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Effects of physico-chemical characteristics of Bigaan River to the species richness and distribution of freshwater *Ichthyofauna*

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Abstract

This study was conducted to assess the physicochemical characteristics of Bigaan River and determine species richness and distribution of *Ichthyofauna*. Water samples were collected from three sampling sites of Brgy. Gango, Brgy. Indahag and Brgy. Cugman using grab sampling method during the wet season to determine water quality parameters namely: Total Solids, Total Suspended Solids (TSS), Turbidity, Total Dissolved Solids (TDS), Conductivity, Density, Redox Potential (ORP), pH, Salinity, Biochemical Oxygen Demand (BOD), Nitrates, Potassium, Phosphate, and Mercury while other parameters were measured onsite namely: Temperature, Dissolved Oxygen (DO), and Flowrate. The collection of fish species was done using purposive sampling. The findings of the study revealed that all physicochemical parameters have not exceeded the given standard values of DAO 2016-08. Results also showed significant differences in the parameters: total dissolved solids and turbidity. There were five identified *Ichthyofauna* species present in Bigaan River and it showed low diversity. *Puntius binotatus* is the most abundant species and *Oreochromis niloticus* is the least number of *Ichthyofauna* species. The *Ichthyofauna* species richness and distribution identified in Bigaan River have different tolerance on water quality. Some species were tolerant and sensitive to the water quality fluctuations and they were absent in a particular area. Although Bigaan River is within the acceptable level for Class C waters according to DAO-2016-08; however, water quality in Bigaan River limits the condition of *Ichthyofauna* species survival and growth because it was disrupted by sudden changes in the water quality.

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Introduction

Prominent anthropogenic activity that influences the water quality is mining. Mining involves exploration and removing of minerals from the earth, this process of removing precious metals from the ore use some heavy metals like mercury in amalgamation process which resulted in contamination of riverine system. Mercury contamination on freshwater from mining may cause by tailing ponds that overflow and runoff' into the surface of water. Mercury is persistent, bio-accumulative and it is known to bio-magnify through aquatic food chains causing deleterious environmental effects (Powell, 2009). When mercury gets into water, bacterial activity can change into a form of methyl mercury which can be absorbed by aquatic organisms. It may affect the distribution and richness of species on freshwater organisms, like fishes and macroinvertebrates. Fish are the most diverse group of vertebrates with more than 30,000 species worldwide (Desidera *et al.*, 2019). It can be found in every underwater habitat such as marine and freshwater. Freshwater fishes are the most threatened group of vertebrates based on more than 5,000 species assessed by the IUCN (Reid *et al.,* 2013). In other words, water quality of a river may affect the growth, survival, and biodiversity of fish on the water.

Bigaan River is one of the seven rivers traversing across the city of Cagayan de Oro (Canencia & Gomez, 2016). Many people depend on Bigaan River because they use it for washing their clothes, bathing and even for their daily food consumption such as fish. The river is now surrounded by communities with high populations (Walag & Canencia, 2016). Population growth can increase the deterioration rate of the Bigaan River on its excessive use and dumping of the waste directly or indirectly into the river. Unfortunately, jeopardizing the water quality can affect living aquatic organisms such as fish. Freshwater fish in the Bigaan River are edible. Many of the local people use them for daily consumptions. In the light of these scenarios, the researchers assessed the physicochemical characteristics of the Bigaan River and the species richness and distribution of freshwater fish. Previous researches conducted were about the accumulation of mercury on fishes but there was no study related to the diversity of fishes, specifically on its species richness and distribution affected by water quality in the Bigaan River. The main objective of this study is to assess the physicochemical characteristics of the Bigaan River during wet season and determine the effects of the water quality on the species richness and distribution of freshwater fish. Specifically, it: i.) determines the physicochemical characteristics of Bigaan River; ii.) compares the measured water quality parameters with DENR (DAO-2016-08) standards; iii.) assess if there is a significant difference in the measured values of water parameters between sampling periods and among sampling sites, and iv.) determines the *Ichthyofauna* species richness and distribution of the river.

Materials and methods

Research Setting

The study was conducted in Bigaan River, Northern Mindanao, Philippines (Fig. 1). Water samples were collected at the identified sampling sites along Bigaan River namely Barangay Gango, Indahag and Cugman that stretches 4,799 meters. Each sampling site has three sub-sites as shown in Fig. 2.

Data Collection Method

Water sampling was conducted during the wet season in each sub-sampling sites (see fig. 2), specifically from November 2018, December 2018 to January 2019, and collection were done from three (3) sampling sites namely: Barangay Gango, Barangay Indahag and Barangay Cugman.

Collection of Water Samples

Polyethylene terephthalate (PET) bottles about 1.5 L were used for the collection of water samples used for some physicochemical parameters and a separate 1 L wide mouthed BOD bottles for the biochemical oxygen demand (BOD) analysis. Water samples were collected below the water surface and the bottles were covered while still in the water to avoid intrusion of atmospheric air. The samples were preserved on an ice-filled ice bucket and brought to

the USTP laboratory for analysis. Water samples for BOD analysis were immediately brought to the laboratory and analyzed within six (6) hours from the time of sampling.

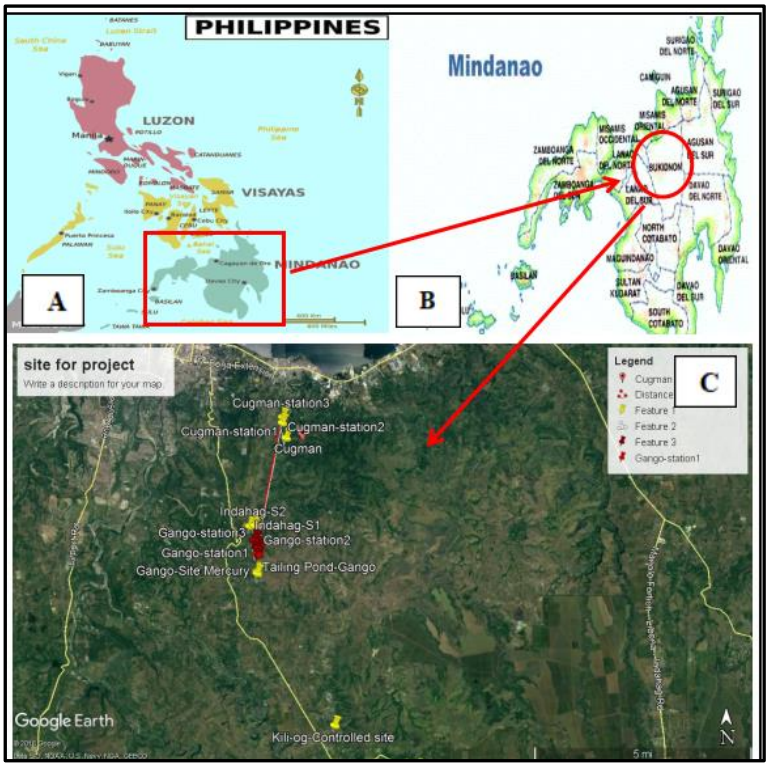

Fig. 1. Map of the Philippines, Mindanao and three sampling sites in Bigaan River.

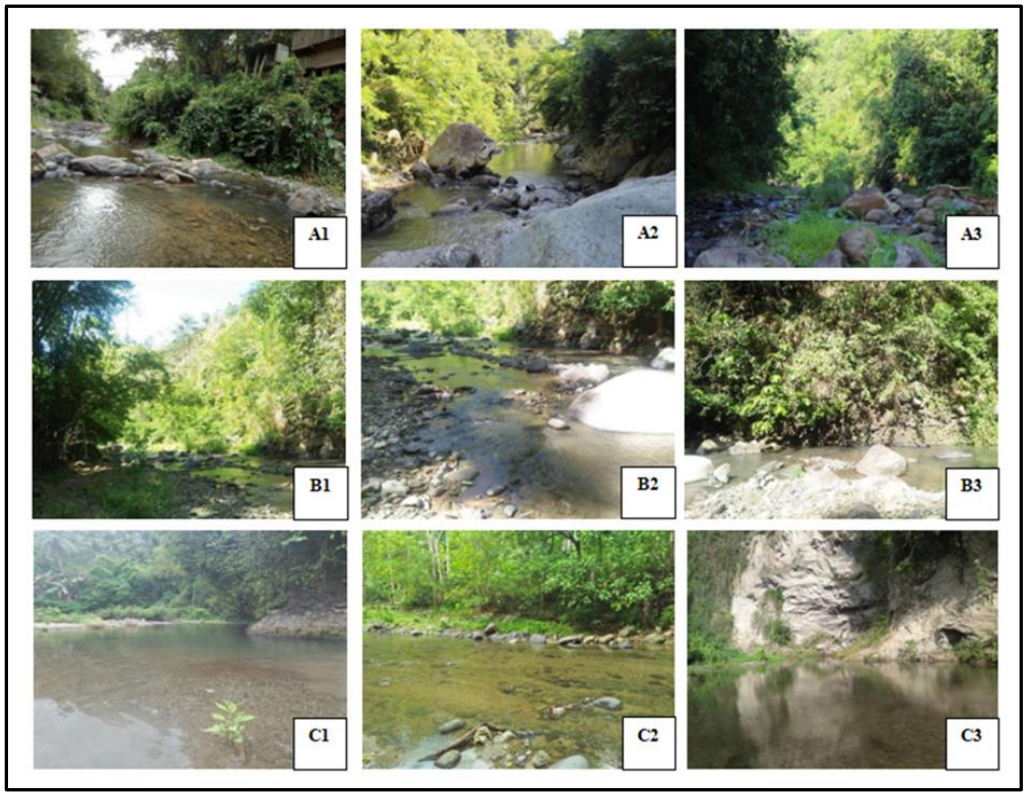

Fig. 2. Study Sampling Sites: Gango subsites (A1, A2 & A3); Indahag subsites (B1, B2 & B3); Cugman subsites (C1, C2 & C3).

On site Analysis

There were water quality parameters which were measured onsite, namely: dissolved oxygen, temperature, and flow rate. These were measured using digital instruments.

Laboratory Analysis

Other water quality parameters were analyzed in the University of Science and Technology of Southern Philippines (USTP) laboratory. These parameters include: conductivity, density, pH, redox potential, salinity, total dissolved solids, turbidity, biochemical oxygen demand, total solids, total suspended solids, nitrates, phosphates, potassium and mercury.

Collection of Fishes and Identification

Fish Sample Collection

On getting samples of fish on each sampling site, the researchers used a purposive method to collect all the fish. All types of fish were collected. Dip nets were used to sample shallow waters with dense aquatic vegetation. The net was thrusted into the vegetation to scare out hiding fishes into the net. Alternatively, dip nets were useful for collecting small fishes that hides or nest in or under rocks in shallow water. The net was simply placed downstream of the rock, the rock is lifted, and the fish usually scares downstream into the net. Fish species were identified by an expert.

Diversity Indices

1. Species Richness

It refers to the number of different species of fish that was present in every sampling site, namely Barangay Gango (site 1), Indahag (site 2), and Cugman (site 3). Species richness was determined by simply counting the total number of different species collected from the three sampling sites of Bigaan River.

2. Species Distribution

It refers to the biological taxon of fish species that has dispersal capabilities, either occupying large areas due to constant alteration of areas or destroying habitats.

3. *Shannon-Weiner Function*

A quantitative measure that reflects how many species present in the sample of certain size. Index Diversity using Shannon-Weiner Function (H^1) is the formula that is commonly adopted.

$$H = -\sum Pi \log_2 Pi$$

Where, H= Shannon- Weiner Index

$$Pi = \frac{ni}{N}$$

Where:

ni = numbers of individuals of each species in the sample

N = total numbers of individuals of all species in the sample.

Results and discussions

Physico-chemical Characteristics of Bigaan River

Different physicochemical parameters were conducted in order to determine the water quality along the three stations of Bigaan River; Brgy. Gango, Brgy. Indahag and Brgy. Cugman. It is also to test whether the water quality has reached its standard value of the water for the consumption of fish. The researchers used the standard set by DAO-2016-08 to evaluate the physicochemical quality of the three different sites of Bigaan River. The average values were obtained from the water quality assessment of the river on November 2018, December 2018 and January 2019. The results of the physicochemical characteristics of Bigaan River with comparison to DAO-2016-08 and statistical analysis p-value is presented in Table 1.

Potential of Hydrogen (pH)

In this study the highest pH value recorded was 9.43 at the Cugman area during in Nov.2018 (see table 1), while the lowest pH value recorded was at 7.48 at the Gango area in the same month. Aquatic organisms are affected by pH because most of their metabolic activities are pH-dependent. The optimal pH range for sustainable aquatic life is pH 6.5-8.2. The pH of an aquatic system is an important indicator of the water quality and the extent pollution in the watershed areas (Kumar & James, 2013). A higher value of pH may be due to the influx of minerals from rocky strata which is carried and deposited much in

the lower part of the river, the Cugman area. Statistically, pH values among sampling sites and between sampling periods of Bigaan River have no significant difference. All pH levels were observed to be slightly basic or alkaline due to the amounts of carbonates, bicarbonates, borates, and silicate compounds which could be present from the rocks and minerals in the river.

Table 1. Physico-chemical characteristics and of Bigaan River during the WET SEASON on November 2018, December 2018 and January 2019 with Standard of DAO-2016-08 and p-values from statistical analysis.

	November, 2018			December, 2018			Januray, 2019			Standard Class C	Statistical Analysis
Parameters	Gango	Indahag	Cugman	Gango	Indahag	Cugman	Gango	Indahag	Cugman	DAO-2016-08	p-value
Temperature, °C	27	25	22	26	26	26	25	25	26	25-31	0.06226
TSS,mg/L	9.38	5.73	4.03	10.83	12.65	18.79	9.84	11.95	4.78	80	0.168221
Total Solids,mg/L	190	223	298	220	241	274	237	235	241	N/A	
Turbidity, NTU	3.46	1.97	0.54	0.94	0.57	0.33	0.66	0.75	0.39	N/A	0.0244299*
Conductivity, uS	271	324	446	313	354	432	323	322	231	N/A	0.097874
Density, g/mL	0.998	0.997	0.997	0.998	0.998	0.998	0.9989	0.9988	0.9985	N/A	0.376591
Flowrate, m/s	0.012	0.062	0.015	0.333	0.045	0.336	0.012	0.058	0.059	N/A	0.179158
ORP, mV	-36	-67	-47	-57	-60	-33	-43	-44	-62	N/A	0.327979
BOD,mg/L	3.06	4.59	5.47	3.27	3.82	3.55	9.84	10.61	7.7	7	0.580814
DO,mg/L	7.29	7.8	7.32	9.27	9.07	10.59	8.63	8.63	8.31	5	0.77695
pH	7.48	8.02	9.43	8.79	8.95	8.53	8.36	8.64	8.4	6.5-9.0	0.070578
TDS,mg/L	181	217	294	209	228	255	227	223	236	N/A	8.3235E-5*
Salinity, ppm	135	164	221	151	175	234	225	229	193	N/A	0.28672
Nitrates,mg/L	1.13	0.53	0.5	1.04	1.08	0.93	0.96	0.85	0.79	7	0.218799
Phosphates,mg/L	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	0.5	1
Potassium,mg/L	3.43	2.9	3.4	2.07	2.28	2.1	4.9	4.9	4.9	N/A	0.982103
Mercury,mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	1

Legend: *Significant

Temperature

Temperature is known to influence the pH, DO, and alkalinity concentration in the water. As shown in table 1, the levels of temperature readings in all sampling sites (Gango, Indahag, Cugman) are within the DAO-2016-08 standard (25°C-31°C). Statistical analysis showed that the measured values in all sampling sites and sampling periods are not significantly different. Major factors that affect the temperature of the river water are the season, surrounding vegetation and the presence of organic wastes in the river. It was observed that in Gango sampling sites, the area is narrow and have few vegetation alongside the river. On the contrary, Indahag and Cugman have abundant vegetation than Gango, vegetation may lessen direct penetration of sunlight into the river that causes the low temperature of the river.

Dissolved Oxygen

Oxygen is the single most important gas of most aquatic organisms because it is needed for respiration (Uddin *et al.*, 2014). Dissolved oxygen (DO) also refers to the volume of oxygen that is contained in the water. According to DAO-2016-08 standard, for class C water body, dissolved oxygen should not be lower than 5.0 ppm. In this present investigation, dissolved oxygen in all sampling sites and sampling periods are all above 5.0 ppm and considered within the DENR standard (see table 1). Statistically, it showed no significant difference. Dissolved oxygen is affected by the presence of organic matter present in the water body and water temperature. Generally, dissolved oxygen in Bigaan River is suitable for the life of aquatic organisms, with the lowest value of 7.29 ppm and the highest value of 10.59mg/L. An increase of dissolved oxygen in the Bigaan River can affect good water quality which is essential for the ecology of the river.

Biochemical Oxygen Demand

Biochemical Oxygen Demand (BOD) is the amount of oxygen required by bacteria and other microorganisms during the biochemical degradation and transformation of organic matter present in water and wastewater under aerobic conditions. It is a valuable parameter to assess water quality.

The BOD measured values of Bigaan River are mostly within DENR standard except for Gango and Indahag in January 2019 with values of 9.84mg/L and 10.61mg/L respectively (see table 1). The measured BOD, in this investigation, revealed that there is no significant difference ($p>0.05$) among sampling sites and between sampling periods. Biochemical oxygen demand is proportional to the amount of organic matter present in the water and, therefore, it is also a measure of the strength of the waste (Raji *et al*., 2015). A low BOD is an indicator of good quality water, while a high BOD indicates polluted water (Khalik *et al*., 2013)

Total Solids

Total solids are simply the summation of total suspended solids and dissolved solids present in the water. In the present study, it was noted that total solids were at maximum at 298mg/L at the Cugman area in November 2018, and the lowest measured value at 190mg/L at Gango area in the same month (see table 1). Possible reasons for the increase in total solids are due to inorganic and organic pollutants in the river which had contributed to the increase in both dissolved solids and suspended solids. Natural weathering and some anthropogenic activities, infrastructures along Bigaan River, urban and agricultural carried runoffs are also some of the contributors of total solids in the river. It was also observed that Bigaan River has a rapid water current or flowrate. It enables to disperse the suspended and dissolved solids faster into the downstream part of Bigaan River which is in Cugman that could results to higher value of total solids.

Total Suspended Solids (TSS)

Total suspended solids refer to waterborne particles that exceed 2 microns in size which include anything that suspends in water; such as sediments, sand, clay, plankton, algae, bacteria and silts. Effluents from anthropogenic activities and solid wastes are directly thrown into the bodies of water contribute to the increase in suspended solids. According to the results, it showed the highest measured values at 18.79mg/L in the Cugman area in December 2018, while TSS is lowest at 4.03mg/L in November 2018 (see table 1). Anthropogenic activities like agriculture, urbanization, and mining contribute to increase in sediments in the water body (Ahmed *et al*., 2012). Results showed no significant differences among sampling sites and between sampling periods with p-value greater than 0.05. Statistically, there is 95% probability that difference in TSS could be attributed to random chance. Comparing all values to DAO-2016-08, it is apparent that it does not exceed with the standard of 80mg/L for the class C water body.

Salinity

Salinity can be defined as the concentration of dissolved mineral salts present in water. It measures how much-dissolved salts or solids are present in the water such as the total concentration of cations that include sodium (Na^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), and potassium (K^+) and anions that include sulphate ($SO4^{2-}$), carbonate (CO_3^{2-}), bicarbonate (HCO_3^{2-}), and chloride (Cl^-) in solution (Simeon *et al*., 2019). Salinity values have shown no significant difference between sampling sites and among sampling periods. Maximum recorded values at 234 ppm in Cugman, December 2018 while lowest value at 135 ppm at Gango area in Nov.2018 (see table 1). Salinity depends on the presence of dissolved solids; therefore, total dissolved solids explain the level of salinity on its increasing and decreasing rate present in the Bigaan River. Sources could be from urbanization as well as the natural weathering condition of the area.

Total Dissolved Solids (TDS)

Total dissolved solids is a term used to describe the inorganic salts and small amounts of organic matter present in solution in water. These include cations of calcium, magnesium, sodium, potassium and anions like carbonates, chlorides, sulfates, and nitrates. (Gupta *et al*., 2017). It is directly proportional to the salinity and electrical conductivity of the river water. The highest TDS value in Bigaan River was at 294mg/L in the Cugman area in November 2018, while the lowest TDS value was at 181mg/L at Gango area in the same month (Table 1).

There is no DENR standard for TDS; however, the statistical analysis showed a significant difference in measured values ($p<0.05$). The measurement of total dissolved solids in the water integrates all anions and cations in the sample and some ions or combinations of ions are substantially more toxic than other ions or combinations of ions (Maglangit *et al.*, 2014; Akhtar & Tang, 2013). Possible sources of dissolved solids in Cugman could be the urbanization in the area as well as the natural weathering condition. As observed, Cugman has a high presence of flora and fauna species. Possibly decaying plants and animals can be a source of total dissolved solids because it contains organic sources of materials.

Turbidity

Turbid water captures more heat from the sun than clear water. There is no DENR standard for turbidity but statistical analysis showed that there is a significant difference in its measured values among sampling sites and sampling periods. Turbidity is directly proportional to the presence of suspended particulates in the water. Results from this study revealed that the highest turbidity recorded was at 3.46 NTU in the Gango area in November 2018, while the lowest recorded value was at 0.33 NTU in the Cugman area in December. 2018 (see table 1). The clearer the water, the deeper sunlight penetrates. Transparency has a direct bearing on the light penetration of water and depends upon suspended matter and dissolved colored substances. Lower reading at the Cugman site suggested that the river water was clearer during sampling. Turbidity is also affected by the presence of suspended particles but would differ to the influence of particle shape, size, and amount of surface that causes variation in reflection, refraction, and absorption of light (Atwebembeire *et al.*, 2018). It is possible that particle size differs in the sediments present in the three sampling sites.

Density

The density of water is dependent on its temperature. The higher the temperature, the lower its density of water. Results of density measured values in Bigaan River showed no significant difference in three sampling sites and sampling periods. Density gradients cause currents and these currents provide a route for heat transfer (Shapley, 2011). Water density doesn't have an absolute value because it varies from the water temperature. Mostly, density values were closer to 1.000 g/cm^3 depending on water temperature. According to Swiatla-Wojcik (2008), water bonds break slowly as temperature decreases and tend to trap fewer extra water molecules on the structure resulting in decreasing its density level. The maximum density level in Bigaan River was recorded at 0.9989 at 20 degrees centigrade and the lowest was 0.9970 at 22 degrees centigrade (Table 1).

Redox potential (ORP)

Oxidation- reduction potential, or ORP measures the ability of a river to cleanse itself or break down waste products. When ORP is high, there is a lot of oxygen present in the water (Al-Samawi *et al.*, 2016). This means that bacteria that decompose dead tissue and contaminants can work more efficiently. It is measured by the electrodes of an ORP meter. A positive reading on an ORP meter means that the substance is an oxidizing agent; while a negative reading indicates that the substance is a reducing agent. A reducing agent has the tendency to lose electrons, and by itself is oxidized (Miao *et al.*, 2006). ORP is an important parameter in the mobilization and availability of heavy metals and sediments (Popenda, 2014). Redox Potential among sampling sites and between sampling periods showed no significant difference. All measured ORP values were negative and signify that the water is itself oxidized. The higher value of redox potential, the more it oxidizes under the water body (Briciu *et al.*, 2020).

Conductivity

Conductivity represents the total soluble salts and mineral salts in the water. It is considered as useful and commonly measured water quality parameter. It is the basis, of most salinity and total dissolved solids calculations because conductivity is an indicator on changing water systems (Fondriest Environmental Inc., 2014). Increasing of conductivity is due to the

highest amount of total dissolved solids (TDS) (Akaahan *et al*., 2017). Results revealed maximum conductivity at 446 uS in Cugman area in November 2018 and lowest value at 231 uS in Cugman area in January 2019 (table 1). There is no DENR standard for conductivity, and statistically, there is no significant difference on the measured values among sampling sites ($p>0.05$). Sources on increasing conductivity and dissolved solids may come from nature, geological condition, and especially human activities (Marandi *et al*., 2013). High conductivity in the water body indicates high amounts of cations and anions which is shown with high total dissolved solids (TDS) and salinity.

Flowrate

Flowrate is an important factor in controlling the distribution of a variety of marine organisms (Bell & Turner, 2002). Results have shown that flow rate did not differ significantly; however, flow rate may be affected by the gradient of the slope that the river moves along, the shape of the river channel, the volume of the water and the amount of friction caused by rough edges within the riverbed. The sampling area in Cugman was observed to have a wider channel as compared to Gango and Cugman sampling areas. The highest flowrate recorded was at 0.3360 m/s in the Cugman area while the lowest flowrate was at 0.012 m/s at the Gango area (table 1). It has also been observed that the area is rocky which enhances water flow, this makes the water current higher than in Gango and Indahag. Flowrate varies due to complicated interaction between the weather-related systems such as rainfall, temperature and evaporation, the landscape such as basin area and relief and human activity such as pollution and power generation (Da Silva *et al*., 2018)

Nitrogen as Nitrates

Nitrates are the result of higher amounts of nutrients that are applied in natural and mineral fertilizers as it is a plant requirement or supplied in adverse conditions (Kyllmar *et al*., 2014). In this study, the highest nitrate value was observed at 1.13mg/L at the Gango area in November 2018 while the lowest nitrate recorded was 0.50mg/L in the Cugman area. Nitrate level in Bigaan River is low and showed no significant difference among sampling sites and between sampling periods ($p>0.05$). Based on DAO-2016-08, nitrate DENR standard for a class C water body is 7.0mg/L, as per the results (see table 1) the measured values were all lower than the given standard. Generally, possible sources of nitrates could be inputs from farmlands and farm animals in nearby areas which could be the source of nutrient leaching; however, it has been observed that agricultural activities are not visible nearby the river.

Phosphorus as Phosphates

Similar to nitrogen, elevated levels of phosphorus are the main cause of poor water quality and loss of aquatic habitats. Wastewater discharges, including domestic waste and sewage, effluents from commercial and industrial establishments, urban run-off, combined with an agricultural run-off which may also contain fertilizers, are major threats in terms of nutrient pollution (Dubey *et al*., 2021). Nitrogen and phosphorus-containing compounds act as nutrients in streams and rivers. The reactions of these compounds in fresh water can cause oxygen depletion. Results of this study showed that all the recorded values were below the detection limit (less than 3.0mg/L) on the colorimeter instrument. Statistically, there is no significant difference in the measured values ($p>0.05$). Phosphorus sources could be from human and animal excreta, could be from open defecation, phosphorus-containing household detergents, and precipitation runoffs.

Potassium

Potassium is the third most important macro-element after nitrogen and phosphorus and it is naturally present in water. Possible anthropogenic sources could be households in the area that discharged their wastes into the river, as well as runoffs that contains macronutrients. Potassium can increase the growth of algae and it occurs widely in nature in plants and animal wastes (Naceradska, 2017). Poor water quality affects the balance between potassium, sodium, magnesium and calcium and this also hinders the

uptake and distribution of potassium and nitrogen (Khetsha, 2013). The potassium level, in this present study, has the highest value at 4.9mg/L in January 2019, and lowest at 2.07mg/L at Gango area in Dec. 2018 (table 1). There is no DENR standard for potassium and statistical analysis showed no significant difference among sampling sites and between sampling periods.

Total Mercury (THg) in Water

One of the most serious contaminants threatening water is mercury because it is a potent neurotoxin on wildlife, humans and fish. Anthropogenic activities like mining may influence mercury contamination of the nearby river and the surrounding area. An increase of mercury levels in the aquatic system may affect aquatic species such as fish that inhabit the area and bottom dweller organisms. Aquatic species are dependent on their environmental habitat, uptake of mercury through prey is the major route of mercury absorption in fish systems (Colaco *et al.*, 2014). Mercury level in Bigaan River in all sampling sites showed that it was below the detectable limit of 0.001mg/L. The density of mercury as an element is 13.56 g/mL, while the density of water is almost 1 g/mL at 4 ^{o}C. Mercury when present in water would not remain on the water surface, since it is heavy, it settles at the bottom and combined with the sediments in the streambed. Microbial methylation is likely the most important origin of methyl mercury (MeHg) in aquatic systems. Diverse bacteria are known to methylate Hg from natural environments. All measured values are below the DENR standard of 0.002 for the class C water body. Although mercury concentration is low in the water; however, it is possible that mercury could be accumulated to aquatic species through their prey or due to uptake with sediments. Physico-chemical characteristics in the river such as conductivity, temperature, flow rate and pH also affect mercury level in Bigaan River.

Fish Species Richness and Distribution

There are five identified fish species in Bigaan River in different sampling sites, these are *Clarias batrachus, Oreochromis niloticus, Channa striata, Puntius binotatus* and Subok. Gango has a total of 144 species, Indahag has 140 species and Cugman has 299 species. The number of fish species found in Gango, Indahag and Cugman was the same but their distribution varied. Water quality in Bigaan River can be a factor in the species richness and distribution of *Ichtyofauna* species. Every species has a different tolerance for them to grow and survive. It was observed that among the three sampling sites in Bigaan River, Cugman has the highest total number of *Ichtyofauna* species in Bigaan River.

Table 2 showed the total number of species found in Bigaan River. It was observed that *Puntius binotatus* was the most abundant species present in Bigaan River with a total of 446 species. While *Oreochromis niloticus* also known as tilapia has the least number with a total of six (6) species present in Bigaan River. *Oreochromis niloticus* also known by its native name tilapia was observed absent in Barangay Gango and Cugman and was found to be present only in Barangay Indahag. In a normal environment, *Oreochromis niloticus* optimal temperature ranges from 27-30°C (Nivelle *et al.,* 2019) and are tropical species that prefer to live in shallow water. It was observed that Gango and Cugman have deep water that is not suitable for tilapia's habitat resulting in their absence of species in the area. *Oreochromis niloticus* (tilapia) is an omnivorous grazer that feeds on phytoplankton, periphyton, small invertebrates, benthic fauna, aquatic plants and bacterial films. As observed in Brgy. Indahag, it has more algae floating in the water that could support tilapia to grow easily and reproduce because it is rich in food. *O. niloticus* can filter feed by entrapping suspended particles, including phytoplankton and bacteria, on mucous in the buccal cavity, although its main source of nutrition is obtained by surface grazing on periphyton mats (Food and Agriculture Organization, 2019). *Puntius binotatus* is a native fish in Asia especially in the Philippines (Lim *et al.*, 2013). *P. binotatus* was utilized as an important bio-indicator on habitat degradation and health status of freshwater environment resources due to its common availability.

Freshwater ecosystem plays an important role in biodiversity and various pollution today that was considered to affect most on water quality (Cabuga Jr. *et al.*, 2017). In Philippines, *P. binotatus* is locally known as "Pait-Pait". Based on the data presented in table 2, *P.* binotatus is the most abundant species and is present in three (3) sampling sites of Bigaan River. Water quality among sampling sites is suitable for *P. binotatus* and an important reference to fish growth and health condition was its water quality. *Puntius binotatus* preferred an 18-30˚C temperature condition. This species inhabits fast flowing streams and highly oxygenated clean water. It is often found on substrates composed of mud, sand, pebbles, rocks, boulders, bedrock with submerged woody structures. Brgy. Gango, Indahag and Cugman sampling area is characterized by sandy, rocky and muddy substrates and temperature range from 22-27˚C. It was observed that dissolved oxygen in Bigaan River is within the standard value able to support the survival of aquatic life. The three sampling sites of Bigaan River determined a good water quality for *P. binotatus*. These fish species have been an essential bio-marker on any environmental stress or good condition of aquatic habitat or ecosystems (Zakeyudin *et al.,* 2012).

Table 2. Fish species richness and distribution.

Species Name	Gango	Indahag	Cugman	Total
Clarias batrachus	50	1	11	62
Oriochromis niloticus	0	6	0	6
Channa Striata	6	2	15	23
Puntius binotatus	88	128	230	446
Subok	0	3	43	46
TOTAL	144	140	299	583

Shannon Diversity Index of Fish Species

According to the total number of fish species on every sampling site, Cugman has the highest number of fish species in Bigaan River (table 2) and it was observed that every species in Cugman has distant values that could affect its diversity index (fig. 3). Gango is relatively higher in diversity index of 0.8 with a total number of 144 species as compared to the other two sampling sites. A dominant species of *P. binotatus* affect the diversity in Cugman. As to compare in Barangay Gango, there are two (2) species that are absent in Gango but values were close to each other that makes the diversity index higher than Cugman.

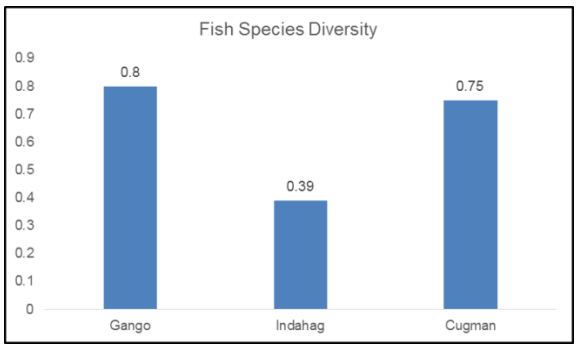

Fig. 3. Shannon diversity index on three sampling sites of Bigaan River during Wet Season.

Legend: 0-2 (Low); 1-2 (Moderate); 3 above (High)

Moreover, diversity index of *Ichtyofauna* species found in Bigaan River was characterized as low. Water quality in the Bigaan River may affect the *Ichtyofauna* species richness and distribution in Bigaan River. The low diversity index in the Bigaan River can be caused by the condition of water quality.

Association of Fish Species Diversity to Physico-chemical characteristics of Bigaan River

Temperature in Bigaan River was moderate and suitable for growth and survival of fish. Thus, present total solids increased while it reached the downstream area by the presence of total dissolved solids, conductivity and salinity. According to Iyasele *et al.* (2015), conductivity and TDS are much independent on each other. Increasing of conductivity is due to the highest amount of total dissolved solids (TDS). Dissolved solids are important to aquatic life by keeping cell density balanced, a very high TDS concentration in water tends to shrink cells and these changes can affect an organism's ability to move in a water column, causing it to float or sink beyond its normal range (Fondriest Environmental Inc., 2014).

Many ecologists revealed that total dissolved solids and turbidity has a positive correlation, since total dissolved solids indicates total amount of organic chemicals in solution. Turbidity in water can affect the presence of *Ichtyofauna* species. It was observed that turbidity in Gango, affects the presence of fish in Bigaan River as they will migrate to another place so that they will not be disturb and can find their mates for their reproduction. Exposure to high turbidity could well affect the feeding motivation of some fish (Chapman *et al.,* 2014). Mortality of fish also depends on pH because acid waters losses fish appetite, growth capacity and tolerance to toxic substances (Sagar *et al.,* 2012). According to Auliar & Bekaroo (2020), the lower the pH, the more harmful it is for the aquatic species especially fishes. It affects the metabolism of fish and has a lower survival rate. In this study pH values among sampling sites were safe for the survival of fish species and it did not affect the presence of fish species in Bigaan River. Another factor is dissolved oxygen. Dissolved oxygen in Bigaan River ranges from 7.29-10.59mg/L it showed that it doesn't affect different fish species as it supports the growth and survival of fish.

Conclusion and recommendation

The findings of the study showed that all values of the physicochemical characteristics of Bigaan River did not exceed the standard of DAO-2016-08 except for the BOD value in January 2019 which slightly exceeded 7.0mg/L. The parameters which differ significantly using 2-way ANOVA are total dissolved solids and turbidity. Moreover, there are five *Ichthyofauna* species found in Bigaan River namely: *Clarias batrachus, Oreochromis niloticus, Channa striata, Puntius binotatus,* and subok. The most abundant *Ichtyofauna* species was *Puntius binotatus* with a total of 446 species present in three sampling sites followed by *Clarias batrachus* (62), subok (42), *Channa striata* (23) and *Oreochromis niloticus* with a total of six (6) species. Results from the diversity index showed low diversity with a value of less than 1.0. Bigaan River has a low diversity index of fish species and water quality affects their species richness and distribution. The low diversity of fish species in Bigaan River could be due to the fluctuating physicochemical characteristics of the river that may disturb and stress the habitat of fish according to their tolerance level.

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