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Macroinvertebrates and plankton diversity as indicators of water quality in Langihan lagoon, Butuan city, Philippines

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Abstract

The study aimed to determine the diversity of aquatic macroinvertebrates and phytoplankton in Langihan Lagoon, Butuan City, Agusandel Norte, Philippines. Results show a total of thirteen (13) species of aquatic macroinvertebrates were found. Macroinvertebrates comprise Molluscs (55%), Arthropods (36%) and Oligochaeta (9%). For the phytoplankton, there were fourteen (14) species mostly belonging to the family Cyanophyta (21 individuals). Conventional physicochemical parameters were measured to describe the waters in relation to standard limits. The study revealed that the pH level, total dissolve solids, temperature, salinity, conductivity and resistivity of Langihan Lagoon were in the acceptable limits. PAST software was used to assess the diversity indices of the species. As to the physicochemical analysis, $p<0.05$ set as significant value to determine the water quality assessment and One Way Analysis of Variance were used.

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Introduction

Macroinvertebrates are diverse array of animals without backbones operationally defined as those that are retained by a sieve or mesh with pore size of 0.2 to 0.5 mm, as used most frequently in stream sampling devices. Lagoon macroinvertebrates include various groups of worms, molluscs, crustaceans, mites, and above all insects (Winterbourn, 2008).

Most invertebrates are important components of lagoon ecosystems. They graze periphyton, assist in the breakdown of organic matter and cycling of nutrients and, in turn, may become food for predators (Hynes, 2012; Jimoh *et al.*, 2011; Uwem *et al.*, 2011). Macroinvertebrates are organisms most commonly used for biological monitoring of freshwater ecosystems worldwide. This is because they are found in most habitats, have generally limited mobility, are quite easy to collect by way of well-established sampling techniques, and there is a diversity of forms that ensures a wide range of sensitivities to changes in both water quality and habitats (Hellawell, 2004; Abel, 2009).

Meanwhile, phytoplankton are microalgae at the base of the food web and directly or indirectly support all marine life. As highly efficient primary producers they are critical to maintaining biodiversity and supporting fisheries throughout the ocean (Randerson, J. T. & Falkowski, P., 2005). Due to their high turnover rates and sensitivity to changes in environmental conditions phytoplankton are useful indicators of changing oceanographic conditions, climate change, and deterioration in water quality (Beaugrand, G., 2008). Some phytoplankton produce toxins which may be accumulated by filter feeding shellfish, causing irritation, serious illness or death to animals and humans.

Phytoplankton growth depends on the availability of carbon dioxide, sunlight, and nutrients. Phytoplankton, like land plants, require nutrients such as nitrate, phosphate, silicate, and calcium at various levels depending on the species. Some phytoplankton can fix nitrogen and can grow in areas where nitrate concentrations are low. They also require trace amounts of iron which limits phytoplankton growth in large areas of the ocean because iron concentrations are very low. Other factors influence phytoplankton growth rates, including water temperature and salinity, water depth, wind, and what kinds of predators are grazing on them.

The fractions of phytoplankton flagellates and coccoid picoplankton, although smaller in size, can account for up to 90% of the total phytoplankton chlorophyll under low biomiass scenarios in offshore waters (Hallegraeff, GM. *et al.*, 2002). The latter are difficult, or impossible, to identify with light microscopy. Including a reliable estimate of biomass, along with cell abundance will provide more realistic information about the phytoplankton community structure at a particular point in time.

With this, aquatic invertebrates and phytoplankton are the most ubiquitous and diverse component of small non-perennial water bodies and have important potential for use in biological assessment of human impacts (ASSAF, 2016). The researcher aims to assess aquatic macroinvertebrate and phytoplankton assemblage and diversity.

Based on records, there is no studies have been conducted in Langihan Lagoon. Thus, this study serves as baseline data about the identification of macroinvertebrates, plankton and physicochemical assessment of water in the lagoon. Results of this study serve as an important reference in the presence of macroinvertebrates, planktons and quality of water.

Materials and Methods

The current study investigated the diversity of macroinvertebrates and plankton in Langihan Lagoon in the six stations with an objective to determine its diversity through water quality indicator. Three replications were measured in each station for data recording. Data were recorded in each station at specified time.

Statistical analysis

Paleontological Statistics (PAST) was used to assess the diversity indices of the species, namely: Evenness, Abundance, Richness and Shannon-Weiner Index. In determining the differences of physico-chemical data between elevations with $p<0.05$ set as a significant value, One way Analysis of Variance was used. Sørensen Index was used to compare the similarity composition of phytoplankton collected in the lagoon.

Water quality assessment

The study used a waterproof Cyberscan CD 650 multimeter kit to measure the selected physic-chemical parameters of water such as the pH, resistivity, temperature, conductivity, salinity, total dissolved solids (TDS), and dissolved oxygen (DO) in Table 1. In every station, there were three triplicates with readings of 30-m distance.

Table 1. Physico-chemical parameters with their corresponding unit of measurement, method of analysis, sample volume needed, reference and instrument.

Parameters	Unit	Method of analysis	Sample volume	Reference/Instrument
1. Conductivity	µS	Direct method (electrode)	Determine on site	Portable conductivity probe
2. pH	Range 0-14	Direct method (electrode)	Determine on site	Portable pH meter probe
3. Temperature	Degree	Direct method (electrode)	Determine on site	Portable conductivity probe
4. Total Dissolved Oxygen(TDS)	Ppm	Direct method (electrode)	Determine on site	Portable conductivity probe
5. Dissolve oxygen (Do)	Mg/L	Direct method (electrode)	Determine on site	Portable meter probe
6. Salinity	mg/L	Direct method (electrode)	Determine on site	Portable meter probe
7. Resistivity	(kΩ)	Direct method (electrode)	Determine on site	Portable meter probe

Collection of samples

The area was transected into six sampling stations with 30m distance. Each sampling stations have 3 replicates with 10-m distance. Sampling stations was established in the accessible sites of the lagoon. The researchers used the opportunistic method in which hand picking of macro invertebrates in shallow water was done. A D-net was utilized in the collection of plankton in the study site. In the identification of macro invertebrates and plankton, LASEZ (Leica Application Suite) was used.

Scoring, photo documentation and species identification

In the laboratory, collected samples of sediment from the different stations were separated through rinsing with running water in a 500um-mesh sieve shaker.

Table 2. Water Quality Index (WQI)

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)

The macroinvertebrates were sorted, counted, placed in a glass vials that was clearly labeled with sampling location and preserved using 95% ethanol. The larger aquatic macroinvertebrates were counted and photographed using digital camera. Reliable Internet sources and journals were used to identify the macroinvertebrates and planktons.

Water quality index (WQI)

The scores to measure the Water Quality Index (WQI) of species developed by Armintage (1983) were scored according to their classifications using a matrix that has its corresponding points of a particular macroinvertebrates. The sum that obtained for all scored species and divided to the total of species that were scored. The resulting value was the WQI, described in Table 2 below.

Table 3. Average Score Per Taxon (ASPT) by Friedrich (1996).

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

Average score per taxon (ASPT)

The Average Score Per Taxon (ASPT) indicates the mean score of all taxa. Aquatic macroinvertebrates species were scored utilizing the Biological Monitoring Working Party (BMWP)

Results and Discussion

Results showed that the pH level, total dissolve solids, temperature, salinity, conductivity and and resistivity of Langihan Lagoon were in the acceptable limits as presented in Table 4. Hence, this value of pH as water quality parameter would simply means it is less desirable for existence of the aquatic organisms (Flores, 2012). Furthermore, there was a significant difference in total dissolve solids, conductivity, resistivity and dissolve oxygen of the three sampling stations. On the other hand, there was no significant difference in the temperature and salinity of the sampling sites.

Table 4. Physicochemical analysis of water quality in Langihan Lagoon.

Physicochemical parameters	Stations					
	Langihan Lagoon					
	s1	s2	s3	s4	s5	S6
TDS (mg/L)	317.5±15.5	317.5±15.5	308±0	320.5±12.5	320.5±12.5	320.5±12.5
Ph	7.37±0.04	7.39±0.03	7.32±0.01	7.41±0.05	7.41±0.05	7.42±0.04
Temperature	29.65±0.55	29.65±0.55	28.6±0	29.4±0.82	9.4±0.8	30.25±0.05
Salinity (mg/kg)	0.305±0.015	0.305±0.015	0.31±0	0.315±0.015	0.315±0.015	0.31±0.01
Conductivity (mS/cm)	0.63±0.013	0.63±0.013	0.62±0	0.64±0.02	0.64±0.02	0.64±0.02
Resistivity (kΩ)	1577.5±78.5	1577.5±78.5	1595±0.04	1547±48	1547±48	1561.5±62.5
DO (mg/L)	5.47±1.46	5.47±1.46	6.75±0	6.84±0.09	6.84±0.09	7.035±0.105

Table 5. Aquatic macroinvertebrates and their corresponding taxa groupings.

Phylum	Order	Family	Scientific name	Common name	Taxa
Arthropoda	Hemiptera	Notonectidae	*Buenoaconfusa*	Backswimmers	2
	Itemiptera	Corixidae	*Hesperocorixiacastanea*	Water Boatman	0
	Hemiptera	Gerridae	*Gerrisremigis*	Water Strider	2
Mollusca	Gastropoda	Planorbidae	*Planobariuscorneus*	Orbs Snail	3
	Gastropoda	Physidae	*physidae*	Pouch Snail or Lunged Snail	3
	Gastropoda	Neritidae	*Neritidae* spp. 1	Nerites	3
	Gastropoda	Physidae	*Physilla*	Bladder Snail	3
Oligochaeta		Annelida	*Oligochaeta*	Aquatic Worm	0

Aquatic Macroinvertebrates Diversity Indices

Table 5 showed the aquatic macroinvertebrates from the six sampling areas with their corresponding APT and WQI. It revealed that the water quality of Langihan Lagoon was evaluated as rather dirty water-average with the score of 4.81 respectively. For its ASPT, Langihan Lagoon has score of 2.36 rated as poor water quality. This is because the lagoon is the (BMWP).

Table 6. Aquatic macroinvertebrates as to their ASPT and WQI Scores.

	Station 1						Station 2						Station 3					
Scientific Name	1	2	3	Total	ASPT	WQI	1	2	3	Total	ASPT	WQI	1	2	3	Total	ASPT	WQI
Thiara scabra	0	0	1	1	3	3	0	0	0	0	3	3	0	0	0	0	3	3
Buenoa confusa	2	4	9	15	5	5	6	13	6	25	5	5	6	1	9	16	5	5
Hesperocoxia costanea	1	0	0	1	5	5	0	0	0	0	5	5	0	0	0	0	5	5
Chironomidae	0	0	1	1	2	2	0	0	0	0	2	2	0	0	0	0	2	2
Planobarius corneus	7	0	0	7	3	3	0	0	0	0	3	3	0	0	0	0	3	3
Neritidae spp. 1	0	0	1	1	6	3	0	0	0	0	6	3	0	0	0	0	6	3
Physilla	3	5	0	8	3	3	0	0	0	0	3	3	0	0	0	0	3	3
Pomacea	13	19	18	50	3	3	7	16	10	33	3	3	15	19	16	50	3	3

Through adding the individual scores was obtained of all indicator species that are present and divided by the number of species that are present, ASPT will be result. The ASPT values correspond to the water quality (Table 3).

Existence of the aquatic organisms (Flores, 2012). Furthermore, there was a significant difference in total dissolve solids, conductivity, resistivity and dissolve oxygen of the three sampling stations. On the other hand, there was no significant difference in the temperature and salinity of the sampling sites. catch basin of liquid wastes from public market and the residents causes very poor water quality.

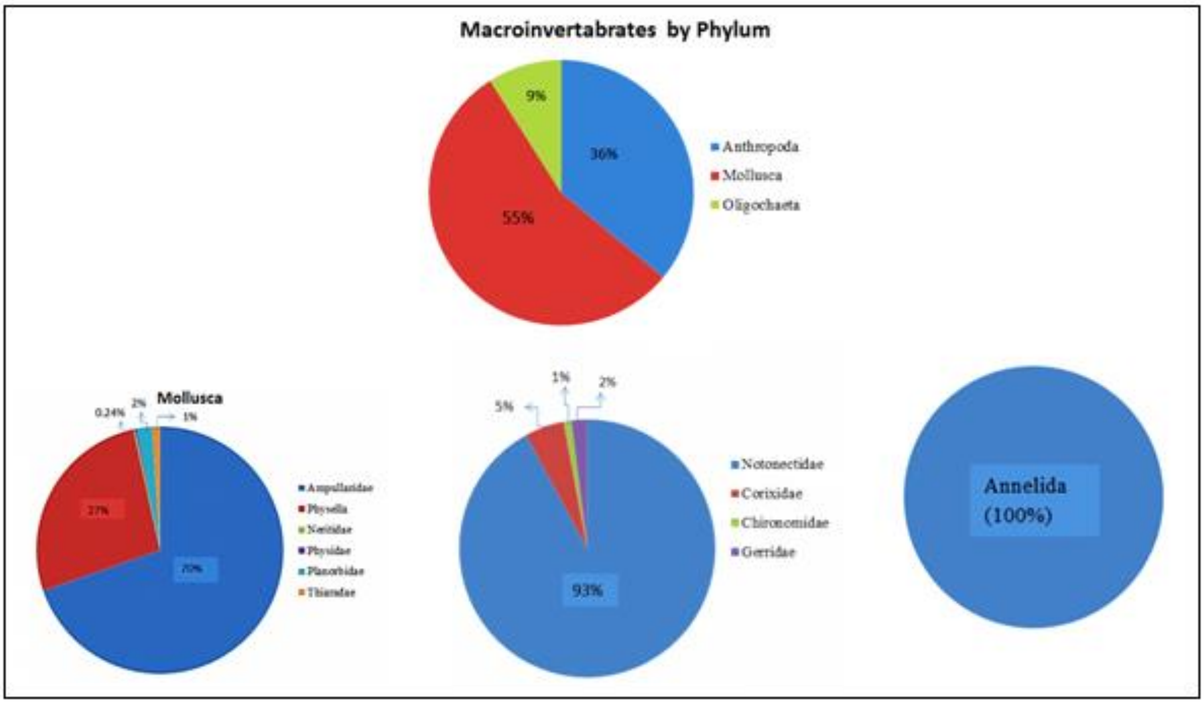

Fig. 1. Percentage of aquatic macroinvertebrates in its respective phyla

There were nine (9) aquatic macroinvertebrates species from eight (8) families collected (Table 2). Mostly of the collected species were Molluscs (55%), Arthropods (36%) and Oligochaeta (9%) as presented in the Figure 1. Among the six (6) sampling sites, Pomacea has the highest number of individuals. Moreover, this station also has the highest value of dissolve oxygen and total dissolve solids. Dissolved oxygen (DO) plays a vital role in an aquatic ecosystem. On the other hand, optimum levels of DO can result to good growth, thus result to high diversity.

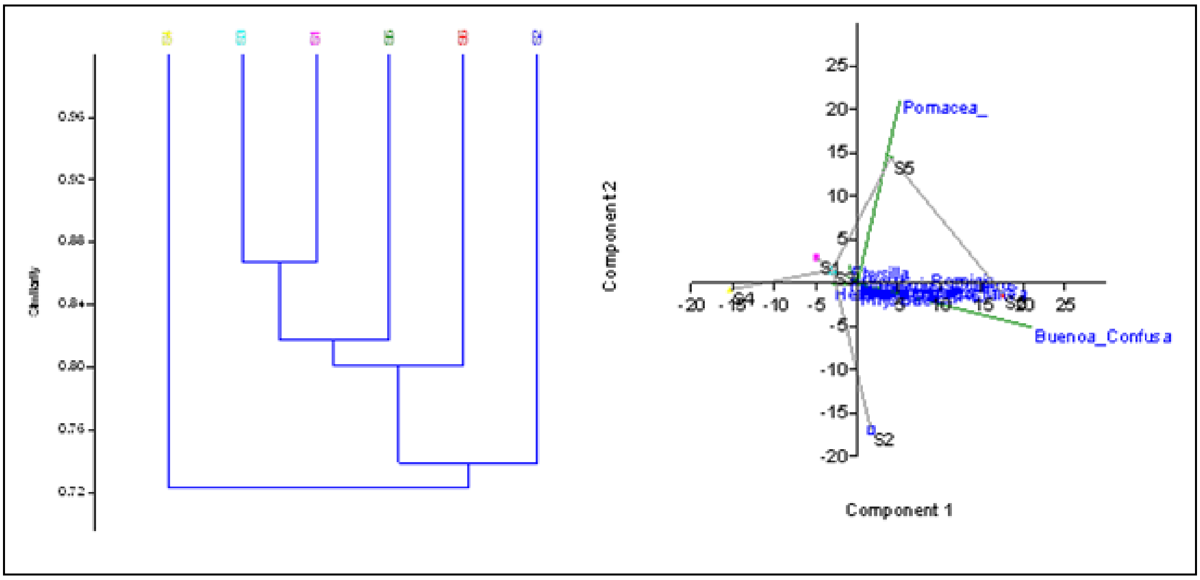

Fig. 2. Multivariate Relationships between Sampling Stations based on the Population of the Aquatic macroinvertebrates. A: Dendogram of the similarity of macroinvertebrates Populations; B: Principal Component Analyses showing Distinct groupings of macroinvertebrates in Langihan Lagoon.

Table 7. Diversity indices of aquatic macroinvertebrates in the lagoon

	S1	S2	S3	S4	S5	S6
Taxa_S	8	3	2	3	4	3
Individuals	84	59	66	55	88	90
Dominance_D	0.4028	0.4927	0.6327	0.686	0.5816	0.503
Simpson_1-D	0.5972	0.5073	0.3673	0.314	0.4184	0.497
Shannon_H	1.258	0.7579	0.5539	0.6002	0.7403	0.7324
Evenness_e^H/S	0.44	0.7113	0.87	0.6075	0.5242	0.6933

Table 8. Phytoplankton groups and dominant species in the lagoon

Phytoplankton Groups	Family	Species	Dominant Species
Cyanobacteria	Cyanophyta	21	*Microsytis*
Diatom	Bacillariophyta	4	*Stephanodiscus*
	Conscinodiscaeae	1	*Conscinodiscus*
Dinoflagellata	Dinophyceae	1	*Alexandrium dinoflagellate*
	Gymnodiniaceae	1	*Gymnodinium*
Protozoa	Euglenophyta	10	*Phacus suecicus*
	Euglenophyta	1	*Phacus longicauda*
	Euglenophyta	1	*Phacus Acatus*
	Euglenophyta	1	*Phacus acuminatus*
	Euglenozoa	2	*Trachelomonas volvocina*
Flagellate	Euglenoida	2	*Peranema spec*
Green Algae	Chlorophyta	7	*Dictyosphaerium*
	Chlorophyta	3	*Surirella striatula*
	Desmidiaceae	1	*Micrasterias* sp.

Table 8 shows the relative abundance of phytoplankton in six (6) sampling stations. Based on the data, mostly Microsytis (18 individuals) plankton were found. This kind of plankton goes in colonies as one number of specie. *Phacus suecicus* has ten (10) individuals in all transected station areas but it was mostly found in station six (6). *Phacus suecicus* has ten (10) individuals found in station three and none in station two. Another species that have more numbers were the *Dictyosphaerium* (7) individuals in all station areas. The stations with mostly found phytoplankton were in station four with five (5) *Dictyosphaerium, Trachelomonas volvocina* and *Peranema spec* has two (2) and three (3) *Surirella striatula*. The phytoplankton that have similar number of individuals are *Phacus acaminatus, Gymnodinium, Alexandrium dinoflagellate, Phacus longicauda, Phacus acatus, Conscinodiscus*, and *Phacus acuminatus* in all transected areas in Langihan Lagoon.

Conclusions

It is concluded that the pH level, total dissolve solids, temperature, salinity, conductivity and resistivity of Langihan Lagoon were in the acceptable limits but it needs more efforts to make the lagoon protected from throwing garbage and dirty drainage desirable for the diversity of the aquatic macroinvertebrates and phytoplankton as indicators of water quality. The water must be conserved because aquatic macroinvertebrates and phytoplankton serve as foods for the fishes and some other organisms living in the lagoon as components of water ecosystem. The lagoon also needs to be protected because many residents were living near the area using the water for washing clothes, watering plants, even fishing as sources of their livelihood or foods. Based on findings, it is recommended that the Local Government Units (LGU) will need to promulgate ordinances to disallow dumping garbage to make the water of the lagoon safe for future use.

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