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**PLANKTON AS BIOMONITORING AGENT OF WATER QUALITY IN UPPER  
EASTERN PAMPANGA RIVER, PHILIPPINES**

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**ABSTRACT**

This study was conducted in order to identify specific types of planktons and plankton communities that could be used as indicator of water quality in the Upper Eastern Pampanga River (UEPR), Philippines. Seven taxa of plankton were identified in UEPR with Phylum Chlorophyta (530.21 ind./mL), Class Crustacea (404.17 ind./mL) and Phylum Cyanophyta (230.21 ind./mL) as the three most abundant groups. Mean diversity of the reported plankton taxa were very low (0.12 to 0.27). Physico-chemical analyses of river water showed that majority of the parameters were within optimum concentration except for dissolved oxygen (DO) (0.16 to 3.99 ppm) and phosphorus (0.85 to 1.00 ppm). Abundance of Phylum Chlorophyta was positively influenced by water visibility, DO and alkalinity. Meanwhile, increase in the abundance of Phylum Cyanophyta was connected to high total dissolved solid (TDS) and nitrite. The abundance of Class Crustacea was significantly correlated to increase visibility, TDS and nitrite of the water. Using the Palmer's pollution index, the river water was confirmed to have high organic pollution or probable high organic pollution.

**Keywords: Plankton, abundance, diversity, water quality, organic pollution**

## INTRODUCTION

Upper Pampanga River Basin (UPRB) is one of the largest rivers in the Philippines. In Central Luzon, UPRB serves as a major source of water for a big population, growing industries and agricultural production. It also provides water in Nueva Ecija for its rice industry. However, due to commercialization in some municipalities, pollution in the river has risen up [1].

Water in the Upper Pampanga River is classified as class A while the water in the Lower Pampanga River is classified as class C [1]. Class A is good for municipal water supply requiring complete treatment such as coagulation, sedimentation, filtration and disinfection while Class C is meant for irrigation [1]. Unfortunately, limited data are available on the quality of water in the Pampanga River where its physical, chemical and biological characteristics are concerned. But, using the naked eye, water in the river is very turbid or with high suspended particles due to sediment load, which may have affected its biota population, mainly fish and crustaceans. At present, this turbidity level shows that the quality of water has indeed deteriorated steadily from Class A in 1975 to a much lower class and this can be attributed

mainly to increase agricultural activities and human settlements [1].

Aquaculture has been a practice in Pampanga after the eruption of Mount Pinatubo. At present, the province is known as the freshwater tilapia capital of the country [2]. Pampanga River serves as the primary source of water for aquaculture in the province of Pampanga and also a waste disposal system [3]. The unregulated inland fishery activities and limited baseline information made it difficult to monitor and assess the currently arising ecological problems in the province [3].

Human health depends on how monitoring is thoroughly done as it is a crucial step in environmental management. Biological monitoring is done when there are possible toxic effects in individuals, communities and ecosystems. Biological monitoring or bio-monitoring is the use of biological response to assess changes in an environment; these changes are generally due to anthropogenic causes. Bio-monitoring involves the use of indicators, indicator species or indicator communities which are usually benthic macroinvertebrates, fish or algae. Several works has been done on using algae as bio-indicators of water quality and pollution. This type of assessment may be

qualitative, semi-quantitative or quantitative. In ecology, it is said that the biological communities present in it, when observed, reflect the total integrity of the ecology and provides measures on how much impact is done by stressors or how fluctuated the environmental conditions are [4].

Basically, planktons are minute organisms floating in the waters of the seas, rivers, ponds and lakes possessing weak locomotor powers. Planktons are the primary producers and/or consumers in an aquatic environment. They may be classified as zooplankton (animal component) or phytoplankton (plant component) [5].

Plankton population observations may be used as biomonitors to assess the state of a given body of water since planktons are very sensitive to what is happening to their environment. The presence or absence of an indicator such as

plankton population reflects the condition of the environment [6].

The main objective of the study was to identify specific types of planktons and plankton communities that could be used as indicator of water quality in the Upper Eastern Pampanga River (UEPR), Philippines. The study also aimed to correlate plankton abundance with the physico-chemical properties of the river.

## MATERIALS AND METHODS

### Collection of Water Sample

Water samples were collected in the UEPR tributaries that covered the municipality of Arayat, Pampanga (Table 1). In every sampling site, 5 L of water sample were collected in the mid-surface using a Kemmerer water sampler. Sampling was conducted on a monthly basis from September to December 2012.

**Table 1: The exact locations of the sampling sites**

Sampling Site	Coordinate
A	N 15° 12' 176", E 120° 47' 333"
B	N 15° 11' 700", E 120° 47' 306"
C	N 15° 11' 515", E 120° 46' 918"
D	N 15° 12' 523", E 120° 47' 332"

### Physico-chemical Analyses of Water

Water parameters such as temperature, secchi disc visibility depth, total dissolved solids (TDS), pH and dissolved oxygen (DO) were determined on-site using multi-parameter water quality equipment

while analyses of alkalinity, total ammonia nitrogen (TAN), nitrite and phosphorous were done in the laboratory.

### Counting of Plankters

Five liters of water was filtered through a plankton net sampler. The 50 mL

filtered water sample was poured in polyethylene bottle and was immediately fixed with 0.15 mL of Lugol’s solution. The filtered water sample was mixed thoroughly and then 1 mL was pipetted into a Sedgwick-rafter counting chamber. The counting chamber was placed beneath the microscope and the plankters seen in every field were identified and counted. Taxonomic keys of Pennak (1978) and Segers (1993) were used for identification [7, 8].

**Calculations of Plankton Abundance and Diversity**

Plankton abundance was computed using the below formula [9]:

$$\text{Abundance (plankton/mL)} = \frac{[(T) 1,000/AN] \times \text{Vol. of concentrate (mL)}}{\text{Vol. of sample (mL)}}$$

where:

- T = total number of plankton counted
- A = area of grid in mm<sup>2</sup> in the Sedgwick-rafter counting chamber
- N = number of grids employed
- 1,000 = area of the Sedgwick-rafter counting chamber in mm<sup>2</sup>

The diversity (H) was calculated using the Shannon Index as follows:

$$H = -\sum p_i \ln p_i$$

where:

- H = the Shannon Index
- p<sub>i</sub> = proportion of species
- ln<sub>p<sub>i</sub></sub> = natural log of proportion of species

The diversity status was categorized as: very low (<1.99), low (2 to 2.49), moderate (2.5 to 2.99), high (3 to 3.49) and very high (>3.5) [9].

**Palmer’s Pollution Index**

Algal pollution indices of Palmer (1969) based on genus, was used in rating water samples for low or high organic pollution. A pollution index factor was assigned to each genus (Table 2). If there are >5 cells of a particular kind of algae on a slide, the algae must be identified and recorded. The pollution status of water was determined through determining the relative number of total points by every alga: 0 to 10 = lacks organic pollution; 10 to 15 = indicates moderate pollution; 15 to 20 = indicates probable high organic pollution and; >20 or more = confirmed high organic pollution [10].

**Table 2: The Palmer’s pollution index factor for algal genera**

Algal Genus	Pollution Index	Algal Genus	Pollution Index
<i>Anacystis</i>	1	<i>Micractinium</i>	1
<i>Ankistrodesmus</i>	2	<i>Navicula</i>	3
<i>Chlamydomonas</i>	4	<i>Nitzschia</i>	3
<i>Chlorella</i>	3	<i>Oscillatoria</i>	5
<i>Closterium</i>	1	<i>Pandorina</i>	1
<i>Cyclotella</i>	1	<i>Phacus</i>	2
<i>Euglena</i>	5	<i>Phormidium</i>	1
<i>Gomphonema</i>	1	<i>Scenedesmus</i>	4
<i>Lepocinclis</i>	1	<i>Stigeoclonium</i>	2
<i>Melosira</i>	1	<i>Synedra</i>	2

### Statistical Analysis

Differences in the abundance and diversity of plankton were analyzed using One-way Analysis of Variance. The possible relationship between water quality parameters and plankton abundance was carried-out using Pearson's Product Moment Correlation Analysis.

## RESULTS AND DISCUSSION

### Plankton Abundance

During September sampling, the river water was dominated by Phylum Chrysophyta with abundance of 250.00 ind./mL (38.19%) (Table 3). Four genera (*Melosira*, *Navicula*, *Surirella* and *Synedra*) were identified under this phylum and genus *Synedra* was the most abundant (September = 162.50 ind./mL; October = 41.67 ind./mL; November = 229.17 ind./mL; December = 29.17 ind./mL) in the group (Table 4).

For October sampling, Phylum Chlorophyta was the most abundant (1,241.67 ind./mL; 61.41%) (Table 3). Eight genera of phytoplankton (*Characiosiphon*, *Charasium*, *Chlorococcum*, *Closterium*, *Pediastrum*, *Scenedesmus*, *Selenastrum*, *Stigeoclonium*) were identified under Phylum Chlorophyta and the genus *Closterium* was the most common across months of sampling (September = 141.67 ind./mL; October = 683.33 ind./mL; November = 158.33

ind./mL; December = 366 ind./mL) (Table 4). A decrease in the abundance of Phylum Chlorophyta in the succeeding months of sampling (November = 166.67 ind./mL; December = 541.67 ind./mL) was observed (Table 3). Meanwhile, reduced abundance of Phylum Chrysophyta was only visible in the last month of sampling (December = 33.33 ind./mL) (Table 3).

The last two months of sampling was dominated by Class Crustacea with November and December abundances of 279.17 ind./mL (31.90%) and 1,158.33 ind./mL (31.54%), respectively (Table 3). Two sub-classes namely Cladocera and Copepoda were only identified under this phylum and the latter had higher abundance. With regards to the other phyla, the most abundant genera across months of sampling were *Oscillatoria* (Phylum Cyanophyta), *Euglena* (Phylum Euglenophyta) and *Filinia* (Phylum Rotifera) (Table 4).

When plankton abundances by month of sampling were combined together, the highest total abundance was recorded in December (3,200 ind./mL), followed by October (2,000 ind./mL), November (875.01 ind./mL) and September (666.66 ind./mL) (Table 3). The water in UEPR was already in eutrophic condition since the total number of plankton exceeded 150 ind./mL [11].

The most abundant taxon of plankton in UEPR was Phylum Chlorophyta based upon average monthly abundance. Mean abundance of Phylum Chlorophyta (530.21 ind./mL) was significantly higher as compared to the mean abundances of Phylum Ciliophora (180.21 ind./mL) and Phylum Rotifera (404.17 ind./mL), but not significantly higher when compared to the abundances of Class Crustacea (404.17 ind./mL), Phylum Cyanophyta (230.21 ind./mL), Phylum Euglenophyta (201.04 ind./mL) and Phylum Chrysophyta (164.58 ind./mL) (Table 5).

#### **Plankton Diversity**

Observed plankton diversities across months of sampling in UEPR were very low (September = 0.06 to 0.26; October = 0.17 to 0.29; November = 0.13 to 0.34; December = 0.04 to 0.30). Phylum Chlorophyta and Phylum Euglenophyta had the highest diversity index (0.26) during September. Phylum Chlorophyta has remained the most diversified (0.29) taxon until October. Meanwhile, Phylum Chrysophyta (0.34) and Class Crustacea (0.30) were the most diversified during November and December sampling (Table 3).

Highest mean diversity was recorded to Phylum Chlorophyta (0.27), followed by Phylum Cyanophyta (0.23) and Class

Crustacea (0.22). The mean diversity of Phylum Chlorophyta was significantly higher as compared to the diversities of Phylum Ciliophora (0.14) and Phylum Rotifera (0.12) only (Table 5).

#### **Physico-chemical Water Quality Analyses**

Observed water quality in UEPR was presented in Table 6. Optimum recorded parameters were temperature (30.05 to 30.79 °C), pH (7.82 to 8.03), alkalinity (98.94 to 181.53 ppm), total ammonia nitrogen (TAN) (0.72 to 1.59 ppm) and nitrite (0.04 to 0.13 ppm). Visibility of water was very high during October to December (29.69 to 36.81 cm) even though observed total dissolved solid (TDS) across months of sampling were high (125.45 to 290.55 ppm). Dissolved oxygen (DO) concentration was very low across months of sampling (0.16 to 3.99 ppm). For flowing environment such as river, a DO concentration of at least 7 mg/L is recommended. High values of phosphorus were recorded from September to December (0.85 to 1.00 ppm). Phosphorus in river should range from 0.01 to 0.05 mg/L only. Low concentration of DO and high level of phosphorus in water are good indications of eutrophication. Phosphorus in the river might come from the agriculture and aquaculture sector, and direct discharge from

industrial, municipal and septic waste systems.

### **Correlation of Plankton Abundance and Water Quality**

Except for Phylum Chlorophyta and Phylum Chrysophyta, majority of the plankton taxa were negatively correlated to temperature with Phylum Rotifera ( $r = -0.905$ ) and Class Crustacea ( $r = -0.632$ ) as highly significant and significant, respectively. Decreasing the visibility of water means increasing the abundances of Phylum Cyanophyta ( $p < 0.01$ ), Phylum Chrysophyta and Phylum Rotifera; opposite result was found in the rest of the taxa with Phylum Chlorophyta and Class Crustacea being significant at  $p < 0.05$  level. Except for Phylum Chrysophyta ( $r = -0.189$ ), increase in TDS of water has also resulted to an increase abundances in most of the taxa with highly significant and significant correlation in Phylum Cyanophyta ( $r = 0.771$ ) and Class Crustacea ( $r = 0.520$ ), respectively. Abundance of Phylum Chrysophyta and Phylum Rotifera was negatively correlated to DO; the rest of the taxa were positively correlated to DO with Chlorophyta as highly significant ( $r = 0.645$ ). Abundance of most of the taxa had positive correlation with pH but

the relationship was not significant. Abundance of Phylum Chrysophyta, Phylum Rotifera and Class Crustacea responded negatively to alkalinity; the remaining taxa showed positive correlation to alkalinity with Phylum Chlorophyta as highly significant ( $r = 0.692$ ). Most of the plankton abundances were negatively correlated to TAN and phosphorus while positively correlated to nitrite. Phylum Cyanophyta ( $r = 0.715$ ) and Class Crustacea ( $r = 0.714$ ) had positive and highly significant correlation to nitrite (Table 7). In a study made by Dogiparti *et al.* (2013), water parameters such as temperature, DO, pH, alkalinity, TAN, nitrite and phosphorus had positive correlation with plankton abundance [12].

### **Palmer's Pollution Index**

Nine algal genera that indicate organic pollution were identified in UEPR from September to December 2012. According to the relative number of total points by every alga, the river water was confirmed with high organic pollution during September (21 points), October (22 points) and December (22 points) samplings, and probable high organic pollution during November (18 points) (Table 8).

Table 3: Monthly composition, abundance and diversity of plankton taxa in Upper Eastern Pampanga River, Philippines

Month	Taxa	Composition (%)	Abundance (ind./mL)	Diversity
September	Chlorophyta	26.79±11.30	170.83±79.39	0.26±0.12
	Cyanophyta	10.38±6.53	70.83±46.21	0.23±0.10
	Chrysophyta	38.19±21.51	250±146.72	0.19±0.10
	Euglenophyta	12.47±14.80	95.83±127.68	0.26±0.11
	Ciliophora	4.17±7.22	25±43.30	0.19±0.15
	Rotifera	1.89±2.27	12.5±13.82	0.06±0.07
	Crustacea	6.12±3.11	41.67±27.64	0.16±0.06
		<i>Total</i>	666.66	
October	Chlorophyta	61.41±11.80	1241.67±444.80	0.29±0.06
	Cyanophyta	13.45±6.36	262.50±114.49	0.25±0.08
	Chrysophyta	6.86±4.60	133.33±84.98	0.17±0.08
	Euglenophyta	10.82±7.39	225.00±172.60	0.21±0.10
	Crustacea	7.46±6.19	137.50±96.73	0.17±0.08
		<i>Total</i>	2000.00	
November	Chlorophyta	19.05±22.64	166.67±71.69	0.27±0.04
	Cyanophyta	3.81±5.28	33.33±31.18	0.14±0.11
	Chrysophyta	27.62±6.07	241.67±159.21	0.34±0.03
	Euglenophyta	10.00±18.83	87.50±124.37	0.13±0.15
	Rotifera	7.62±18.88	66.67±69.72	0.13±0.14
	Crustacea	31.90±10.71	279.17±351.46	0.25±0.10
		<i>Total</i>	875.01	
December	Chlorophyta	19.13±9.69	541.67±230.49	0.29±0.09
	Cyanophyta	17.32±6.13	554.17±223.10	0.29±0.04
	Chrysophyta	1.19±1.29	33.33±35.36	0.04±0.05
	Euglenophyta	13.55±17.40	395.83±514.16	0.17±0.12
	Rotifera	17.28±6.14	516.67±107.37	0.29±0.04
	Crustacea	31.54±20.90	1158.33±1083.88	0.30±0.04
		<i>Total</i>	3200.00	

Table 4: Monthly composition and abundance of plankton taxa in Upper Eastern Pampanga River, Philippines

Taxa	September		October		November		December	
	Composition (%)	Abundance (ind./mL)						
<b>Chlorophyta</b>								
<i>Characiosiphon</i>	2.97±2.15	16.67±11.79	23.32±16.66	462.50±332.58	1.25±2.17	8.33±14.43	0.09±0.16	4.17±7.22
<i>Charasium</i>	----	----	----	----	0.62±1.08	4.17±7.22	----	----
<i>Chlorococcum</i>	2.17±3.77	8.33±14.43	0.35±0.36	8.33±8.33	2.95±4.13	12.50±13.82	5.36±3.14	150.00±88.98
<i>Closterium</i>	21.15±11.20	141.67±83.75	34.03±7.12	683.33±270.03	24.20±17.81	158.33±55.90	12.99±7.55	366.67±180.66
<i>Pediastrum</i>	----	----	2.05±1.83	45.83±39.75	----	----	0.55±0.76	16.67±20.41
<i>Scenedesmus</i>	----	----	1.66±1.48	41.67±44.88	----	----	0.14±0.24	4.17±7.22
<i>Selenastrum</i>	----	----	----	----	0.45±0.79	4.17±7.22	----	----
<i>Stigeoclonium</i>	0.50±0.87	4.17±7.22	----	----	----	----	----	----
<b>Cyanophyta</b>								
<i>Anabaena</i>	0.69±1.20	4.17±7.22	----	----	----	----	0.16±0.28	4.17±7.22
<i>Merismopedia</i>	----	----	----	----	1.25±2.17	4.17±7.22	----	----
<i>Nostoc</i>	----	----	0.98±1.01	25.00±27.64	----	----	----	----
<i>Oscillatoria</i>	9.69±5.61	66.67±42.49	12.47±6.39	237.50±98.87	7.95±10.00	50.00±67.70	17.15±6.23	550.00±227.00
<b>Chrysophyta</b>								
<i>Melosira</i>	9.26±8.29	58.33±58.33	----	----	----	----	----	----
<i>Navicula</i>	4.23±3.57	29.17±32.00	4.46±5.17	75.00±83.75	6.82±5.41	45.83±39.75	0.15±0.27	4.17±7.22
<i>Surirella</i>	----	----	0.57±1.00	16.67±28.87	----	----	----	----
<i>Synedra</i>	24.69±17.08	162.50±124.37	1.82±0.97	41.67±34.36	23.09±8.31	229.17±161.75	1.04±1.07	29.17±29.76
<b>Euglenophyta</b>								
<i>Euglena</i>	9.59±14.21	75.00±120.47	8.21±7.47	175.00±160.08	1.36±2.36	12.50±21.65	11.55±14.31	337.50±422.52
<i>Phacus</i>	2.88±2.09	20.83±13.82	2.62±1.44	50.00±26.35	----	----	2.00±3.10	58.33±91.67
<b>Ciliophora</b>								
<i>Cryptosporidium</i>	4.17±7.22	25.00±43.30	----	----	----	----	----	----
<b>Rotifera</b>								
<i>Brachionus</i>	0.50±0.87	4.17±7.22	----	----	0.62±1.08	4.17±7.22	2.93±2.22	95.83±73.95
<i>Filinia</i>	1.39±2.41	8.33±14.43	----	----	8.75±7.40	62.50±71.08	14.35±5.13	420.83±80.26
<b>Crustacea</b>								
<b>Cladocera</b>								
<i>Cladocera</i>	0.98±1.70	8.33±14.43	----	----	----	----	4.36±7.56	200.00±346.41
<b>Copepoda</b>								
<i>Copepoda</i>	5.14±2.30	33.33±16.67	7.46±6.19	137.50±96.73	20.67±22.03	279.17±351.46	27.17±13.95	958.33±742.60

**Table 5: Comparison of mean abundance and mean diversity of plankton taxa in Upper Eastern Pampanga River, Philippines**

Taxa	Mean Abundance (ind./mL)	Mean Diversity
Chlorophyta	530.21±507.45 <sup>b</sup>	0.27±0.08 <sup>b</sup>
Cyanophyta	230.21±242.97 <sup>ab</sup>	0.23±0.10 <sup>ab</sup>
Chrysophyta	164.58±147.30 <sup>ab</sup>	0.18±0.12 <sup>ab</sup>
Euglenophyta	201.04±311.61 <sup>ab</sup>	0.19±0.13 <sup>ab</sup>
Ciliophora	180.21±314.26 <sup>a</sup>	0.14±0.13 <sup>a</sup>
Rotifera	148.96±223.25 <sup>a</sup>	0.12±0.14 <sup>a</sup>
Crustacea	404.17±723.77 <sup>ab</sup>	0.22±0.09 <sup>ab</sup>

Different superscript shows significant at p<0.05.

Table 6: Mean water quality parameters in Upper Eastern Pampanga River, Philippines

Month	Temp. (°C)	Visibility (cm)	TDS (ppm)	D.O. (ppm)	pH	Alkalinity (ppm)	TAN (ppm)	Nitrite (ppm)	Phosphorus (ppm)
September	30.79±0.35	14.61±2.77	125.45±5.42	3.99±0.81	7.82±0.13	85.77±9.12	1.59±0.52	0.04±0.02	1.00±0.06
October	30.05±0.15	35.56±0.00	290.55±4.55	0.16±0.08	8.03±0.11	181.53±5.20	0.72±0.18	0.11±0.01	0.85±0.05
November	30.42±0.04	36.81±0.01	154.54±1.72	1.51±1.13	7.97±0.14	98.94±4.33	1.36±0.25	0.13±0.03	0.96±0.03
December	30.69±0.07	29.69±1.98	149.71±0.76	1.76±0.21	8.00±0.06	98.94±2.57	1.13±0.20	0.11±0.01	0.97±0.04

Table 7: Correlation (r) between plankton abundance and water quality parameters in Upper Eastern Pampanga River, Philippines

Taxa	Temp. (°C)	Visibility (cm)	TDS (ppm)	D.O. (ppm)	pH	Alkalinity (ppm)	TAN (ppm)	Nitrite (ppm)	Phosphorus (ppm)
Chlorophyta	0.001	0.530*	0.435	0.645**	-0.375	0.692**	-0.529*	0.229	-0.379
Cyanophyta	-0.279	-0.794**	0.771**	0.486	0.159	0.217	-0.437	0.715**	0.373
Chrysophyta	0.057	-0.365	-0.189	-0.333	-0.101	-0.183	0.067	-0.190	0.089
Euglenophyta	-0.337	0.336	0.343	0.044	0.072	0.163	-0.437	0.191	-0.455
Ciliophora	-0.373	0.384	0.366	0.066	0.083	0.133	-0.545	0.164	-0.555
Rotifera	-0.905**	-0.511	0.464	-0.596	0.287	-0.391	-0.514	0.437	-0.737*
Crustacea	-0.632*	0.618*	0.520*	0.036	0.503	-0.153	-0.524*	0.714**	-0.567*

\*significant at p<0.05 level; \*\*highly significant at p<0.01 level

Table 8: Monthly Palmer’s pollution index factor for algal genera

Algal Genus	Pollution Index			
	September	October	November	December
<i>Closterium</i>	1	1	1	1
<i>Euglena</i>	5	5	5	5
<i>Melosira</i>	1	0	0	0
<i>Navicula</i>	3	3	3	3
<i>Oscillatoria</i>	5	5	5	5
<i>Phacus</i>	2	2	0	2
<i>Scenedesmus</i>	0	4	0	4
<i>Stigeoclonium</i>	2	0	0	0
<i>Synedra</i>	2	2	2	2
Total	21	22	18	22

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**CONCLUSION**

Biological monitoring is the use of living organisms to determine the presence, amounts, changes in and effects of physical, chemical, and biotic factors in the environment. In aquatic ecosystems, bio-monitoring can be used to monitor changes in water quality, stream habitat, or even surrounding watersheds [13]. Plankton population observation may be used as a reliable tool for bio-monitoring studies to assess the pollution status of aquatic bodies [6].

Majority of the water quality parameters were still within optimum concentration except for DO and phosphorus. Low concentration of DO and high level of phosphorus in water are good indications of eutrophication.

Increased visibility, DO and alkalinity of the river water had a significant positive effect on the abundance of Phylum Chlorophyta. Abundance of Phylum Cyanophyta was positively influenced by TDS and nitrite concentration. Meanwhile, abundance of Class Crustacea was significantly correlated to increase visibility, TDS and nitrite of the river. Using the Palmer's pollution index, the river water was confirmed to have high organic pollution or probable high organic pollution.

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