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Water quality standards and plankton species composition in selected river system in Cagayan de Oro City, Philippines

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Abstract

This study describes the water quality standards in terms of physico-chemical characteristics of river system in Cugman and Bigaan Rivers and the composition of plankton species (Phytoplankton and Zooplankton). Specifically, this study determined if there are differences in physico-chemical properties and plankton composition in upstream, midstream and downstream water samples (Class B Classification) and compared these values to the DENR standards. Standard methods were employed for the physico-chemical characteristics of the river water. General findings on three sampling periods for Cugman river for physico-chemical parameters conformed to the standard set by the DENR for Class B water except that the TSS value and lead concentrations in water were higher while Bigaan river adhered with the standard except for the high values of lead concentration which may affect the quality of water and the life of aquatic organisms. For water quality analysis, it is concluded that the water quality of Bigaan river is by far of good condition which may allow planktons and other aquatic organisms to exist while Cugman river might have a less diverse plankton composition because of the high value of TSS which may affect photosynthetic activity of the planktons. The dominant phytoplankton in Cugman river is *Chaetoceros decipiens* while *Thalassionema nitzchiodes* and *Dissodinium pseudolunula* in Bigaan river. Zooplanktons species in Cugman river and Bigaan river are mayfly (*Ephemeroptera*), midge larvae (*Chironomidae*) and stonefly (*Plecoptera*). The planktons collected and identified are indicators of good water quality and within the standards set by the DENR, Philippines.

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Introduction

Water is an important element of all living beings. It performs exceptional and crucial activities in earth ecosystem, biosphere and biogeochemical cycles. The extent of human activities that influences the environment has increased dramatically during the past few decades. Terrestrial, freshwater and marine ecosystems are all affected. The scale of socio-economic activities, urbanization, industrial operations and agricultural production has reached to the points where it interferes with the natural processes within the same watershed that affected the water resources.

Water quality can be determined by several factors like the growth and diversity of aquatic micro flora and fauna in river system is which highly inclined by several physico-chemical and biological parameters. Several factors can also be used to determine river water quality like pollution (Amaya, Gonzales, Hernandez, Luzano, & Mercado, 2012; O.P. Canencia, Dalugdug, Emano, Mendoza, & Walag, 2016), biotic communities (Miltner, White, & Yoder, 2004), physico-chemical parameters (Shane, De Michele, & Cannon, 1971), and many more.

Several studies have been conducted around the world and in the Philippines have been conducted to determine river water quality through various physico-chemical parameters and through various biotic component (Alvarez-Mieles *et al.*, 2013; Bhatt & Pandit, 2010; Ogleni & Topal, 2011, Canencia & Daba, 2015). The good river system on the other hand is determined by its plankton composition that gives more information on changes in water quality. Plankton studies and monitoring are valuable for control of the physico-chemical and biological conditions of the water. Over the last few decades, there had been much attention in the processes influencing the development of plankton communities, primarily in relation to physico-chemical factors (M. O. Canencia & Metillo, 2013; Elliott, Irish, & Reynolds, 2002; Scherwass, Bergfeld, Schöl, Weitere, & Arndt, 2010; Thompson, 2012).

The importance of determining plankton composition in river systems is that these organisms are primordial to the survival of a freshwater ecosystem since they serve as baseline of food webs (Thompson, 2012).

Microinvertebrates such as phytoplankton and zooplanktons have also been used as bio-indicators of stream biological reliability (Miltner *et al.*, 2004). Within this structure, the use of a multi metric approach that utilizes the index of biotic integrity (Karr, 1981) has gained interest in biological assessment of rivers and streams in urban and suburban catchments. Not just plankton composition should be noted but also the different physico-chemical parameters since they are immediately affected by seasonal variability which would regulate the type and abundance of plankton in an area (De Castro, San Diego-McGlone, & Talaue-McManus, 2005). Various pollution and degradation to water can also be determined through various physico-chemical parameters which often lead to the quality of plankton life as shown in the study conducted in Christina River (Shane *et al.*, 1971)

Cagayan de Oro is a city abundant in water characterized by seven rivers traversing across the city which empties into the Macajalar Bay. Two of the seven rivers found in Cagayan de Oro City, Cugman and Bigaan Rivers, have been surrounded with communities noted to have high population growth high rate of urbanization (Walag & Canencia, 2016). This increased population and waste generation in the nearby communities of the two river systems prompts for an immediate determination of the water quality as shown in various studies where population growth is seen to helping increase the deterioration of water quality (Amaya *et al.*, 2012; Scherwass *et al.*, 2010; Welker & Walz, 1999).

Moreover, a study on Cugman Watershed Assessment conducted by (Pasco & Picut, 2010) emphasized the vulnerability of the river due to natural and man-made hazards but it was not able to present the physico-chemical aspects of the river and the plankton composition.

At present, there has been no empirical data related to the conduct of the study of Cugman and Bigaan Rivers in terms of the composition of planktons and analysis of the river water quality, hence this study. Hence, the main aim of this study is assess the water quality and plankton composition of Bigaan and Cugman Rivers. Thus, it specifically aims to: (1) determine the pH, DO, TSS, BOD, water and air temperature, lead and chromium concentration; and (2) determine the plankton present in the two river systems.

Materials and methods

Study Area

The whole study area is located at Barangay Cugman with the two rivers as boundaries between Barangay Cugman and Barangay FS Catanico for Cugman river and Barangay Gusa and Barangay Cugman for Bigaan river. However, the sampling area for Cugman river started at the upper part of Barangay Cugman near FS Catanico boundary. Sampling area for Bigaan river started at the Upper part of Barangay Gusa particularly Sikyop Area.

Table 1. Geographic coordinates of the upstream, midstream, and downstream of Cugman and Bigaan Rivers.

River	Site	Landmarks	Coordinates
Cugman river	Upstream	Boundary between FS Catanico and Cugman	08°27'48.6" N, 124°42'32.4" E
	Midstream	Zone 2, Dike Area	08°27'45.9" N, 124°42'30.2" E
	Downstream	Zone 1 and 3, Boracay Area	08°28'28.0" N, 124°42'14.7" E
Bigaan river	Upstream	Upper Gusa Sikyup Area	08°27'27.4" N, 124°41'04.3" E
	Midstream	None	08°28'19.6" N, 124°41'23.7" E
	Downstream	Zone 8 and 10, Cugman Area	08°28'43.3" N, 124°41'16.1" E

Survey and ocular inspection of the research site had been done. Upstream, midstream and downstream location site samples were identified using GPS device as summarized in Table 1.

Sample Collection

The study has collected water samples from the upstream, midstream and downstream sampling sites. A GPS device was used to determine the exact location for the sampling spot. Proper collection procedures were observed to prevent any significant change in the composition of the samples prior to their analysis to ensure accurate analytical results. Water sample containers were properly labeled.

In this study, since the water sample collected was held in a container, a temperature of 4–10°C was maintained by putting chunks of ice inside the container and the samples were analyzed in 6 hours after collection. The water samples for physico-chemical analysis were collected for three sampling periods and it was collected in the middle section of the river.

The plankton sampling procedure was conducted simultaneously with the water sampling for physico-chemical characteristics but since the plankton collections for three trials were not successful, the sampling was done for about eight times. The sampling method for plankton was more rigid since the water was collected three times in a cross sectional area.

Water Quality Analyses

For the water quality assessment, parameters such as air and water temperature, pH, dissolved oxygen (DO), solids content (suspended), biochemical oxygen demand (BOD), and heavy metals (lead, chromium) concentration were determined. Methods employed for the analysis of the physical and chemical characteristics of the river water were classical gravimetric and volumetric methods which varied from simple field testing to laboratory-based, multi-component instrumental analyses.

Temperature (water, air) and pH value were recorded in-situ (on site). Analytical procedures were derived from the Standard Methods for the Examination of Water and Wastewater of American Public Health Association, American Water Works Association, & Water Environment Federation (1999). Lead and chromium heavy metal analyses were done using a Shimadzu Atomic Absorption Spectrophotometer. Total suspended solid (TSS) was determined through the filtration apparatus using fiberglass disk while Dissolved oxygen (DO) was determined using Hach Titration and dilution methods. Biological oxygen demand (BOD) was determined using the 5-day BOD Test.

Plankton Composition and Determination

The water sampling for plankton analysis was conducted in a three cross-sectional area. Sample bottles were prepared by covering it with a carbon paper to regulate temperature change and covered with a black garbage bag to avoid light penetration since planktons are sensitive to light. The three (3) sample bottles labeled trial 1, 2, 3 which correspond to the three cross-sectional in every sampling site, were filled with 100.0 mL water from the container bottle after the plankton net was thawed. The samples were properly labeled particularly on the location of the sampling site. The mesh size of the plankton net utilized was 28 micrometer. Logul's iodine solution was added in the sample as a preservative. The sampling bottles were then placed in a container with a regulated temperature of 4°C.

The samples were examined for both phytoplankton and zooplankton under a compound microscope under high power objective. The counting was done in a counting chamber through Sedgwick-Rafter Counting Chamber.

Results and discussion

Physicochemical parameters of the two rivers covered in the study were taken to assess the water quality of river compared to the standards set by the Department of Environment and Natural Resources (DENR) is summarized in Table 1. Both rivers passed the standard set by DENR except for Cugman river for TSS and lead concentrations for both Cugman and Bigaan Rivers. These parameters are indicators of pollution from nearby communities and may be due to the fact that both rivers, especially Cugman river where it is considered as dumping sites of many solid and liquid wastes from nearby households. It is also good to note that there were no traces of chromium in both rivers which may be due to succeeding rainfalls in the area that might diluted the concentration of chromium in the river water

Table 2. Mean physicochemical parameters in Cugman and Bigaan rivers.

Parameters	Cugman river			Bigaan river			Standard*
	Upstream	Midstream	Downstream	Upstream	Midstream	Downstream	
pH	8.17	8.2	8.1	8.03	7.9	7.87	6.5-8.5
DO (mg/L)	5.57	7.96	7.66	7.52	7.11	7.13	5
TSS (mg/L)	82.89	82.77	118.78	12.11	17.67	17.78	65
BOD (mg/L)	0.8	0.95	1.62	1.09	0.46	0.51	5
Water Temperature	22	22.33	22.67	24.33	24.67	25	26-30
Air Temperature	23.67	24	24	26.33	26.67	26.67	23-30
Lead (ppm)	0.597	0.636	0.675	0.464	0.456	0.647	0.01
Chromium (ppm)	nil**	nil	nil	nil	nil	nil	0.01

*Department of Environment and Natural Resources Standards of Class B Water, **no traces detected

The composition of phytoplankton in Cugman and Bigaan rivers is summarized in Table 3. *Thalassionema nitzchiodes* (Bacillariophyta) and *Dissodinium pseu dolunula* (Dinophyta) species were identified in Bigaan river while *Chaetoceros decipiens* (Bacillariophyta) species was identified in Cugman river. *Thalassionema nitzchiodes* (Bacillariophyta) dominated Bigaan river from upstream to downstream level. *Thalassionema nitzschioides* (Bacillariophyta) *has* valve end which is similar in width and length. Marginal structure visible with ribs.

The sternum is wide with one marginal row of areolae which is circular (Belcher & Swale, 1979). *T. nitzchiodes* is a diatom (Bacillariophyta) which is a major group of algae and is one of the most common types of phytoplankton. Most diatoms are unicellular and producers within the food chain (Boonyapiwat, 1999).

Another phytoplankton that appears in the midstream part of the Bigaan river was *D. pseudolunula* (Dinophyta). *D.* (Dinophyta) is a dinoflagellates. Dinoflagellates are unicellular protists that manufacture own food using sunlight. Dinoflagellates are perhaps best known as a cause of harmful algal blooms known as red tides.

C. decipiens (Bacillariophyta) dominated Cugman River from upstream to downstream. *Chaetoceros* is a single-cell organism belonging to the group of algae called diatoms. Diatoms are unique among phytoplankton in having a glasslike exterior made of silica. *Chaetoceros* forms chains and has long spinelike projections, called setae, to help it stay afloat in the water column. The chloroplasts appear to be quadrangular in singular view and elliptic or circular in valve view (Wetz & Wheeler, 2007).

Table 3. Phytoplankton and zooplankton species in Cugman and Bigaan Rivers.

Type	Species	Cugman	Bigaan
Phytoplankton	*Thalassionema nitzchiodes*	-	+
	Dissodinium pseudolunula	-	+
	Chaetoceros decipiens	+	-
Zooplankton	Meroplanktons		
	Stonefly (Plecoptera)	+	+
	Midge Larvae (Chironomidae)	+	+
	Midge Pupae (Chironomidae)	+	+
	Mayfly (Ephemeroptera)	+	+
	Copepoda		
	Cyclops sp. (Crustacean)	-	+

In Cugman river, the mayfly (Ephemeroptera) dominated the upstream, midstream and downstream area of the river. It was then followed by the population of midge larvae and stonefly as shown in Table 4. In Bigaan river, midge larvae dominated upstream, midstream and downstream area of the river. It was then followed by mayfly and stonefly.

Table 4. Distribution of Zooplanktons in Cugman and Bigaan Rivers.

Rivers	Upstream	Midstream	Downstream
Cugman	Mayfly Stonefly Midge larvae	Midge pupae Mayfly	Mayfly Midge larvae Stonefly
Bigaan	May fly Midge larvae Stonefly	Midge larvae Mayfly stonefly	Midge larvae Copepod

Conclusion

It has been concluded based on the findings during the three sampling periods that Cugman River met some aspects of the physico-chemical water parameters test such pH, BOD, DO, air and water temperature and a negative concentration of heavy metal chromium but unable to meet the standard TSS value and lead concentrations in water with the standard set by the DENR for Class B water.

Furthermore, Bigaan River adhered with the standard set by the DENR for Class B water in terms of its pH, BOD, DO, air and water temperature, TSS and a negative concentration of heavy metal chromium but the water in Bigaan River registered a high value of lead concentration of water which may affect the quality of water and the life of aquatic organisms. The two rivers possessed a variety of compositions in terms of its phytoplankton and zooplankton. The existence of the planktons in both rivers is an indicator that the river is still not polluted and less affected by anthropogenic activities.

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