



## Macroinvertebrates as bio-indicator of water quality in Estuaries

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### Abstract

Anthropogenic activities are increasingly impacting the biological, physical, and chemical conditions of aquatic ecosystems. This descriptive research aimed to determine the water quality of estuaries in the municipality of Manuel A. Roxas, Zamboanga del Norte, Philippines by utilizing the Biological Monitoring Working Party and Average Species Per Taxon (BMWP-ASPT) Index. BMWP-ASPT is used to evaluate water quality using families of macroinvertebrates as biological indicators since aquatic invertebrates have different tolerance to pollution. Data were collected through field sampling and were analyzed using descriptive statistical tools. A total of twelve families were recorded. Eight (8) of the twelve families were identified as indicator species which include Atyidae, Penaeidae, Coenagrionidae, Gerridae, Simuliidae, Lumbriculidae, Lymnaeidae, Neritidae. Pachychilidae has the highest relative abundance value of 51.40% while Coenagrionidae has the lowest relative abundance value of 0.22%. The BMWP-ASPT index indicated that the estuaries of Piao, Dohinob Daku, and Dohinob Diut have scored 4.16, 4.2, and 4.5 respectively which is interpreted as good water quality. Langatian estuary scored 3.0, interpreted as moderate. The water quality and abundance of macroinvertebrates in Langatian are impacted by the domestic waste and sewage disposal since the River traverses the town's urban barangay. It is recommended that regular monitoring of the sampling sites will be conducted to sustain and protect those estuaries with good water quality and improve the water quality of Langatian considering population expansion.

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## Introduction

Estuaries provide vital nesting and feeding habitats for many aquatic plants and animals because of the presence of high level of nutrients due to tidal overmixing (Smith *et al.*, 2012). However, contaminated urban run-off has been increasing the pollution load on these aquatic habitats (Orwa, O. 2013) thereby exposing the population of macroinvertebrates to major pollutants. Several studies have been conducted to assess water quality using families of macroinvertebrates as biological indicators since it is thought that aquatic invertebrates have different tolerance to pollution. (Uherek, C. and Gouveia, F. 2014).

Biological parameters integrate information over longer periods and better represent the responses of aquatic habitats making biotic monitoring indices excellent tools for the sustainable development of water resources (Pereira, Couceiro, as cited by Uherek, C. and Gouveia, F. 2014). While several reviews suggest different bio-indicators to utilize for the assessment of water quality, the use of aquatic macroinvertebrates is still the best (Duran, 2011) and it is well documented because of the amount of sample that the researcher could get, they were manageable and relatively easy to collect.

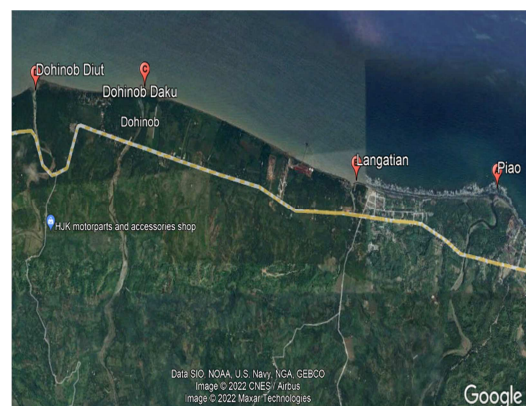
The study was conducted to determine the estuarine water quality of the four river systems in the Municipality of Roxas, Zamboanga del Norte being the industrial center of the Dapitan-Dipolog-Polanco-Katipunan-Roxas Manukan (DDPKaRoMa) Economic Alliance. The result of the study is helpful in the policy and decision-making processes and guidelines for resources management of the estuaries.

## Material and methods

### Study area

The study area is the municipality of Roxas, a second-class municipality of Zamboanga del Norte. The land features of the municipality are generally hilly. Only about one-third of the total land area is level ground or flat. Most of the barangays are located on the high ground except for six barangays like Dohinob, Upper

Irasan, Lower Irasan, Langatian, Piao, and Nabilid which are along the coastal area. The municipality is traversed by three wide rivers of Dohinob Daku River, Tangian River, and Piao River. These rivers not only favor the farmers in the cultivation of various crops but also serve as natural drainage. Along these riverbanks are strips of cultivated level ground. Domestic, industrial, and commercial activities threaten the health of the aquatic environment. (LGU Roxas. html).



**Fig. 1.** Roxas, Zamboanga del Norte; Study Site (Source: Google Maps 2022).

### Sampling

Field sampling for this study was conducted from January 2020 to March 2020. Technical report writing and data analysis were done from May 2020 to July 2020. Macroinvertebrates were collected in randomly selected sites by manual collection. For each working pair, one member held the net with the tip of the bag in a vertical position against the rocky riverbed with the mouth facing upstream while the

partner disturbed (by kicking, jabbing) the area upstream at a distance of about 1m, allowing the macroinvertebrates to be transported and dislodged into the net. Other types of nets such as beat nets and sweep nets were used for catching different insects. Macroinvertebrates were collected by using forceps after pouring the net contents into a container with water for removing mud. All collected specimens were poured into vials containing ethanol and transported to the JRMSU-K laboratory after labeling for identification to the family level using a hand lens, microscope, and morphology-base identification keys. Samples were also sorted based on their specific habitat.

**Analysis**

Descriptive analyses were done and BMWP-Average Score Per Taxon (Arslan, N. *et al.*, 2016) biotic index was used to determine water quality. The BMWP-ASPT index is an adapted version of the BMWP index. The system is based on ascribing scores between 1 and 10 to different families of macroinvertebrates encountered. This system assumes that the identification of the organisms must be up to the family level. The families most sensitive to pollution are on the top of the list and are assigned a score of 10. The most tolerant families get a lower score.

All families present in the combined samples which are composed of all samples taken at the sampling sites are listed. The ASPT was calculated by dividing the Biological Monitoring Working Party (BMWP) score calculated by adding the individual scores of all indicator organisms present by the number of families present, The ASPT values correspond to a water quality described by (Uherek, C. and Gouveia, F. 2014).

**Results and discussion**

*Composition and Distribution*

Phylum Arthropoda was the most diverse and Phylum Annelida was the least diverse group in the four study sites. There were eight families of macroinvertebrates collected in Piao, Dohinob Diut, and Dohinob Daku while in Langatian there were only six families. Simuliidae was only found in Langatian while the presence of Lumbriculidae, Thiaridae, and Pachychilidae was observed in all sampling sites. The presence of indicator species (marked with \*) was recorded as a basis in determining the water quality of the estuaries. There were seven indicator species in Piao, five in Dohinob Diut, four in Dohinob Daku, and 3 in Langatian. Lumbriculidae is present in the three sampling sites except for Langatian.

**Table 1.** Composition and Distribution of Macroinvertebrates in the four sampling sites.

Phylum	Order	Family	Common Name	Piao	Langatian	Dohinob Diut	Dohinob Dako
Arthropoda	Decapoda	Atyidae*	Shrimps	+	-	+	-
		Penaeidae*	Shrimps	+	-	-	+
		Panopeidae	mud crab	+	+	-	+
		Portunidae	Crab	-	-	+	-
	Odonata	Coenagrionidae*	Damselfly nymph	-	-	+	+
	Hemiptera	Gerridae*	Water striders	+	-	+	+
Annelida	Diptera	Simuliidae*	Blackfly	-	+	-	-
	Oligochaeta	Lumbriculidae*	Aquatic worms	+	+	+	+
	Mollusca	Basommatophora	Lymnaeidae*	Pond snails	+	+	+
Cycloneritida		Neritidae*	Snails	+	-	+	-
Sorbeoconcha		Pachychilidae	snails	+	+	+	+
	Neotaenioglossa	Thiaridae	trumpet snails	+	+	+	+

\*Indicator Species + Present - absent

*Relative Abundance*

Relative species abundance is a component of biodiversity and it refers to how common or rare a

species is relative to other species in a defined location or community. A total of 891 individuals from 12 families were collected.

Among 12 families, Pachychilidae has the highest relative abundance value of 51.40% while Coenagrionidae has the lowest relative abundance value of 0.22%. Pachychilidae gastropods are a conspicuous element of the freshwater macro-invertebrate fauna of South-East Asia (Köhler, F., Dames, C., 2009).

Thiaridae family ranks next to Pachychilidae with a relative abundance value of 28.17%. Thiaridae which are found mostly in tropical to subtropical regions worldwide, inhabit virtually all freshwater and brackish-water bodies, both in lotic (including springs, creeks, rivers, and streams) and lentic habitats (lakes and ponds) (N. Veeravechskij, D. Krailas *et al.*, 2018).

Atyidae and Penaeidae are widespread families of macroinvertebrates that have high economic value (Tenorio, *et al.*, 2015) that inhabit, rivers or estuaries. It was observed that these families were present in three sampling sites except in Langatian. On the other hand, Simuliidae were recorded in Langatian. The presence of these organisms in bodies of water indicates urban pollution impacts (Docile, *et al.*, 2015) since they can adapt in an aquatic environment with low oxygen, high or low pH, and warmer water (Walsh, 2006). Lumbriculidae was noted to be present in Piao and Langatian. This family of macroinvertebrates is known to be pollutant-resistant that can survive in an ecosystem with poor water quality (Jablonska, 2014).

**Table 2.** Relative Abundance of Macroinvertebrates sampled in four estuaries.

Family	No. of Ind.	R.A	Family	No. of In	R.A.
Atyidae	12	1.35%	Pachychilidae	458	51.40%
Coenagrionidae	2	0.22%	Panopeidae	5	0.56%
Gerridae	7	0.79%	Penaeidae	16	1.80%
Lumbriculidae	4	0.45%	Portunidae	7	0.79%
Lymnaeidae	3	0.34%	Simuliidae	5	0.56%
Neritidae	121	13.58	Thiaridae	251	28.17%
			Total	891	100%

*Water Quality Assessment*

The water quality of the four estuaries in the municipality of Roxas was determined using the BMWP-ASPT index from January to March 2020. Piao, Dohinob Daku, and Dohinob Diut scored 4.16, 4.2, and 4.5 respectively which is interpreted as good water quality. The presence of Coenagrionidae (damselfly nymph) in Dohinob

Diut and Dohinob Daku indicates a good water quality since this family of macroinvertebrates are very sensitive to water pollution. During sampling, it was observed that there were no signs of human activities and no non-biodegradable wastes found in these two sites including Piao because these rivers traverses rural barangays with few or no residents on the riverbanks.

**Table 3.** Comparison of Water Quality of the Four Estuaries.

	Piao	Score	Langatian	Score	Dohinob Diut	Score	Dohinob Daku	Score
Atyidae*	+	6	-		+	6		6
Penaeidae*	+	6	-				+	
Coenagrionidae*	-		-		+	8	+	8
Gerridae*	+	3	-		+	3	+	3
Simuliidae*	-		+	5	-		-	
Lumbriculidae*	+	1	+	1	+	1	+	1
Lymnaeidae*	+	3	+	3	+	3	+	3
Neritidae*	+	6	-		+	6	-	
BMWP Score*		25		9		27		21
ASPT		4.16		3.0		4.5		4.2
Interpretation		Good		Moderate		Good		Good

Source: \* Uherek, C. and Gouveia, F. 2014

Langatian estuary scored 3.0, interpreted as moderate water quality. The status of water quality could be attributed to human-related activities since the river traverses an urban barangay of the town. Domestic waste and sewage disposal contributed to the pollution in the estuary thereby changing the abundance of macroinvertebrates (J. L. Domingo & M. Nadal *et al.*, 2009).

The findings of this study showed similar results with Orwa *et al.*, (2012) in areas with higher human disturbance compared to the less disturbed sites. Family distribution of macroinvertebrates can also be altered by unpredicted floods and other biological factors.

### Conclusion

The BMWP-ASPT index indicated a "moderate" to "good" water quality of the estuaries in Roxas, Z.N. The use of Macroinvertebrates as a bioindicator emphasizes its utility as a monitoring tool in assessing water systems through time, as well as their ease of usage. Along with this, regular monitoring of the sampling sites is recommended to sustain, protect those estuaries with good water quality and improve the quality of impacted waters due to anthropogenic activities.

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