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Bioassessment of Macroinvertebrates in Coban Rais River, Oro-Oro Ombo Vilage, Post Administrative of Batu, Batu City

Adelina do Rego Soares[1]*, Sri Sudaryanti[2], Koderi[2]

[1] Environmental Resource Management and Development Program, Graduate School, Universitas Brawijaya, Malang, Indonesia.
[2] Lecturer, Graduate School, Universitas Brawijaya, Malang, Indonesia.

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Corresponding Author:
Adelina do Rego Soares
ade.drsl@gmail.com

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Abstract: Coban Rais, part of the Brantas River upstream area, is a tourist destination with natural waterfalls and anthropogenic activities affecting its river health. This study analyzed river health using macroinvertebrates sampled at nine stations with varying land uses. Samples were collected with hand nets (500 µm mesh) using a 10-meter kicking technique in riffle areas. Data were analyzed using the SIGNAL2 index. A total of 76 macroinvertebrate families from 15 orders, 3 subclasses, and 1 suborder were identified. Station 4 had the highest diversity (33 families), including Hydropsychidae and Caenidae, while Station 9 recorded the lowest (7 families), including Naididae and Chironomos thummi. SIGNAL2 results categorized stations 1 and 2 as unpolluted (values of 6.26 and 5.39, respectively), stations 3–8 as lightly polluted (values between 3.71 and 4.79), and station 9 as heavily polluted (3.61). Recommendations include maintaining unpolluted stations through regular cleaning and erosion control, reducing waste disposal near lightly polluted stations, and treating livestock waste before discharge at heavily polluted sites. Public awareness campaigns are vital to promote river health and protect macroinvertebrate diversity.

Keywords: Bioassessment; Macroinvertebrates; River.

Introduction

Coban Rais River, situated in Batu, Indonesia, is a significant natural resource that traverses three villages: Oro-Oro Ombo, Tlekung, and Dadaprejo. The river originates from the Coban Rais waterfall, which is approximately 20 meters high and located at an altitude of 1025 meters above sea level on the eastern slope of Mount Panderman. The surrounding environment is characterized by dense vegetation and large boulders, contributing to the river's aesthetic and ecological value (Albutra et al., 2017). The river's ecosystem is vital for local biodiversity, particularly for macroinvertebrates, which serve as bioindicators of water quality due to their sensitivity to environmental changes (Mazzoni et al., 2014; Olson & Hawkins, 2017).

Anthropogenic activities, including tourism, agriculture, and urbanization, have been shown to adversely affect the water quality of Coban Rais River. Increased visitor numbers lead to littering and pollution, while agricultural practices around the riverbanks result in habitat degradation and reduced water absorption capacity (Fernández et al., 2018; Zhang et al., 2021). Such disturbances can significantly impact the aquatic organisms inhabiting the river, particularly macroinvertebrates, which are known to respond sensitively to changes in water quality (Fierro et al., 2015; Gandini & Costa Sampaio, 2014). The relationship between land use and macroinvertebrate diversity has been well-documented, highlighting the importance of monitoring these organisms to assess the ecological health of freshwater systems (Castro‐López et al., 2019; Kahirun, 2023).

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Research has indicated that macroinvertebrates can effectively reflect the ecological status of rivers, making them crucial for bioassessment (Martínez-Sanz et al., 2014; Mutea et al., 2021). The Environmental Protection Agency (EPA) emphasizes the importance of biological assessments in evaluating water bodies, where macroinvertebrates are often utilized due to their diverse habitats and varying tolerance levels to pollutants (Gething et al., 2020; Ruiz-Picos et al., 2017). In the context of Coban Rais, understanding the diversity and abundance of macroinvertebrates can provide insights into the river's health and the impact of human activities on its ecosystem (Castro‐López et al., 2018; Scotti et al., 2019).

Given the pressing issues surrounding Coban Rais River, this study aims to investigate the macroinvertebrate communities as bioindicators of water quality. By assessing these organisms, the research seeks to contribute to the ongoing efforts to mitigate the negative effects of anthropogenic activities and promote sustainable management of the river's ecosystem (Valentini et al., 2016; Vasquez et al., 2022). The findings could inform local authorities and stakeholders about the ecological status of Coban Rais and guide conservation initiatives to protect this vital natural resource (Górski et al., 2018; Koty, 2024).

Methods

The methodology employed in this quantitative descriptive research is grounded in established practices for sampling macroinvertebrates, which are critical bioindicators of aquatic ecosystem health. The study utilized primary data collected from nine sampling stations along the Coban Rais River, employing a purposive sampling method to ensure that the selected sites accurately represented the overall water conditions. This approach is supported by previous research indicating that targeted sampling can yield more representative data regarding macroinvertebrate communities in diverse habitats (Brua et al., 2010; Feeley et al., 2011).

The kicking method for macroinvertebrate sampling, as described in the study, is widely recognized for its effectiveness in collecting benthic organisms from shallow water bodies. This technique allows for the disturbance of substrate, facilitating the capture of organisms that may otherwise remain hidden (Moore & Murphy, 2015). Studies have shown that kick sampling can provide a comprehensive view of macroinvertebrate communities, often outperforming other methods in terms of taxa richness and community structure (Moore & Murphy, 2015). Moreover, the duration of sampling—three to five minutes depending on stream width—aligns with best practices that recommend sufficient time to ensure adequate representation of the community (Feeley et al., 2011; Moore & Murphy, 2015).

The tools and materials used for sampling, including hand nets with a mesh size of 500 µm, are consistent with standard protocols for aquatic invertebrate collection. The choice of equipment is crucial, as it influences the efficiency and accuracy of the sampling process (Hertika, 2024). The use of benthic jars and strainers for sorting and preserving samples further ensures that the collected data remains intact for subsequent laboratory analysis, which is essential for accurate identification and assessment of macroinvertebrate diversity (Hertika, 2024).

In the laboratory, the application of compound microscopes and identification books facilitates the precise identification of macroinvertebrate taxa, which is vital for assessing water quality through bioindication methods. The integration of both field and laboratory techniques underscores the comprehensive nature of the research methodology, allowing for a robust analysis of the ecological health of the Coban Rais River (Ganguly et al., 2018).

Overall, the methodological framework established in this study is supported by a wealth of literature that emphasizes the importance of standardized sampling techniques and the role of macroinvertebrates as indicators of environmental quality. By adhering to these established protocols, the research aims to provide valuable insights into the ecological status of the Coban Rais River and the impacts of anthropogenic activities on its aquatic ecosystems (Krause et al., 2010; Sabatino et al., 2017) as shown in the Figure 1.

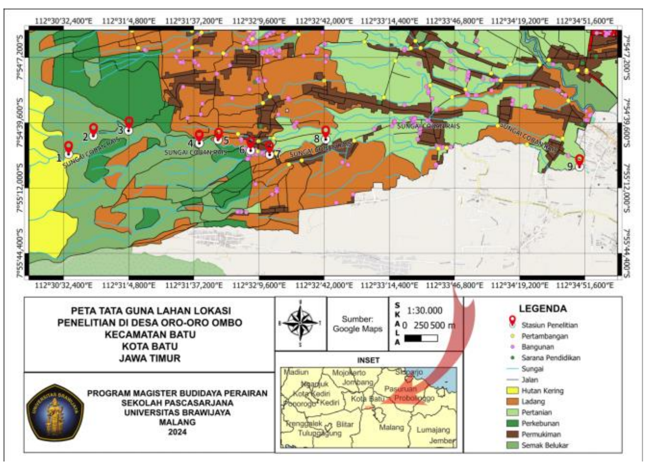

Figure 1. Sampling location map

Table 1. Description of sampling locations

Sampling Station	Sampling Coordinate	Description
Station 1	7°54′55.22′′S 112°30′34.86′′E	Primary Forest
Station 2	7°54′48.13′′S 112°30′48.94′′E	DAM
Station 3	7°54′43.55′′S 112°31′04.69′′E	Agriculture
Station 4	7°54′43.7′′S 112°31′ 17.1′′E	Tourism
Station 5	7°54′48.4′′S 112°31′ 48′′E	Agriculture
Station 6	7°54′43.7′′S 122°31′ 17.1′′E	Settlement
Station 7	7°54′55.4″S 112°32′15.1″E	Settlement & Livestock
Station 8	7°54′47.5″S 112°32′43.0″E	Agriculture
Station 9	7°55′02.42″S 112°34′49.34″E	Settlement

Result and Discussion

The biological assessment of macroinvertebrates was carried out in Coban Rais River. The data obtained was then analyzed using macroinvertebrate abundance and relative density, and the Invertebrate Grade number average level (SIGNAL) index.

Relative Density is calculated by the Formula 1.

$$KR = \frac{ni}{N} x100\% \quad (1)$$

Description:
KR= Relative Density
ni = Number of individuals per taxa
N = Number of individuals of all taxa

The macroinvertebrate communities found in this observation consisted of the composition and relative density of macroinvertebrates in the Coban Rais river, Oro-Oro Ombo Village carried out on April 03-05, 2024 consisting of station 1 to station 9. The results of these observations are presented in the Figure 2.

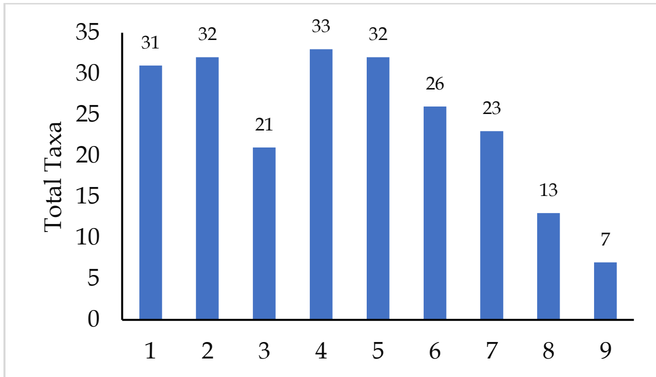

Figure 2. Macroinvertebrate Density in Coban Rais River

A total of 76 families were identified from the macroinvertebrates and 15 orders (Amphipoda, Coleoptera, Diptera, Decapoda, Ephemeroptera, Hemiptera, Lepidotera, Lumbriculida, Neotaenioglossa, Odonata, Phyllodocida, Pleocoptera, Tricoptera, Tricladida and Tubificida), 3 sub-classes Caenogastropoda, Collembola and Hirudinea), and 1 sub-order named Hygrophila. For more details, see Table 2.

Table 2. Macroinvertebrate relative density

Taxa	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6		Station 7		Station 8		Station 9	
	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR %
AMPHIPODA																		
Gammaridae	1	0.08	4	0.45														
Eusiridae					1	0.17												
CAENOGASTROPODA																		
Thiaridae					1		1	0.04										
COLEOPTERA																		
Elmidae (D)	54	4.53	65	7.29	2	0.35	10	0.38	6		1	0.11	2	0.38				
Elmidae (Larva)	35	2.94	38	3.14	1	0.17	8	0.30	11	0.48	1	0.05						

Taxa	Station 1		Station 2		Station 3		Station 4		Station 5	
	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)
Dysticidae	5	0.42	1	0.11						0.26
Elmidae (P)	1	0.08								
Scirtidae	1	0.08	1	0.11			1	0.04		
Tenebrionidae			1	0.11						
Curculionidae					10	1.74	10	0.38		
Hydrophilidae (D)							4	0.15		
Amphiterygidae				0.22			3			0.26
Dysticidae (D)							23	0.87	1	0.04
hydropsychidae	103	8.65		10.09		8.7		15.15	179	7.81
Lampyridae									2	0.09
Hydrophilidae (L)									4	0.17
Chrysomelidae									1	0.04
Dysticidae (L)									1	0.04
Psephenidae										
Elateridae										
COLLEMBOLA										
Collembola					1	0.17				
DIPTERA										
Tanypodinae	3	0.25	4	0.45			56	2.12	22	
Chironominae (SF)	42	3.53			17	2.96				0.96
Orthocladinae (SF)	8	0.67			1					
Tipulidae	17	1.43					18	0.68	40	1.75
Chironomidae	5	0.42							8	0.35
Simuliidae					356	61.91			5	0.22
Muscidae			9	1.01	1	0.17			2	0.09
Simuliidae (L)	433	36.36	145	16.26			149	5.64	60	2.62

Taxa	Station 6		Station 7		Station 8		Station 9	
	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR %
Dysticidae	1	0.05						
Elmidae (P)	1	0.05						
Scirtidae								
Tenebrionidae								
Curculionidae								
Hydrophilidae (D)	1	0.05						
Amphiterygidae								
Dysticidae (D)								
hydropsychidae	64	3.38	18	3.44	2			
Lampyridae	1	0.05						
Hydrophilidae (L)								
Chrysomelidae								
Dysticidae (L)								
Psephenidae			1	0.19				
Elateridae			1	0.19				
COLLEMBOLA								
Collembola								
DIPTERA								
Tanypodinae	56	2.96	51	9.75				
Chironominae (SF)					1	0.24		
Orthocladinae (SF)								
Tipulidae	11	0.58	2	0.38	2	0.47		
Chironomidae					20	4.73		
Simuliidae		0.05						
Muscidae								
Simuliidae (L)			78	14.91	7	1.65	7	0.28

Taxa	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6		Station 7		Station 8		Station 9	
	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR %
Chironomidae (P)		0.59	14	1.57			16	0.61			21	1.11	7	1.34				
Chironominae			25	2.8			156	5.91	147		311	16.45	88	16.83	6	1.42	1	0.04
Empididae							1	0.04										
Orthocladinae			12	1.35		0.17	87	3.3	20	0.87	10	0.53	8	1.53				
Simuliidae (P)	2	0.17					2	0.08			4	0.21	1	0.19		1.89		
Ceratopogonidae							2	0.08					2	0.38				
Psychodidae									1	0.04	4	0.21	10	1.91				
Athericidae									3	0.13								
Chironomus Thummi											1	0.05	13	2.49	349	82.51	7	0.28
Stratimydae													1	0.19				
Culicidae																	1	0.04
DECAPODA																		
Grapsidae	5	0.42		0.22										0.38	1	0.24		
Atydae							4	0.15										
Sundatelphusidae													2	0.38				
EPHEMEROPTERA																		
Baitidae	246	20.65	306	34.3	28	4.87	591	22.39	1615	70.49	1368	72.34	192	36.71	7	1.65	6	0.24
Caenidae	1		8	0.9			752	28.48	18	0.79	2	0.11	1	0.19	6	1.42		
Heptageniidae			3	0.34														
Tricorythidae	1	0.08																
HEMIPTERA																		
Corixidae			1	0.11	10	1.74	23	0.87										
Hebridae					1	0.17												
Pentatomatidae (F)					1	0.17												
Gerridae					2	0.35	3	0.11										
HYGROPHILA																		
Lymnaeidae	2	0.17										0.11						

Taxa	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6		Station 7		Station 8		Station 9	
	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR (%)	Density (ind/5 m²)	KR %
Physidae	1											0.05						
Planorbidae	1	0.08										0.05						
HIRUDINEA																		
Richardsonianidae													2	0.38				
LEPIDOPTERA																		
Noctuidae			1	0.11					1	0.04								
LUMBRICULIDA																		
Lumbriculidae	5		6	0.67					16	0.7	6	0.32				2.36	10	
NEOTAENIOGLOSSA																		
Bithyniidae					1	0.17												
Thiaridae			1	0.11		0.17												
ODONATA																		
Gomphidae					4	0.7	1	0.04	6	0.26								
Caenagrionidae			1				2	0.08	14	0.61								
Cordulegastriade		0.08		0.11			2	0.08	2	0.09	3	0.16						
Amphipterygidae			2					0.11	6									
PLEOCOPTERA																		
Perlidae	64	5.37	37	4.15	1	0.17	63	2.39	31	1.35								
Perlolidae		0.42	4	0.45	24	4.17	16	0.61	16	0.7								
PHYLLODOCIDA																		
Nereidae																		0.04
TRICOPTERA																		
Lepidostomatidae	18	1.51	86	9.64			17	0.64	16	0.7	14	0.74						
Hydropsychidae	103	8.65	90		50		400											
Leptoceridae	3	0.25	2	0.22			2	0.08								0.47		
Limnephilidae	3	0.25	3	0.34														
Glossosomatidae	105	8.82	3	0.34														
Polycentropodidae	12	1.01																
Philopotamidae	1	0.08	6	0.67			36	1.36		0.04								
TRICLADIDA																		

Taxa	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6		Station 7		Station 8		Station 9	
	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR (%)	Density (ind/5 m^2)	KR %
Planaridae			18	2.02		10.78		6.02		1.44		0.16		0.19				
TUBIFICIDA																		
Naididae			3	0.34				0.83	3	0.13	1	0.05	39	7.46	4	0.95	2	0.08

The findings regarding the number of taxa at different sampling stations along the Coban Rais River highlight the influence of environmental conditions and land use on macroinvertebrate diversity. At station 9, the presence of only 7 taxa, including Baetidae, Naididae, and Chironominae, suggests a potentially degraded habitat, likely influenced by the surrounding plantation land use in Dadaprejo Village. This observation aligns with research indicating that agricultural runoff and land use changes can significantly affect the composition and abundance of macroinvertebrate communities (Kasangaki et al., 2008).

The highest diversity observed at station 4, with 33 taxa including various families such as Elmidae and Chironomidae, indicates a healthier ecosystem. The presence of diverse substrate types—sand, gravel, and stone—at this station is conducive to supporting a wide range of macroinvertebrate species, as noted by Xu et al. (2018), who emphasized the importance of substrate composition in fostering macroinvertebrate habitats. The relationship between substrate type and macroinvertebrate diversity is well-documented, with studies showing that heterogeneous substrates promote greater biodiversity by providing various niches for different taxa (Feld et al., 2013; Leigh & Sheldon, 2009).

The ecological significance of macroinvertebrates as bioindicators of water quality is underscored by their sensitivity to environmental changes. Research has demonstrated that macroinvertebrate assemblages can reflect the ecological health of freshwater systems, making them valuable for monitoring the impacts of anthropogenic activities (Kędzior et al., 2021; Zhang et al., 2021). The contrasting taxa richness between stations 4 and 9 exemplifies how land use and habitat conditions can shape macroinvertebrate communities, reinforcing the need for continued monitoring and assessment of river ecosystems (Getachew, 2023; Paillex et al., 2012).

Overall, the data collected from the Coban Rais River underscores the intricate relationship between land use, habitat conditions, and macroinvertebrate diversity. This research contributes to the broader understanding of how anthropogenic influences can alter aquatic ecosystems and highlights the importance of implementing effective management strategies to protect these vital habitats (Dirisu & Olomukoro, 2021; Negishi et al., 2002).

Macroinvertebrate measurement results using SIGNAL2

Based on the analysis using stream invertebrate grade number average level 2 (SIGNAL2), macroinvertebrates in the Coban Rais River, Oro-Oro Ombo Village, Batu District were categorized as macroinvertebrates obtained from 9 observation stations as in Table 3.

Table 3. Results of Macroinvertebrate Calculations Using Stream Invertebrate Grade Number Average Level (SIGNAL2)

Station	Signal Value	Number of Taxa	Desc.
Station 1	6.14	30	Not polluted
Station 2	5.39	32	Not polluted
Station 3	4.59	21	Lightly polluted
Station 4	4.74	33	Lightly polluted
Station 5	4.70	32	Lightly polluted
Station 6	4.07	26	Lightly polluted
Station 7	3.79	23	Lightly polluted
Station 8	3.65	13	Lightly polluted
Station 9	3.53	7	Heavily polluted

The results of SIGNAL2 analysis of macroinvertebrates show that the health status of the Coban Rais River ranges from unpolluted to severely polluted along the Coban Rais River.

Conclusion

This research found a total of 76 families of macroinvertebrates were found, 15 orders (Amphipoda, Coleoptera, Diptera, Decapoda, Ephemeroptera, Hemiptera, Lepidotera, Lumbriculida, Neotaenioglossa, Odonata, Phyllodocida, Pleocoptera, Tricoptera, Tricladida and Tubificida), 3 sub-classes (Caenogastropoda, Collembola and Hirudinea), and 1 sub-order (Hygrophila). The lowest number of taxa found at station 9 compared to other stations was 7 taxa, including Baitidae, Naididae, *Chironomos Thummi*, Culicidae, Nereidae, Simulidae (L) and Chironominae. The number of SIGNAL2 value at station 1 of 6.26 and station 2 of 5.39. The lightly polluted category included those at station 3 with a value of 4.59, station 4 with a value of 4.79, and station 5 with a value of 4.69, station 6 of 4.06, station 7 of 3.78, and station 8: of 3.71. Lastly, station 9 was the heavily polluted river with a value of 3.61.

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Author Contributions
Conceptualization, ARS., S.S and K.K.; methodology, ARS.; validation, S.S and K.K.; formal analysis, ARS.; investigation, ARS.; resources, ARS.; data curation, S.S., and K.K.; writing—original draft preparation, ARS; visualization, S.S and K.K. All authors have read and agreed to the published version of the manuscript.

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Conflicts of interest
The authors declare no conflict of interest.

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