Impact of Coal Washing Activities on Water Quality And The Community of Aquatic Life In The Barito River, South Barito Regency

Lovina Gianina[1]*, Ipung Fitri Purwanti[2]

[1,2] Master of Environmental Management Program, Department of Environmental Engineering, Faculty of Civil, Planning, and Geotechnical Engineering, Sepuluh Nopember Institute of Technology Surabaya, Indonesia
* Corresponding Author:
Email: Lovinagnn@gmail.com

Abstract.

The Barito River is a recipient of pollution from various human activities such as agriculture, settlements, and especially the mining industry. Coal washing activities along the Barito River Basin (DAS) are one of the activities that have the most significant impact on water quality degradation. This research aims to analyze the impact of coal washing activities on water quality and aquatic biota communities in the Barito River, South Barito Regency. The research location is the Barito River, South Barito Regency. Sampling points were taken at three points: upstream, outfall, and downstream of the Barito River. Water quality parameters in the Barito River include physical aspects (temperature and TSS), chemical (DO, pH, Fe, and Mn), and biological (nekton, plankton, and benthos) measured using the SNI method and specific fishing gear. Water quality assessment was carried out using the Storet method and the Pollution Index (IP) to determine water quality status based on parameters that do not meet quality standards. The water quality of the Barito River is classified as lightly to moderately polluted. Most physicochemical parameters are still within quality standards, except for low DO and Mn at several points exceeding the threshold. Storet results showed a score of -10 (class B, light pollution), while the Pollution Index (IP) was 1.98 (light pollution). Coal washing activities affected the distribution of aquatic biota. The diversity index (H') of nekton was moderate-high (2.64–3.17), plankton was moderate (1.70–2.06), and benthos was low (0.64–0.69). High evenness and low dominance values indicated a relatively stable community, despite anthropogenic pressures. The presence of bioindicators such as Rasbora caudimaculata, Macrobrachium rosenbergii, and Bithynia sp. confirmed the influence of human activities on the ecosystem.

Keywords: *Water quality; aquatic biota; environment and Barito River.*

I. INTRODUCTION

Indonesia is known as an archipelagic nation with abundant natural resources, particularly in the aquatic sector. With waters covering more than two-thirds of the country's total area, Indonesia boasts the second-highest level of biodiversity in the world after Brazil. Its strategic geographic position between the Indian and Pacific Oceans provides Indonesian waters with dynamic ocean currents and a rich and complex ecosystem. No fewer than 4,000–6,000 fish species live in seas, rivers, and lakes throughout Indonesia (LIPI, 2010). This diversity not only contributes to its ecological identity but also plays a strategic role in supporting the economy, food security, and environmental conservation. Rapid human development without regard for sustainability has placed serious pressure on Indonesia's aquatic ecosystems, both physically, chemically, and biologically. Kalimantan, one of the largest islands in Indonesia, with an area of 736,000 km², boasts a river system that plays a vital role in supporting human life and providing habitat for a variety of aquatic life. Kalimantan's undulating geography and numerous valleys have resulted in an extensive and complex river network. These rivers not only serve as natural transportation routes but also serve as a primary source of economic activities for communities such as fishing, agriculture, and clean water supply (Nurudin et al., 2013). Among the major rivers in Kalimantan, the Barito River is one of the main rivers, playing a vital role in the socio-economic life of the people of Central and South Kalimantan.

This river stretches 900 km, flowing from the Muller Mountains in North Kalimantan to its outlet into the Java Sea via the Banjar Estuary (Rupawan, 2013). The Barito River's geomorphological characteristics include a muddy, sandy bed with a high level of turbidity, especially during the rainy season. The Barito River receives pollution from various human activities, including agriculture, settlements, and especially the mining industry. Coal washing activities along the Barito River Watershed (DAS) are among the activities that have the most significant impact on water quality degradation. Liquid waste from coal washing generally contains suspended solids, organic matter, and heavy metals, which can disrupt the balance of aquatic ecosystems (Nasution et al., 2024). Surface runoff from open areas and settlements carries excess nutrient loads and domestic waste, which worsen the water quality of the Barito River (Ageliani et al., 2019). Ecologically, these environmental pressures directly impact the sustainability of the aquatic biota communities that live within it. Aquatic biota such as nekton (fish), benthos (bottom organisms), and plankton (microscopic organisms in the water column) function as natural bioindicators that reflect the quality of the aquatic environment, as each biota group has different sensitivities to changes in water quality (Raihani et al., 2025).

The selection of the South Barito Regency as a research location was based on the high intensity of mining and residential activities along the Barito River. This region is one of the areas most affected by aquatic environmental degradation, where the river no longer serves only as a natural habitat but also as a dumping ground for domestic and industrial wastewater. The impact of this pollution not only degrades the river's ecological quality but also impacts the social and economic aspects of the surrounding community. Polluted river water has the potential to cause health problems, reduce fish catches, and disrupt agricultural activities that depend on the river's water resources.Mining activities around the Barito River watershed, particularly coal leaching, have the potential to cause significant changes to the physical and chemical parameters of the water, river morphology, and ecosystem structure (Leatemia & Manangkalangi, 2017). A bioindicator-based environmental engineering approach is a strategic method for comprehensively evaluating aquatic ecosystem quality. Environmental studies in the Barito River were conducted by analyzing biological parameters such as the diversity, uniformity, and dominance of nekton, benthos, and plankton communities as indicators of ecosystem condition (Herliwati et al., 2021). Aquatic biota community analysis is considered more accurate than solely measuring physical-chemical parameters because it can illustrate the long-term impacts of pollution.Research shows that mining activities can cause a decrease in dissolved oxygen levels, an increase in heavy metals such as Hg, Pb, Cd, and Zn, and an increase in organic matter due to sedimentation (Sudarmo et al., 2023). This results in a shift in the structure of aquatic biota communities, with sensitive species disappearing and being replaced by pollution-tolerant species such as Oligochaeta and Chironomidae.

Fery et al. (2023) reported that lead (Pb) levels in the Barito River exceeded the Class II river water quality standards based on Government Regulation No. 22 of 2021, with a concentration reaching 0.050 mg/L and an average total suspended solid (TSS) level of 58.00 mg/L. Furthermore, zinc (Zn) levels reached 0.0513 mg/L, along with an average pH of 5.93, which is below the normal range, indicating a decline in aquatic habitat quality.A bioindicator approach based on biological parameter analysis is a crucial step in the conservation and sustainable management of the Barito River (Pratiwi et al., 2020). Aquatic biota community data analyzed using ecological indices such as the Diversity Index (H'), Evenness Index (E), and Family Biotic Index (FBI) provide an empirical picture of pollution levels and their impacts on aquatic ecosystems (Seethong et al., 2023). This research aims to analyze the impact of coal washing activities on water quality and aquatic biota communities in the Barito River, South Barito Regency.

II. METHODS

The research location was determined through purposive sampling in the Barito River in South Barito Regency. Sampling was conducted at three points: the upstream, outfall, and downstream points of the Barito River. The selection of these three points was based on a spatial approach to evaluate longitudinal changes in environmental quality due to activities around the river. The upstream point was chosen to represent the condition of the riverbed before receiving input from coal washing activities. The outfall point was selected near locations strongly suspected of being sources of pollution or experiencing intensive activity, thus reflecting the direct impact on water quality. The downstream point represents the condition of the river after passing through the impacted area, to assess the extent of changes and the potential for self-purification of the river flow.

Table 1. Barito River Water Quality Parameters

No	Parameter	Unit	Method
Physics			
1	Temperature	ºC	SNI 6989.3-2019
2	TSS	mg/l	SNI 6989.3-2019
Chemistry			
3	*DO*	mg/l	IKM-01-LabDLH-TBL
4	pH	pH	SNI 6989.11.2019
5	Fe	mg/l	SNI 6989.11.2019
6	Mn	mg/l	SNI 6989.11.2019
Biology (Biological Diversity)			
7	Nekton	-	Fishing gear includes trammel nets (three-layer nets), gill nets (single-layer nets), nets or luntas, fishing rods, scoop nets, and longlines.
8	Plankton	Sel/m²	Plankton Calculation Using Ln
9	Benthos	Sel/m²	Benthos Calculation Using Logs

Recommended Method Based on Storet and Pollution Index (IP)

The recommended method for assessing water quality in the Barito River is the Storet and Pollution Index (IP) methods. The Storet method is used to determine water quality status by assigning a score based on the number of parameters that do not meet quality standards. The calculated results are then classified into categories of good, moderate, lightly polluted, and heavily polluted, as stipulated in Government Regulation No. 22 of 2021. The Pollution Index (IP) method is recommended because it can indicate the level of pollution relative to permitted water quality parameters. The IP calculation results are then used to categorize water quality into categories of meeting quality standards, lightly polluted, lightly polluted, and heavily polluted. By combining the Storet and IP methods, the research results are more comprehensive because they include both quantitative and qualitative water quality evaluations to assess the impact of coal washing activities on the Barito River aquatic ecosystem.

III. RESULT AND DISCUSSION

Barito River Water Quality Based on Physico-Chemical Parameters

Barito River Water Quality Results

The Barito River water quality analysis results indicate that several physical and chemical parameters exceed established quality standards. The physical parameters, including water temperature, show significant variation, influenced by nearby industrial activity, while high turbidity levels indicate the presence of suspended particles that can disrupt aquatic habitats. The results of the Barito River water quality analysis are presented in the following table:

Table 2. Barito River Water Quality Analysis Results

No	Parameter	Unit	*Upstream*	*Outfall*	*Downstream*	Class II Quality Standard
Physics						
1	Temperatur	ºC	29,8	30,2	29,8	-
2	TSS	mg/l	21	7	28	50
Chemistry						
3	*DO*	mg/l	4	3	5	4
4	pH	pH	6,56	7,87	6,36	6-9
5	Fe	mg/l	0,20	<0,3	0,27	0,3
6	Mn	mg/l	<0,03	<0,3	<0,03	0,1

Analysis of the Barito River water quality at three observation points: upstream, the affected area (Outfall), and downstream, showed variations in several physical and chemical parameters. The Barito River water quality remains relatively good, with most parameters below the Class II quality standard threshold (PP No. 22 of 2021).The Barito River water temperature ranges between 29.8–30.2°C, indicating relatively stable conditions that support tropical biota. This stable temperature is essential for maintaining the metabolism, growth, and physiological activity of aquatic organisms. Temperature increases due to anthropogenic activities can reduce oxygen solubility and accelerate the decomposition of organic matter, potentially reducing dissolved oxygen (Asrini et al., 2017). Ulhaq (2024) in the Sebamban River, where temperature fluctuations due to mining activities also contributed to the decline in dissolved oxygen.Total suspended solids (TSS) levels were recorded at 21 mg/L upstream, dropping to 7 mg/L in the affected area, and then rising to 28 mg/L downstream, still below the 50 mg/L threshold. This fluctuation indicates sediment dynamics resulting from human activities such as agriculture and mining. Increased TSS can reduce water clarity, inhibit light penetration, and disrupt the photosynthesis process of aquatic organisms (Nguyen et al., 2019).DO values ranged from 3–5 mg/L and remained below the minimum quality standard of 6 mg/L, indicating the presence of organic pollution. DO is an important indicator for the survival of aquatic organisms and is strongly influenced by temperature, turbidity, and organic matter content.

The decrease in DO in the affected area indicates possible waste input, while the increase downstream is due to natural reoxygenation processes (Pratama et al., 2016).The pH value in the Barito River ranged from 6.36–7.87, still within the safe range of 6–9. This condition indicates relatively neutral to slightly alkaline waters, which generally support the biological activity of aquatic organisms. The higher pH values in the affected area are thought to be influenced by alkaline waste discharge, while the decrease downstream is due to the accumulation of organic matter (Siburian et al., 2017; Raihani, 2025).Iron (Fe) concentrations ranged from 0.20–0.27 mg/L, still below the threshold of 0.3 mg/L. However, the increase in Fe values downstream indicates potential metal accumulation due to leaching of pyrite minerals from coal. Excessive Fe levels can interfere with fish respiration and reduce light penetration in the water (Saha et al., 2017). Conversely, manganese (Mn) levels, which were below 0.03 mg/L at all points, indicated safe conditions and were well below the 0.1 mg/L standard. Nevertheless, monitoring is still necessary because Mn can increase under anaerobic conditions and is toxic to aquatic organisms (WHO, 2017; Ulhaq, 2024). The water quality parameters of the Barito River still meet class II quality standards, however, indications of decreasing DO levels and increasing metals in the downstream areas require attention to prevent future degradation of the aquatic ecosystem.

Barito River Water Quality Results

The Barito River water quality status shows significant variations in physicochemical parameters, reflecting challenges in water quality management. The combination of water quality factors underscores the importance of implementing more effective pollution control strategies to maintain the Barito River's water quality. The results of the research analysis are presented in the following table:

Table 3. Barito River Water Quality Status

No	Sample	Total Score	Class	Water Quality Status
1	Temperature	0	A	Good
2	TSS	0	A	Good
3	DO	-2	B	Lightly Contaminated
4	pH	0	A	Good
5	Fe	0	A	Good
6	Mn	-8	B	Lightly Contaminated

The results of the calculations in the table regarding the Barito River Water Quality Status show that each parameter has a significant influence on river water quality. The Storet method calculation results for Barito River water quality are as follows:

- Total Score: -10
- Class: B
- Upstream Water Quality Status: Slightly Contaminated

The results of calculations using the Storet method show quite clear variations in the Barito River water quality status across physical and chemical parameters. Temperature, TSS, pH, Fe, and Mn parameters are still within the quality standard range, with relatively low scores. This indicates that, from a physical perspective, such as temperature and turbidity, the Barito River water conditions still support the functioning of the aquatic ecosystem. The measured temperature is stable at around 29–30°C, which is still suitable for tropical aquatic organisms, while the relatively low TSS levels indicate that turbidity levels do not significantly interfere with light penetration into the water. Likewise, the pH, which ranged from 6.36 to 7.87, remained within safe limits for aquatic life. Iron (Fe) and manganese (Mn) concentrations generally approached the quality standard limits, although Mn at one point showed a score of -8. This indicates that although metals were detected in small amounts, their presence does not indicate severe pollution, although it still requires attention due to the accumulative nature of heavy metals.The dissolved oxygen (DO) parameter showed a relatively low value, with a score of -10, categorizing it as class B, indicating light pollution. Low dissolved oxygen levels are crucial to monitor because DO is a key indicator for assessing the health of aquatic ecosystems.

Declining DO levels can be influenced by anthropogenic activities around rivers, such as the discharge of domestic, agricultural, and industrial waste, which can increase the organic matter content. The presence of high amounts of organic matter can stimulate the decomposition process by oxygen-requiring microorganisms, leading to a decrease in dissolved oxygen levels. This condition can ultimately impact the aquatic ecosystem's ability to support fish and other organisms. The Storet method yielded a total score of -10, placing the Barito River's water quality at Class B, with light pollution. This means that although some parameters remain in good condition and meet quality standards, the decline in quality, particularly in dissolved oxygen and Mn, significantly impacts the overall quality status. The Barito River is no longer in optimal condition and could face ecological stress if pollution is not promptly controlled.Stricter water quality management strategies are needed, including controlling pollution sources from both domestic waste and industrial activities around the river basin. Regular monitoring with an integrated approach between the government, the community, and the private sector is key to reducing the pollution load. Rehabilitation efforts for the aquatic environment through riparian vegetation planting, increasing public awareness, and implementing environmentally friendly wastewater treatment technologies are essential to restore the Barito River's water quality to a better level.

Barito River Pollution Index (IP) Results

The Pollution Index (IP) is used to comprehensively assess water quality by comparing the concentration of water quality parameters against applicable quality standards. Pollution levels can be categorized into several classes, ranging from meeting quality standards to light, moderate, and heavy pollution. The application of the IP method to the Barito River aims to provide a comprehensive picture of the water's condition, considering the river's important role as a source of raw water, fisheries, transportation, and economic activity for the surrounding community. The results of the Barito River Pollution Index calculation are presented as follows:

Table 4. Barito River Pollution Index Results

Sample	Class 1		Class 2		Class 3		Class 4	
	Cij/Lij	Cij/Lij baru	Cij/Lij	Cij/Lij baru	Cij/Lij	Cij/Lij baru	Cij/Lij	Cij/Lij baru
Temperature	-	-	-	-	-	-	-	-
TSS	0,47	0,47	0,37	0,37	0,19	0,19	0,05	0,05
DO	0,67	0,67	1,00	1,00	1,33	1,62	4,00	4,01
pH	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33
Fe	0,86	0,86	0,86	0,86	0,86	0,86	0,86	0,86
Mn	1,20	1,40	1,20	1,40	1,20	1,40	1,20	1,20
Cij/Lij is average	0,74		0,74		0,74		1,29	
Cij/Lij Max	1,40		1,40		1,40		4,01	
IP	1,44		1,44		1,44		3,29	
Average IP	1,98 Tercemar ringan / slightly polluted							

The results of the calculations in the table regarding the Barito River Water Pollution Index show that each parameter has a significant impact on river water quality. The results of the Pollution Index calculation method for Barito River water quality are as follows:

- IP Score: 1.98
- IP Water Quality: Slightly polluted

The Pollution Index (IP) calculation for the Barito River shows an average IP value of 1.98, placing the river's water quality in the slightly polluted category. This means that most physical and chemical parameters remain within the quality standard threshold, but several parameters exceed the standard value, contributing to the increase in the IP score. This condition indicates that the river ecosystem is beginning to be stressed by human activities, including domestic waste, mining activities, and agricultural activities along the riverbanks.The greater pollution pressure in certain locations is likely due to the high input of organic and inorganic waste. Based on Regulation of the Minister of Environment and Forestry Number 27 of 2021, increased water pollution can be indicated if the ratio of the test parameter concentration to the quality standard (Ci/Lij) exceeds 1, both for the average (Ci/Lij)R value and the maximum (Ci/Lij)M value. Therefore, points with high IP values require more attention, particularly in terms of controlling pollution sources originating from human activities.An IP value that remains in the lightly polluted category reflects that the Barito River water quality still has sufficient carrying capacity for aquatic organisms.

An increase in the IP score, along with an increase in parameters that do not meet the quality standard, indicates a declining trend in quality. Aulia et al. (2024) found that an increase in the IP score is closely related to the number of metrics that fail to meet the quality standard and high pollutant concentrations, both of which are indicators of deteriorating river water quality. Environmental factors such as relatively low river discharge can also exacerbate pollution, as the dilution rate is reduced and pollutant concentrations accumulate more easily. A (2024) found that rivers with a steady flow throughout the day tend to have better water quality due to the minimal amount of sedimented pollutants. Furthermore, the absence of large industries near the research site also contributes to reducing the amount of hazardous waste, resulting in more light household activities as sources of pollution.The water quality status of the Barito River, based on the Pollution Index method, remains in the lightly polluted category, with an average IP value of 1.98. This situation requires appropriate water quality management strategies, particularly at points with the highest pollution levels. Control of domestic, agricultural, and mining waste is necessary to prevent pollution from escalating to moderate or severe levels. If left unchecked, the decline in water quality could impact the aquatic ecosystem, reduce biodiversity, and diminish the Barito River's role as a source of life for the surrounding community.

Evaluation of the Relationship between Water Quality and Aquatic Biota in the Barito River

Number of Individual Nekton Species and Biodiversity Conservation Status

The conservation status of each fish species, based on the IUCN Red List, Cites Appendices, and Regulation of the Minister of Environment and Forestry No. P.106/MENLHK/SETJEN/KUM.1/12/2018 concerning protected plant and animal species found in the Barito River, is presented as follows:

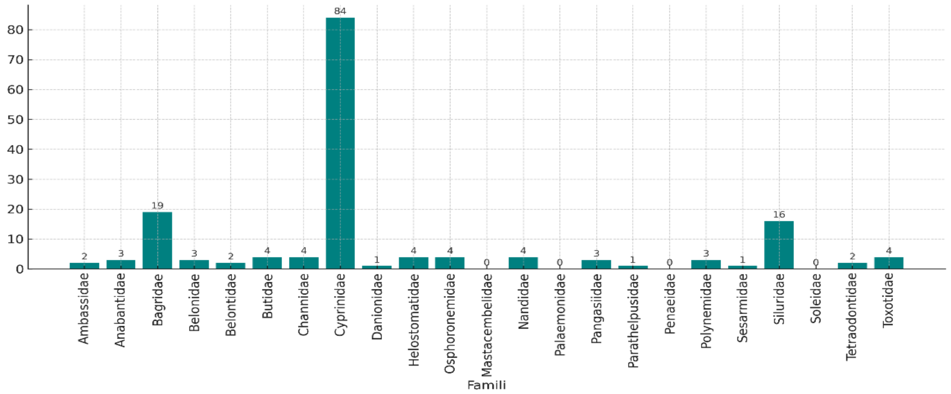
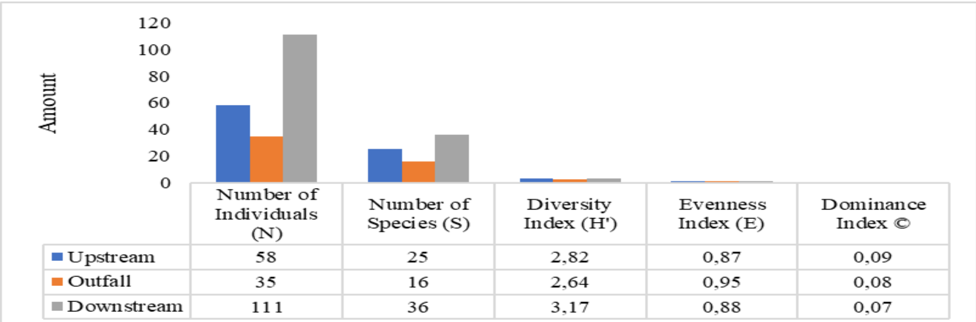


Fig 1. Number of Nekton Individuals in the Barito River



	Number of Individuals (N)	Number of Species (S)	Diversity Index (H')	Evenness Index (E)	Dominance Index ©
Upstream	58	25	2,82	0,87	0,09
Outfall	35	16	2,64	0,95	0,08
Downstream	111	36	3,17	0,88	0,07

Fig 2. Nekton Index of the Barito River

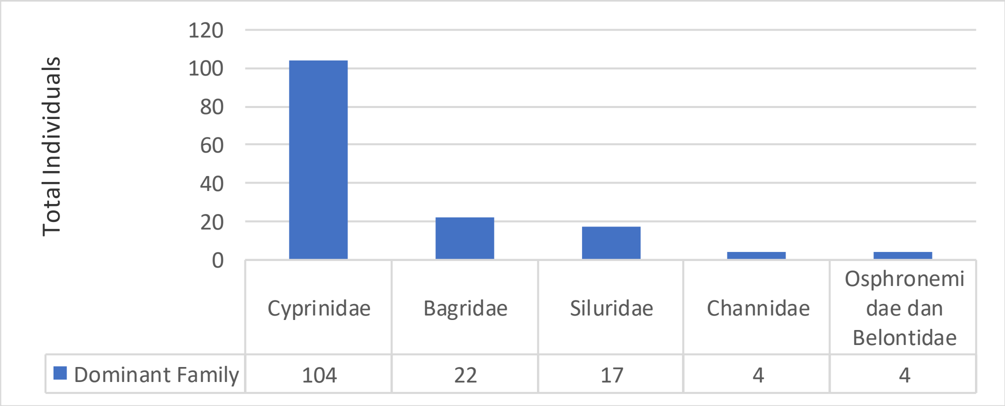


Fig 3. Dominant Families of the Barito River

The number of nekton species and individuals in the Barito River, the total number of individuals found in the three monitoring locations (upstream, outfall, and downstream) reached 204 individuals. When sorted by the number of individuals per family, there are five most dominant families, namely Cyprinidae, Bagridae, Siluridae, Channidae, and Osphronemidae and Belontidae. The Cyprinidae family is the group with the highest number of individuals, namely 104 individuals or more than half of the total, with species such as Rasbora caudimaculata, Puntius bulu, Barbodes schwanenfeldii, Parachela oxygastroides, and Rasbora argyrotaenia. The dominance of this family indicates that small freshwater fish still dominate the waters of the Barito River, indicating environmental conditions that still support omnivorous and herbivorous fish communities as important components in the food chain. Next, the Bagridae family ranks second with 22 individuals, consisting of Mystus nemurus, Mystus singaringan, and Mystus baramensis, which are carnivorous bottom fish and play a role in controlling the population of benthic organisms. The Siluridae family ranks third with a total of 17 individuals consisting of Kryptopterus schilbeides, Belodontichthys dinema, and Kryptopterus parvanalis, indicating the stability of the riverbed habitat is still good. The Channidae family, consisting of Channa striata and Channa lucius, only numbers 4 individuals but has an important ecological role as a mid-level predator that indicates the balance of the trophic chain and the availability of swamp habitat around the river. Meanwhile, the Osphronemidae and Belontidae families also have a total of 4 individuals, consisting of Trichogaster trichopterus, Trichopodus sp., and Belontia hasselti, which have labyrinth organs so they can survive in waters with low oxygen levels.

The presence of these families, which are found in abundance in the outfall and downstream areas, demonstrates their ability to adapt to environmental conditions with fluctuating water quality. The dominance of these five families overall reflects the relatively diverse nekton community structure in the Barito River, and the ecosystem's ability to support various fish groups with distinct ecological roles.The nekton diversity in the Barito River reflects the complex aquatic ecosystem, with a total of 204 individuals from 58 species. Twenty-five species were found in the upstream, 16 in the impacted area, and 36 downstream, indicating distributional variations due to differences in environmental conditions and anthropogenic pressures. The highest number of individuals was found downstream, indicating that the area still supports nekton life despite being affected by human activities. The diversity index (H') values were 2.82 (upstream), 2.64 (impacted), and 3.17 (downstream), respectively—categorized as moderate to high according to the Shannon-Wiener category, indicating the ecosystem still supports a variety of species. These values are higher than those found in the study by Ermawati et al. (2017), which recorded the highest H' of 1.570 and the lowest of 0.908 in the Banua Lawas River, indicating the Barito River's greater ecological carrying capacity. The evenness index (E) was also high, at 0.87–0.95, indicating an even distribution of individuals between species, despite slight dominance by Rasbora caudimaculata. According to Riki et al. (2023), a high evenness index indicates a stable and balanced community. A low dominance index (D) (0.07–0.09) indicates no species significantly dominates, indicating a healthy community.

The Cyprinidae family was the most dominant in terms of species number, followed by Bagridae, Channidae, and Pangasiidae, reflecting the complexity of the ecosystem. Several species, such as Paracrossochilus arceus (VU) and Achiroides leucorchynchos (EN), are categorized as important for conservation by the IUCN, indicating that the Barito River also serves as critical habitat that needs to be protected.Ermawati et al. (2017) showed that the Barito River had a significantly higher number of individuals and families than surrounding small rivers, likely due to greater habitat breadth and environmental variation. Similar results were presented by Raihani (2025) that anthropogenic pressures can affect diversity, although the H' value in the downstream remains the highest. Water quality analysis shows a light-moderate pollution status (IP 1.98–2.90), indicating the influence of chemical pollution such as DO, Fe, and Mn. The presence of food fish such as Channa striata, Oxyeleotris marmorata, and Pangasius polyuranodon indicates high economic potential, but needs to be balanced with conservation efforts to maintain population sustainability. Species with NE and DD status such as Rasbora larestiata and Palaemon elegans emphasize the need for further research. The results of the study indicate that the Barito River has moderate to high diversity, good uniformity, and low dominance. This condition describes a relatively healthy ecosystem, although monitoring of pollution and exploitation is still needed to maintain the ecological carrying capacity of the Barito River sustainably.

Number of Plankton Individual Species

Plankton are important biological components as part of one link in the food chain in aquatic environments, particularly the presence of phytoplankton. Plankton generally float in water and drift with water currents. Plankton are generally very small, but some are large, such as jellyfish, found in marine areas. Plankton can be used as biological indicators in determining water quality because they occupy various trophic levels, including producers, consumers, parasites, saprophytes, transformers, and decomposers (Basmi, 2000). The results of the research analysis are presented as follows:

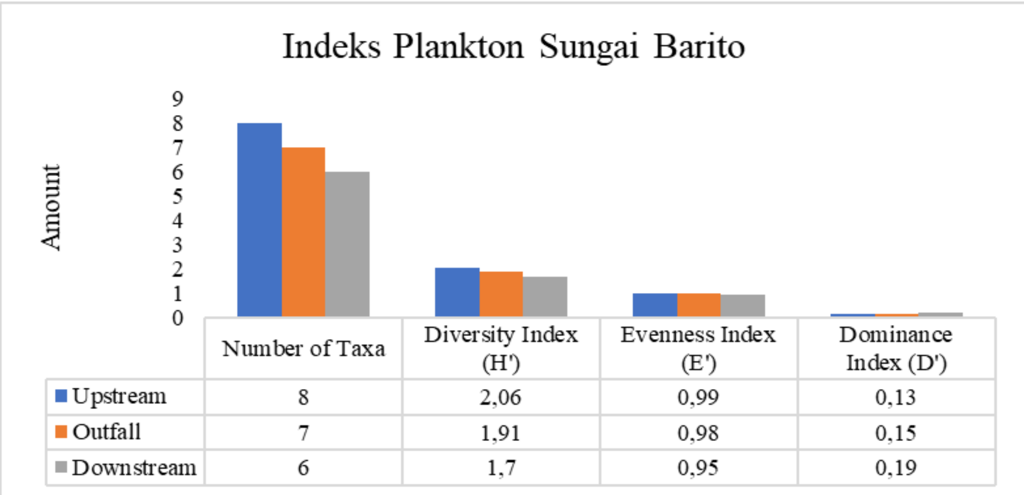


Fig 4. Plankton Index of the Barito River

Observations of the number of plankton species and individuals show variations in distribution across three monitoring locations: upstream, the impacted area (Outfall), and downstream, reflecting differences in physical and chemical conditions and anthropogenic pressures on water quality. In the upstream Barito River, the plankton count reached 1,197 individuals/L, consisting of 8 taxa, with a diversity index (H') of 2.06, an evenness index (E') of 0.99, and a dominance index (D') of 0.13, indicating a stable and evenly distributed community among species. In the impacted area, the plankton count decreased to 882 individuals/L, consisting of 7 taxa, an H' of 1.91, an E' of 0.98, and a D' of 0.15, indicating environmental pressures beginning to impact the plankton community. Downstream, plankton abundance was lower, at 756 individuals/L with 6 taxa, H' 1.70, E' 0.95, and D' 0.19, reflecting a simpler community with a tendency for certain species to become more dominant. This trend aligns with aquatic ecology theory, which states that water quality generally declines from upstream to downstream due to pollutant accumulation (Magurran, 1987; Nurruhwati et al., 2017).Phytoplankton comprise Chlorophyceae (e.g., Cosmarium obsatum, Closterium acerosum, Ulothrix aequalis), Cyanophyceae (Oscillatoria sp.), and Chrysophyceae (Navicula sp., Nitzschia sp., Pinnularia viridis, Surirella robusta, Synedra ulna). Oscillatoria sp. were dominant in the upstream and affected areas, indicating an increased nutrient load, while Nitzschia sp. Abundant, up to 1,449 cells were found throughout the site, indicating that the waters support phytoplankton growth despite environmental pressures.Zooplankton consist of Mastigophora (Trachelomonas sp.), Sarcodina (Arcella vulgaris), Ciliates (Colpoda cucullus), and Rotatoria (Trichocerca birostris), with lower abundances than phytoplankton. The presence of zooplankton follows the availability of phytoplankton, the primary producers. Plankton abundance and diversity decrease from upstream to downstream, influenced by physical and chemical factors such as water clarity, temperature, pH, and dissolved oxygen. This condition emphasizes the importance of water quality management to maintain the balance of aquatic ecosystems and the sustainability of fisheries resources (Magurran, 1987; Nurruhwati et al., 2017).

Number of Benthic Species

Benthos are aquatic organisms that live on the bottom of still or flowing waters. They can move freely or attached. The existence of benthos must be maintained to maintain the balance of the aquatic ecosystem. This is because benthos play several roles. They contribute to the nutrient cycle in waters, specifically in the decomposition of organic material through their feeding activities. They also play a role in absorbing pollutants in the waters. Benthos are consumers in the aquatic ecosystem food chain, and their survival is determined by their tolerance to environmental conditions and the availability of food. The results of the benthos analysis of the Barito River are presented as follows:

Fig 5. Benthos Index of the Barito River

Observations of benthos in the Barito River revealed only two gastropod taxa, namely Bithynia sp. and Pleurocera acuta, while Brotia sp. was absent from all locations (upstream, affected area, and downstream). The highest number of individuals was recorded in the affected area (104 individuals/m²), while only 39 individuals/m² were recorded in the upstream and downstream, reflecting variations in environmental quality that influence the distribution and abundance of benthos. The diversity index (H') was low, 0.64–0.69, with a high evenness (E') of 0.92–1.00, indicating that despite the limited number of species, the distribution of individuals among species was relatively even. A dominance index (D') of 0.50–0.56 indicates dominance by certain species (Bithynia sp. and Pleurocera acuta) but not extreme (Ojan, 2010).

The absence of Brotia sp. and the dominance of tolerant species indicates environmental stress, including heavy metal pollution and accumulation of organic matter due to human activities such as coal mining (Winarno et al., 2000). Physical and chemical factors of water, including sedimentation, pH, dissolved oxygen, and availability of bottom substrate, also influence the abundance of Benthos (Hilmi et al., 2015; Gitarama et al., 2016). A value of H' < 1 indicates a stressed ecosystem, while high dominance indicates that only tolerant species survive, in accordance with the concept of Benthos as a bioindicator of pollution (Shannon–Wiener; Rizka et al., 2016). Rizka et al., (2016), the Benthos community in the Barito River is still poor with low diversity, high dominance, and a limited number of taxa, confirming that stressed water quality impacts the structure of the Benthos community and the stability of the aquatic ecosystem (Winarno et al., 2000; Gitarama et al., 2016).

IV. CONCLUSION

The water quality of the Barito River is classified as mild to moderately polluted. Most physicochemical parameters are still within quality standards, except for low DO and Mn at several points exceeding the threshold. The Storet results show a score of -10 (class B, mild pollution), while the Pollution Index (IP) is 1.98 (mild pollution). Coal leaching activities affect the distribution of aquatic biota. The diversity index (H') of nekton is moderately high (2.64–3.17), plankton is moderate (1.70–2.06), and benthos is low (0.64–0.69). High evenness and low dominance values indicate a relatively stable community, despite anthropogenic pressures. The presence of bioindicators such as Rasbora caudimaculata, Macrobrachium rosenbergii, and Bithynia sp. confirms the influence of human activities on the ecosystem.

REFERENCES

[1] Ageliani, K., Yunita, R., & Yasmi, Z. (2019). Fish species diversity in the Barito River, Aluh-Aluh District, Banjar Regency, South Kalimantan Province. Aquatic. 2(2), 1–79.

[2] Asrini, N. K., Adnyana I. W. S., & Rai, I. N. (2017). Water Quality Analysis Study in the Pakerisan River Watershed, Bali Province. ***Ecotrophic Journal***, 11(2), 101–107.

[3] Aulia, N. S., Irsan, R., & Saziati, O. (2024). Study of Water Quality Index (IKA) Determination Using the Pollution Index (IP) Method in the Tempayan River, Kubu Raya Regency. ***Journal of Wetland Environmental Technology,*** 12(4), 996–1004.

[4] Basmi, J. 2000. Planktonology: Plankton as Bioindicators of Water Quality. Faculty of Fisheries and Marine Sciences, Bogor Agricultural University. Bogor.

[5] Ermawati, Rizmi Yunita, & Mijani Rahman. (2017). Fish Diversity in the Batang Banyu River, Banua Lawas District, Tabalong Regency, South Kalimantan Province. Aqutika, 2(1): 73-88

[6] Fery, A. N., Susanto, A., & Sulistyowati, L. (2023). Analysis of Barito River water quality and the impact of small-scale gold mining on agriculture in South Barito Regency. ***Jurnal Daun***, 10(1), 24–39.

[7] Gitarama, A.M., K. Majariana, R. Dewi, A. Priyono. 2016. Macrobenthic communities and chromium accumulation in the Cimanuk Lama River, West Java.***Indonesian Journal of Agricultural Sciences***,21(1),48-55.

[8] Herliwati, Mijani R, A. Rahman. 2021. "Analysis of Pollution Index and Pollution Load Carrying Capacity of the Jaing River, Tabalong Regency, South Kalimantan Province." Fish Scientiae, 11(1), 70-82.

[9] Hilmi, E., A.S. Siregar, L. Febryanni, R. Novaliani, S.A. Amir, A.D. Syakti. 2015. Community structure, zonation, and biodiversity of mangrove vegetation in Segara Anakan, Cilacap. OmniAkuatika, 11(2): 20–32.

[10] IUCN Red List. https://www.iucnRedlist.org/

[11] Leatemia, S. P. O., & Manangkalangi, E. (2017). Benthic macroinvertebrates as bioindicators of water quality in the Nimbai River, Manokwari, West Papua. ***Indonesian Journal of Agricultural Sciences (JIPI),*** 22(1), 25–33.

[12] LIPI. 2010. Fish in Indonesia. Online at http://www.biologi.lipi.go.id/bio_english.

[13] Magurran AE. (1987). Ecological Diversity and Its Measurement. New Jersey: Princeton University Press.

[14] Nasution N.A.S., C. Rizka, Imaniah B.W., and Risma Nurlim. 2024. "River Conservation Efforts and Benefits of the Panyabungan Barat Community, North Sumatra, Based on the Local Wisdom of Lubuk Larangan." Symbiotic: ***Journal of Biological Education and Science***. 5(1), 15–33

[15] Nguyen, H. T., Vo, Q. H.,&Bui, T.M. (2023). Integrated river basin management in Southeast Asia: Community-based approaches and ecological perspectives.***Journal of Environmental Management***,336, 117643.

[16] Nurruhwati, Isni; Zahidah; Sahidin, A. (2017). Plankton Abundance at Cirata Reservoir, West Java Province. Plankton Abundance at Cirata Reservoir, West Java Province. Introduction: A reservoir is a lake or body of water. Research Methods: This research was conducted in the reservoir area. 2(2), 102–108.

[17] Nurudin, F. A., Martuti, N. K. T., & Irsadi, A., 2013. Fish Species Diversity in the Sekonyer River, Tanjung Puting National Park, Central Kalimantan. ***Unnes Journal of Life Science***. 2 (2)

[18] Ojan, 2010. Utilization and Potential of Macrozoobenthos. https://ojanmaul.wordpress.com/category/biologi-laut/,

[19] Pratama, D. R., M. Yusuf, and M. Helmi, 2016. Study of the condition and distribution of water quality in the southern waters of Sampang Regency, East Java Province. ***Journal of Oceanography***. 5 (4), 479-488.

[20] Pratiwi, A., Fachrul, M. F., & Hendrawan, D. I. (2020). The macrozoobenthos as a bioindicator of water quality of the Kali Baru Barat River. ***International Journal of Scientific & Technology Research***, 9 (1), 3511–3515.

[21] Raihani, N., Herliwati, H., Fitria, A., & Hadi, A. (2025). Identification of Plankton in the Tabalong Kiwa River, Tabalong Regency, South Kalimantan, Indonesia. ***International Journal of Research and Review***, 12(2), 413–419.

[22] Riki,Utama,KP.,Purnama,M.F.,& Fekri,L.(2023).Abundance and Diversity of Fish in the Konaweha River Estuary,Konawe Regency,Southeast Sulawesi Province.***Journal of Aquatic Resources Management***,8:63–75.

[23] Rizka, S., Z.A. Muchlisin, Q. Akyun, N. Fadli, I. Dewiyanti, A. Halim. 2016. Macrobenthic Communities in the Tripa Peat Swamp Estuary, Aceh Province. ***Scientific Journal of Marine and Fisheries Students, Unsyiah***, 1(1), 134–145.

[24] Rosalia A. 2017. Determination of Water Quality Status of the Kalimas River Using the STORET Method and Pollution Index. Thesis. Sepuluh November Institute of Technology.

[25] Rupawan. 2013. Utilization of Fish Resources in the Barito River Estuary, South Kalimantan. Research Seminar Paper. Research Center for Fisheries and Fish Resources Conservation. Jakarta.

[26] Saha, N., Rahman, M. S., Ahmed, M. K., & Maruo, M. (2017). Characterization of surface water quality by principal component analysis and regression models for the Ganges River, Bangladesh. Environmental Earth Sciences, 76(19), 663.

[27] Seethong, K., Chunkao, K., Dampin, N., & Wararam, W. (2023). Using Benthos as a bioindicator to assess the efficiency of constructed wetland community wastewater treatment systems. ***Global Journal of Environmental Science and Management***, 9(SI), 47–60.

[28] Siburian, R., L. Simatupang, and M. Bukit. 2017. Analysis of marine water quality in relation to activities in the Waingapu-Alor Port area, East Sumba. ***Journal of Community Service***. 23 (1), 225-232.

[29] Sudarmo, A. P., Ali, M., Anggraeni, D. P., Dwirastina, M., Ditya, Y. C., Makri, S. M., Kaban, S., & Samuel. (2023). Assessing benthic communities and water quality as bioindicators of the environment in Semayang Lake, East Kalimantan, Indonesia. ***Polish Journal of Environmental Studies***, 32 (5), 4281–4290.

[30] Ulhaq, A. (2024). Analysis of water quality and water quality status, as well as directions for river mitigation policies in the Sebamban River, Tanah Bumbu Regency. Thesis, Master's Program in Natural Resources and Environmental Management, Postgraduate Program, Lambung Mangkurat University, Banjarbaru.

[31] Winarno, K., P.A. Okid, A.D. Setyawan. 2000. Monitoring the water quality of Jabung Swamp based on the diversity and richness of benthic communities. Biosmart, 2(1), 40-46.