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Macrozoobenthic biodiversity: An indicator of water quality in Ngrowo River, Tulungagung, East Java

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ABSTRACT. The Ngrowo River in Tulungagung, East Java, plays a crucial role in supporting the surrounding ecosystem and local communities. An aquatic ecosystem can be assessed by examining the composition and diversity of macrozoobenthic organisms, which are known to be sensitive to environmental change. This study aims to characterize the macrozoobenthic community in the Ngrowo River, including the identification and quantification of benthic invertebrate taxa. A total of 3 sampling sites along the Ngrowo River were selected. Using standardized sampling techniques, macrozoobenthic were collected, physical and chemical parameters were measured at each location. The results revealed a total of 8 genus macrozoobenthic were found, belonging to various groups, including *Tubifex*, *Anodonta*, *Crocothemis*, *Pomacea*, *Melanoides*, *Filopaludina*, *Macrobrachium* and *Potamonautes*. The Shannon-Winner index was calculated to assess overall biodiversity. The average value is 0.997, indicating low species diversity in the study area. Analysis of water quality parameters revealed significant differences between sampling locations. Dissolved oxygen pH, temperature, TDS and TSS from perspective of *baku mutu* PP number 22 years of 2021 were shown on level 1, DO from 1st sampling location was level 1, 2nd place was level 3, and 3th place was level 2. BOD of all sampling place was on level 3. COD from 1st, 2nd place of sampling were on level 3 then 3th place sampling was on level 2. Correlation analyzes were performed to investigate the relationship between macrozoobenthic biodiversity and water quality parameters using Pearson. As a result, a positive correlation was observed between the biodiversity index and water quality parameters such pH, DO, BOD and COD has positive correlation with *Filopaludina* and *Macrobrachium*, then current level, TSS and TDS were positively correlated with *Anodonta*, *Crocothermis*, *Pomacea*, and *Potamonautes*. This study highlights the importance of macrozoobenthos benthic biodiversity as an indicator of water quality and provides valuable information for the management and conservation of aquatic ecosystems.

Keywords: Biodiversity; bioindicator; macrozoobenthic; Ngrowo River, water quality

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INTRODUCTION

The Ngrowo River, located in Tulungagung, East Java, is an essential freshwater ecosystem that supports various ecological functions. It serves as a water source for domestic, agricultural, and industrial activities in the region (Ecoton, 2023), making it crucial to monitor and maintain its water quality. Assessing the health of aquatic ecosystems requires comprehensive evaluation, and macrozoobenthic biodiversity has proven to be an effective indicator of water quality in many freshwater systems worldwide (Dudgeon, *et al*., 2006). Water quality assessment is vital for understanding the ecological integrity and overall health of aquatic ecosystems. It helps to identify potential pollution sources, evaluate the effectiveness of environmental management strategies, and guide conservation efforts (Liang, *et al*., 2016). Traditional water quality monitoring methods typically focus on physicochemical parameters such as dissolved oxygen, pH, temperature, and nutrient concentrations (Li, *et al*., 2017). While these parameters are crucial, they provide limited insights into the biological responses and long-term health of the ecosystem.

Macrozoobenthic organisms, including benthic invertebrates such as insects, crustaceans, mollusks, and worms, play essential roles in freshwater ecosystems. They inhabit the riverbed and are directly influenced by the physicochemical conditions of the water, making them highly sensitive

to changes in water quality. The composition, abundance, and diversity of macrozoobenthic communities reflect the overall ecological condition of the river (Jourdan, *et al*, 2018).

Numerous studies have demonstrated the utility of macrozoobenthic biodiversity as an indicator of water quality. Changes in community structure and composition, as well as alterations in species richness and diversity, can be indicative of pollution, habitat degradation, or other stressors. The presence or absence of certain pollution-sensitive taxa can also provide insights into the specific types of contaminants present in the ecosystem (Ruse, *et al.*, 2019). In the case of the Ngrowo River, little research has been conducted regarding its macrozoobenthic biodiversity and its relationship to water quality. This research aims to fill this knowledge gap by assessing the macrozoobenthic community structure, composition, and diversity in the river and investigating the potential correlations with physicochemical parameters. By doing so, we can gain a better understanding of the current state of the Ngrowo River ecosystem and its ecological health. The interconnectedness between macrozoobenthos and physicochemical parameters, such as water temperature, dissolved oxygen, pH, and nutrient levels, provides valuable insights into the intricate dynamics of aquatic environments (Xiong, *et al*., 2016). Changes in these physicochemical factors can directly influence the composition and distribution of macrozoobenthic communities, while, in turn, the presence and activities of these benthic organisms contribute to the biogeochemical processes shaping water quality (Wang, *et al*., 2014). Investigating this dynamic interplay offers a holistic understanding of the ecological integrity of aquatic systems, informing effective water quality assessment and management strategies.

The specific objectives of this study are as follows: Characterize the macrozoobenthic community in the Ngrowo River, including the identification and quantification of benthic invertebrate taxa. Assess the physicochemical parameters of the water, such as dissolved oxygen (DO), pH, temperature, COD, BOD, TDS, TSS and current level. Analyze the relationships between macrozoobenthic biodiversity and water quality parameters. Evaluate the potential of macrozoobenthic biodiversity as an indicator of water quality in the Ngrowo River to comparing with *baku mutu* PP number 22 years of 2021.

By conducting this research, we hope to contribute to the understanding of the Ngrowo River's ecological health and provide valuable information for water resource management and conservation efforts. The results of this study may serve as a basis for future monitoring programs and the implementation of effective strategies to ensure the sustainable use and protection of this vital freshwater ecosystem in Tulungagung, East Java.

MATERIALS AND METHODS

The research was conducted in the Ngrowo River, located in Tulungagung, East Java. The river stretches over a specific study area, which was selected based on accessibility and representation of the river's ecosystem (Lucas *et al.,* 2009). The study area covered a section of the river approximately 6 km in length, starting from Kalituri and ending at Waung Boyolangu.

The research procedure for macrozoobenthic biodiversity: an indicator of water quality in Ngrowo River Tulungagung, East Java was sample collection, laboratory analysis and data analysis. Sample collection for Benthic invertebrates were collected using a standardized sampling technique, such as collected using appropriate sampling equipment (Luckenback, 1986). In situ measurements were conducted using portable water quality meters calibrated prior to data collection. Water samples for laboratory analysis were immediately stored in a cooler or icebox to preserve their integrity until analysis (TSS, COD, BOD and DO).

Laboratory analysis. the collected benthic invertebrate samples were sorted and identified to the lowest possible taxonomic level. Taxonomic identification was performed using appropriate taxonomic keys, reference materials, and expert consultation if needed (Nakano & Nakamura, 2008). The abundance and biomass of each identified taxon were recorded for further analysis. Species richness, Shannon diversity index, and other biodiversity metrics were calculated based on the collected data. Water samples collected for laboratory analysis were processed within a specified time

to minimize changes in water chemistry. The samples were analyzed for physicochemical parameters using standard laboratory methods and equipment.

The formula for calculating biodiversity index (H') using Shannon-Weiner (Japoshvili *et al.*, 2015).

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

$$pi = \left(\frac{ni}{N}\right)$$

Notes:
H' = Biodiversity Index
pi = i is the proportion of individuals of each species belonging to the ith species of the total number of individuals
ni = total individual
N = total number of individuals

Data analysis. The correlation analysis between macrozoobenthic diversity index and chemophysical factors were using pearson correlation analysis with the PAST 4.03 application (Chao, *et al.*, 2005).

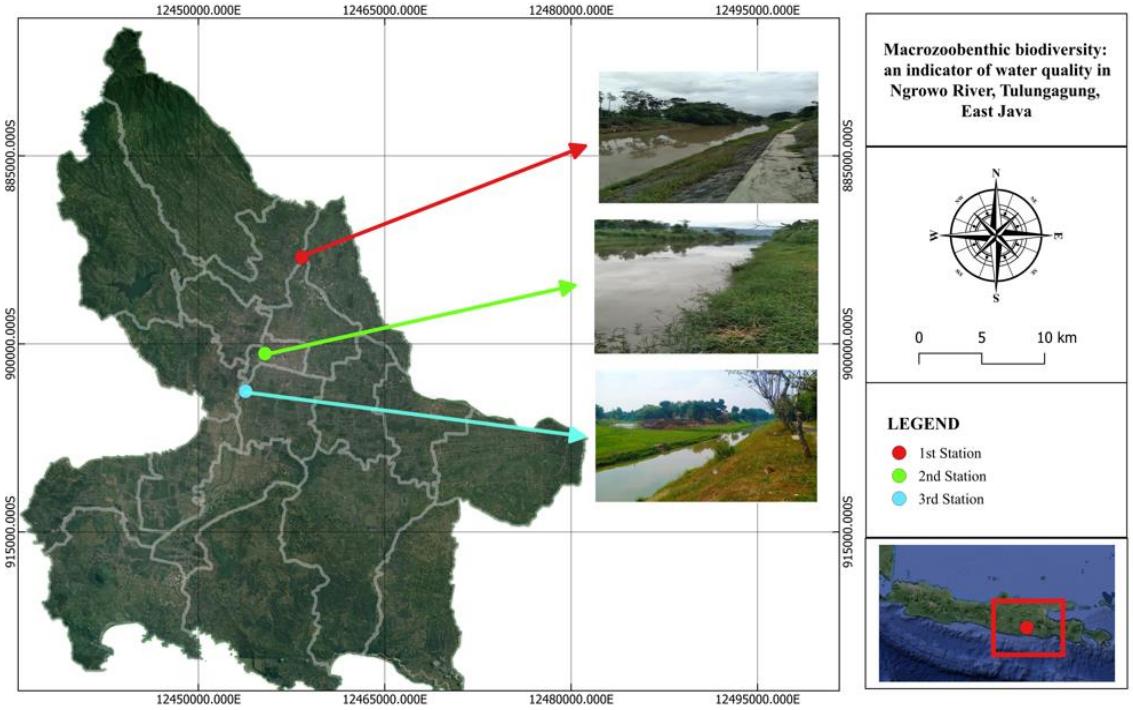

Fig. 1. The observation station in the Ngrowo River Tulungagung: a) Station 1 the beginning of ngrowo river (7°59'48"S 111°54'53"E), b) Station 2 Taman Kali ngrowo approximately as the center of ngrowo river which has a lot off human activities (8°03'53"S 111°53'18"E), c) stasiun 3 the end off ngrowo river flow (8°05'26"S 111°52'27"E).

RESULTS AND DISCUSSION

Procedures for macrozoobenthic biodiversity: an indicator of water quality in Ngrowo River, Tulungagung, East Java consist of sample collection, laboratory analysis and data analysis. Sample collections from Ngrowo River consist of macrozoobenthic specimens and water sample for physical and chemical analysist in laboratory. The collected samples consisted of various benthic invertebrates, including insects, crustaceans, mollusks, and worms. Taxonomic identification in this research was using "An Introduction to the Aquatic Insects of North America" by Merritt, R.W., Cummins, K.W., & Berg, M.B. (2008). Revealed the presence of several indicator taxa known for their sensitivity to water quality, such as *Tubifex* (order: Haplotaxida), *Macrobrachium* (order: Decapoda), *Melanoides* (order:Gastropoda), *Anodonta* (order: Unionida), *Filopaludina*

(order:Architaenioglossa), *Crocothemis* (order: Odonata), *Potamonautes* (order: Decapoda), and *Pomacea* (order: Architaenioglossa) (Fig. 1.)

Analysis of macrozoobenthic biodiversity metrics provided insights into the overall ecological health of the Ngrowo River. Species richness, Shannon diversity index, and other biodiversity indices were calculated based on the collected data. The results showed that the highest diversity index value is station three with a value of 1.325 (Table 1), this could be due to the fact that station three has a more abundant amount of nutrients than other stations so that many macrozoobenthos live well there. Sites with higher water quality tended to exhibit higher species richness and diversity, indicating a healthier and more diverse macrozoobenthic community (Merritt *et al.*, 2008).

Fig. 1. Macrozoobenthic samples from Ngrowo River, Tulungagung, East Java. a. *Tubifex*; b. *Macrobrachium*; c. *Melanoides*; d. *Anodonta*; e. *Filopaludina*; f. *Crocothemis*; g. *Potamonautes*; h. *Pomacea*.

The assessment of physicochemical parameters revealed the variability in water quality along the Ngrowo River (Table 2.). Dissolved oxygen levels were generally within acceptable ranges for supporting aquatic life, indicating good oxygenation. The pH of the Ngrowo River is around 7≥8. Based on the PP quality standard no 22 of 2021 it still meets the quality standards for river water and the like, namely in the pH range of 6-9. According to Rotvit and Jacobsen (2013) organisms that live in waters can live at a pH range of 7 to 8.5. The temperature in the ngrowo river ranges from 27.6°C to 29.8°C. The temperature range of 20°C-30°C is a good temperature for living aquatic organisms in the river, so that many macrozoobenthos can live in the Ngrowo River.

Table 1. Biodiversity and domination index of macrozoobenthic at Ngrowo River

Stations	Biodiversity Index ($H^{'}$)	Domination Index ($C^{'}$)
I	0.974	0.408
II	0.693	0.501
III	1.325	0.419
Average	0.997	0.443

The results of TDS measurements range from 10.6 - 15.4 mg/L. If the TDS value is high, the turbidity in the water is stated to be high. Dwityaningsih *et al.* (2018) which states that the more turbid the waters, the higher the TDS value. Turbidity in a water area can be affected by dissolved particles and silt, if the higher the turbidity value, the more particles in the waters. TSS values range from 7.6 to 21.3 mg/L. TSS is a solid material that causes water turbidity originating from soil erosion, silt or fine sand. According to Dumeier *et al.* (2018) if a water has high TSS levels, the dissolved oxygen

level in the water will decrease, then the water will become anaerobic so that aerobic organisms will die. The high TSS can also directly interfere with biota and can also hinder the production of organic matter in water areas.

Penetration of sunlight to the surface or to the inside does not take place effectively. Based on PP No. 22 of 2021 the TSS value of the Ngrowo River is still included in class 1 quality standard. Class 1 quality standard is a quality standard that is used as a standard that the waters are still safe for use as a source of drinking water for humans. The flow of the Ngrowo River has the highest value of 0.92 m/s at station 3 and the lowest value (small current) at station 2 is 0.65 m/s. The speed of the fast-flowing river ranges from 0.5 m/s to 1 m/s, so that the flow of the ngrowo river is still in the category of fast-flowing river.

Table 2. Physicochemical value of water sample from Ngrowo River

No	Physicochemical Test	Stations		
		I	II	III
1	pH	7.8	7.9	7.8
2	Temperature (°C)	27.6	28.7	29.8
3	TDS (mg/L)	12.76	15.4	10.6
4	TSS (mg/L)	12.8	7.6	21.3
5	Current level (m/s)	0.72	0.65	0.92
6	DO (mg/L)	7.3	3.7	2.1
7	BOD (mg/L)	8.47	11.1	7.21
8	COD (mg/L)	28.24	41.76	24.6

Statistical analysis was performed to explore the relationship between macrozoobenthic biodiversity and water quality parameters. Correlation analysis revealed significant associations between macrozoobenthic biodiversity metrics and certain water quality parameters. For instance, species richness and diversity showed a positive correlation with dissolved oxygen, indicating the importance of well-oxygenated habitats for supporting diverse macrozoobenthic communities. Negative correlations were observed between TDS, COD, BOD and biodiversity metrics, suggesting the potential negative impacts of nutrient pollution on macrozoobenthic biodiversity (Tabel 3.).

Table 3. Statistical analysist results of physicochemical and macrozoobentos biodiversity index correlation

Genus	Physicochemical parameters						
	pH	Temperature	TDS	TSS	Current Level	DO	BOD
Tubifex	0.5756	-0.9123	-0.0874	0.0378	-0.2190	0.7634	-0.2873
Anodonta	0.5020	0.7549	-0.8662	0.8858	0.9854	0.2663	-0.7493
Crocothemis	0.5020	0.7549	-0.8662	0.8858	0.9854	0.2663	-0.7493
Pomacea	0.5020	0.7549	-0.8652	0.8858	0.9854	0.2663	-0.7493
Melanoides	-0.1638	0.9987	-0.3536	0.4207	0.6243	-0.4055	-0.1587
Filopaludina	-0.9830	0.3722	0.7534	-0.7231	-0.5375	-0.9982	0.8711
Macrobrachium	0.9830	-0.3722	-0.7534	0.7231	0.5375	0.9982	-0.8711

The results of this study emphasize the importance of macro-biodiversity as an indicator of water quality in the Ngrowo River. The presence of pollution-sensitive species and the positive correlation between biodiversity measures and dissolved oxygen concentrations indicate the ecological health of the river. However, the negative correlation between nutrient concentrations and biodiversity measures highlights the potential impact of nutrient pollution on macrozoobenthic communities and overall ecosystem health (Strayer & Dudgeon, 2010).

Based on the results, it is important to implement conservation and management strategies to maintain and improve the water quality of the Ngrowo River. Efforts should be made to reduce nutrient inputs from agricultural sources through better land management practices and the implementation of nutrient management plans. Protecting and restoring riparian areas can help reduce sedimentation and maintain the quality of habitat for macrobiotic organisms (Palmer, Menninger, and

Bernhardt, 2010). Regular monitoring programs using macrozoobenthic biodiversity as an indicator should be established to monitor long-term changes in water quality and ecosystem health.

In conclusion, the macrozoobenthic biodiversity of the Ngrowo River is an important indicator of water quality and ecosystem health. The presence of pollutant-sensitive species, variation in biodiversity measurements between sampling points, and the correlation between macro-biodiversity and water quality parameters provide information, valuable for water resource management and conservation efforts (Roni *et al*., 2008). The results of this study can contribute to the development of effective strategies to protect and maintain the Ngrowo River ecosystem in Tulungagung, East Java. Recognizing the importance of macrozoobenthic diversity is essential for effective ecosystem management and conservation efforts. Conservation strategies should aim to protect and restore benthic habitats, minimize pollution and sedimentation, and promote sustainable practices to maintain healthy macrozoobenthic communities. By safeguarding macrozoobenthic diversity, we contribute to the conservation of aquatic ecosystems, ensure their resilience, and ensure the continuation of essential services that benefit both nature and human well-being can be provided.

CONCLUSION

Average Macrozoobenthic diversity in this study was categorize low that is 0.997 but for station III the diversity index of macrozoobenthic was high (1.325). Analysist correlation between macrozoobenthic species and physicochemical index shown a diver's correlation, a positive correlation was observed between the biodiversity index and water quality parameters such pH, DO, BOD and COD has positive correlation with *Filopaludina* and *Macrobrachium*, then current level, TSS and TDS were positively correlated with *Anodonta, Crocothermis, Pomacea*, dan *Potamonautes*. By safeguarding macrozoobenthic diversity, we contribute to the conservation of aquatic ecosystems, ensure their resilience, and ensure the continuation of essential services that benefit both nature and human well-being. can be provided.

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