INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 15, No. 5, p. 46-60, 2019
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Zooplankton Assessment and the Physico-Chemical Characteristics of Bitan-ag Creek Cagayan de Oro City

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Article published on November 30, 2019

Key words: Zooplankton, Physico-chemical, Nutrient load, Bitan-ag Creek

Abstract

This research study aimed to analyze the physico-chemical characteristics of Bitan- ag creek and to assess zooplankton diversity. Specifically, it determined (1) the physico-chemical condition and nutrient load of the creek and compared to DENR Administrative Order (DAO) standard, (2) assessed how the physico-chemical parameters affect the distribution and abundance of zooplankton, (3) identify zooplankton species that are found in each sampling sites, (4) measure significant difference on the abundance and diversity of zooplankton between sites. The study made used of the descriptive-comparative design to determine quantitatively water quality parameters such as conductivity, water temperature, TDS, turbidity, salinity, water current, COD, DO, pH, nitrates and phosphorus. The results clearly revealed that some physico-chemical and nutrient load parameters exceeded the standard of class "C" water body, this includes: conductivity, TDS, turbidity, DO and phosphate content. A total of five (5) species of zooplankton belonging to three (3) families namely: *Appendicularia, Daphniidae and Ameiridae* were present. Family *ameiridae* had the highest total number of three individuals which are found in first and third sites, whereas, the *appendicularia and daphniidae* settled only in the third sampling sites. Further, the study also showed significant difference on the abundance and diversity of zooplankton between sites. Thus, the distribution and abundance of zooplankton in Bitan –ag creek were greatly influenced by the condition of its physico-chemical and nutrient chemistry. The research suggested that there should be rehabilitation of Bitan –ag creek to avoid further degradation of its water quality.

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Introduction

Creeks are valuable part of the aquatic resources serving as feeder-rivers, providing flood control, storm water drainage, habitat to wildlife, creating neighborhood beauty and improving quality of life (Saliu and Ekpo, 2006). Bitan-ag Creek is one of many water tributaries in Cagayan de Oro City. According to some natives in the City, Bitan-ag was formerly known as a river that has been surrounded by grasslands. It was used as a source of drinking water for the native people and for their animals. With anthropogenic activities through time, the very clean body of water has become polluted (Canencia *et al.,* 2011). Its conversion also goes with the developmental stage of the City. Bitan-ag Creek is now a waterway that cuts across Lim Ketkai Mall and a state university (University of Science and Technology of Southern Philippines) and drain towards the shores bordering Barangays Macabalan and Lapasan, Cagayan de Oro City.

According to the Department of Environment and Natural Resources (DENR), the status of Bitan-ag Creek has never been classified to its designation, hence, the national government approved to include it in "Adapt an Estero Program". However, it was temporarily assigned as class "C" inland water. As such, it is useful for fishery water in propagation and growth of fish and other aquatic resources. It is usable also for recreational and for industrial water supply.

Bitan-ag Creek has, by and large, ceased to be really useful creek except as disposal site for whatever wastes people can think of –solid wastes and non-solid wastes alike. The survey and ocular inspections made revealed that where there are communities that have sprouted near the creek, then, that part of the creek becomes a victim of human abuse. This is even true in the high upstream portions of the creek where people use the water from the creek for washing clothes and for other household purposes. Even there, the evidence of dumping lawn wastes glared to the observers. In fact, the people even burnt disposed solid wastes right on the bed of the creek where there is no water (Del Rosario and Palmes, 2010).

Based on the findings of previous studies (Del Rosario *et al.,* 2010; Canencia *et al.*, 2011), it revealed that the Bitan-ag Creek is in badly serious condition in terms of pollution. The need of assessing the current status of water quality and the zooplankton level is a necessity to know if the water quality are still conducive for organisms to survive.

The study of zooplankton, which has a key position in the trophic chain, can highlight its fundamental role, and as a consequence, the functioning of the aquatic systems can essentially better be understood. Hence, the development of its conservation requires the realization of this study. Therefore, this paper aims at determining the existing status of the distribution and abundance of zooplankton in relation to nutrient chemistry as well as to the physico-chemical characteristics of the creek and its potential to affect other organisms via the food chain.

Materials and methods

Research Design

The study uses descriptive –comparative research design wherein the researchers conducted assessment of the physico-chemical parameters of the water and compared the values to its DAO standard of Class C water bodies. Measurements for the water quality parameters like DO, TDS, salinity, conductivity, water temperature, water current, turbidity and pH were conducted onsite; while COD, nitrates and phosphates analysis were done inside the laboratory.

Description of Study Area

Bitan-ag Creek (Fig. 1) is one of the polluted water bodies in Cagayan de Oro City. The creek is bordered by urban community showing signs of industrialization. The inhabitants of the study site dump their domestic waste directly into the water and since centralized sewage system is not being practice in the area then all the waste from bathrooms and toilets goes directly into the water body. The color of the water is usually black and have unpleasant odor at areas in the midstream and downstream part, while the water is clearer yet turbid at the upstream part of the creek.

Data Collection Method

Identification of sampling sites

An ocular inspection was done prior to actual sampling to locate and identify the sampling areas using Oregon 550 Global Positioning System (GPS).

After the inspection, three (3) sampling sites were established in the area based on the different sources of water discharges, as shown in the map of Bitan-ag creek (see Fig. 1). Fig. 2 shows the image of the first sampling site designated as site A in Tierra del Puerto, Barangay Camaman-an (N08°28.960', E124°39.617') which is surrounded with residential settlements. Fig. 3 shows the image of the second sampling site designated as site B in C.M. Recto Avenue, Barangay Lapasan (N08°28.118', E124°39.315') in which residential and commercial establishments are present. Fig. 4 shows the image of the third sampling site designated as site C in Lapaz1, Agora, Barangay Lapasan (N08°29.116', E124°39.457') which have residential and industrial establishments as stressors for the water body.

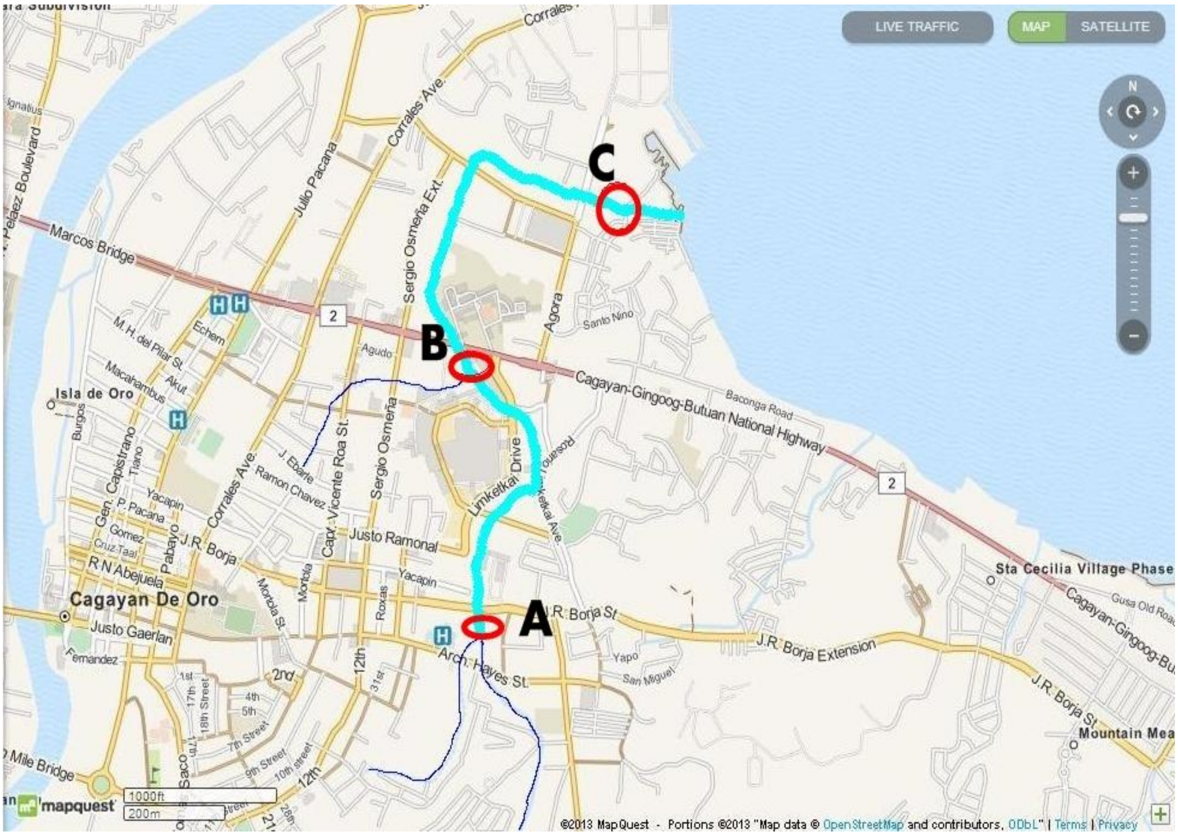

Fig. 1. Map of Bitan –ag Creek, Cagayan de Oro, showing the sampling sites.

Fig. 2. Tierra Del Puerto, Brgy. Camaman-an, Cagayan de Oro City (Upstream).

Fig. 3. C.M. Recto Avenue, Brgy .Lapasan Cagayan de Oro City (Midstream).

Fig. 4. Lapaz 1, Agora, Brgy. Lapasan, Cagayan de Oro City (Downstream).

Collection of samples

All samples were collected between 8:00am to 10:50am. Clean plastic bottle polyethylene (PET) type were used as water container during the collection of water samples for water quality parameters which need to be analyzed inside the laboratory like chemical oxygen demand (COD), nitrates and phosphates. The water bottle is cleaned properly, acid washed, and properly labelled before use.

Water Quality Analysis

In situ measurements were conducted for physical and chemical parameters, a 500mL of water sample in each sampling site was collected in a dipper and was brought to the side of the creek for the measurement of parameters that have digital apparatus available like temperature, dissolved oxygen, conductivity, total dissolved solids, turbidity, salinity, water current and pH.

Physical Parameters

Majority of the physical parameters were analyzed with the use of digital instruments as shown in table 1. For the water current, an orange fruit (in the absence of flow meter) was used as float to measure stream velocity. To maintain accuracy and precision.

Sampling was performed in replicates and the average was computed to get the accurate data of all parameters mentioned.

Table 1. Apparatus used in this research for physical parameters.

Parameter	Apparatus	Model
Conductivity	Conductivity/TDS meter	LT Lutron YK-22CT
Salinity	Refractometer	Atago master-s28m
Temperature	Dual channel thermometer	LT Lutron TM-914C
TDS	Conductivity/TDS meter	LT Lutron YK-22CT
Turbidity	Turbidity meter	LT Lutron TU-2016

Chemical Parameters

Table 2 indicates the actual digital instruments used for the analyses in the chemical parameters. Chemical Oxygen Demand (COD) was determined in the laboratory premise using open reflux method. To maintain precision and accuracy, again, replicates was conducted in each sampling site, and the average was computed to get a reliable amount of COD, pH, and DO.

Nutrient Load

Water samples for the analysis of nutrient load were collected just below the water surface in a well-labelled 1.5 liter plastic container with caps to reflect appropriate details such as site, date and time of collections of all study sites. The samples were partially preserved in an ice-filled ice bucket and transferred to the school laboratory for analysis. In the laboratory premise, colorimetric method was applied for nitrate-nitrogen content while stannous chloride method was applied for phosphate-phosphorus content.

Table 2. Apparatus used in this research for chemical parameters.

Parameter	Apparatus	Model
pH	Digital pH meter	LT LutronpH-221
DO	DO meter	LT Lutron DO-5519

Zooplankton Collection Method

The collection of water samples for zooplankton assessment was conducted in each sampling sites. There were two improvised methods that were used in this study: One, was with the use of 20µm plankton net to filter a pail (approximately10L) of subsurface water, and the other one was with the use of same size plankton net, it was attached to a circular frame stick then tied up unto a larger stick and manually towed horizontally at a low speed for 10 minutes in the body of water. Only a 40mL supernatant was collected and preserved in 5% unbuffered formalin. Samples from each site were brought to the school laboratory for further investigations. The biological samples were sorted using stereomicroscope with calibrated eye piece at different magnifications (x10 and x40). The sorted species were identified, classified and validated by an expert.

Biological Indices

The status of zooplankton was determined based on premature assessment and *International Union for Conservation of Nature* (IUCN) standards whether these species are rare, prevalent, vulnerable and common. Determination of Density (D), Relative Density (RD), Frequency (F), Relative Frequency (RF), Dominance (C), Relative Dominance (RC). Species Importance Value (SIV) and Species Diversity (SD) was done.

A. Density

Species density or species richness is the number of different species represented in an ecological community, landscape or region. Species richness is simply a count of species, and it does not take into account the abundance of the species or their relative abundance distributions. According to Paulose & Maheshwari, 2008, the following formula was used.

D = N/A

Where,
D = Density
N = Number of samples
A = Area of interest

B. Relative Density

Species Relative Density is the percentage value of the density of species and was evaluated by:

RD = (D/tD) x100

Where,
RD = Relative Density
D = Density of Species
tD = Total Density

C. Frequency

The concept of frequency refers to the uniformity of a species in its distribution over an area. No counting is involved just a record of species present. Each individual of the species present is recorded, is a more accurate and reliable method of sampling. The proportion of sub samples which contain the species A was calculated by using the formula:

F = Npo/Npe

Where,
F = Frequency
Npo = Number of plots in which species occurred
Npe= Number of plots examined

D. Relative Frequency

Frequency is usually expressed as a percentage and sometimes called a Frequency Index. The percentage value of frequency of species A was determined by the following formula:

RF = (Fv/tF) x100

Where,
RF = Relative Frequency
Fv = Frequency value for species
tF = Total of frequency for all species

E. Dominance

Simpson's Index of Dominance is an index use to compute for the most common species in the area and the formula below was used to determine dominance.

$C = \Sigma [ni/N]^2$

Where,
C = Dominance
N = Total number of individuals in the plot
ni = Total number of individual species in a plot

F. Relative Dominance

Relative dominance is simply the percentage value of computed dominance. Below formula was used:

RC = (Ds/TDom) x 100

Where,

RC = Relative Dominance

DS = Dominance of Species

TDom = Total Dominance of all species

G. Species Importance Value

One measure of the relative dominance of species in a particular community is called the Importance Value (IV). Importance values rank species within a site based upon three criteria:

- How commonly a species occurs across the entire site;
- The total number of individuals of the species;
- The total amount of sampling sites occupied by the species.

The following formula was utilized:

SIV = RD + RF + RDom

Where,

SIV = Species Importance Value

RD = Relative Density

RF = Relative Frequency

RDom = Relative Dominance

Shannon- Weiner Function (H')

Species diversity is an expression of community structure and is a characteristic unique to the community level of organization. A community demonstrate a high species diversity if many equally or nearly equally abundant species are present. If a community is composed of only a few species, or if only a few species are abundant, then species diversity is low. High species diversity indicates a complex community in which a high degree of species interaction is possible. For this reason, communities with higher diversities typically have higher levels of energy transfer (food webs), predation, competition and niche availability. It is most often calculated as follows:

$H = -\sum -(n_i/N \log(n_i/N)$

Where,

H= Species Diversity

N = the total number of individuals of all species

ni = the number of individuals of species i

Data Analysis Procedure

To ascertain the significant relationship that exists in the physico-chemical and nutrient load of the water samples among the three (3) sampling sites, One-way Analysis of variance (ANOVA) was used at 0.05 significant levels. Tukey's Test was applied to determine whether there were any significant relationships between the means of all parameters in three (3) sampling sites to the water quality, and nutrient load.

Results and discussion

Physico-chemical Conditions of Bitan-ag Creek

According to the revised water usage and classification/water quality criteria amending section no. 68, the quality of Philippine waters shall be maintained in a safe satisfactory condition according to their best usages. For this purpose, all waters shall be classified according to its beneficial usage (DAO 2016-08). While the Bitan-ag Creek has not yet been classified to its designated classification, Class "C" inland water shall be the standard basis of this study. The results of the physico-chemical parameters analyzed in this study are presented in Table 3.

Conductivity

Bozkurt and Sagat (2008) reported that the acceptable water conductivity value for aquatic organisms to be between 250-500 micromhos per centimeter (max: 2000 micromhos per centimeter or 0.2 S/m). Conductivity values were generally high in the downstream area with an average value of 3.88S/m, lower conductivity values have 0.770S/m in the midstream and the lowest value was found in the upstream area with an average value of 0.298S/m, hence, the latter area is less polluted than that of the downstream. These readings could be attributed by several factors such as industrial and municipal effluents. See Fig. 5 for the trend.

The conductivity variations can be an important regulator of the structure of zooplankton assemblages, especially for species diversity and richness (Sousa *et al.,* 2008).

Table 3. Variation in physico-chemical parameters in Bitan-ag creek.

Parameter	Unit	Sampling Sites A B C			Mean	Standard Class "C"
Conductivity	s/m	0.289	0.77	3.88	1.65	*0.2
Temperature	℃	26	28.3	34.7	29.67	**26-30
TDS	mg/L	197.67	517	2595	1103.22	*0-1000
Turbidity	NTU	23.75	18.88	17.97	20.2	*50
Salinity	PSU	0	0	0	0	*0-0.5
Water current	ft.^{3}/sec	0.994	1.071	2.62	1.56	-
DO	mg/L	4.4	0.251	0.181	1.61	**5.0
pH	mg/L	7.73	7.54	7.49	7.59	**6.5-8.5
COD	mg/L	24.5	63	143.5	77	**60
Nitrates	mg/L	2.82	0.32	1.57	1.57	**10
Phosphates		51.09	15.87	176.30	81.09	**0.1

*criteria standard for freshwater ecosystem

**DAO90-34 standard for class C water

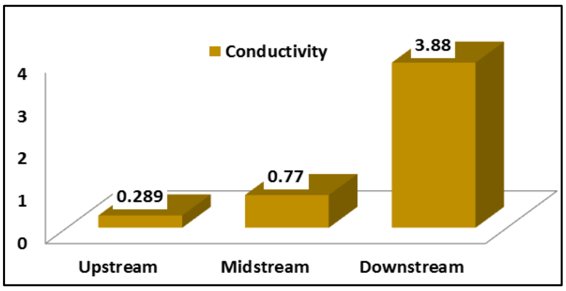

Fig. 5. Conductivity levels of water by sampling sites in S/m.

Temperature

As shown in Fig. 6, the intensity of the heat stored in a volume of water in the study area were 26°C, 28.3°C, and 34.7° C, from upstream to downstream respectively. The variations of results were perhaps caused by shades of trees and other vertical infrastructures present in the sampling sites. Since the temperature affects solubility of many chemical compounds in the downstream portion then it elevates the metabolic oxygen demand which in conjunction with reduced oxygen solubility and impacts many aquatic lives. These results could also be attributed by industrial effluents, forest, and urban development. Toxic wastes and disease wastes often raise water temperature.

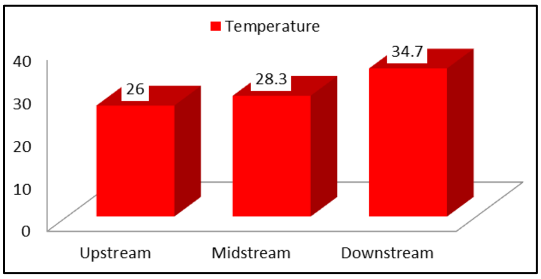

Fig. 6. Temperature levels of water by sampling sites in °C.

Temperature is one key factor that regulates the growth of zooplankton populations (Gillooly, 2000). There is a positive significant relationship between temperature and zooplankton groups. Many other studies were also in agreement that temperature controls the vertical mixing of plankton distribution (Rose *et al.*, 2007). The positive correlation between temperature and zooplankton can be attributed to the increase of phytoplankton and algae providing food resources for zooplankton (Pereira *et al.*, 2002).

Total Dissolved Solids (TDS)

The measures of the amount of dissolved materials in the water column from upstream to downstream were 197.67mg/L, 517mg/L, and 2,595mg/L respectively (Fig. 7). There is no issue for the first two results since it falls within the criteria for fresh water standard value (0-1000mg/L). This result is also in agreement with the result of Del Rosario *et al.*, (2010) which has relatively high dissolved solids content indicated in the downstream portion. It could be possible that the downstream areas have higher dissolved salts such as sodium, chloride, magnesium, and sulfates.

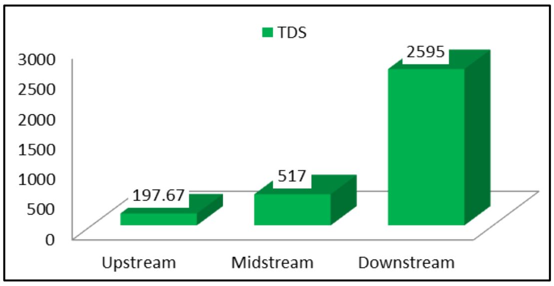

Fig. 7. Total Dissolved Solids (TDS) levels of water by sampling sites in ppm.

As an implication, high concentration of TDS limits the sustainability of water as a drinking source and irrigation supply. Possible sources of such high concentration in TDS are poor sewage system since the area is almost covered by informal settlers along the creek and the effluents coming from different establishments in the Lapasan area is possibly untreated.

Turbidity

The suspended particulate matter in a water body which interferes with the passage of a beam of light through the water from upstream to downstream have the mean value of 23.75, 18.88 and 17.97 respectively (Fig. 8). Distinct water quality guidelines for suspended sediments and turbidity are required for the protection of aquatic life during clear flow and turbid flow periods. The terms clear flow period and turbid flow period are used to describe the portion of the hydrograph when suspended sediment concentrations are low (i.e., less than 25mg/L or less than 8 NTU) and relatively elevated (i.e., greater than or equal to 25mg/L or greater than or equal to 8 NTU), respectively (Environmental Protection Agency, 2001). When the water is turbid, floating particles absorb heat from the sun and cause the water temperature to rise. High temperature causes oxygen level to fall, limiting the ability of aquatic organisms particularly the zooplankton to survive.

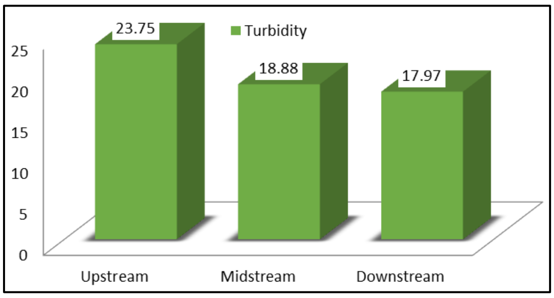

Fig. 8. Turbidity levels of water by sampling sites in NTU.

Salinity

The time of sampling period in three specified sites was during low tide then the amount of minerals (salts) that were dissolved in water from upstream to downstream were recorded a uniform outcome of 0mg/L. See Fig. 9 for the trend values. Some planktonic species may be distributed only within restricted zones in coastal waters, such as the low-salinity regions of estuaries, while others may reside only in coastal waters and the high salinity reaches near the estuary mouth (D.Knott, SCNNR Marine Resources Research Institute).

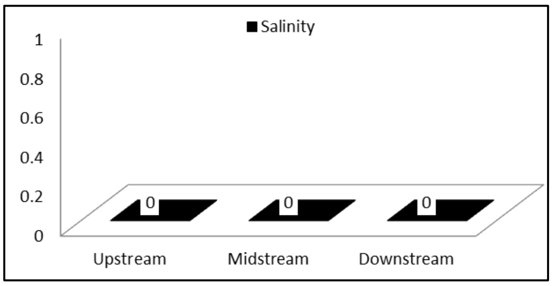

Fig. 9. Salinity levels of water by sampling sites in PSU.

Water current

As shown in Fig. 10, the mean water current from upstream to downstream were 0.994cubic feet ($ft.^3$)/sec, 1.071$ft.^3$/sec, 2.62$ft.^3$/sec respectively. The calculated results show low flow velocity of water. In terms of sediments, slow-flowing streams will settle quickly to the stream bottom. The three sampling sites have relatively minimum flow rate. Thus, it is expected that the amount of dissolved oxygen present is lesser and inversely proportional to the dissolved and suspended solids in the water.

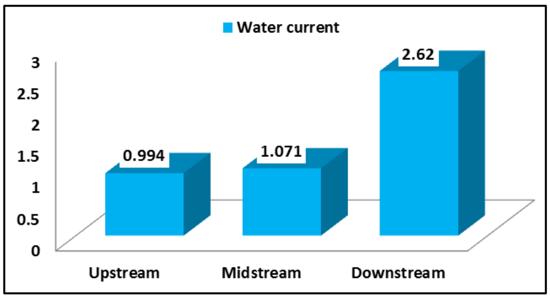

Fig. 10. Water current levels by sampling sites in ft^3/sec.

Dissolved Oxygen (DO)

Dissolved oxygen is essential to the respiratory metabolism of most aquatic organisms. Fig.11 shows that upstream has a DO average value of 4.40mg/L, while midstream has 0.251mg/L and downstream area has an average value of 0.181mg/L in which any of the streams do not fall within DAO 34 standard. The amount of dissolved oxygen status of the creek is low and it is not sufficient for aquatic organisms to survive and it cannot maintain the equilibrium between the DO and its consumers. This is also similar to the result of Del Rosario *et al.*, (2010) in which the dirty segment of the creek in the midstream and downstream registered zero or almost zero dissolved oxygen unlike in the upstream.

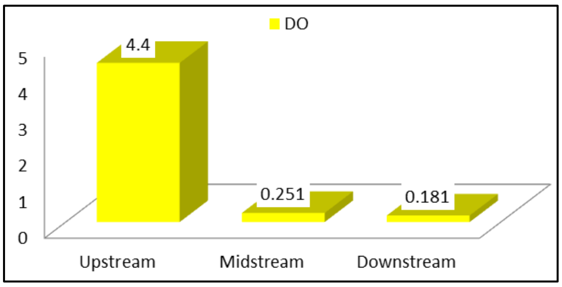

Fig.11. Dissolved Oxygen (DO) levels of water by sampling sites in ppm.

pH

Most aquatic organisms adapt to a specific pH level and may die if the pH of the water changes slightly. The resulting pH in this study has a range of 7.49-7.73 in which falls within the standard range of 6.5-8.5. Thus, there is no discrepancy in terms of pH level in Bitan-ag Creek during the time of this study. See Fig. 12. Most of the biological processes and biochemical reactions depend on pH, which therefore affects the distribution of zooplankton (Dorak *et al.,* 2014).

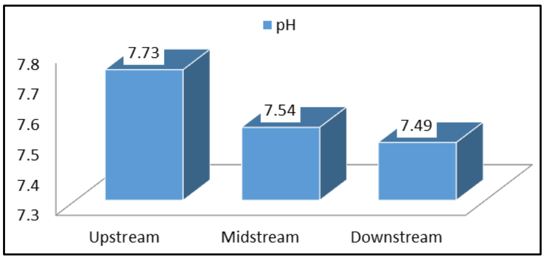

Fig.12. pH levels of water by sampling sites.

Chemical Oxygen Demand (COD)

Specific empirical procedures have been devised to measure oxygen demand. Biochemical oxygen demand (BOD) is a standard microbial incubation procedure that measures the oxygen required to oxidize organic material and certain inorganic materials over a given period of time. Alternatively, the measure for the amount of oxygen required to chemically oxidize reduced minerals and organic matter of a sample is termed chemical oxygen demand (COD). COD is used as an organic pollution index including phytoplankton growth. A COD of less than 1mg/l is assumed not to be caused by anthropogenic influence. Waters under this condition are suitable for conservation of the natural environment. Meanwhile, in the case of Bitan-ag Creek as a Class "C" water body, there is a great discrepancy in terms of COD level because only the upstream area falls within the Class "C" standard (60mg/L) with a mean value of 24.5mg/L. Whereas, midstream (63mg/L) and downstream (143.5mg/L) are clearly beyond the standard (Fig. 13). These results are also true with the results of Del Rosario *et al.*, (2010) in which there is a relatively high COD indicated in the downstream portion of Bitan-ag Creek.

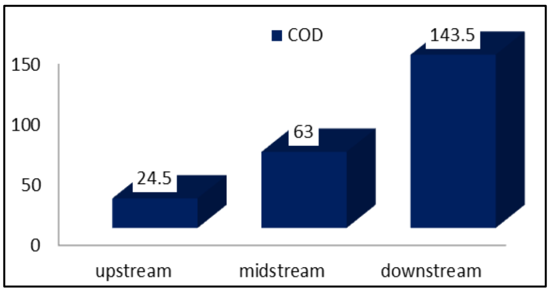

Fig.13. Chemical Oxygen Demand (COD) levels of water per sampling site in ppm.

Nitrates and Phosphates

As decomposition of plant and animal material occurs, dissolved oxygen levels decrease and nitrate levels increase. In addition, bacteria breaks down large protein molecules into ammonia which combines with oxygen to form nitrates and nitrites. Of these, nitrate is usually the most important to consider when determining water quality. Normally only small amounts are found naturally, but an increase in nitrate levels can come from many man-made sources such as septic systems, fertilizer runoff and improperly treated wastewater. As nitrates increase, they act as a plant nutrient and cause an increase in plant growth. As the plant material dies and decomposes, dissolved oxygen levels decrease (Tesoriero *et al.,* 2009). An increase in nitrates may be followed by an increase in phosphates.

As phosphates increase and the growth of aquatic plants is encouraged, algal blooms can occur. With the increase in algae growth and decomposition, the dissolved oxygen levels will decrease (Dodds, 2006).

Bitan-ag Creek has a nitrate range value of 0.33ppm-2.83ppm (see Fig. 14) which falls within the standard of 10ppm. While phosphates range value is 15.87ppm-176.30ppm which is far beyond the standard of 0.1ppm allowable value. The highest nitrates level is in the upstream (2.83ppm) while the highest phosphates level is in the downstream portion (176.30ppm). The phosphates levels are observed to be high most likely due to detergents (Del Rosario *et al.*, 2010). Sources of phosphates include septic tanks, runoff from feedlots, and runoff from agriculture and waste water treatment plants. In addition, detergents with phosphates were a prime source before manufacturers developed phosphate-free alternatives. Onyema and Ojo (2008) stated that high levels of nitrates and phosphates usually give rise to high abundance of some micro algal species in aquatic water environments. Thus, the present study shows that the high nutrient level in the downstream area sustains the life of microorganisms particularly the three found zooplankton families.

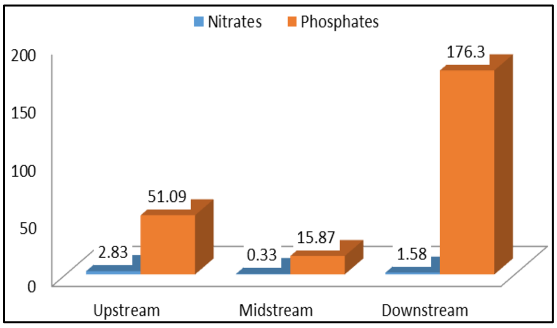

Fig.14. Nitrates and phosphates levels of water per sampling site in ppm.

Table 4 and Fig.15 shows the summary of the Analysis of variance of the collected data and overall trend of results of all parameters (except for TDS) in all sampling sites. In table 4, it showed that there are parameters which significantly differ among sampling sites, suggesting that source of pollution is a factor in water quality. In Fig. 15, in order to appreciate the data, the TDS has not been included due to its extreme values. Hence, the TDS results have a range value of 197.67-2595ppm.

Table 4. Summary of Analysis of Variance (ANOVA) for physico-chemical Analysis.

Parameter	P-value	Remarks
Conductivity	5.06E-08	Significant
Temperature	1.305E-06	Significant
Total Dissolved Solids	8.21E-08	Significant
pH	0.000164	Significant
Turbidity	9.58E-06	Significant
Water current	4.59E-05	Significant
Dissolved Oxygen	9.72E-06	Significant
Chemical Oxygen Demand	7.84E-13	Significant
Nitrates	7.96E-13	Significant
Phosphates	4.06E-21	Significant

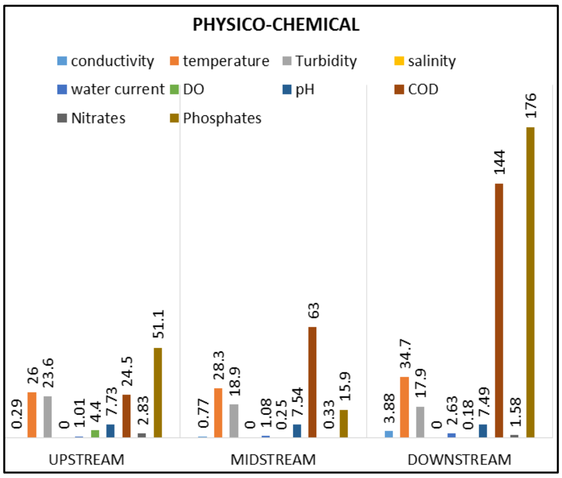

Fig.15. Summary result of all parameters.

Biological Indices

Species Composition of Zooplankton

Five (5) species of zooplankton belonging to three (3) families were collected and identified in the three sampling sites of Bitan-ag Creek. List of the different species with their corresponding families and their conservation status (IUCN) is shown in Table 5. These three (3) families collected are just a fraction of a vast diverse group of zooplankton found globally in the fresh and marine water ecosystem.

Among the three (3) families, the Fritillariidae has been more studied due to its occurrence to a several aquatic ecosystem unlike Daphniidae and Ameiridae. In fact, Ameiridae was a new species found in South Africa and believed to be potentially endemic in the area since it never appeared in their study before (Coyle *et al.,* 2008).

Table 5. Zooplankton Species collected at Bitan-ag creek, Cagayan de Oro City.

Family	Conservation Status (IUCN)
Ameiridae	rare
Fritillariidae	common
Daphniidae	common

Species Richness in Bitan-ag Creek

Table 6 shows that the downstream area has the highest species richness, followed by the upstream area. However, the least species richness is in the midstream in which there is no species found in this area. The present status of physico-chemical has greatly influenced the distribution and abundance of zooplankton in the study area. High species richness indicates a favorable environment for the successive development of the three families in the downstream portion. The estuarine zooplankton are of considerable trophic importance. Many copepods and other zooplankters, especially estuaries species, are omnivores that derived the majority of their nutrition by feeding on heterotrophic protists such as ciliates, and dinoflagellates, although under some circumstances they may rely more heavily on microplankton (Nejstgaard *et al.*, 2001).

Table 6. Species Richness.

Family/Species	Upstream	Midstream	Downstream
Ameiridae	√	X	√
Fritillariidae	X	X	√
Daphniidae	X	X	√

Legend:

√ --- Present

X --- Absent

Table 7 shows the number of species in each sampling site. Among the three sampling sites, the downstream portion found out to have three kinds of zooplankton species belonging to three (3) families. Whereas, only two (2) species under family Ameiridae was found in the upstream area. And no species of zooplankton was found in the midstream portion.The emergence of three species in the downstream portion is influenced by high level of turbidity, total dissolved solids (TDS), chemical oxygen demand (COD), DO, water temperature and phosphates in which the three species were tolerant to such level of pollution. However, in all sampling sites, the numbers of species found were extremely limited due to the very bad water quality status. Factors such as turbidity have been identified as critical factor in the development of zooplankton (Dejen *et al.*, 2004). Other authors (Wetzel, 2001; Hylander *et al.,* 2001) studied the influence of environmental and biotic interactions on the composition and abundance of zooplankton.

Table 7. Number of Species in three sampling sites.

Sampling site	Number of Species
Upstream (Tiera del Puerto)	2
Midstream (C.M. Recto Avenue)	0
Downstream (Lapaz 1)	3

Table 8 shows the number of families with total number of individuals collected in every sampling sites. It is shown that Ameiridae family has the highest total number individuals while Fritillariidae and Daphniidae families have the same number of individuals.

Classification of Zooplankton

The species of zooplankton collected in Bitan-ag Creek, Cagayan de Oro City are shown in Fig. 16. The classification, identification and description of these species are as follows.

Table 8. List of Families and their Total Number of Individuals in three sampling sites.

Family / Species	Upstream	Midstream	Downstream	Total
1. *Ameiridae*	2	0	1	3
2. *Fritillariidae*	0	0	1	1
3. *Daphniidae*	0	0	1	1
Total	2	0	3	5

Classification, Diagnostic Characteristics of Zooplankton species

1.)

Kingdom: Animalia

Phylum: Chordata

Subphylum: Tunicata
Class: Appendicularia
Order: Copelata
Family: Fritillariidae

Fritillariidae (see Fig. 16A) are small, free swimming pelagic tunicates with a trunk and a permanent chordate tail. The trunk epithelium secretes a gelatinous "house" that encloses the animal. Fritillariidaens have features that resemble those of the "tadpole" larval stages of the sessile Class Ascidiacea - therefore they have been called Larvacea before. Most species of Fritillariidaens are warm water forms, found in all oceans. Also, most of them live in the epipelagic, but increasingly new species are discovered in the meso- and bathypelagic. In general, Fritillariidaens are a few millimetres long (including the tail but without the house), some are much larger, up to 90mm (Brena *et al.,* 2003)

2.)
Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Crustacea
Class: Branchiopoda
Order: Cladocera
Family: Daphniidae

According to (Tiberti, 2011) daphnia (or Daphnids) are members of a collection of animals that are broadly termed as "water fleas". These are predominantly small crustaceans, and Daphnia belong to a group known as the Daphniidae which in turn is part of the Cladocera, relatives of the freshwater shrimp, (Batzer *et al., 2004*) and the brine shrimp, Artemia spp. They get their common name from their jerky movement through the water. Daphnia tend to be almost kidney shaped (see Fig. 16B), possessing only a single compound eye (though they have an ocellus, a simple eye), two doubly branched antennae (frequently half the length of the body or more), and leaf-like limbs inside the carapace that produce a current of water which carries food and oxygen to the mouth and gills. Their bodies are almost transparent and with a microscope you can see the heart beating, and sometimes even their last meal (the gut may appear green if the individual has been feeding on algae). A few species of Cladocera are predacious but most are herbivores or detritivores (Nandini *et al.,* 2009).

3.)
Kindom: Animalia
Phylum: Anthropoda
Subphylum: Crustacea
Class: Maxillopoda
Order: Harpacticioda
Family: Ameiridae

Harpacticoids (see Fig. 16C) is considered as bottom dwellers and have short antennae and crawling legs for living in the bottom sediments (Hunt & Stanley 2003)). Harpacticoids are distinguished from other copepods by the presence of only short pair of first antennae the second pair of antennae are biramous, and the major joint within the body is located between the fourth and fifth body segments. They typically have a wide abdomen and often somewhat wormlike body. Moreover, harpacticoids are more sensitive to pollutants which make them good indicator of pollution (Tackx *et al.,* 2004; Nakane *et al.,* 2011). Ameiridae is the third largest harpacticoid family; they are currently classified into 46 valid valid genera (Dolan 2011). Ameridae exhibit a wide range salinity tolerance since they occur in a variety of different habitat (rock pools, lagoons and sandy beaches) which naturally experience wide salinity fluctations (Yoshida *et al.,* 2012). Although, primarily marine, ameirids have succesfully radiated into freshwater habitats and can be found today from abyssal dept to freshwater caves (Gasca *et al.,* 2007).

Diversity Status of Identified Zooplankton

Diversity parameters were considered in the study such parameters include: Density, Frequency, Dominance, Species Importance Value and Diversity. As shown on table 7 & 8, five individuals from three different families of zooplankton were collected and identified. Family Ameiridae has the highest density value (see Table 9) which contributes 60% of the total species collected.

On the other hand, an equal number of species density from family Fritillariidae (20%) and Daphniidae (20%) were also identified. Ameiridae also obtained the highest frequency value of 0.67 or equivalent to 50% relative frequency, followed by family Daphniidae (25%) and Fritillariidae (25%) respectively (see Table 10). Ameiridae is the most dominant species as it was observed in the upstream and downstream part of the creek, followed by Daphniidae and Fritillariidae which was equally recorded and was noted only at the downstream portion.

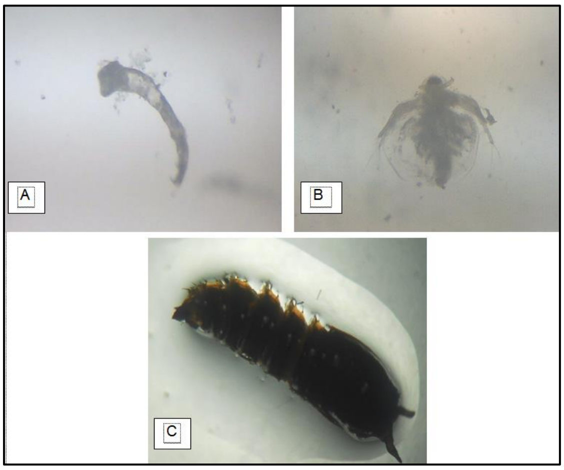

Fig. 16. Image of Zooplankton species found in Bitan-ag Creek, (A). Fritillariidae, (B) Daphniidae (C) Ameiridae.

Table 9. Density and Relative Density of Zooplankton in three sampling sites.

Family/Species	Density (D)	Relative Density (RD)
Ameiridae	3	133.33
Fritillariidae	1	33.33
Daphniidae	1	33.33
Total	5	199.99

Table 10. Frequency and Relative Frequency in three sampling sites.

Family/Species	Frequency (F)	Relative Frequency (RF)
Ameiridae	0.67	50
Fritillariidae	0.33	25
Daphniidae	0.33	25
Total	1.33	100

Table 11 shows the dominance and relative dominance while Table 12 shows the top species with high importance value in three sampling sites. Among the three families, Ameiridae has the highest species importance value and relative dominance, followed by Daphniidae and Fritillariidae. A better understanding of the structure, evolution and functioning of the aquatic and natural ecosystem is certainly a better preservation of biodiversity. Species diversity was computed using the Shannon-Wiener Index Diversity. The Shannon-Wiener index (H) <1.0 indicates that there is low diversity. A value of species diversity, 1.0<(H)>2.0 indicates moderate diversity while a value of (H) > 3.0 indicates high diversity. Data revealed that Bitan-ag Creek has a low diversity (see Table 13) in terms of zooplankton, an indication that Bitan-ag Creek is greatly disturbed. Factors such as area development, introduction of industries and anthropogenic activities attributes to the disturbance of Bitan-ag Creek. Furthermore, the flow rate and distance between sampling sites were also the factors that affect the migration of zooplankton. Thus, the diversity of zooplankton was limited.

Table 11. Dominance and Relative Dominance.

Family/Species	Dominance (D)	Relative Dominance (RD)
Ameiridae	1.11	133.33
Fritillariidae	0.11	33.33
Daphniidae	0.11	33.33
Total	1.33	199.99

Table 12. Top Species with high Importance Value in three sampling sites.

Family/Species	SIV	RANK
**Ameiridae*	316.66	1
**Fritillariidae*	91.66	2
**Daphniidae*	91.66	2

Table 13. Species Diversity.

Family/Species	ni	ni/N	logni/N	(ni/N)log(ni/N)
Ameiridae	3	0.6	-0.22	-0.132
Fritillariidae	1	0.2	-0.69	-0.138
Daphniidae	1	0.2	-0.69	-0.138

Conclusion and recommendation

Based from the result of the study it was clearly shown that among the physico-chemical and nutrient load parameters assessed and measured, six parameters were not able to meet the standard of a class "C" water body, these includes: conductivity, TDS, turbidity, DO, COD and phosphate content. Moreover, the species of zooplankton found in the area are belonging to the families *Ameiridae, Fritillariidae and Daphniidae*. Consequently, the result has also shown that in some species of zooplankton, there is an occurrence of *ameiridae* in the first and third sampling sites whereas the *fritillariidae* and *daphniidae* settled only in the third sampling site. This might have been attributed among other factors by area development within the vicinity and industrialization.

Thus, the distribution and abundance of zooplankton in the study sites were greatly influenced by the condition of physico-chemical and nutrient chemistry in the three sampling sites. This study has also concluded that there is a significant difference on the abundance and diversity of zooplankton between sampling sites. This research suggests that a rehabilitation must be imposed in the community.

A collaborative effort between Local Government Units (LGUs), private sectors, institutions, private and public settlers and the whole community in general is urgently and strictly needed to protect and improve Bitan-ag Creek water quality by implementing proper waste disposal within the community, cleaning and consistent maintenance of the creek.

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