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Water quality assessment of Surigao River, Surigao city, Philippines

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Abstract
The importance of knowing the water quality status with the use of macroinvertebrates diversity gives an establishment to proper practices to prevent pollution in Surigao River, Surigao City, Philippines. Riparian, Channel, and Environmental Inventory were used in describing the vegetation of the three-sampling stations. The occurrence of macroinvertebrates was supported by selected physicochemical parameters, WQI, and ASPT. RCE scores for the three sampling stations were good, very good, and fair. physicochemical parameters were within standard limits of DAO 2016-08 except for pH and temperature for station 1. WQI results, stations 1 and 2 were "rather dirty-water average," while station 3 was "dirty" Stations 1 and 2 were rated as "moderate," while station 3 had a rate of "very poor in ASPT. There were 13 aquatic macroinvertebrates collected from the 12 families, including Annelida (9%), Arthropoda (30%), and Mollusca (61%). There was an absence of EPT and station 2 was the most diverse. Constant monitoring, particularly for the improvement of riparian zones, heavy-metal tests, and microbiological parameters, should be conducted to relieve and manage the existing problems of water quality status.

Keywords: Macroinvertebrates, riparian, ASPT, WQI, physicochemical, river

Introduction
Knowing the status of the water and the riverbanks will aid in the establishment of proper practices to avoid pollution and maintain the river's stability. It is everyone's duty to provide safeguard and preserve the fresh, brackish, and marine quality of water. Section 2 of Republic Act 9275, also known as the Philippine Clean Water Act of 2004, aims to actively promote education and awareness and informed and active public participation in water quality monitoring and management. In accordance with their best uses, the quality of Philippine waters must be maintained in a safe and satisfactory condition [1]. Freshwater ecosystem research and conservation receive significantly less attention than terrestrial [2] and marine habitats. It is important to perform a water quality analysis at a specific site since it will be utilized to keep track of how the freshwater has been doing. 180 of the 421 rivers and other bodies of water in the nation are now so filthy that they may soon be deemed biologically dead, according to research by the Department of Environment and Natural Resources [3]. Most responsible waste for the freshwater area was found to be domestic sewage, followed by commercial and industrial wastes. Understanding the freshwater ecology is important not only for its biological reasons but also because it needs careful regulation and preservation of natural resources such as freshwater as it is essential for any living organism, including humans. Numerous environmental factors that affect species diversity and the physiological capabilities of individual organisms have an impact on the evolution of aquatic life, which would be the flora and fauna in surface waters [4].

Macroinvertebrate presence would be a widely used bioindicator for determining the quality of water [5]. Aquatic macroinvertebrates are living things that live in water and lack an internal skeleton. They can be seen by the naked eye and therefore do not require the use of a microscope [6]. Macroinvertebrate taxa can be used as environmental indicators and other organisms in freshwater systems [7]. Every aquatic macroinvertebrate does indeed have a different level of pollution tolerance, while others are extremely sensitive to changes and can only survive in rivers with low pollution, cool temperatures, and high oxygen levels. Some aquatic macroinvertebrates can survive in contaminated waters despite the fact that they cannot

avoid pollution because they have the capacity to integrate the effects of the stressors they are exposed to over time, both individually and in groups [8]. A macroinvertebrate's chemical and physical components were typically in good form as well when in good physical and chemical health.

To evaluate the state of the water, physicochemical indicators for freshwater were also used. In order to establish whether or not water is contaminated, it must be required to study the physicochemical and biological components of water quality [9]. This includes the pH, conductivity, total dissolved solids, temperature, dissolved oxygen, salinity, transparency, chemical oxygen demand, nitrate, and phosphate. Changes in these physical and chemical properties would provide essential information about the river's water quality [10].

In determining water quality, physicochemical parameters collaborate with biological indicators. The Riparian, Channel, and Environmental Inventory, which consists of sixteen characteristics that will define the structure of the riparian zone, stream channel morphology, and the biological condition in both habitats, would be used to further evaluate the physical and biological condition of small streams within a particular landscape [11]. It would act as a checklist for gathering the needed data by evaluating the physical and ecological characteristics of tiny streams in lowland settings. It also confirms that all approaches will be used to assess a stream's water quality if the information gathered matches that from the Taxa Grouping, Water Quality Index, Average Score Per Taxon, and Physicochemical Parameters.

The city's largest river is the Surigao River and all major tributaries from creeks, irrigation drains, and urban drainage flows into one main canal. It is situated in Surigao City, Surigao del Norte Province, Caraga Region, Philippines, with a terrain height above sea level of around 4 meters. It is classified by the Environmental Management Bureau-CARAGA Region (XIII), Surigao River is classified as Class A [12]. As determined during the census last 2020, there are 171,107 people and a land area of 173.91 square kilometers. The upstream of the river is located at Barangay Bonifacio with a total population of 3,822 people. For the midstream, it is situated at Barangay Luna which has 13,233 people living in the area. The downstream site is at Barangay Sabang with 6,114 residents [13]. As observed from the collected data, Barangay Luna is the most populated barangay among the rest of the situated barangay which are Barangay Bonifacio and Barangay Sabang.

This study provides the first thorough evaluation of the macroinvertebrate populations in the Surigao River, and the information gathered may serve as a template for subsequent monitoring. The Surigao River in Surigao City, the Philippines, has been evaluated for its physicochemical water quality, macroinvertebrate diversity, water quality index, and average per taxon. The physical and biological conditions of several water bodies were compared using the numerical scores derived from the data collected in evaluating the riparian and channel assessment.

Materials and Methods

Description of the study site

The research was carried out on the Surigao River, which has a length of 36.022238 km and is located in Surigao City, Philippines. The sampling station was divided into three (3) stations; Station 1 which is the upstream is located at Brgy. Bonifacio (125.49588, 9.73632), Station 2 is for the midstream located at Barangay Luna (125.47871, 9.77646), and Station 3 is for the downstream located at Bgry. Sabang (125.47090, 9.78824). The upstream situation near the mountain is exposed at the national highway, and there are residents found living nearby and close making the river exposed to some household wastes. The riverbank and riparian vegetation are present in the area. The midstream part of the river was also exposed to the inhabitants living nearby making it not difficult to be affected by the anthropogenic activities, the domestic airport can be found close to the river, near the Kinabutan Bridge, and also not far from the national highway. Riparian vegetation was also present in this area, but there is a wall on the other side of the river. Despite the fact that this area has a large population, houses are not located near the river. Downstream, it has inhabitants also living close to the river making it exposed to anthropogenic activities, it has anahaw on each side, with its minimal riparian vegetation, and the Sabang bridge situates on it. It has many garbage and some feces floating on it. The stream is constantly polluted as a result of domestic waste disposal and farming activities. These activities endanger the health of the aquatic environment, which includes all aquatic life, animals, plants, and local residents. Each stream consists of a 100-m sampling. The study area's map, specifically its upstream, midstream, and downstream sections, as well as the accompanying sampling sites, were shown in Figure 1.

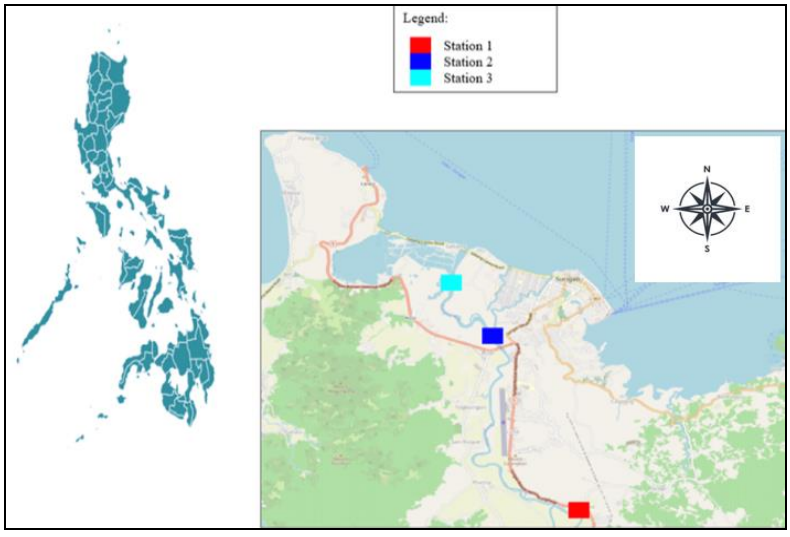

Fig 1: Map of Surigao River showing Station 1, Station 2, and Station 3

Sampling Dates and its Weather

The river was sampled for Riparian Channel and Environmental Inventory (RCE), Physicochemical Parameters, Water Quality Index, and Average Score Per Taxon (ASPT) last May 7 and May 15, 2022.

On May 7, 2022, the weather was partly clear with light rain. The weather was partly cloudy with brief rain last May 15, 2022 [26].

River Habitat in Usage Sampling

The sampling of macroinvertebrates is commonly done in two types of river natural habitats which are the riffles and edges. The riffle habitat was characterized by broken water with rapid current and the presence of cobbles or boulders. If the broken water habitats in a river lack cobbles and boulders, thus collecting a macroinvertebrate sample may be inappropriate. For the edge habitat, it is a section of the riverbank side where there is little or no water flow. Backwaters have leaf litter, fine organic/silt deposits, macrophyte beds, overhanging banks, and areas with extending bank vegetation, all of which indicate good places to sample at the river's edge. Surface-dwelling insects are common in these [25].

Riparian Channel and Environmental (RCE) Inventory of Surigao River

The Riparian, Channel, and Environmental (RCE) Inventory, which consists of sixteen characteristics that always define the structure of the riparian zone, stream channel morphology, and the biological condition in both habitats of each sampling station, was used to further evaluate the physical and biological condition of small streams within a specific landscape [11]. Waterways have been altered to varying degrees by human activity. There might have been a few riparian areas that were unaltered and unchanged. It would be advantageous to have a method or survey that enables researchers to compare the degree of riparian disturbance in various locations. In order to assess the 16 RCE parameter qualities, the evaluator will stroll along the 100-meter stream length that contains the three freshwater biological stations. The evaluator carefully observed the chosen 100 meters of stream channel and riparian area, focusing on the most noticeable features of the first attribute by completing the Riparian Observations data sheet while out in the field conducting the RCE. Table 1 will be used as a reference to determine the class rating and the suggested course of action [14].

Table 1: Scoring References for RCE

Class Score	Score	Evaluation	Recommended Action
1	293-360	Excellent	Biomonitoring and protection of the existing status
2	224-292	Very Good	Selected alterations and monitoring for changes
3	154- 223	Good	Minor alterations needed
4	86-153	Fair	Major alterations needed
5	16-85	Poor	Complete structural reorganization

Water Quality Assessment

A 100-m transect line was used for data collection. For the purpose of determining some physicochemical parameters, the Surigao River's three sampling stations-Station 1 upstream, Station 2 midstream, and Station 3 downstream-were each created (Table 2). Dissolved oxygen, pH, temperature, total dissolved solids, and conductivity were the chosen physicochemical parameters, and they were measured on-site using a physicochemical kit. To get high-quality findings by resolving its average mean, it was measured three times.

Table 2: List of Physico-chemical parameters with their corresponding unit of measurement, method of analysis, sample volume needed, and device used

Parameters	Unit	Method of Analysis	Sample Volume	Device Used
Conductivity	µS	Direct Method	Determined on site	Lutron - PH/ORP, DO, CD/TDS Meter, Temperature Bench type - Model No-WA-2015
pH	Range 0-14	Direct Method	Determined on site	Lutron - PH/ORP, DO, CD/TDS Meter, Temperature Bench type - Model No-WA-2015
Temperature	ºC	Direct Method	Determined on site	Lutron - PH/ORP, DO, CD/TDS Meter, Temperature Bench type - Model No-WA-2015
Dissolved Solids (TDS)	Ppm	Direct Method	Determined on site	Lutron - PH/ORP, DO, CD/TDS Meter, Temperature Bench type - Model No-WA-2015
Dissolved Oxygen (DO)	mg/L	Direct Method	Determined on site	Lutron - PH/ORP, DO, CD/TDS Meter, Temperature Bench type - Model No-WA-2015

Establishing Sampling Procedures

SWAMP's Reach-wide benthos (Multihabitat) procedure were used. The data was gathered in a 100-m transect line at each sampling point. With the use of 500 µ D-nets that are 0.3 m wide (-1.0 ft. frame width), it was employed and submerged for 3 to 5 minutes, which were the recommended time for collecting macroinvertebrates.

Over the length, twenty (20) punches or kicks were delivered (100 meters). Each jab's collected samples were placed in a vial or container, preserved in 90% ethanol, and labeled with the appropriate sample identifying information [15].

Identification and Documentation of the Species Collected from the River

The samples were carefully washed with running water using the 500µ-mesh filter by the researchers after the macroinvertebrate collection to get rid of any sediments that had adhered to the samples. To prevent the loss of any collected material and to make it easier to recover spilled organisms, the researchers reversed the contents of the D-frame net and performed this technique on a big tray. After carefully checking for clinging creatures, if it is possible, remove the larger twigs and rocks by hand. Use forceps to

remove any organisms that are still attached to the net, then put them in the sample jar. In accordance with protocol, samples were collected, sorted, counted, and taxonomically identified. Macroinvertebrate species were identified using credible and trusted online resources, journal publications, and field guides [23]. The stream name, sampling site, and taxonomic group codes were written on the sample jars or vials [16].

Taxa Groupings of the Macroinvertebrates Collected from the River

Depending on how sensitive or tolerable they were to pollution or other aquatic disturbances in the stream, the macroinvertebrates were divided into three taxa: Taxa 1, Taxa 2, and Taxa 3 [17]. It has organisms that were sensitive to pollution and high-quality water for Taxa 1. Low-temperature-associated species are found in the orders Ephemeroptera, Diptera, Plecoptera, and Trichoptera. It requires more dissolved oxygen, remains in cold water, and has a neutral pH. There were considerably more dissolved oxygen here since the water was cooler. The majority of contaminants make aquatic insect nymphs like mayflies, stoneflies, and caddisflies sensitive, and they are unable to survive if the dissolved oxygen content in a stream fall below a certain threshold. If there are no mayflies, stoneflies, dragonflies, or caddisflies in an area that once supported them, dissolved oxygen levels have fallen to a point where they can no longer reproduce or where they were immediately killed [22]. Species can survive in a wide range of water quality conditions because of Taxa-2, which has a moderate level of water quality. Specimens come from a variety of species, making them very tolerable to low dissolved oxygen, lower or higher pH levels, and warm water [18]. Blackflies, aquatic worms, and midges were several examples of macroinvertebrates that can withstand high levels of pollution in Taxa 3. They have adaptations that enable them to thrive in waters with low dissolved oxygen, turbidity, or nutrient concentrations, as well as in waters with poor water quality [28].

Utilizing the Surigao River's Water Quality Index to Assess Water Quality

The species were assessed using the matrix with equivalent scores for each macroinvertebrate species, regardless of abundance [19]. The identified macroinvertebrate taxonomic hierarchy was sorted and scored. For scoring, a matrix with corresponding points for each macroinvertebrate species present was used, regardless of species abundance. After scoring all of the macroinvertebrates, the total was tallied and divided by the number of macroinvertebrates types collected. The WQI is the associated result, which is described using the following range of scores. Table 2 depicts the Water Quality Index scoring system [20].

Table 3: Water Quality Index Scores and Indications

Score	Indication
7.6-10	Very Clean Water
5.1-7.5	Rather clean-clean Water
2.6-5.0	Rather Dirty-Water Average
1.0-2.5	Dirty Water
0	Very Dirty Water (No Life at All)

Average score per taxon in measuring water quality of Surigao River

The average score per taxon was calculated by adding the individual scores of all present indicator species and dividing by the number of species present [17]. The species level was used to categorize organisms. The Biological Monitoring Working Party (BMWP) assigned the collected species their correct numbers based on the family to which they belong [21]. The ASPT indications for water quality were displayed in the table below [20].

Table 4: Average score per taxon scores and indications for water quality

Score	Indications
5 and above	Excellent
4-4.5	Good
3-3.5	Moderate
2-2.5	Poor
1-1.5	Very Poor

Data Analysis

The data needs to have a quality result in the study, PAST Software or Paleontological Statistics Software were used in order to calculate the Diversity Indices [24]. The Department of Environment and Natural Resources Administrative Order series of 2016-08 Class A standards were compared to the data acquired from the physicochemical parameters in three sample stations.

Results and Discussion

Riparian Channel and Environmental Inventory (RCE)

The RCE Inventory shows the scores given by the evaluator using the catchments were collected and summed up in order to know its corresponding equivalent rate. It was conducted in a 100m-length of the river wherein three stations got chosen. Results can be seen in Table 5, as Station 1 indicates the Upstream, obtained a score of 195 with an equivalent indication of “good” due to its vegetation were still intact but the trees and shrubs were sparse in the area. Station 2 for Midstream scored 250 which means “very good” due to the vegetation area were also intact. Aside from that, various trees can be seen along the riverbank. Lastly for the Station 3 in the Downstream, it scored 134 indicates “fair” mainly because the vegetation area were sparse, with few channel obstructions. With its corresponding indicator to be given more attention, certain measures will be used to improve and preserve the surroundings of the streams in a particular area.

THE RCE: a Riparian, channel, and environmental inventory for small streams in the agricultural landscape

Table 5: Riparian, Channel, and Environmental Inventory with its relative sampling stations

Sampling Stations				
Catchment		Station 1	Station 2	Station 3
1.	Land-use pattern beyond the immediate riparian zone	20	20	20
2.	Width of riparian zone from stream edge to field	20	30	20
3.	Completeness of riparian zone	20	20	20
4.	Vegetation of riparian zone within 10m of channel	5	15	5
5.	Retention devices	5	10	1
6.	Channel structure	10	5	1
7.	Channel sediments	10	10	5
8.	Stream-bank structure	15	15	5
9.	Bank undercutting	5	20	5
10.	Stony substrate; feel and appearance	15	15	15
11.	Stream bottom	5	15	1
12.	Riffles and pools, or meanders	20	10	10
13.	Aquatic vegetation	10	10	1
14.	Fish	15	15	15
15.	Detritus	5	25	5
16.	Macrobenthos	15	15	5
Total		195	250	134

Physicochemical Assessment

A comparison of the physicochemical characteristics of the Surigao River stations 1, 2, and 3 in Surigao City, Philippines, revealed variances. Table 6 compares the outcomes of the three sampling stations' physicochemical analysis to the requirements set out in the Department of Environment and Natural Resources Administrative Order series of 2016-08.

Table 6: Physico-chemical parameters used to measure the three-sampling station with its corresponding DAO 2016-08 standard values

Physico-chemical Parameter	Station 1	Station 2	Station 3	DENR Administrative Order Standards series of 2016-08
Conductivity (uS/cm)	167	168	135	<1,500 uS/cm
Dissolved Oxygen (mg/L)	16.9	15.3	12.6	>5 mg/L
pH	4.69	5.38	5.7	6.5-8.5
Temperature (ºC)	25	27	26.1	26 ºC-30 ºC
Total Dissolved Solids (mg/L)	133.6	134.4	108	<1000 mg/L

Water quality affects aquatic life as well as the ecosystem's health. Understanding water quality parameters is an important part of environmental monitoring and habitat condition determination. Except for the pH in all sampling stations and the temperature at station 1, all physicochemical test parameters met the DAO series of 2016-08 water quality standards, according to the findings.

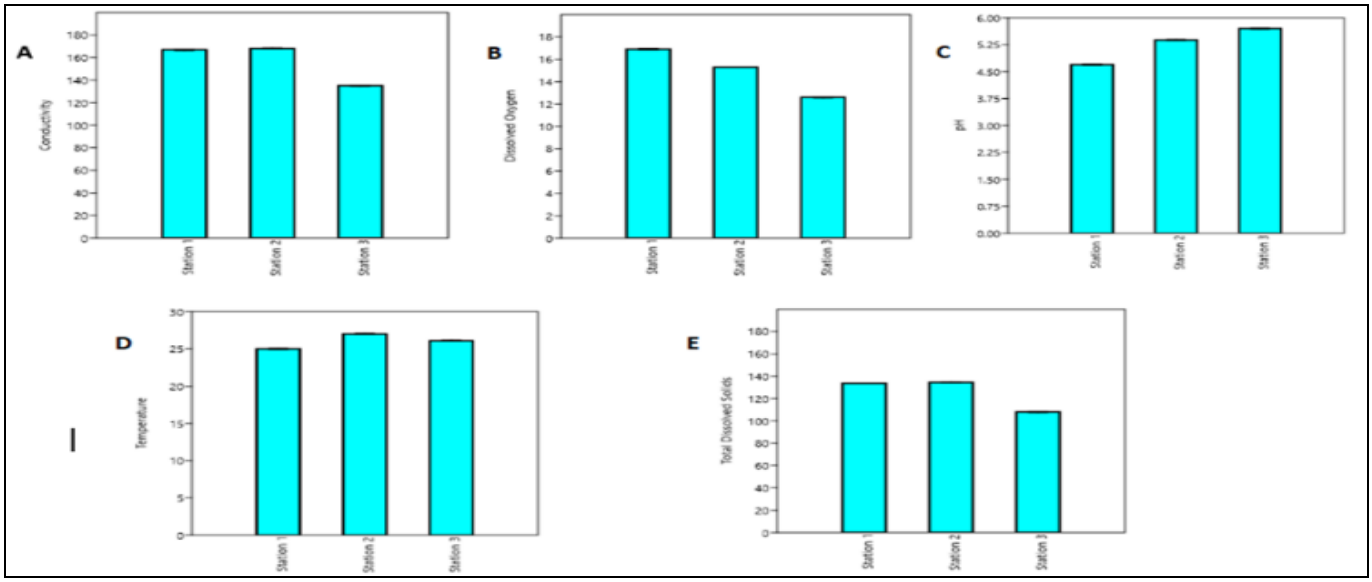

Fig 2: Physico-chemical Parameters used to measure the water quality of the three sampling stations in Surigao River, Surigao City, Philippines: A) Conductivity, B) Dissolved Oxygen, C) pH, D) Temperature, E) Total Dissolved Solids

The conductivity of the three sampling sites did not exceed the DAO 2016-08 standard levels. Station 2 significantly outperformed stations 1 and 3, with results of 167 uS/cm and 135 uS/cm, respectively. The temperature of the water had

also an impact on conductivity; as the temperature rises, so does the conductivity. Water conductivity has always been significant since it can indicate the number of dissolved chemicals, minerals, and other elements that were actually present in the water. The main factor affecting conductivity in streams and rivers was the geology of the region through which the water flows. Conductivity may be impacted by stream discharges depending on their composition. When measuring conductivity, one may also assess how quickly electricity passes through water and get a rough idea of the amount of salt that was there. A discharge or other source of pollution entering a stream could be indicated by significant fluctuations in conductivity [5]. Pollution can also increase river conductivity because industrial and human wastewater, particularly wastewater from anthropogenic activities, seems to be frequently highly conductive.

Dissolved oxygen values were observed to be within the range indicating when the temperature drops, the concentration of dissolved oxygen rises [5], especially in station 1 where the value of DO results in 16.9 mg/L with its temperature at 25 ºC. This appears to be critical for the survival of fish and other aquatic organisms because wind aeration causes oxygen to dissolve in surface water. This parameter was among the most sensitive to changes in water quality [29]. Results gathered from station 2 and station 3 were 15.3 mg/L and 12.6 mg/L with its corresponding temperature at 27 ºC and 26 ºC stays within the standard also. The accumulation of organic wastes was the most important factor in contributing to changes in the level of DO. The lower the DO concentration, the lower the quality of the water.

When the pH becomes low, toxic elements and compounds, such as heavy metals, can become available for uptake by aquatic plants and animals [5]. Three sampling stations' observed pH values were below norms since they only came out to 4.69, 5.38, and 5.7, respectively, demonstrating the acidity of the station's heterogeneous environment, vegetation, water discharges, and human activities. Some river creatures may not be able to endure pH fluctuations, while others may be sensitive to them. An aquatic system's pH would be a crucial gauge of the water's quality and pollution levels.

Water temperature affects the abundance of habitat for many aquatic species as well as the type of macroinvertebrates present in rivers as a survival factor for some aquatic organisms [30]. Temperature influences water quality and environmental parameters because it governs the types and diversity of aquatic life, stabilizes the maximum dissolved oxygen concentration in the water, and influences the frequency of chemical and biological reactions. Station 1 garnered a result of 25 ºC which were below the standard values while station 2 and station 3 results were 27 ºC and 26 ºC making it within the standards. The temperature of the water can also indicate the effects of human activity.

Aquatic life, especially those of the macroinvertebrates, has always required a steady level of minerals in the water. Since the density of total dissolved solids governs the flow of water into and out of a person's cells, changes in dissolved solids concentrations can be hazardous. The growth and eventual demise of many aquatic creatures could be impacted by total dissolved solids concentrations that are too low or too high [30]. The outcomes from the three sampling sites met the requirements of DAO 2016-08. Station 2 had the highest result among the three sample stations with a result of 134.4 mg/L, while Station 3 had the lowest result with a result of 108 mg/L. Station 1 had collected 133.6 mg/L.

The physicochemical condition of the river should be continuously monitored. In order to solve the problem with the water quality of the Surigao River, a test for heavy metals and microbiological parameters should be carried out.

Assessment of Macroinvertebrates using the Biotic Indices (WQI and ASPT) and its Diversity

ASPT and WQI score were shown in Table 7, indicating the scores of each presence of species garnered in the sampling. The WQI results showed that the water quality at station 1 for the upstream and station 2 for the midstream of the Surigao River was "rather dirty-water average," with scores of 3.08 and 3.38, respectively. Its downstream received a score of 1.54, indicating that the water quality was "dirty." The ASPT scores for stations 1, 2, and 3 were 3.15, 3.54, and 1.46, respectively. Water quality at stations 1 and 2 was rated "moderate," while station 3 was rated "very poor." This demonstrates that the majority of the species found in the sampling stations belong to Taxa 2, which can live in moderate water quality, and Taxa 3, which can live in poor water quality, making it highly tolerant to pollution [18, 24]. Pollution-sensitive species that belong to Taxa 1 were nowhere to be found.

Water striders and dragonflies were both found at station 1 and station 2 lacks their presence at station 3. Water striders were useful predatory insects that feed on live and dead aquatic insects. Mosquito larvae and adults, dragonfly larvae, and midges are the most common prey species, but they were able to consume just about any bug or larva they can find, live or dead, as long as they will get dropped into the water [31]. Asian clams have been collected at all sampling stations, with the greatest number of individuals collected at station 3, followed by station 2 and station 1. Quilted melania can be found also in all sampling stations with station 1 has the highest rate than station 3 and station 2. The presence of Apple snail were found in the three sampling stations the same with red worm, freshwater snail, and river shrimp. The least individuals and species collected were amano shrimp, midge larva, and water striders.

Table 8 shows the Taxonomic Classifications and the Taxa of species collected from the sampling stations. Urbanization has an impact on water quality since more pollutants are produced in urban areas. Pesticides, heavy metals, pathogenic microbial populations, and organic pollutants were all prevalent. Water pollution has reduced the abundance, diversity, and diversity of invertebrates. Increased stream flow, changes in the stream bed substrate, and pollution all have an impact on aquatic animals. Rivers and streams may be compromised as more areas become urbanized [27] making the sampling stations affected by such activities. There were 13 aquatic macroinvertebrates species collected from the 12 families which were composed of Annelida (9%), Arthropoda (30%), and Mollusca (61%) as what have shown in Figure 3. It shows in Table 8 that station 1 were most of the species had collected dominated by the Family Thiaridae in a Phylum Mollusca. The Phylum Mollusca family Cyrenidae had the greatest number of individuals in stations 2 and 3. Station 3 had the fewest species.

Table 7: WQI and ASPT scores of the Aquatic Macroinvertebrates collected from Surigao River at three Sampling Stations

Common Name		Species	Sampling Station, WQI, and ASPT								
			Station 1	WQI	ASPT	Station 2	WQI	ASPT	Station 3	WQI	ASPT
1.	Red Worm	*Limnodrilus hoffmeisteri*	1	1	1	2	1	1	7	1	1
2.	River Shrimp	*Gammarus pulex*	2	4	6	1	4	6	3	4	6
3.	Amano Shrimp	*Caridina multidentata*	2	4	6	0	0	0	0	0	0
4.	Midge Larva	*Chironomus sp.*	1	2	2	1	2	2	0	0	0
5.	Asian Clam	*Corbicula fluminea*	2	6	3	8	6	3	12	6	3
6.	Apple Snail	*Pomacea maculata*	6	3	3	1	3	3	4	3	3
7.	Quilted Melania	*Tarebia granifera*	13	3	3	2	3	3	5	3	3
8.	Malaysian Trumpet Snail	*Melanoides tuberculata*	6	3	3	2	3	3	0	0	0
9.	Skimmers/ Water Striders	*Gerries marginatus*	1	5	5	2	5	5	0	0	0
10.	Riffle Bug	*Microvelia sp.*	0	0	0	5	5	5	0	0	0
11.	River/ Freshwater Crab	*Geothelphusa sp.*	0	0	0	6	3	6	0	0	0
12.	Freshwater Snail	*Semisulcospira libertina*	1	3	3	2	3	3	4	3	3
13.	Dragonfly/Tutubi	*Orthetrum serapia*	5	6	6	4	6	6	0	0	0
		Total	40	40	41	36	44	46	35	20	19
				3.08	3.15		3.38	3.54		1.54	1.46

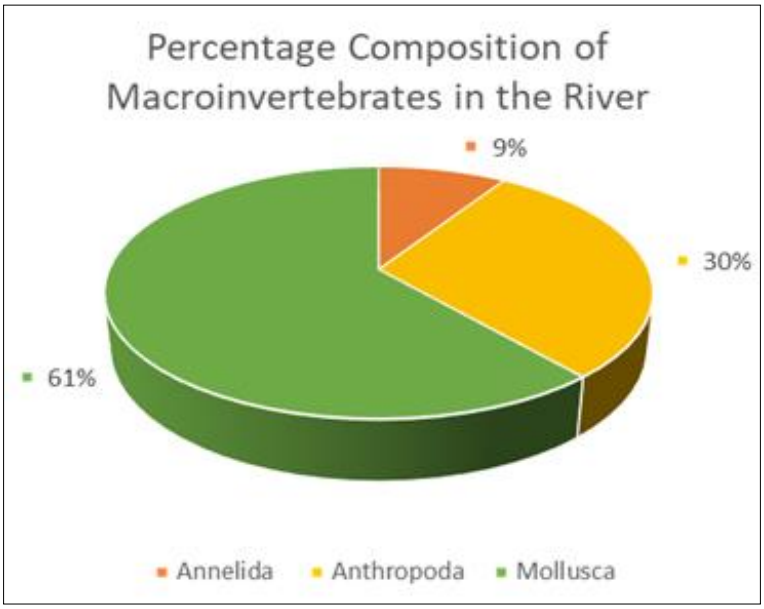

Fig 3: Percentage Composition of Macroinvertebrates in all three sampling stations collected from the Surigao River

Table 8: Taxonomic Classifications of the Species Collected and its corresponding Taxa

Phylum	Class	Order	Family	Scientific name	Common name	Taxa
Annelida	Clitellata	Haplotaxida	Naididae	Limnodrilus hoffmeisteri	Red Worm	3
Arthropoda	Malacostraca	Decapoda	Atyidae	Caridina multidentata	Amano Shrimp	2
	Insecta	Diptera	Chironomidae	Chironomus sp.	Midge Larva	3
	Malacostraca	Amphiphoda	Gammaridae	Gammarus pulex	River Shrimp	2
	Insecta	Hemiptera	Gerridae	Gerries marginatus	Skimmers/ Water Striders	2
	Malacostraca	Decapoda	Potamidae	Geothelphusa sp.	River/ Freshwater Crab	2
	Insecta	Hemiptera	Veliidae	Microvelia sp.	Riffle Bug	2
	Insecta	Odonata	Libellulidae	Orthetrum serapia	Dragonfly/ Tutubi	2
Mollusca	Bivalvia	Venerida	Cyrenidae	Corbicula fluminea	Asian Clam	2
	Gastropoda		Ampullariidae	Pomacea maculata	Apple Snail	3
	Gastropoda		Semisulcospiridae	Semisulcospira libertina	Freshwater Snail	3
	Gastropoda		Thiaridae	Tarebia granifera	Quilted Melania	3
	Gastropoda		Thiaridae	Melanoides tuberculata	Malaysian Trumpet Snail	3

Legend

Taxa 1: Pollution sensitive organisms found in good water quality;
Taxa 2: Can exist in a wide range of water quality conditions; generally moderate water quality;
Taxa 3: Can exist in a wide range of water quality conditions; highly tolerant to poor water quality

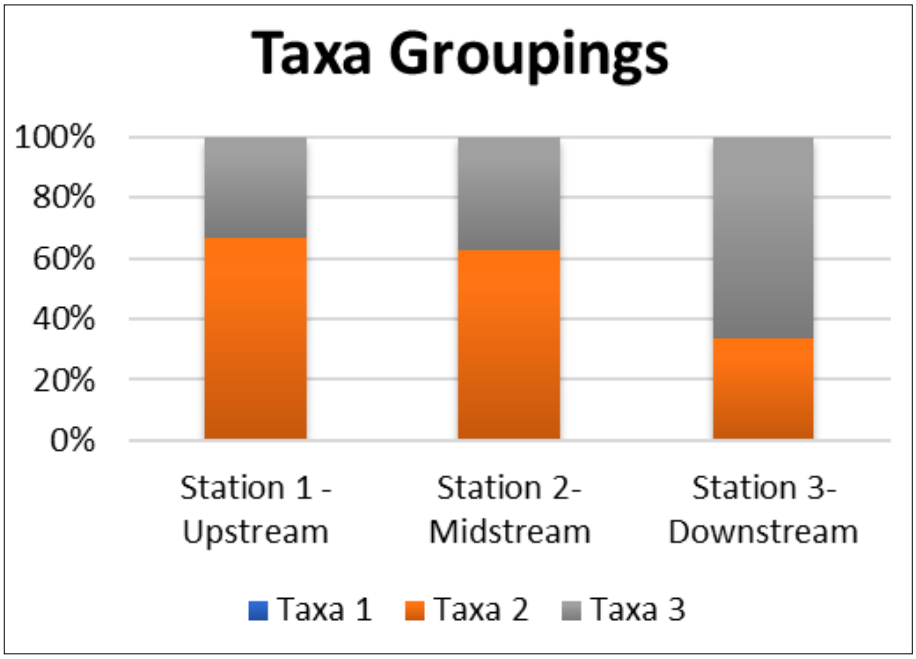

Fig 4: Taxa Groupings of Macroinvertebrates in all three sampling stations collected from Surigao River

The majority of the macroinvertebrates collected can live in moderate water, which is Taxa 2, followed by highly tolerant to poor water quality, which is Taxa 3, and there were no pollution sensitive macroinvertebrates, which is Taxa 1, as shown in Figure 4. Mayflies (Ephemeroptera) and caddisflies (Trichoptera) have been affiliates of the EPT taxon, which appears to be made up of aquatic macroinvertebrates that were already commonly used to assess the health of streams and rivers and belongs to Taxa 1. The presence or absence of EPT taxa indicates whether or not the aquatic environment has been polluted. These macroinvertebrates can only be found in streams and rivers with good water quality due to their low tolerance for pollutants, making them an effective bioindicator of a healthy aquatic environment [6]. Since there has been an absence of the EPT, the water quality of the three sampling stations was subject to deterioration. With this, proper monitoring and discipline must be highly implemented in order to prevent damage and preserve the health of the river. Furthermore, quarterly sampling of macroinvertebrates in the Surigao River should be prioritized in order to monitor the river's water quality.

Table 9 shows the results of the diversity indices of the macroinvertebrates collected from Surigao River in three sampling stations. Result shows that with all the 13 species collected, station 2 has 12 species present during the sampling followed then by station 1 with 11 species gathered and station 3 with 6 species making station 2 the highest number of species richness.

Table 9: Diversity Indices of the Aquatic Macroinvertebrates collected from Surigao River in Three-Sampling Stations

Diversity Indices	Station 1	Station 2	Station 3
Taxa_S	11	12	6
Individuals	40	36	35
Dominance_D	0.1762	0.1265	0.2114
Simpson_1-D	0.8238	0.8735	0.7886
Shannon_H	2.013	2.253	1.673
Evenness_e^H/S	0.6802	0.7928	0.8882

Station 1 had the most individuals collected, with a total of 40, followed by stations 2 and 3, which had 36 and 35 individuals collected, respectively. The number of individuals collected from the three sampling stations came to 111. Station 3 has the highest number of dominance with a value of 0.2114, followed by stations 1 and 2 with values of 0.1762 and 0.1265, respectively. As a result, station 3 has the most dominant species. Simpson's diversity index (SDI) assesses a community's diversity. The scale will be from 0 to 1, with high scores near 1 indicating high diversity and low scores near 0 indicating low diversity [32]. Simpson's Diversity Index results for all sampling stations were close to one, indicating high diversity. Meanwhile, station 2 has the highest score with its result of 0.8735 followed by station 1 and station 3 with their results, 0.8238 and 0.7886. The Shannon diversity index can be used to estimate the diversity of species within a community. The higher the index, the more diverse the species in the habitat. If the index was zero, the community would only have one species [33]. Since the index were greater than zero, the resulted values were apparently high. Station 2 took the spot of the highest index with a result of 2.253, with station 1 on the next spot with its value of 2.013 and station 3 as the least index with 1.673. It also means that there was more than one species present in the area based on the resulted index. Station 3 had the highest species evenness with a value of 0.8882, followed by station 2 and station 1 with values of 0.7928 and 0.6802, respectively. Station 2 has the highest species diversity according to the Simpson and Shannon Diversity Index.

Conclusion

This is the first study to report on the macroinvertebrates assessment as an indicator for the water quality in Surigao River. Riparian, Channel, and Environmental Inventory, station 1 represents the upstream and gained a score of 195, indicating "good," station 2 represents the midstream and obtained a score of 250, indicating "very good," and station 3 represents the downstream and garnered a score of 134, indicating "fair." Station 1situates near the national highway even though it has vegetation due to the fact that residents were living nearby to the river and same goes on with station 2 making it the most populated among the three sampling stations. Most of the houses were not built near to the river or

some of it were far from the river, there lies also the Kinabutan bridge that connects to the other barangay, and its vegetation were most likely intact and has various trees in the riverbanks. For the station 3, most of the people were living directly to the river. Many garbages and feces were observed floating on the surface of the water. Though it has vegetation but sparse, it has been surrounded most likely by Anahaw. The physicochemical parameters were all within standard limit except for the pH in all sampling stations and temperature for station 1. Anthropogenic activities were most likely affected some of the results of the physico-chemical parameters especially the pH wherein it results to below the standards. According to the WQI results, the water quality at station 1 for the upstream and station 2 for the midstream of the Surigao River was "rather dirty-water average," with scores of 3.08 and 3.38, respectively. Its downstream received a score of 1.54, indicating that the water quality was "dirty," while the ASPT scores for stations 1, 2, and 3 were 3.15, 3.54, and 1.46, respectively.

Water quality at stations 1 and 2 were rated as "moderate," while station 3 had a rate of "very poor." There were 13 aquatic macroinvertebrates collected from the 12 families, which would include Annelida (9%), Arthropoda (30%), and Mollusca (61%). Asian clams have been collected at all sampling stations, with station 3 collecting the most individuals, followed by stations 2 and 1. Amano shrimp, midge larva, and water striders had the fewest individuals and species collected. The presence of Taxa 2 and Taxa 3 macroinvertebrates were influenced by water quality, significant environmental issues, human activity disturbance, and non-point source environmental damage. Since there were no EPT species were observed across the three sampling stations, this indicates that the water quality of Surigao River is at risks for possible pollutants that were more likely deteriorate its quality. Based on the Simpson and Shannon Diversity Index, station 2 is the most diverse of all three sampling stations. The results of RCE, Physicochemical Parameters, WQI, and ASPT shows that the results obtained scores gives an impact especially to the diversity of the macroinvertebrates in Surigao River since there were no EPT collected during the time of sampling, indicating that the water is not clean.

To help relieve and manage the existing problems of water quality status, constant monitoring should indeed be undertaken especially for the improvement of the riparian zones, a test on heavy metals and microbiological parameters.

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