the COD level value still met the quality standards, but the highest COD value was at station 3, namely 13.72 mg/l. The high COD value at this station is due to the large level of pollution at station 3. High COD values can cause the dissolved oxygen content to be low. Low oxygen content causes a major influence on macrozoobenthos life. This is because oxygen is needed for the growth and reproduction of macrozoobenthos in waters (Buss and Vitorino, 2022).

CONCLUSION

The macrozoobenthos found in the Kendedes River, Malang, East Java consists of four families and six species, namely, *Pilsbryoconcha exilis, Melanoides tubercula, Melanoides maculata, Semyla riquetti, Pila ampullacea, Sucospira testudinaria*. The highest macrozoobenthos diversity index value of the Kendedes River, Malang, East Java is at station 2 at 1.26 and the lowest is at station 3 at 1.21, the total value of the diversity index for the Kendedes River, Malang, East Java is 1.07 and is in into the medium diversity index category. Based on the results of research on macrozoobenthos as a bioindicator of water quality carried out in the Kendedes River, Malang, East Java, a diversity index value of 1.07 was found. With this index value, the water quality in the Kendedes River, Malang, East Java is classified as moderately polluted waters.

ACKNOWLEDGEMENTS

The authors would like to thank the Ecology team of the Department of Biology, Universitas Negeri Surabaya for their assistance in the identification and verification of macrozoobenthos species.

CONFLICT OF INTEREST

There is no conflict of interest

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