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RESEARCH PAPER

# Characterization of benthic macrofauna in Iloilo River

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**Abstract**

Iloilo River is a vital area for fishing, tourism, and various economic activities. It has experienced rapid changes with developments along the area that may influence its ecological processes.This study is an assessment of the abundance and diversity of benthic macrofauna in Iloilo River through the identification of the major taxonomic groups found along the area. Bivalvia dominated all the sampling stations with a count of 115-4935 individuals contributing to 71.70% of all the identified individuals. Overall diversity (H') was poor with a range of 0.45-1.12. The taxon richness (S) indicated that there were only 3-4 taxa present at each sampling station. Taxon evenness (J') was also relatively low with a range of 0.32-0.84. The biological indices suggest poor taxon diversity and low population uniformity. Although redox potential showed that the sediment habitat of these macrofauna are under oxic conditions, low D.O. may suggest influence on the distribution of the benthos.

## Introduction

Rivers are seen as an essential ecosystem as they hold a large portion of the world's biodiversity. Rivers also act as an important passageway for the movement of various species of flora and fauna in the ecosystem and are responsible for the movement of the various nutrients throughout the environment (Sinha et al., 2020). Benthic macrofauna are organisms that are composed of various species, but not limited to, such as annelids, coelenterates, mollusks, arthropods, and chordates. They play an important role in the distribution of nutrients in the environment due to their role in the acceleration of the breakdown of detritus which falls into the water and settles on the substrate. Due to this, benthic macrofauna is responsible for the introduction of nutrients that are used by aquatic plants as the first link in the food chain of the ecosystem. Furthermore, they are also responsible for processing and oxygenating the substrate through their movement such as burrowing and irrigating, making them a major contributor in the ecosystem.

There are many factors that can affect the distribution and diversity of the benthic macrofauna, mainly both environmental and biological factors such as habitat type, water and sediment quality, and the available food supply (Haque et al., 2020). Both spatial and temporal distribution of the macrobenthos are influenced by environmental parameters such as depth of the water, temperature, salinity, current, density and the organic matter present. Furthermore, the presence of stress factors due to anthropogenic activities which cause unstable substrates and introduce toxic substances into the water column have also been noted to affect the distribution and community structure of the benthic macrofauna (Abowei, Ezekiel, and Hansen, 2012).

The Iloilo River is an estuarine river which is an inlet of seawater from the Iloilo Strait, located in Panay Island. This river is classified by the Department of Environment and Natural Resources (DENR) as a class C water system, defined as an area for propagation of fish and other aquatic resources. This body of water has been a site of rapid urbanization with which establishments have been seen to be placed along the central portion of the river, which is seen as a source of sewage and garbage pollution (Besana and Padilla, 2017; Palla, Campos, and del Norte-Campos, 2013; Taneza and Philip, 2009).

This study aims to describe the benthic macrofauna present in various points of Iloilo River. Specifically, abundance and diversity through major taxonomic composition and density, individual counts, and the presence of a dominant taxonomic group were determined.

## Materials and Methods

### Study site

The Iloilo River is within Iloilo City found in Panay Island of the Philippines. It draws its water from the Iloilo Strait. This body of water serves as a route for marine transportation and the propagation of multiple fish species. The river stretches a total distance of 11 kilometers from its source which is the Iloilo Strait up until its inner reaches located in Arevalo, Iloilo City. The river serves as a drainage area for various fish ponds and agricultural plantations; and passes through the city’s highly populated economic and commercial areas (Besana and Padilla, 2017).

### Sampling stations

Five sampling stations (SS1 to SS5) were placed along the 11 kilometer stretch of the river (Figure 1). Each station was placed along bridges which were seen to be points of interest where different effluent sources of pollution such as discharge from shipping vessels, commercials establishments, petroleum depots and fueling stations, a power-generating station, as well as informal settlements with which majority do not have access to proper sanitation facilities, and further upstream, additional organic load comes from fishponds dotted along the river and Calajunan Creek which receives various forms of water pollution from garbage pollution coming from a garbage disposal sight, agricultural land, and industrial buildings (Taneza and Philip, 2009).

### Density of macrobenthic fauna

Mean density of the benthic macrofauna (ind.m$^2$) was calculated from the number of individuals per taxa per surface area of the grab sampler converted into m$^2$ (Pawar and Al-Tawaha, 2017).

### Field sampling

The collection of the sediment samples for the benthic survey was based on the methodology of Sany et al. (2015). Sediment samples were collected in triplicates using an Ekman grab sampler (area, 0.16 m2, depth, 6.5 cm) during the lowest tide. Prior to the collection of the sediment samples, water parameters such as bottom DO (dissolved oxygen), pH, and salinity were measured on site using a DO meter (Ecosense ODO200, USA), pH meter, and refractometer, respectively.

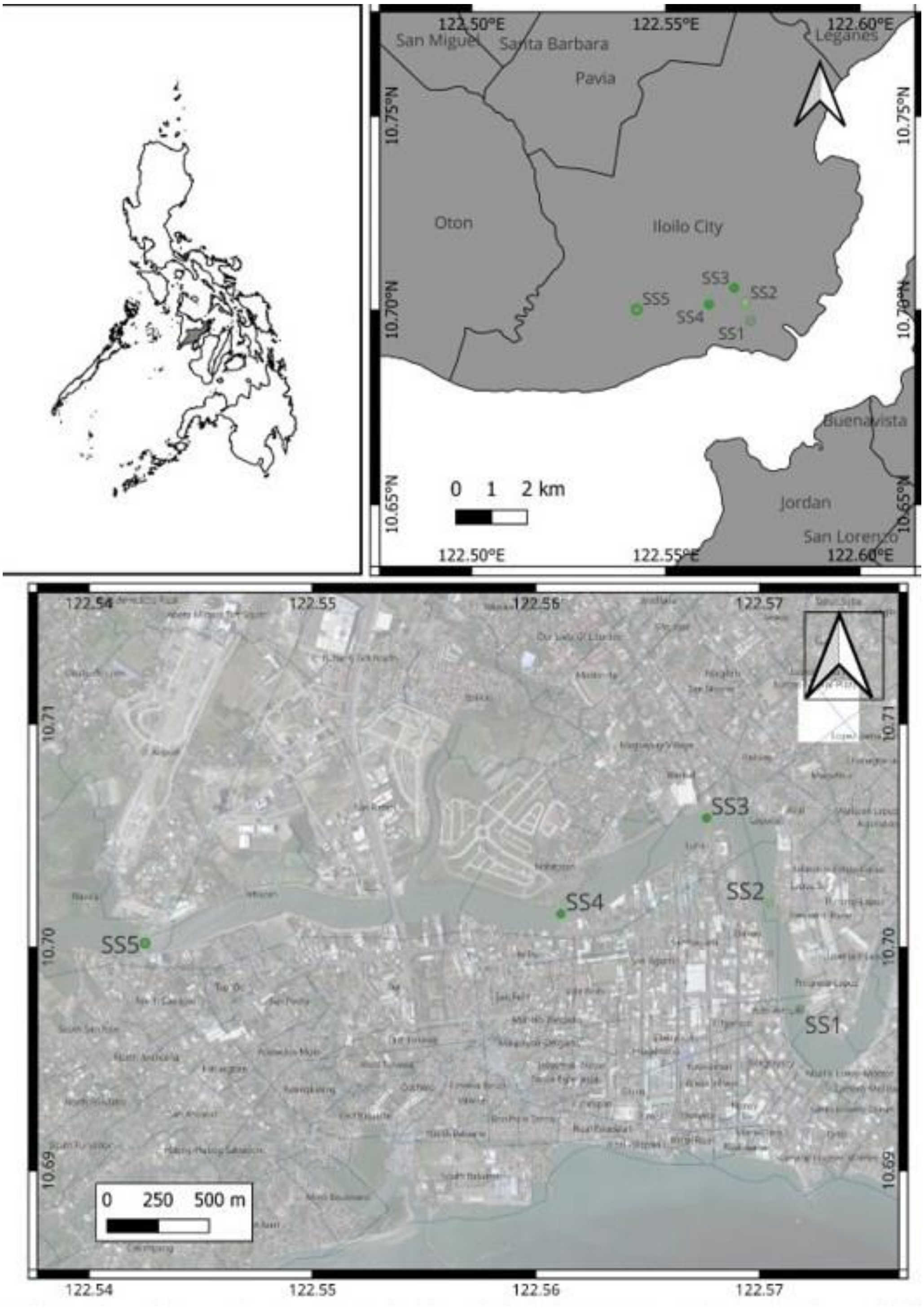


**Figure 1.** Map of sampling stations 1 to 5 in Iloilo River. SS1 - Drilon Bridge, SS2 - Quirino Lopez Bridge, SS3 - Taytay Forbes. SS4 - Jalandoni Bridge, SS5 - Carpenters Bridge

Immediately after sediment collection, a redox meter (D-14, Horba, Japan) was used to measure the reduction-oxidation potential of the sediment by embedding an Ag/Ag/Cl probe of the pH/mV meter at the upper 1 cm layer of the sediment, and corrected with ±150 mV. Each sample was placed into a ziploc bag preserved with 10% buffered formalin solution with rose Bengal dye.

**Laboratory analysis**

All samples collected were sieved with 0.5 mm mesh sieve and rinsed with filtered sea water in order to collect all the macrofaunal

**Table 1.** Coordinates and characteristics of the five sampling stations in Iloilo River

| Sampling Station | Coordinates | Characteristics |
|---|---|---|
| SS1 (Drilon Bridge) | 10º41'49.876"N, 122º42'17.96"E | Presence of sewage outlet connected to downtown area and from nearby marine vessels docking along the port of Iloilo |
| SS2 (Quirino Lopez Bridge) | 10º42'6.814"N, 122º34'13.148"E | Presence of sewage outlet connected to nearby supermarket and surrounding business |
| SS3 (Taytay Forbes) | 10º42'20.866"N, 122º34'3.544"E | Presence of sewage outlet connected to nearby business establishments, a mall, residential homes and nearby hospital |
| SS4 (Jalandoni Bridge) | 10º42'5.728"N, 122º33;39.811"E | Presence of creek connected to sewage outlets and many hotels, a mall, and different business and commercial establishments |
| SS5 (Carpenters Bridge) | 10º42'0.259"N, 122º32'33.161"E | Presence of sewage outlet connected to residential homes and commercial establishments |

organisms contained in the sediment. The collected animals were then transferred to plastic containers, labeled according to their respective sampling site, and fixed with 10% buffered formalin with Rose Bengal dye. The whole sieved samples from each sampling station were sorted and identified to major taxonomic groups using a dissecting microscope.

## Statistical analysis

Data collected were analyzed for mean density and standard error of means. The biological indices used for this study were based on the studies of Lu et al. (2021). H' (Shannon-Weaver's diversity index), J' (Pielou's Evenness), and S (Species Richness) were used as the biological indices for the study.

The diversity index criteria (H') are as follows (Lu et al., 2021):

<1 = Bad Diversity

1-2 = Poor Diversity

2-3 = Moderate Diversity

3-4 = Good Diversity

>4 = High Diversity

The evenness index values range from 0-1, and are as follows:

$0 < J' \leq 0.5$ = Depressed Community

$0.5 < J' \leq 0.75$ = Unstable Community

$0.75 < J' \leq 0.75$ = Stable Community

# Results

## Abundance and composition of macrobenthic fauna

A total of 11643 individuals were counted from the collected samples with a total of five macrobenthic taxa identified (Table 2). The identified macrobenthic taxa were as follows: Bivalvia (115-4935 individuals), Gastropoda (121-671 individuals), Polychaeta (110-409 individuals), Thecostraca (0-8 individuals), and Malacostraca (0-123 individuals).

Class Bivalvia was observed to be the dominant taxa encountered in the Iloilo River. This class had accounted for 71.70 % of the total composition of the individuals identified. The abundance of bivalves was influenced by access to the type of food especially in estuarine areas, where a majority of the organic matter is refractory and the turbidity of the water is high. Furthermore, factors such as sediment characteristics in the area also play a role in influencing the abundance of fauna such as that of bivalves (Jaida et al., 2021). The distinguishing characteristic of the substrate is its muddiness which allows for more niches to be established which leads to an increase in the abundance of the bivalves in the area since these organisms tend to live a sedentary lifestyle and would prefer to bury themselves in the soft substrate. It is also important to note that the presence of finer sediments such as mud suggests that the sediment holds more organic matter which allows it to support more individual bivalves as these organisms feed on organic materials (Asadi, Iranawati, and Andini, 2018; Blair and Mcpherson, 1999).

The density of the macrobenthic taxa identified from all five sampling stations (Table 3) indicate that class Bivalvia had the highest density (718-30843 ind.m-$^{2}$), followed by class Gastropoda (681-4193 ind.m$^{-2}$), class Polychaeta (687-2556 ind.m$^{-2}$), class Malacostraca (0-768 ind.m$^{-2}$), and lastly class Theocostraca (0-50 ind.m$^{-2}$). Variabilities in the number of organisms may be attributed to the physicochemical conditions of the water along the sampling stations as the levels of dissolved oxygen, salinity, pH, and the organic matter present can affect their growth and success in reproduction.. Moreover, the dissolved oxygen in the environment is utilized by the gastropods for their metabolic activities, which could be a limiting factor to their abundance. (Velasco, Lopez, and Devanadera, 2018).

**Table 2.** Abundance of macrobenthic taxa found from sampling station 1 (SS1) to sampling station 5 (SS5) in Iloilo River. N=3. SEM= standard error of mean

| Station | Bivalvia | SEM | Gastropoda | SEM | Polychaeta | SEM | Theocostraca | SEM | Malacostraca | SEM |
|---|---|---|---|---|---|---|---|---|---|---|
| SS1 | 115 | 12 | 378 | 32 | 110 | 12 | 0 | 0 | 0 | 0 |
| SS2 | 425 | 80 | 121 | 22 | 409 | 40 | 8 | 1 | 0 | 0 |
| SS3 | 4935 | 332 | 616 | 50 | 369 | 48 | 0 | 0 | 61 | 10 |
| SS4 | 878 | 38 | 671 | 16 | 172 | 4 | 0 | 0 | 123 | 17 |
| SS5 | 1998 | 70 | 109 | 2 | 135 | 7 | 0 | 0 | 10 | 2 |

**Table 3.** Mean density of macrobenthic taxa identified in Iloilo River for sampling station 1 (SS1) to sampling station 5 (SS5). Values are mean densities (ind.m-2) ± standard error of mean (SEM); N=3

| Station | Bivalvia | SEM | Gastropoda | SEM | Polychaeta | SEM | Theocostraca | SEM | Malacostraca | SEM |
|---|---|---|---|---|---|---|---|---|---|---|
| SS1 | 718 | 77 | 2362 | 194 | 687 | 55 | 0 | 0 | 0 | 0 |
| SS2 | 2626 | 488 | 756 | 135 | 2556 | 247 | 50 | 10 | 0 | 0 |
| SS3 | 30843 | 2014 | 3850 | 307 | 2306 | 295 | 0 | 0 | 381 | 65 |
| SS4 | 5487 | 230 | 4193 | 98 | 1075 | 24 | 0 | 0 | 768 | 106 |
| SS5 | 12487 | 424 | 681 | 13 | 843 | 45 | 0 | 0 | 62 | 12 |

## Biological indices

The total number of taxa encountered (S) ranged from 3-4 taxon per sampling station (Table 4). The taxon diversity (H') ranged from 0.92 to 1.12, and the taxon evenness (J') ranged from 0.49 to 0.84. Using the criteria of Lu et al. (2021) it was seen that the taxon diversity (H') was poor with an average of 0.84 throughout the sampling stations.

It was observed that sampling station 4 had the highest taxon diversity, while sampling station 3 had the lowest taxon diversity and evenness which is attributed to the dominance of bivalves in the sampling station. A poor taxon diversity (H') is an indicative sign that there are only a few taxa which can survive the current status of the environment. Furthermore, a low taxon diversity is an indication that there are changes in the physical parameters, such as the salinity, temperature, DO, and other chemical components that attribute the physical parameters of a river ecosystem which in turn affect the taxon diversity (Rakib et al., 2022). An unstable community structure for the taxon evenness (J') could be an indication that there is a smaller uniformity of the population leading to the dominance of one taxon over another (Ulafah et al. 2019).

**Table 4.** Taxon diversity (H'), taxon richness (S), and taxon evenness (J') of sampling stations in the Iloilo River. SD = standard deviation

| Station | *H'* | *S* | *J'* |
|---|---|---|---|
| SS1 | 0.92 | 3 | 0.84 |
| SS2 | 1.03 | 4 | 0.74 |
| SS3 | 0.68 | 4 | 0.49 |
| SS4 | 1.12 | 4 | 0.81 |
| SS5 | 0.45 | 4 | 0.32 |
| Mean | 0.84 | 3.80 | 0.64 |
| SD | 0.27 | 0.45 | 0.22 |

## Physico-chemical conditions

There was no significant variation among the water parameters noted except for the values concerning the dissolved oxygen and the salinity (Table 5). The variation in the bottom salinity values can be attributed to the freshwater effluents present in the sites.

Results obtained from the analysis of the water parameters indicated that the water had low levels of dissolved oxygen (2-4 mg/L). Lowered dissolved oxygen values can be attributed to the presence of outlets that discharge waste from both commercial and residential buildings; furthermore, the construction of esplanades on both sides of the river at the time of sampling may enhance enrichment alongside the topography of the river. In the 2020 Regional State of the Brown Environment Report by the Environmental Management Bureau, it was seen that the overall mean of the DO from the sampling stations, which was at 3.44 mg/L, had not passed the Water Quality Guideline Value (WQGV) which is 5 mg/L (Environmental Management Bureau, 2020). The low DO values can be attributed to the degradation of organic matter which can lead to enrichment of sediments (Palla, Campos, and del Norte-Campos, 2013).

The reduction-oxidation of the sediments is an indication of the level of oxidation of the sediment or whether the sediment is oxic or anoxic. The reduction oxidation potential of the sediment also serves as an indicator for the availability of electrons within the sediments (Doble and Kumar, 2005). The results indicated (Table 5) that the sediments collected were oxic and also have a high number of readily available electrons in the system. Any redox potential values which surpass 100 mV is an indication that the environment is oxic (Hussein and Scholz, 2017).

## Conclusion

Abundance and diversity of the benthic macrofaunal organisms were identified in Iloilo River. The results indicated that there were five macrobenthic taxa identified from the sampling stations, such as: Bivalvia, Gastropoda, Polychaeta, Theocostraca, and Malacostraca. A total of 11643 individuals were identified from all the samples and these were dominated by Bivalvia at 71.70 %.

Although redox potential showed that the sediment habitat of these macrofauna are under oxic conditions, low D.O. may suggest influence on the benthos. Other physical and chemical parameters; and temporal changes that were not measured in this study may also play a large role in these current observations.

**Table 5.** Water parameters and sediment redox-potential in sampling stations along Iloilo River. Values are means ± standard error of means (SEM). N= 3

| Station | Temperature ± | Salinity | pH | D.O. | Redox-Potential |
|---|---|---|---|---|---|
| SS1 | 28.73 ± 0.12 | 27.33 ± 0.88 | 8.13 ± 0.09 | 3.28 ± 0.12 | 211.33 ± 23.21 |
| SS2 | 28.7 ± 0.12 | 28.3 ± 0.33 | 8.40 ± 0.06 | 4.10 ± 0.5 | 332.33 ± 11.67 |
| SS3 | 28.67 ± 0.09 | 28.00 ± 0.58 | 7.93 ± 0.09 | 3.64 ± 0.09 | 292.33 ± 13.25 |
| SS4 | 28.77 ± 0.15 | 27.33 ± 0.33 | 7.77 ± 0.15 | 3.20 ± 0.06 | 332 ± 10.15 |
| SS5 | 28.67 ± 0.07 | 25.3 ± 0.33 | 7.77 ± 0.09 | 2.98 ± 0.05 | 349.67 ± 7.97 |
| Average | 28.7 ± 0.03 | 27.27 ± 0.67 | 8.00 ± 0.16 | 3.44 ± 0.25 | 303.53 ± 32.12 |

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## Ethical approval

The authors declare that this study complies with research and publication ethics.

## Informed consent

Not applicable.

## Conflicts of interest

There is no conflict of interests for publishing this study.

## Data availability statement

The authors declare that the data from this study are available upon request.

## Funding organizations

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## Author contribution

**PAB Fernandez -** Conceptualization, Sampling, Analyses, Writing; **SSSantander-de Leon -** Conceptualization, Analyses, Supervision, Editing

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