

# Riverine macroinvertebrates and physico-chemical characteristics: An indicator of water quality of Balogo River

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## ***Abstract***

The study assessed the ecological condition of the Mainit section of Balogo River in Pasacao, Camarines Sur using riverine macroinvertebrates and physicochemical characteristics as indicators of water quality. The research employed a quantitative descriptive design and utilized the Rapid Bioassessment Protocols for wadable rivers and streams. Macroinvertebrate samples were collected from three sampling stations representing upstream, midstream, and downstream sections of the river. Physical parameters such as water depth, temperature, turbidity, odor, color, and stream flow were measured in situ, while chemical parameters including pH, dissolved oxygen (DO), total suspended solids (TSS), nitrate, and phosphate were analyzed using standard laboratory procedures. A total of 10 macroinvertebrate species belonging to three phyla (Mollusca, Arthropoda, and Annelida) were identified, with 568 individuals recorded. The most abundant species were freshwater snails and river crabs, while sensitive taxa such as Ephemeroptera, Plecoptera, and Trichoptera were minimally represented. Diversity indices indicated low Shannon–Wiener diversity, suggesting uneven species distribution and dominance of pollution-tolerant species. However, Simpson’s Diversity Index showed relatively high diversity, indicating the presence of several species within the river ecosystem. Physicochemical analysis revealed that the water quality parameters generally fall within the Class C water classification under the DENR Administrative Order No. 2016-08, indicating suitability for agricultural irrigation, livestock watering, and certain industrial uses. Observed anthropogenic activities such as agricultural runoff, domestic waste disposal, and recreational

use were identified as possible factors affecting the river's ecological condition. The findings provide baseline ecological information on the macroinvertebrate community and water quality of the Mainit Balogo River. These results highlight the importance of biological monitoring and support the development of conservation and management strategies to protect the river ecosystem.

**Keywords:** riverine macroinvertebrates, water quality, Balogo River, macroinvertebrates biodiversity, species inventory

## **Riverine macroinvertebrates and physico-chemical characteristics: An indicator of water quality of Balogo River**

### **1. Introduction**

Aquatic macroinvertebrates are small animals without a skeleton that live in the water for at least part of their life cycle. Macro invertebrates are found in rivers, estuaries, and wetlands. There are thousands of aquatic macroinvertebrate species, and they are a key food source for platypus, fish, and frogs. There are several species of macroinvertebrates unique to our region, such as the Dandenong amphipod, that are particularly important to the community (Melbourne Water, 2018). Diversity in macroinvertebrate species enhances ecosystem resilience and function, including resistance to disturbances, biomass production, and decomposition processes. Functional and phylogenetic diversity among macroinvertebrates improves niche complementarity and ecosystem specialization, contributing to the overall health and stability of freshwater systems (Cai et al., 2023).

Aquatic macroinvertebrates are widely recognized as reliable bioindicators of water quality because of their sensitivity to environmental changes and varying tolerance levels to pollution. They respond to habitat alterations, nutrient enrichment, and other disturbances, making their community structure an effective measure of ecological health. In the Philippines, studies have also demonstrated the importance of macroinvertebrate assemblages in assessing freshwater ecosystems, such as in Lake Mainit, where diversity and distribution patterns were found to reflect water quality variations across sampling stations (Paylangco et al., 2020). Macroinvertebrate communities are influenced by multiple factors such as aquatic habitat structure, channel morphology, substrate type, and aquatic vegetation. Their species diversity, dominant taxa, and relative abundance are key indicators of habitat quality and water condition (Xiaohong Hu et al., 2022). As such, they are widely used in bio-assessment protocols to evaluate freshwater ecosystem health (Zhang et al., 2023). However, anthropogenic pressures, including industrial discharges, urbanization, and agricultural runoff, have severely impacted macroinvertebrate diversity and community structure on both global and local scales (Thakur et al., 2023). These disturbances lead to habitat degradation, shifts in species composition, and reduced ecosystem resilience.

**Objective of the Study** - Generally, the study aimed to assess the health of the Mainit, Balogo river using Macroinvertebrates as indicator species. Specifically, the objectives of the study were:

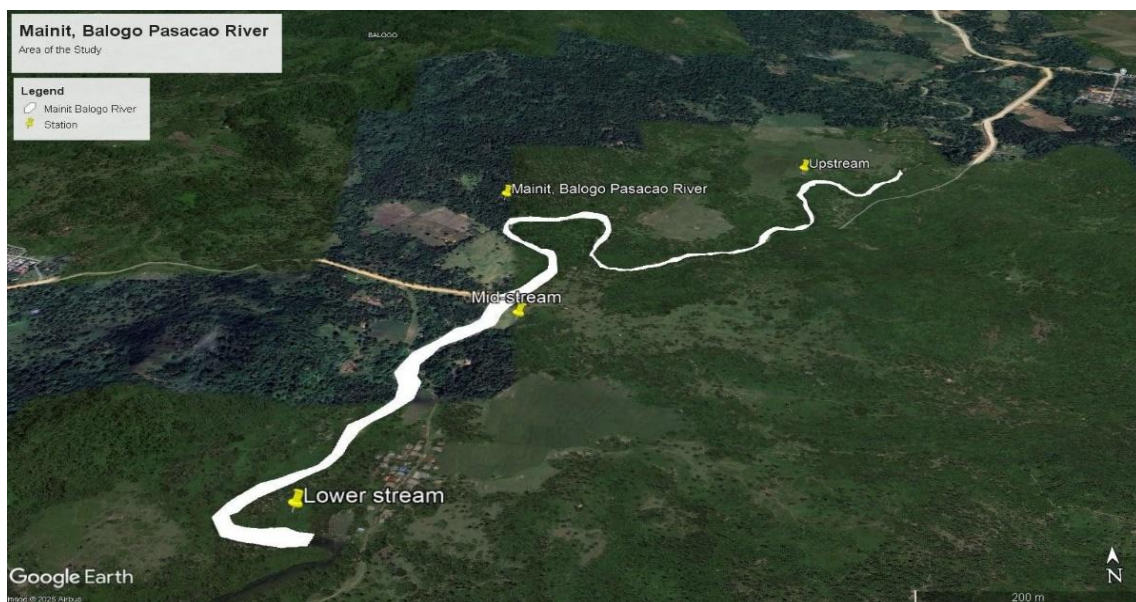
- To determine the macroinvertebrates species found in the Mainit, Balogo River?
- To determine the level of diversity of macroinvertebrates in the Mainit–Balogo River in terms of relative abundance, population density, relative population density, frequency, relative frequency, dominance, relative dominance, taxonomic diversity, field biotic index, and diversity index.
- To identify the physicochemical parameters of the Mainit–Balogo River in Pasacao, Camarines Sur, in terms of physical parameters (water depth, temperature, turbidity, odor, color, and stream flow) and chemical parameters (hydrogen-ion concentration (pH), dissolved oxygen (DO), total suspended solids (TSS), nitrate, and phosphate).
- To determine the anthropogenic activities observed in the Mainit, Balogo River, Pasacao, Camarines Sur?
- To propose effective strategies may be suggested to improve river management and conservation efforts?

### **2. Methodology**

A detailed research approach was used to conduct the study and fulfill its objectives, which is discussed in this

section.

**Area of the Study** - The study was conducted in the municipality of Pasacao (*figure 1*), a coastal municipality located approximately 26 kilometers south of Naga City. Geographically, Pasacao is situated at coordinates 13°30'52" north latitude and 123°2'36" east longitude. According to Client challenge, (2017). The municipality of Pasacao has a total land area of 13,420.18 hectares (134.20 square kilometers) and is politically subdivided into 19 barangays. One of these barangays is Barangay Balogo, which has a total land area of 1,137.2 hectares (11,372 square meters). Barangay Balogo shares common boundaries with Calascagas, Bical, and Maragñi in the municipality of San Fernando, as well as Odicon and San Cirilo (Poblacion) within the municipality of Pasacao, (BALOGO I Municipal Govenment of Pasacao, Camarines Sur, 2022). Specifically, the study was conducted in Mainit River, located in Barangay Balogo. The barangay is considered one of the contributors to the tourism industry of Pasacao, which is known as the summer capital of Camarines Sur (Ocampo, 2017). Geographically, Barangay Balogo lies at approximately 13.5048° latitude and 123.0789° longitude on the island of Luzon. The area has an estimated elevation of 13.8 meters (45.3 feet) above mean sea level, based on records from the Municipal Government of Pasacao (2022). The Mainit River in Barangay Balogo served as the primary research site for the collection and identification of macroinvertebrate species in this study.



**Figure 1.** Area of the Study

**Sampling Stations** - Macro-invertebrates were collected from three different stations (*Figure 2*) along the Mainit, Balogo River in Pasacao, Camarines Sur. Each station covered a 100-meter stretch of the river. The upstream station, situated near the river's source at coordinates 13.50234° N and 123.07744° E (Google Earth, 2025), is located in a predominantly rocky area with minimal human activity. The water in this area is clear and cold, indicating a clean and natural environment. The riverbank is lush with vegetation, featuring a variety of plant species growing densely along the edges. The midstream station is found in the middle part of the river at coordinates 13.50096° N and 123.07605° E (Google Earth, 2025). In this area, the water is calm and flows smoothly, and there are fewer rocks on the riverbed. There are some plants around, like grass and small bushes growing near the riverbanks. The water is a bit warmer than in the upstream area, and small fish can sometimes be seen. This part of the river is accessible, and the adjacent community utilizes the river for everyday living. The downstream station is located near the side road of Balogo at coordinates 13.49996° N and 123.07527° E (Google Earth, 2025). The river in the area flows gently and is wider than in the upstream and midstream sections. The riverbanks are more open and easier to reach, with clear paths and spaces where people often gather. The downstream poses and is used as recreation for some locals and visitors; due to this, trash is noticeable in this area. These three stations were chosen to study and compare the types and number of macro-invertebrates found in different stations of the

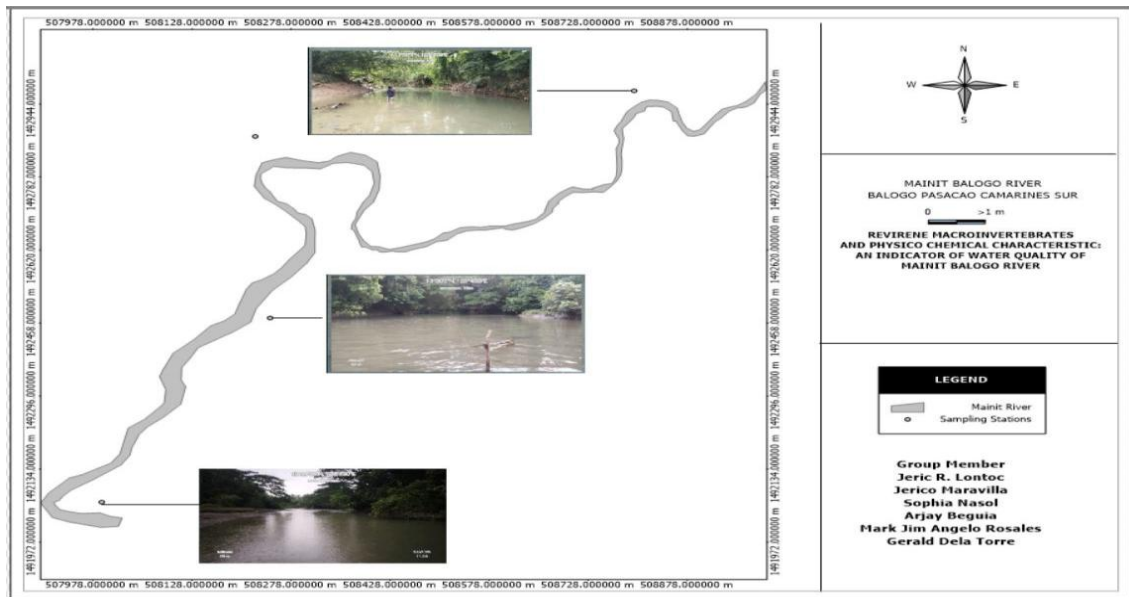


Figure 2. Sampling Station

**Data Collection and Identification** - An ocular inspection was conducted prior to the commencement of the study. The study was carried out during the month of October. A 100 m transect line was placed along the river, and macroinvertebrates were identified by disturbing the riverbed within the sampling area.

#### Physical Parameters

- **Water Depth.** Depth is the perpendicular measurement downward from the surface water of the river. The depth of water was measured using a meter stick through composite sampling in each sampling station. Average depth represented by centimeters (cm).
- **Temperature.** Temperature is the measurement of the intensity of heat. The water temperature was measured using a DO meter, where the tip of the DO meter dipped into the water column. This can be obtained through composite sampling at each sampling station. The procedure can be done during low tide. The average temperature expressed in degrees Centigrade (C°).
- **Turbidity.** Turbidity is a measure of how clear or cloudy water is. This can be measured using a secchi disk.
- **Odor.** It is a physical characteristic of river water that helps identify if the water is clean or affected by waste and pollution.
- **Color.** It can indicate the presence of organic matter or potentially harmful substances.
- **Stream Flow.** Streamflow refers to the volume of water moving through a specific point in a stream or river over a period of time. It is commonly expressed as discharge, typically measured in cubic feet per second (cfs) or cubic meters per second (cms).

#### Chemical Parameters

- **Hydrogen-ion concentration (pH).** PH is one of the primary indicators used in evaluating water quality and the sustainability of the surface water for diverse utilization. determined using a pH meter. The tip of the pH meter will dip in the water column. This can be obtained through composite sampling in each sampling station.

- **Dissolved Oxygen (DO).** Dissolved Oxygen is the amount of oxygen that is present in the water and is one of the most important indicators of water quality. It measured by the DO meter and can be done during the measurements of the temperature of the water.
- **Salinity (S).** Salinity refers to the number of dissolved salts in water. It is measured using a refractometer.
- **Total Suspended Solids (TSS).** TSS are particles that are larger than two microns found in the water column. Most suspended solids are made up of inorganic materials whose concentration is contributed to by bacteria and algae. This was determined using the Gravimetric method.
- **Phosphates.** Phosphate was analyzed through a laboratory method following the Standard Methods for the Examination of Water and Wastewater (Federation & American Public Health Association, 2005).
- **Nitrates.** analyzed through laboratory method following the Standard Methods for the Examination of Water and Wastewater (Federation & American Public Health Association, 2005).

***Anthropogenic Threats in Mainit, Balogo River in Pasacao, Camarines Sur: Identification of Threats -***

Anthropogenic activities in the study area were identified primarily through direct visual observation. The researcher assessed human activities along the river using visual observations to document practices and conditions that may influence the river's water quality and ecological state.

### **3. Results and Discussions**

This part of the study presents and interprets the collected data on the river's physical and chemical parameters, as well as the diversity of macroinvertebrates found in the study area. The results are compared with relevant standards and environmental guidelines to understand the overall health and condition of the Mainit, Balogo River.

***Identified Macroinvertebrate Species*** - Table 1 presents the identified macroinvertebrates in Mainit, Balogo, River Pasacao, Camarines Sur, comprising ten (10) species of macroinvertebrates that shows in (figure 3) and 568 individuals. These species belonged to three phyla: Mollusca, Annelida, and Arthropoda. In the Phylum Mollusca, two classes were identified: Gastropoda and Bivalvia. Under the class Gastropoda, three families were identified, namely Pachychilidae (*Jagora asperata*) with 152 individuals found in Station 1, 12 in Station 2, and 0 in Station 3, with a total of 180 individuals.

The *Jagora asperata* observed in the study area showed coloration ranging from light brown to dark brown and greenish-brown. The shell had 4–7 whorls, with an average shell width of 11 mm and shell length of 17.45 mm. Variation in shell color among freshwater snails is common and is influenced by environmental conditions such as substrate type, water chemistry, and food availability (Strong et al., 2018). The number of shell whorls also increases as the snail grows, making it a useful characteristic in identifying gastropod species and determining their developmental stage (Ruppert et al., 2019). Family Lynmaeidae (*Lymnaea stagnalis*) with 5 individuals found in Station 1, 15 in Station 2, and 0 in Station 3, with a total of 20 individuals. The *Lymnaea stagnalis* showed shell coloration of light brown, yellowish-brown, and amber. It had 3–5 shell whorls, with a shell width of 13 mm and shell length of 17.4 mm. Pond snails typically display lighter shell colors which help them blend with sediments and aquatic vegetation in freshwater habitats (Dillon, 2019). The shell whorls and elongated shell shape are also common morphological features that assist in their movement and survival in slow-moving waters (Strong et al., 2018).

Family Ampullaridae (*Pomacea canaliculate*), with 0 individuals both in Station 1, 2, and 158 individuals were found in Station 3. The *Pomacea canaliculate* had shell coloration ranging from dark brown to light brown. It had 5–6 shell whorls, with a shell width of 30 mm and shell length of 35 mm, indicating a larger body size compared to other snails in the study. This species is known for its large and rounded shell structure, which allows protection and supports rapid growth in freshwater ecosystems (Suartini et al., 2021). The golden apple snail (*Pomacea canaliculata*) is also known for its high adaptability and reproductive capacity, which allows it to thrive in many aquatic habitats (Hollis, 2022). Under the class

Bivalvia, which belonged to the family Veneridae (*Ruditapes philippinarium*) of 13 individuals were found in station 1, 32 in station 2, and 0 in station 3, a total of 45 individuals respectively.

In the phylum Arthropoda, two classes were identified: Malacostraca and Insecta. Under the class Malacostraca, there were three families identified, namely, Family Sergestidae (*Acetes spp.*), with 0 individuals in Station 1, 7 in Station 2, and 7 in Station 3, with a total of 14 individuals in the respectively. Under the family Portunidae (*Scylla spp.*), only 1 was found in Station 2, and 0 in Stations 1 and 3. The *Scylla spp.* observed in the study had dark green and dark brown coloration, with a carapace width of 111.4 mm and length of 8.4 mm. The dark coloration helps mud crabs blend with muddy substrates where they usually live (Lee et al., 2020). Mud crabs are commonly found in estuarine and freshwater environments where they burrow into soft sediments and feed on small invertebrates and organic matter. Family Grapsidae (*Varuna litterata*) of 22 individuals were found in Station 1, 51 in Station 2, and 42 in Station 3 a total of 115 individuals respectively. The river crab had dark brown, dark green, and blackish coloration. It measured 40.2 mm in width and 30.1 mm in length. Freshwater crabs generally exhibit darker coloration which helps them camouflage among rocks and sediments in river habitats (Cumberlidge et al., 2019). Their strong carapace and claws allow them to survive in flowing water and defend against predators.

Under the class Insecta, there were two families identified, namely Gerridae and Veliidae sp. Under the class Gerridae (*Gerris lacustris*), with only 1 found both in station 1 and station 2, and 0 in station 3, a total of 2 individuals were found in the study area. In the phylum Annelida, only one class was identified; class Oligochaeta was represented, which belonged to the family Naididae, a group of small, primarily freshwater worms. both Station 1 and Station 2, recorded zero in Naididae, in Station 3, only 2 individuals observed. The *Hediste diversicolor* displayed greenish, reddish, and gray coloration with a body length of 143 mm. *Hediste diversicolor* belong to segmented worms that are commonly found in aquatic sediments. Their body coloration and elongated segmented body help them move through sediments and feed on organic material (Hutchings et al., 2019). Ragworms are important components of aquatic food webs because they contribute to nutrient cycling and sediment aeration.

**Table 1**  
*Identified Macroinvertebrates Species in Mainit, Balogo River, last October 2025*

Phylum	CLASS	FAMILY	SCIENTIFIC NAME	COMMON NAME	Morphological Description			
					Coloration	No. of shell whorls	Shell width (mm)	Shell length(mm)
Mollusca	Gastropoda	Pachychilidae	<i>Jagora asperata</i>	Fresh Snail	Light brown Dark brown greenish brown	4 - 7	11 mm	17.45 mm
		Lymnaeidae	<i>Lymnaea stagnalis</i>	Pond Snail	Light brown Yellowish-brown Amber	3 – 5	13 mm	17.4 mm
		Ampullaridae	<i>Pomacea canaliculata</i>	Golden apple snail	Dark brown Light brown	5 – 6	30 mm	35 mm
	Bivalvia	Veneridae	<i>Ruditapes philippinarum</i>	Clam	Light brown Dark brown Blackish brown	6 – 12	23.1 mm	36.1 mm
Arthropoda	Malacostraca	Sergestidae	<i>Acetes spp.</i>	Paste shrimp	Transparent Grayish	n/a	4 mm	7.4 mm
		Portunidae	<i>Scylla spp.</i>	Mangrove crab	Dark green Dark brown	n/a	111.4 mm	8.4 mm
		Grapsidae	<i>Varuna litterata</i>	River crab	Dark brown Dark green blackish	n/a	40.2 mm	30.1 mm
	Insecta	Gerridae	<i>Gerris lacustris</i>	Water strider	Black Dark brown	n/a	n/a	13.5 mm
		Veliidae	<i>Veliidae spp.</i>	Broad-shouldered WaterStriders	Black Grayish	n/a	4 mm	13 mm
Annelida	Oligochaeta	Nereididae	<i>Hediste diversicolor</i>	Ragworm	Greenish Reddish Gray	n/a	n/a	143 mm



**Figure 1.** Image of the ten (10) macroinvertebrates found within the three stations in Mainit, Balogo River, (a) *Jagora asperata*, (b) *Lymnaea stagnalis*, (c) *Pomacea canaliculate*, (d) *Ruditapes philippinarium*, (e) *Acetes* spp, (f) *Scylla* spp, (g) *Varuna litterata*, (h) *Gerris lacustris*, (i) *Veliidae* (j) *Hediste Diversicolor*.

**Level of Diversity of Macroinvertebrates in Balogo River** - The macroinvertebrate community in the Mainit–Balogo River is composed of several species with varying levels of abundance, density, frequency, and dominance. Overall, the data indicate that a few species contribute a large proportion of the total population, while others are present in relatively low numbers. This suggests an uneven distribution within the community, where certain organisms are more adapted to the existing environmental conditions. The computed values for relative abundance, population density, and dominance reveal that the community structure is influenced by species that occur more frequently and in higher quantities. Meanwhile, the presence of less abundant species still contributes to the overall biodiversity of the river. In general, the table reflects a moderately diverse macroinvertebrate community, with

both dominant and rare species playing important roles in indicating the ecological condition of the river ecosystem.

**Simpson's Diversity Index** - The data showed that Simpson's Diversity Index of macroinvertebrate species recorded in Mainit, Balogo River was 0.79. It can be noted that the Mainit Balogo River has high diversity, which implies that the river system was composed of a variety of macroinvertebrate assemblages. The high diversity of macroinvertebrates in Mainit Balogo River can be attributed to: First, the good water quality with adequate dissolved oxygen allows both sensitive and tolerant macroinvertebrates to thrive, which conforms with the physicochemical results gathered during the conduct of the study, where the dissolve oxygen (DO) in the river ranges from 7.3 to 7.4 mg/L (According to Dalu et al. (2021), higher dissolved oxygen and cleaner water conditions promote the presence of diverse macroinvertebrate groups. Second, the variety of substrates, such as rocks, sand, and organic matter, provides suitable habitats and feeding areas for many taxa. Marziali et al. (2020) stated that habitat diversity and substrate variation strongly influences the richness and abundance of benthic organisms in river ecosystems.

**Shannon Weiner Diversity Index** - Table 2 shows that the Shannon-Weiner Diversity Index of macroinvertebrate species in Mainit, Balogo River was 1.77. It can be observed that the overall Shannon-Weiner Diversity obtained was a low value, which implied that the Mainit Balogo River has low diversity of macroinvertebrates. The low Shannon–Wiener Diversity Index ( $H' = 1.77$ ) indicates that the river has limited species diversity, suggesting environmental disturbance and the dominance of a few tolerant species. This low diversity may be attributed to organic pollution and agricultural runoff, which reduce water quality and suitable habitats for sensitive taxa. According to Dalu et al. (2021), pollution and nutrient enrichment can lower macroinvertebrate diversity in tropical rivers. Mwedzi et al. (2020) also reported that land use and habitat modification negatively affect aquatic communities. Furthermore, Keke et al. (2021) emphasized that human activities such as farming and waste disposal near riverbanks contribute to ecological imbalance and low species diversity.

**Table 2**  
*Macroinvertebrates Diversity in Mainit, Balogo Pasacao*

SCIENTIFIC NAME	COMMON NAME	NO. OF INDIVIDUALS (n)	SIMPSONS		SHANNON-WEINER		
			n-1	n(n-1)	Pi	Ln (Pi)	Pix Ln (Pi)
<i>Jagora asperata</i>	Fresh Snail	164	163	26,732	0.29	-1.24	-0.36
<i>Lymnaea stagnalis</i>	Pond Snail	20	19	380	0.04	-3.22	-0.13
<i>Pomacea canaliculate</i>	Golden Apple Snail	158	157	24,806	0.28	-1.27	-0.36
<i>Jagora asperata</i>	Mud Snail	16	15	240	0.03	-3.51	-0.12
<i>Ruditapes philippinarum</i>	Clam	45	44	1,980	0.08	-2.53	-0.20
<i>Acetes spp.</i>	Paste Shrimp	14	13	182	0.02	-3.91	-0.08
<i>Portunus pelagicus</i>	Mud Crab	1	0	0	0.001	-6.91	-0.007
<i>Varuna litterata</i>	River Crab	115	114	13,110	0.20	-1.61	-0.32
<i>Gerris lacustris</i>	Pond Sketers	2	1	2	0.003	-5.81	-0.02
<i>Veliidae</i>	Water Striders	31	30	930	0.05	-2.99	-0.15
<i>Hediste diversicolor</i>	Ragworm	2	1	2	0.003	-5.81	-0.02
TOTAL		568	557	68,364			
				D= 0.79		H= 1.77	
				HIGH DIVERSITY		LOW DIVERSITY	

**Taxonomic Diversity of Macroinvertebrates in Mainit, Balogo River** - The taxonomic diversity of macroinvertebrates collected from Mainit, Balogo River. Taxonomic diversity refers to the variety of organisms in an ecosystem based on their classification at different taxonomic levels such as kingdom, phylum, class, order, family, and genus. Studying taxonomic diversity helps researchers understand the biological composition of a habitat and the ecological relationships among organisms. A higher taxonomic diversity usually indicates a healthier ecosystem because it shows that many different groups of organisms are present. In this study, ten (10) macroinvertebrate species were identified and classified under three major phyla: Mollusca, Arthropoda, and Annelida. These organisms play important roles in the aquatic ecosystem as food sources, decomposers, and indicators of environmental conditions.

**Field Biotic Index** - The Field Biotic Index values of macroinvertebrates obtained from Mainit, Balogo River

were 7.07, which revealed that the water quality of Mainit, Balogo River was fairly poor and somewhat polluted. This value suggests that the river supports a community dominated by tolerant macroinvertebrate species, which are capable of surviving in environments with moderate to high organic pollution and low dissolved oxygen levels (Hilsenhoff, 1999; Dalu et al., 2021). The fairly poor water quality indicated by the FBI value of 7.07 may be attributed to various anthropogenic activities occurring near the river. Local farmers Those who apply fertilizers to their rice fields contribute to agricultural runoff, increasing nutrient levels and promoting organic pollution. This nutrient enrichment can lead to algal growth and low oxygen levels that affect aquatic organisms (Dalu et al., 2021). Some fishermen engage in chemical fishing practices, releasing harmful substances that degrade water quality and reduce macroinvertebrate diversity (Marziali et al., 2020).

**Physicochemical Parameters of Mainit, Balogo River** - Physical and chemical characteristics of the river were shown in Table 3, such as odor, color, water depth, stream flow, water temperature, salinity, hydrogen concentration ion (pH), dissolved oxygen, total suspended solids, nitrate, and phosphate.

#### *Physical Parameters*

- **Odor.** Based on the results, stations 1 and 3 appear odorless, while station 2 showed a fairly muddy smell. This can be noted that more organic particles are present in the river. A fairly muddy smell in river water is often a symptom of increased organic particles and microbial activity, which result from decomposing organic matter in the water body (Wnorowski, 2019).
- **The upstream.** which appeared dark green, is likely due to higher algal presence and greater organic matter from nearby vegetation (Li et al., 2020). In contrast, the midstream displayed a lighter green color, possibly because of the faster flow that station 2 has, 98.6 stream flow, reducing algal concentration and suspended particles (Uehlinger et al., 2018). Meanwhile, the downstream showed clear or colorless water, likely caused by stronger dilution and sediment deposition, which decreases pigments and suspended matter (Dodds & Whiles, 2020).
- **Water Depth.** Based on the results, the highest depth in the Mainit, Baologo River was recorded in Station 1 at 150.2 cm deep, followed by Station 3 of 36.3 cm, and the lowest depth was in Station 2 of 31.3 cm. Generally, all sampling stations have shallow water, which can be attributed to riverbed structure, where certain portions form deeper pools while others stay shallow due to sediment accumulation. Increased sedimentation from surface runoff and agricultural soil erosion can also reduce water depth (Zhang et al., 2021).
- **Stream Flow.** The data revealed that stream flow in the Mainit, Balogo Rivers varied across stations. Station 1 recorded the lowest discharge (0.98 m<sup>3</sup>/s), indicating slower water movement. Slow flow often allows sediments and organic particles to settle, which may reduce oxygen levels and create calmer habitats (Zhang et al., 2021). Station 2 showed moderate flow (1.53 m<sup>3</sup>/s), suggesting a balanced condition where water movement supports stable habitat and better oxygen distribution. Moderate stream flow can support a wider range of aquatic organisms because it reduces sediment buildup while still maintaining suitable substrate conditions (Li et al., 2022).

Meanwhile, Station 3 exhibited the highest discharge (2.40 m<sup>3</sup>/s). Faster stream flow is commonly associated with steeper gradients or narrower channels that accelerate water velocity. High flow increases oxygen availability and can transport finer sediments downstream (Gao et al., 2020; Chen et al., 2023). These conditions may favor species adapted to fast-moving water.

- **Water Temperature.** The results showed that the highest temperature was noted in station 3 of 26.13°C, followed by station 2 of 25.67°C, and the lowest water temperature was observed in station 1 of 25.4°C. This can be attributed to shading, water depth, and water flow. Shaded or faster-flowing areas, like Station 1, usually remain slightly cooler because reduced sunlight and stronger water movement limit

heat absorption, whereas Station 3 may be warmer due to greater sun exposure or slower flow that allows more heat uptake (Lencioni, 2021).

The results showed that water temperature in Balogo River ranged from 25.40 °C at Station 1, 25.67 °C at Station 2, and 26.13 °C at Station 3. These values indicate only slight variation among stations. According to DAO 2016-08, temperature in surface waters must not increase by more than 3 °C above the natural background level. Since the observed differences are less than 1 °C, all stations comply with the temperature guideline (DENR, 2016). These temperature levels also fall within the tolerance range of tropical freshwater macroinvertebrates, which generally thrive between 20–30 °C. Therefore, the recorded temperature conditions remain suitable for supporting macroinvertebrate communities within the river.

- **Turbidity.** The data revealed that turbidity levels varied across the three stations of the Balogo River. Station 1 recorded the highest turbidity at 0.84 m. This can be attributed to greater suspended particles present in the water. High turbidity in this area may be due to soil erosion, agricultural runoff, and disturbance of the riverbed, which introduce sediments and organic matter into the water column. Increased turbidity can reduce light penetration and affect aquatic organisms that rely on visual feeding or photosynthesis (Zhang et al., 2020). Station 3 showed moderate turbidity at 0.49 m, suggesting a lower presence of suspended materials compared to Station 1. Meanwhile, Station 2 had the lowest turbidity at 0.33 m, indicating clearer water conditions. Lower turbidity may be related to reduced disturbance, lesser runoff input, or better bank stability that prevents soil from entering the river (Huang et al., 2021).

**Table 3**  
*Physico-chemical characteristics of Mainit, Balogo River, October, 2025*

PARAMETERS	STATION 1	STATION 2	STATION 3	Water Quality Standard DAO 2016-08	REMARKS
<b>Physical Parameters</b>					
Odor	Odorless	Fairly muddy	Odorless	n/a	n/a
Color	Dark green	Light green	Colorless	≤ 75 TCU	n/a
Water Depth (cm)	150.2	31.3	36.3	n/a	n/a
Stream flow (m <sup>3</sup> /s)	0.98	1.53	2.41	n/a	n/a
Temperature (°C)	25.4	25.67	26.13	25 - 31 °C	PASSED
Turbidity (m)	0.84	0.33	0.49	n/a	n/a
<b>Chemical Parameters</b>					
Hydrogen Ion Concentration (Ph)	7.79	8.02	7.91	6.5 - 9.0	PASSED
Dissolve Oxygen (mg/L)	7.3	7.4	7.4	≥ 5 mg/L	PASSED
Salinity (ppt)	0	0	0	0–0.5 ppt	PASSED
Total Suspended Solid (mg/L)	9.3	9.3	11.0	≤ 80 mg/L	PASSED
Nitrate (ppm)	34.65	35.70	32.55	≤ 7 ppm	FAILED
Phosphate (ppm)	4.03	3.43	3.43	≤ 0.5 ppm	FAILED

*Chemical Parameters*

- **Hydrogen Ion Concentration (Ph).** The data revealed that the pH levels in the Balogo River ranged from 7.79 to 8.02, showing slightly alkaline conditions across all sampling stations. Among the three stations, Station 2 recorded the highest pH value (8.02), followed by Station 3 (7.91), while Station 1 obtained the lowest (7.79). Although differences were observed, the values remained relatively close to each other, suggesting stable river ph. Slightly alkaline conditions are common in river ecosystems and may be influenced by several factors such as the buffering capacity of the water, surrounding geological formations, and photosynthetic activity of aquatic plants and algae, which reduce carbon dioxide and increase alkalinity (Boyd, 2020). The slightly higher pH in Station 2 may be associated with increased algal photosynthesis or lower organic decomposition.

All pH values recorded fall within the preferred tolerance range of most freshwater macroinvertebrates, typically 6.5–8.5. This range supports important biological processes, including proper respiration, feeding, and reproduction (Merritt et al., 2019). Thus, the river’s pH levels provide suitable conditions for the survival of

macroinvertebrate communities. Under DAO 2016-08, Class C waters intended for propagation of aquatic resources should maintain a pH between 6.5–8.5. The results from all stations conform to the requirements of the DAO2016-08 standard, indicating that pH in the Balogo River meets regulatory guidelines and is not likely a limiting factor for aquatic organisms, including macroinvertebrates.

- **Dissolved Oxygen (DO).** The data revealed that the dissolved oxygen (DO) levels in the Balogo River ranged from 7.3 to 7.4 mg/L. Stations 2 and 3 recorded the highest concentrations (7.4 mg/L), while Station 1 had 7.3 mg/L, showing only slight variation among sites. These findings suggest that oxygen availability is consistent throughout the river.

Higher DO levels in Stations 2 and 3 can be attributed to improved aeration through faster water flow, which increases atmospheric oxygen mixing into the water (Li et al., 2021). The Balogo River provides favorable oxygen levels for macroinvertebrate communities. DAO 2016-08 states that Class C waters must maintain DO at  $\geq 5$  mg/L. All stations exceed this guideline, indicating that DO levels meet national water-quality standards and are suitable for aquatic life, including macroinvertebrates.

- **Salinity.** The data show that the salinity level in all stations of the Balogo River was 0 ppt, indicating a purely freshwater system. This condition is expected because the river is located inland, with no seawater intrusion, and is continuously supplied by rainfall and upstream freshwater flow that keeps salt concentration low. Similar findings were noted in Philippine rivers where salinity remained near zero due to consistent freshwater input (Paller et al., 2022). According to DAO 2016-08, no specific salinity limit is provided for Class C freshwater systems, and therefore, the recorded value aligns with the expected natural freshwater condition of a Class C River.
- **Total Suspended Solids.** The data revealed that Stations 1 and 2 have the same amount of total suspended solids of 9.3 mg/L, which is higher than the amount of total suspended solids in Station 3 of 11.0. The highest TSS concentration in station 3 can be attributed to increased surface runoff. Meanwhile, the lower TSS in Stations 1 and 2 may be influenced by upstream vegetative cover that reduces soil erosion and sediment influx (Jacinto et al., 2020). These TSS levels are relatively low and remain suitable for freshwater macroinvertebrates, as moderate levels do not significantly obstruct respiration or feeding. According to DAO 2016-08, Class C waters should not exceed 100 mg/L TSS; therefore, the values recorded (9.3–11.0 mg/L) comply with national water quality standards.
- **Nitrate.** The data revealed that the highest amount of nitrate was observed in Station 2 of 35.70 ppm, followed by Station 1 of 34.65 ppm, and the lowest was noted in Station 3 of 32.55 ppm. The highest amount of nitrate can be attributed to agricultural runoff. Fertilizers used in nearby farms dissolve in rainwater and are carried into the river, increasing nitrate levels. This is a common cause of nitrate enrichment in Philippine rivers. Another possible factor is domestic wastewater discharge, where household waste and detergents enter the water system, contributing additional nitrate load (Saludes et al., 2020).
- **Phosphate.** The data revealed that the highest amount of phosphate concentrations was in Station 1 at 4.03 ppm, and the lowest in Stations 2 and 3 at 3.43 ppm. The higher level of phosphate in station 1 can be attributed to agricultural runoff and domestic wastewater, which often carry elevated phosphate loads from fertilizers and detergents (Hallberg, Djodjic and Bieroza, 2024). These variations in phosphate levels can influence macroinvertebrate communities; According to the DAO 2016-08 of the Department of Environment and Natural Resources (DENR), these concentrations fall within the Class C water quality standards suitable for agriculture, irrigation, livestock watering, and certain industrial uses but their nutrient enrichment potential warrants ongoing ecological monitoring.

Generally, the results of the physicochemical parameters measured in the Mainit Balogo River indicate that, the results are favorable for Macroinvertebrates in the river, according to the water quality standards set by DAO

2016-08, the river falls under Class C classification. This suggests that the river is suitable for agriculture, irrigation, livestock watering, and certain industrial uses, while also highlighting the need for monitoring to maintain ecological balance.

***Anthropogenic Threat in Mainit, Balogo River*** - The researchers observed several human activities around Mainit, Balogo River that may affect the river's water quality and overall ecological condition. During the fieldwork, agricultural practices were noted near the riverbanks, along with local fishing activities and small bridges where people frequently pass and may dispose of waste. These observations indicate the presence of anthropogenic pressures that can influence the health of the river ecosystem. The researchers observed that agricultural activity near Mainit, Balogo River may significantly impact water quality. According to the study of Araza, Perez, & Cruz, (2021), state that land use conversion and farming near waterways contribute to elevated nutrient loading and sediment runoff. Additionally, Fertilizer and pesticide runoff from fields can enter the river, increase nutrient levels and Another threat observed by the researchers is solid waste and littering by passers, especially in areas with small bridges crossing the river. In the Philippine rivers reported high plastic and macro-litter accumulation along riverbanks, largely from improper waste disposal by nearby communities and by-passers (Frontiers in Environmental Science, 2024). Such waste can degrade habitat quality, increase turbidity, and negatively affect macroinvertebrates. The researchers also observed local fishing activities in the area, which raise concerns about possible unregulated practices. Although studies that directly document chemical fishing in the Philippines are limited, broader research indicates that many rivers in the country experience different human pressures that degrade water quality and reduce biodiversity (Ramirez, Pulhin, & Garcia, 2019).

***Effective Strategies for the Conservation and Management of the Mainit River*** - The data shows that the river is influenced by human activities such as agricultural runoff, soil erosion, and possible domestic waste discharge. To address these issues, several effective strategies for river management and conservation are recommended.

#### *Effective Strategies*

As part of the study's effort to promote environmental awareness and research dissemination, an infographic was developed and distributed to the community on April 9, 2026. This material served as a communication tool to present key findings and encourage public participation in protecting the Mainit-Balogo River. The infographic focused on macroinvertebrates as indicators of water quality and emphasized the importance of maintaining a clean and healthy river ecosystem. It was designed to present scientific information in a simple, clear, and visually engaging way that can be easily understood by the public. The material first introduced macroinvertebrates and explained that these organisms, such as insects, worms, and snails, live in water and can be used to determine whether the river is clean or polluted. It highlighted their role as bioindicators because they are sensitive to environmental changes. This helps the community understand how these organisms reflect the overall condition of the river.

The infographic also presented common issues affecting the river, including improper waste disposal, water pollution, and the decline of sensitive aquatic species. These problems were clearly identified to raise awareness about the current environmental condition of the river and the effects of human activities on water quality and biodiversity. In addition, the infographic emphasized the importance of a clean river by explaining its benefits. These include providing safe water for daily use, supporting aquatic life, protecting human health, and maintaining a safe and sustainable community. This helps connect environmental protection to the daily lives of local residents. Moreover, the material provided simple and practical strategies that individuals and the community can follow to help protect the river. These include proper waste disposal, participation in clean-up drives, tree planting to reduce erosion, waste segregation, and active involvement in environmental programs. These actions encourage community participation and promote shared responsibility in conserving the river. The infographic also included a call to action, encouraging the community to take part in protecting the river for future generations. Overall, the use of this infographic proved to be an effective way to share information, increase awareness, and encourage

community involvement in river conservation.

These conservation efforts align with national laws that aim to protect water bodies and biodiversity. The Philippine Clean Water Act of 2004 (Republic Act 9275) mandates the protection and restoration of water quality through pollution control and sustainable watershed management. The Philippine Fisheries Code (RA 8550, as amended by RA 10654) also emphasizes protecting aquatic habitats to support biodiversity, including macroinvertebrates that rely on clean and stable water conditions. Furthermore, the Enhanced National Greening Program (E.O. 193, s. 2015) supports reforestation and riverbank vegetation, which help improve water quality. Strengthening the implementation of these laws, combined with community involvement and environmental education, will support long-term river conservation and protect the ecological health of macroinvertebrates and other aquatic organisms. Generally, these approaches align with the Sustainable Development Goals, particularly SDG 6 (Clean Water and Sanitation), SDG 14 (Life Below Water), and SDG 15 (Life on Land), which emphasize the protection and sustainable use of freshwater and terrestrial ecosystems. Strengthening these efforts, together with community involvement, will support long-term conservation of Balogo River and maintain healthy conditions for macroinvertebrates.

#### 4. Conclusion

Based on the findings of the study, it can be concluded that the Mainit section of Balogo River in Pasacao, Camarines Sur still supports a variety of macroinvertebrate species, indicating that the river maintains a certain level of biological diversity. However, the dominance of pollution-tolerant species and the low Shannon–Wiener Diversity Index suggest that some parts of the river may already be experiencing environmental stress. The physicochemical parameters measured during the study generally fall within the acceptable limits for Class C water bodies under DENR Administrative Order No. 2016-08, indicating that the river remains suitable for agricultural irrigation, livestock watering, and other related uses. Despite this, the presence of anthropogenic activities such as agricultural runoff, domestic waste disposal, and recreational use along the riverbanks may contribute to changes in water quality and macroinvertebrate diversity. The results of the study further demonstrate that macroinvertebrates are effective biological indicators in assessing the ecological health and water quality of freshwater ecosystems. Therefore, continuous monitoring and proper management strategies are essential to preserve and improve the ecological condition of the Mainit section of Balogo River.

**Recommendations** - Based on the findings and conclusions, the researcher recommends the following:

- Establish riparian buffer zones with vegetation to reduce soil erosion and filter runoff before it reaches the river.
- Investigate River History to understand long-term environmental changes.
- Conduct Heavy Metal Analysis in macroinvertebrates to detect possible contamination.
- Assess Riparian Vegetation to evaluate its role in bank stability and water quality protection.
- Promote sustainable agricultural practices, such as controlled fertilizer application and proper pesticide management, to minimize nutrient pollution.
- Encourage collaboration among the community, schools, and government agencies to support the conservation and preservation of the current ecological health of the Mainit, Balogo River.

**Implications for Learners** - The findings of this study emphasize the importance of helping learners understand environmental concepts through real-life and locally relevant contexts. By learning about macroinvertebrates found in the Mainit–Balogo River, learners can better appreciate how these organisms serve as natural indicators of water quality. The use of simplified and visually engaging materials, such as infographics, supports clearer understanding of scientific ideas and promotes interest in environmental issues. This approach

may also enhance learners' observational and analytical skills while encouraging them to become more responsible and active participants in protecting local ecosystems.

**Implications for Teachers and Academe** - The findings of this study suggest that both teachers and academic institutions play an important role in improving environmental education. Teachers can make lessons more effective by using local examples, such as macroinvertebrates found in the Mainit–Balogo River, to help students better understand water quality and environmental issues. The use of simple and visual materials like infographics can also make complex ideas easier to learn and increase student interest. At the same time, the academe can support this by improving the curriculum to include more local and real-life environmental topics. Schools and universities are also encouraged to promote research and share results with the community through easy-to-understand materials. In addition, academic institutions can strengthen community programs that involve students and teachers in environmental activities, helping connect learning with real-world actions and promoting environmental awareness.

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