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Water Quality Analysis Seen from Macrobenthos (Gastropoda) Bioindicators in the Coastal Waters of Kotania Hamlet

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Abstract. Macrobenthos, aquatic biological resources that live on the seabed, are highly sensitive to changes in environmental quality. this study was to determine the diversity of macrobenthos as an indicator of pollution in the coastal waters of Kotania. Descriptive studies that use a random sampling method with a square transect. Data collection through observation of macrobenthos populations. The results of the macrobenthos diversity study obtained were in the Gastropoda class with six families namely Cerithiidae, Neritidae, Mitridae, Nassariidae, Littorinidae and Potamididae consisting of nine species namely Cerithium coniculatum, Nerita polita, Nerita patula, Nerita alveolus, Mitra pica, Nasarius pullus, Litorina scabra, Terebralia palustris and Telescopium telescopium, which shows its role as a potential bioindicator associated with dissolved oxygen, water clarity, and higher nutrient levels, indicating its suitability as an indicator of mild to moderate pollution conditions. These findings indicate Descriptive studies show that macrozoobenthos communities are sensitive to land use changes and can show variations in coastal water characteristic.

Keywords: water quality; macrobenthos; bioindicators

INTRODUCTION

Macrobenthic diversity and water quality are influenced by land use along the watershed, according to previous studies (Goodarzi et al. 2023; Pratiwi et al. 2024; Aweng et al. 2021; Shamaskin et al. 2022; Camara et al. 2019). Every kind of land use might have an effect on specific river ecosystems (Keke et al. 2021; Adesakin et al. 2023). Human pressure is relatively low in areas dominated by natural forests, which maintains habitat quality and ecosystem function (Cornejo et al., 2019). On the other hand, agricultural land use can increase nutrient loads and introduce chemical residues into river systems (Guellaf and Kettani 2025). In addition, soil erosion often occurs in agricultural lands close to river banks. This can cause sedimentation and increase overall suspended solids (Ebsa et al. 2022; Pratiwi et al. 2024). However, domestic waste consisting of organic and inorganic substances can increase organic pollution in residential areas. This can cause a decrease in dissolved oxygen levels as well as changes in the ecological balance of the air (Al-Ali and Al-Dabbas 2022; Isroni et al. 2023; Bhaskar 2020; Dębska et al. 2021). Recently, such pressures can change the water and sediment's physical characteristics.

Thus, the structure of macrobenthic communities changes (Hughes et al. 2019; Islamy and Hasan 2020; Delves et al. 2023; Goodarzi et al. 2023). The spread of pollution-tolerant species, coupled with a decrease in diversity in affected areas, is a common ecological response (Eriksen et al. 2021; Arias et al. 2022). This pattern aligns with the results of several research demonstrating how different land use types affect the Shannon-Wiener diversity index (H). The highest values are found in natural areas, while lower values are found in areas more heavily impacted by human activities (Octavina et al. 2025; Pratiwi et al. 2024; Gholizadeh et al. 2021). River ecosystems typically support higher biodiversity in upstream areas dominated by natural forests (Zhao et al. 2024; Al et al. 2022). On the other hand, downstream areas affected by settlements and intensive agriculture tend to experience declines in water quality, and biodiversity decreases, while tolerant species become dominant. By examining the relationship between macrobenthic communities and environmental factors, predictions of disturbances caused by human activities can be made (Shabani et al. 2019; Wang et al. 2020; Aweng et al. 2021; Tayung et al. 2022; Semenchenko et al. 2024).

We can obtain a more comprehensive and long-term understanding of the state of aquatic ecosystems by integrating physicochemical and biological data when evaluating changes in water quality (Chazanah et al., 2020; Muntalif et al., 2023; Farhan et al., 2024). Furthermore, macrobenthos is a very useful tool for monitoring environmental quality in aquatic ecosystems. This approach helps identify the characteristics of macrobenthos species in relation to different land use types (Al-Izhar and Tanjung 2023; Okoro et al. 2024). As a useful bioindicator for evaluating the ecological health of river ecosystems, numerous studies have demonstrated its efficacy (Harahap et al., 2018; Eriksen et al., 2021; Al et al., 2022). Macrozoobenthos is very useful for determining the state of aquatic ecosystems impacted by pollution because to its relative persistence and sensitivity to variations in water quality (Boudeffa et al. 2020; Adesakin et al. 2023; Sany et al. 2023).

While river water quality in Indonesia has been the subject of several studies, study focused examining water quality analysis using macrobenthic bioindicators (Gastropoda) in the coastal waters of Kotania Hamlet, West Seram Regency, Maluku Province, remains limited. Consequently, scientific understanding of macrobenthic bioindicators in this area remains underdeveloped. The impact Ecologists face difficulties in comprehending the impact the influence of biotic components by land use in river basins, which is a crucial issue in ecosystem management (Scotti et al. 2020; Shamaskin et al. 2022). impact the effects of land use in river basin environments on biotic components these responses. Therefore, this study aims to determine the impact of various land uses on macrobenthic distribution and to explore how macrobenthic bioindicators are integrated with different physicochemical and sediment parameters., specifically in Kotania Hamlet. We concentrate on water quality as seen from macrobenthic bioindicators (Gastropoda) in the coastal waters of Kotania Hamlet, West Seram District, West Seram Regency.

METHODS

This study was carried out in January 2026 in the coastal waters of Kotania Hamlet, West Seram Regency, Maluku Province. The population comprised the coastal waters of Kotania Hamlet, with an area of 2,000 m^2, a length of 50 m2, and a width of 40 m^2. The location of the study conducted is shown in Figure 1.

Figure 1. Research Location

Work procedures

1. Prepare tools and materials.

2. Area survey to see the presence of macrobenthos (gastropods) at the location before making a transect.
3. Plant wood at the research location, then measure it using a meter roll which is pulled from the highest area to the lowest tide with a width of 25 m^2.
4. Make 5 quadrants measuring 1x1m^2 on each transect.
5. The distance between quadrants is 5m.
6. The distance between transects is 10m.
7. Put the sample in plastic and label it to avoid mistakes on each transect.

The sampling method using a linear transect can be seen in Figure 2.

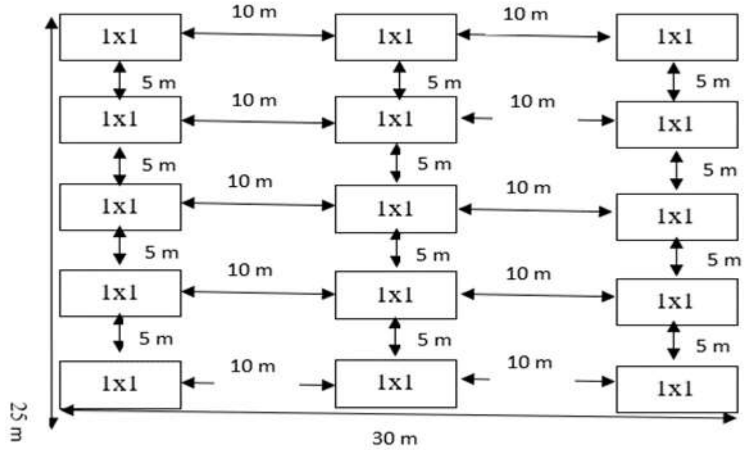

Figure 2. Sampling Method Design using Linear Transect

Data Analysis Techniques

The collected data will be analyzed descriptively, qualitatively, and quantitatively. The methods used to analyze the data in this study are as follows:

1. To analyze water quality parameters at the research location, qualitative descriptive analysis was used. The The descriptive method is a technique for assessing an object's or a group of people's a set of conditions, or a class of events in the present. The goal of descriptive research is to create a systematic, factual, and up-to-date description, depiction, a depiction of the details, traits, and connections among the phenomena being investigated (Nazir, 2003).
2. To analyze macrobenthos (gastropod) bioindicator data to assess water quality, including species composition, density, abundance, and frequency of presence, it is calculated using the formula developed by Krebs (1978) as follows:

a. $\text{Density (ind/m}^2) = \frac{\text{Number of Individuals of a Species}}{\text{Total Observation Quadrants}}$

b. $\text{Relative Density (\%)} = \frac{\text{Number of Individuals of a Species}}{\text{Total Individuals of All Species}} x100$

c. $\text{Abundance (ind/m}^2) = \frac{\text{Number of Individuals of a Species}}{\text{Total Observation Quadrants Where Species Were Found}}$

d. $\text{Relative Abundance (\%)} = \frac{\text{Abundance of a Species}}{\text{Total Abundance of All Species}} \text{ x } 100\%$

e. Frequency of Attendance (%) = $\frac{\text{Number of Quadrants Where a Species is Found}}{\text{Total Number of Quadrants}}$

f. Relative Attendance Frequency (%) = $\frac{\text{Frequency of Presence of a Species}}{\text{Total Presence of All Species}}$ x 100

RESULTS AND DISCUSSION

Result

Environmental Parameters

The environmental parameter values observed while conducting the study are as shown Table 1.

Table 1. Average Values of Environmental Parameters for Each Transect

No	*Environmental Parameters*	Transect 1	Transect 2	Transect 3	Average value
1.	Temperature (°c)	24	24	28	25
2.	Salinity (ppt)	28	30	27	28
3.	pH	8	6	7	7

Macrobenthos Composition (Gastropoda)

Based on the results of the identification of macrobenthos (gastropods) at the research location, this can be seen in Table 2.

Table 2. Macrobenthos's composition (Gastropoda) at the Research Location (Kotania Hamlet Waters, West Seram Regency)

Phylum	Class	Family	Species
Molusca	Gastropoda	*Cerithiidae*	*Cerithium coniculatum*
		Neritidae	*Nerita polita*
			Nerita patula
			Nerita alveolus
		Mitridae	*Mitra pica*
		Nassariidae	*Nasarius pullus*
		Littorinidae	*Litorina scabra*
		Potamididae	*Terebralia palustris*
			Telescopium telescopium

Based on the results of the macrobenthos diversity composition study in Table 2, is nine species were identified across 3 transects. These nine the macrobenthos species are as follows: nine organisms in the gastropoda class of the Mollusca phylum and six from the families: Cerithiidae, Neritidae, Mitridae, Nassariidae, Littorinidae, and Potamididae. Based on these results, the number of macrobenthos species found in the coastal waters of Kotania Village, West Seram Regency, Maluku Province was determined.

Density, Abundance, Frequency of Macrobenthos Presence at the Research Location

In light of the findings of the data analysis, the values of individual density (K), relative density (KR), individual abundance (K), relative abundance (KR) and frequency of presence (FK) of macrobenthos (gastropods) at the research location were obtained.

The density and relative density of gastropods found in the coastal waters of Kotania Hamlet are displayed in Tables 3, 4, and 5.

After the Density and Relative Density data were found, the next step was to calculate the relative abundance and frequency of presence and relative frequency of presence of Gastropods as shown in Table 4. After the Frequency of Attendance and Relative Frequency of Attendance of Gastropods Found in the Waters of Kotania Hamlet of Gastropods as shown in Table 5.

Table 3. Density and Relative Density of Gastropods Found in the Coastal Waters of Kotania Hamlet

Spesies	Transect I		Transect II		Transect III	
	Density (Ind/m^2)	Relative Density (%)	Density (Ind/m^2)	Relative Density (%)	Density (Ind/m^2)	Relative Density (%)
Cerithium coniculatum	0,533	11,42	1,466	18,8	2,066	11,39
Telescopium telescopium	1	21,42	2	25,64	4,666	25,73
Nerita patula	0,333	7,142	0,666	8,54	1,333	7,35
Nerita alveolus	0,333	7,142	0,333	4,27	1,066	5,88
Nerita polita	0,466	10	0,533	6,83	1,4	7,72
Littorina scabra	1	21,42	1,666	21,36	4,466	24,63
Mitra pica	0,133	2,857	0,133	1,7	0,4	2,2
Nassarius pullus	0,2	4,285	0,266	3,41	0,666	3,67
Terebralia palustris	0,666	14,28	0,733	9,4	2,066	11,39

Table 4. Abundance and Relative Abundance of Gastropods Found in the Waters of Kotania Hamlet

Spesies	Transect I		Transect II		Transect III	
	Abundance (ind/m2)	Abundance Relatif (%)	Abundance (ind/m2)	Abundance Relatif (%)	Abundance (ind/m2)	Abundance Relatif (%)
Cerithium coniculatum	1	13,27	2,75	22,9	3,875	13,96
Telescopium telescopium	1	13,27	2	16,65	4,666	16,81
Nerita patula	0,625	8,29	1,25	10,4	2,5	9
Nerita alveolus	1	13,27	1	8,32	3,2	11,52
Nerita polita	0,777	10,32	0,888	7,4	2,333	8,4
Littorina scabra	1	13,27	1,666	13,87	4,466	16,09
Mitra pica	0,666	8,84	0,666	5,55	2	7,2
Nassarius pullus	0,75	9,95	1	8,32	2,5	9
Terebralia palustris	0,714	9,48	0,785	6,54	2,214	7,97

Tabel 5. Frequency of Attendance and Relative Frequency of Attendance of Gastropods Found in the Waters of Kotania Hamlet

Spesies	Transect I		Transect II		Transect III	
	Frequency of Attendance (ind/m2)	Frequency of Attendance Relatif (%)	Frequency of Attendance (ind/m2)	Frequency of Attendance Relatif (%)	Frequency of Attendance (ind/m2)	Frequency of Attendance Relatif (%)
Cerithium coniculatum	1,875	9,26	1,875	9,26	0,533	9,87
Telescopium telescopium	1	4,94	1	4,94	1	18,51
Nerita patula	1,785	9,26	1,875	9,26	0,533	9,87
Nerita alveolus	3	14,82	3	14,82	0,333	6,17
Nerita polita	1,666	8,23	1,666	8,23	0,6	11,11
Littorina scabra	1	4,94	1	4,94	1	18,51
Mitra pica	5	24,7	5	24,7	0,2	3,7
Nassarius pullus	3,75	18,52	3,75	18,52	0,266	4,93
Terebralia palustris	1,071	5,29	1,071	5,29	0,933	17,28

Analysis of Diversity (Diversity Index) and Dominance of Macrobenthos (Gastropoda) Species

Based on the results of data analysis, The Diversity Index of Shannon-Wiener (H') and macrobenthos (gastropod) Dominance the Index values they were obtained at the research location as shown in Table 6.

Table 6. Values of the dominance and diversity indices of gastropods found in the waters of Kotania

Hamlet

No	Species	Indeks Dominasi	Pi2(ni/N)	ln (Pi)	H'(indeks Keanekaragaman) Pi Ln Pi
1	*Cerithium coniculatum*	31	0,113971	2,171814862	0,247523017
2	*Telescopium telescopium*	70	0,257353	1,357306824	0,349306903
3	*Nerita patula*	20	0,073529	2,610069793	0,191916897
4	*Nerita alveolus*	16	0,058824	2,833213344	0,166659608
5	*Nerita polita*	21	0,077206	2,561279629	0,197745854
6	*Littorina scabra*	67	0,246324	1,401109447	0,345126224
7	*Mitra pica*	6	0,022059	3,814042597	0,084133293
8	*Nassarius pullus*	10	0,036765	3,303216973	0,1214418
9	*Terebralia palustris*	31	0,113971	2,171814862	0,247523017
	Total	**273**	**1**	**22,22386833**	**1,951376614**

Water Quality Assessment

Table 7. Determination of Water Quality Status Based on the Storet Method.

Class	Score	Criteria
A	0	Meet Quality Standards
B	-1 s/d – 10	Lightly polluted
C	-11 s/d -30	Moderately polluted
D	D≥ - 31	Lightly polluted

DISCUSSION

Environmental Parameters

Water quality can be ascertained by evaluating physical, chemical, and biological factors. The water in the Bawean Island waterfall ecosystem's physical and chemical parameters are displayed in Table 1. Among the physical and chemical factors are temperature (°C), pH, and salinity levels. Based on measurements, the water temperature at the research location on transects 1 to 3 ranged between 24-28°C, with the average temperature at the research location being 25°C. This temperature is normal in tropical regions, where the effective water temperature is 25 °C (Harahap et al.). (2018).

Temperatures in tropical areas range from 20-28℃, and temperatures decrease with increasing water depth (Basyuni et al., 2018). Temperature is used by producer organisms for photosynthesis, making it an important environmental component that can determine the presence of certain species (Boyd et al., 2013). The ideal temperature for benthic organisms is, according to Basyuni et al. (2018). macroinvertebrate life ranges from 25-32℃. In residential land use areas, conductivity and salinity parameters increase. caused by seawater intrusion, which usually occurs downstream areas of the river. In contrast, TDS and TSS did not show a significant difference, although Both trends indicate a shift from natural forest to settlements (Yolanda et al., 2023). With significant increases, suspended matter loads increase. increase on Organic pollution from home activities is indicated by COD and BOD values in residential land use areas (Stepenuck et al. 2002; Wang et al. 2020; Arias et al. 2022). It is possible that deterioration of water quality and modifications to the physicochemical properties of aquatic environments. The results of the studies by Dębska et al. (2021) and Pratiwi et al. (2024) show that land use in the surrounding area river basins might impact river water quality, are consistent with this.

The average pH value for transects 1 to 3 monitored ranged from 6-8 (Table 1). All water observed at the research location still complies with Government Regulation No. 22 of 2021 concerning National Water Quality Standards for Class 1, namely a water quality standard of 6-9. In addition, all water observed also met the requirements. for irrigation water, as stipulated in the FAO's international irrigation water quality standard of 6.5-8.4. Fluctuations in water acidity can disrupt the survival of organisms, such as interfering with the metabolic and respiratory systems (Selleslagh et al. 2012). According to Wang et al. (2012), the ideal pH range for benthic macroinvertebrate life is 5<pH<9. Chemical and organic pollution frequently results in sharp variations in pH levels, according to Darojat et al. (2020). In the meantime, the acidity of water will rise due to the presence of free minerals and carbonic acid.

Water quality based on the structure of the macrobenthos (Gastropoda) community can also be observed via the computation of multiple macrobenthos (Gastropoda) biotic indices as bioindicators, such as the Family Biotic Index/FBI (Mandaville 2002). The results of the FBI value calculation can be seen in Table 7. It is evident that the water quality in the Kotania coastal waters is free from organic material contamination (very good). The FBI value is included in the low category because the waterfall location is still found in many macrobenthos families with low tolerance values range 0–4, including Hydropsychidae and Baetidae (Mandaville 2002; Darojat et al. 2020). Previous studies have shown that Trichoptera, Plecoptera, and Ephemeroptera are EPT creatures show high-quality water in other pure water ecosystems (Hamid and Rawi 2017).

Density, Abundance, Frequency of Macrobenthos Presence at the Research Location

Density, Abundance, Frequency of Macrobenthos Presence of gastropods in Kotania waters are presented Tables 3, 4, and 5. The density of gastropods in Table 3 in Kotania coastal waters shows that in transect 1 for the Species Telescopium telescopium and Litorina scabra have the highest density (1 Ind/m2) and also have the highest relative density value, namely (21.42%). The density of gastropods in Kotania coastal waters on transect 2 for the Species Telescopium telescopium has the highest density (1 Ind/m2) and has the highest relative density value, namely (25.64%). The density of gastropods in Kotania coastal waters on transect 3 for the Species Telescopium telescopium has the highest density (4,666 Ind/m2) and has the highest relative density value, namely (25.73%). According to Kurniawan (2007), the whether gastropods exist or not at the research the site may have a connection with condition of the substrate or habitat of each species. The presence nutritional factors such as dirt and environment as well strongly support the life of the gastropod species found. Therefore, the species with the highest density and relative abundance values in transects 1 to 3 is Telescopium telescopium.

According to the Table 5 of Distribution, the quantity of macrobenthos species discovered, with 9 across the three transects, indicates that the ecological conditions at the study site are very good, supporting macrobenthos growth. Supporting factors include nutrient-rich soil structure, which optimally supplies organic matter, enriching macrobenthos growth and development (Sturm et al., 2006; Rahardjanto, 2019).

The class of gastropods dominates the spread of macrobenthos. Several reasons for this class's high dominance include its ability to adapt to the environment, both in the right substrate conditions and in situation with minimal substrate and high levels of pollution (Nurainie et al., 2021). Gastropods have waterproof shells with good environmental protection, allowing them to survive better than other classes (Romdhani et al., 2016). The operculum is an extra feature found in gastropods that may readily open and seal tightly in the shell's gaps, allowing for proper circulation of water and serving as an additional protective structure for this class.

Analysis of Diversity (Diversity Index) and Dominance of Macrobenthos (Gastropoda) Species

Based on observations of macrobenthos in the coastal waters of Kotania, variations in the composition and abundance of macrobenthos were found (Table 6). These variations are and high levels of pollution. The macrobenthos diversity index ranged from 0.084 to 0.349 with a 1.39 average. According to the Shannon-Wiener diversity index, the mean degree of diversity in the coastal waters of Kotania is categorised as having moderate ecological pressure. Natural forest land use has the highest evenness value of 0.84, suggesting that the distribution of The distribution of macrobenthos individuals across different species was somewhat uniform in this area. In the meantime, residential land use near the Citumang River had the highest species domination. estuary with a value of 70 for the species Telescopium telescopium. This value indicates the dominance of one or more species in an area, as indicated by the high abundance of Telescopium telescopium, reaching 70 individuals/m² which dominates the area. However, this dominance contributes to the overall variation in macrobenthos abundance. The highest abundance of macrobenthos in these areas is dominated by estuarine taxa that are tolerant of salinity and pollution, such as Telescopium telescopium. This indicates that despite the high abundance of macrobenthos found, species diversity in these areas low numbers indicate that environmental conditions only favor certain species.

Characteristics that facilitate salinity tolerance and adaptation are influenced by seawater intrusion and tidal changes (Sahidin et al. 2021; Oyeku et al. 2023; Ardyatma et al. 2020). Characteristics of downstream residential areas, where the river flow velocities tend low and the majority of the substrate consists of clay and mud that Organic materials tends to accumulate (Stepenuck et al. 2002), thus support survival of tolerant species in this zone (Arias et al., 2022; Baharuddin et al., 2023). As stated by Fuller et al. (2022), distribution and abundance are influenced by changes in substrate properties along the river flow macrobenthos, which tends to decrease on large rock substrates. In addition, domestic waste in settlements contributes to increased organic matter (Pohlmann et al. 2018; Han et al. 2019), which leads to deterioration of water quality (Minshall et al. 2014; Souza et al. 2021; Delgado et al. 2023) and as a result reduces the abundance of macrobenthos in the area. This circumstance results from each species' a different tolerance range for substrate properties together with additional environmental factors (Al-Izhar and Tanjung 2023; Oyeku et al. 2023).

CONCLUSIONS

The results of the macrobenthos diversity study obtained are in the Gastropoda class with six families namely Cerithiidae, Neritidae, Mitridae, Nassariidae, Littorinidae and Potamididae consisting of nine species namely Cerithium coniculatum, Nerita polita, Nerita patula, Nerita alveolus, Mitra pica, Nasarius pullus, Litorina scabra, Terebralia palustris and Telescopium telescopium, which shows its role as a potential bioindicator related to dissolved oxygen, the water becomes dirtier, and higher nutrient levels, indicating its suitability as an indicator of mild to moderate pollution conditions. this result indicate this the macrozoobenthos community responds sensitive to changes in land use and can show differences in coastal water quality.

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