Spatial Distribution and Diversity of Phytoplankton and Zooplankton and Status of physico-chemical parameters in White Nile, Blue Nile and River Nile

Abstract

The present study documents the distribution of phytoplankton, zooplankton and their correlation with physico-chemical conditions of water for White Nile, Blue Nile and River Nile. Some of the important physicochemical factors of the research stations have been analyzed and the water temperature (°C) were (22.00±1.00, 21.00±0.00 and 21.00±0.00), pH (8.47±0.31, 7.6.00±0.35 and 8.07±0.12) and Transperancy (cm) (34.67±11.06, 85.33±4.16 and 47.00±8.54) for White Nile, Blue Nile and River Nile repectivley. The result revealed that there are 18 species of phytoplankton and 18 species of zooplankton were recorded from all the stations. Among these Bacillariophyceae was the most dominant class in phytoplankton 5 genus, followed by 4 genus Chlorophyceae, 3 genus Cyanophyceae, 3 genus Zygnematophyceae, 2 genus Xanthophyceae and 1 genus Coscinodiscophyceae. While zooplankton, 18 different genera, the genus are represented by 6 genus Rotifera, 2 genus for (Crustacea, Rhizopoda, Lobosea and Eurotatoria), 1 genus for (Adenophorea, Phylactolemata, Secernetea and Ciliata). Statistically, phytoplankton showed significat result with zooplankton (r^2 = 0.81) and with water temperature and PO_4 (r^2 =0.43); non-significant different with transperancy (r2 = 0.01); for zooplankton the results showed that the positive relation between zooplankton and transperancy (r^2 =0.27) and non-significat with other parameters.

Keywords: Phytoplankton, Zooplankton, Physico-chemical parameter, River Nile, Blue and White Nile

Introduction

Rivers play a significant role as they serve not only the purpose of water supply for domestic, industrial, agricultural and power generation but also utilized for the purpose of sewage and industrial waste and therefore are put under tremendous pressure (Subin and Husna, 2013). Most of the rivers have been unmindfully used for the disposal of domestic and industrial effluents far beyond their assimilative capacities and have been rendered grossly polluted (Baskaram and De Britto, 2010). The consideration of temporal and spatial variability in aquatic systems is essential for understanding the ecology of freshwater biota (Schindler, 2001). Variability may be perceived as an impediment to understanding the forces that structure an ecosystem, but it can also be used to assess the relative importance of processes operating within a system (Kratz et al., 1987). Aquatic ecologists have typically examined space and time separately, either by sampling several lakes in a single year (often once), or one lake for many years (Rusak et al., 2002).

Organisms in an aquatic environment include phytoplankton, zooplankton, macrophytes, macro invertebrates and vertebrates. It is well established fact that more than 75% of freshwater fish feed on plankton at one or the other stage of their life cycle. The measurement of primary and secondary productivity is essential for estimation of fish production (Baskaram and De Britto, 2010). The components of the bioseston are the plankton and nekton, in most large inland waters the bulk of living matter found in water is phytoplankton and hence their biological importance is immense. Phytoplanktons are the primary producers of water bodies; these are the main source of food directly or indirectly to the fish population (Yousif et al., 2017, 2018).

The plankton way of life implies, by definition, suspension and drifting water. The modes of interaction between water motion and phytoplankton organisms are divers. At large scales relative to the size of the organisms, water motion control the transport both of the organisms themselves and of relevant physicochemical properties of the water (Horne and Platt, 1984).

Phytoplankton account for <1% of the photosynthetic biomass on Earth, but are nevertheless for nearly 50% of global net primary production and are the primary energy source for aquatic ecosystems (Field et al., 1998), The fate of these processes is critically dependent on phytoplankton community composition.

Zooplankton is one of the most important biotic elements that impact all functional aspects of aqueous ecosystems including food chains and tropic networks, energy flow, and the circulation of matter. They occupy a central position in pelagic zone food webs (Lampert, 1997; Ahmad et al., 2011; Alexander, 2012; Cottenie et al., 2001; Rajagopal et al., 2010; Richardson, 2008). Environmental factors are also important elements; for instance, water temperature impacts the growth and development of organisms and can influence their mortality (Hall and Burns, 2001). Different species show varied tolerances to increases or reductions in temperature ranges, and particularly sensitive individuals are eliminated by them (Andrulewicz et al., 2008; Tunowski, 2009; Ojaveer et al., 2010).

Materials and Methods

Time and Place of the Study

The present study results from limnological investigation undertaken during the dry season (April-May 2022) on three different location in White Nile, Blue Nile and River Nile as shown in (Table 1) by using GPS.

Table 1. Locations of the samples collection

	White Nile	Blue Nile	River Nile
A	N” 15°.31125 E” 32°.30011	N” 15°.6125840, E 32°.58454	N” 15°.707589, E” 32°.5356880
B	N” 15°.31625 E” 32°.30011	N” 15°.36351 E 32°. 43540	N” 15°.707590, E” 32°.5365680
C	N” 15°.31´464 E” 32°.30011	N” 15°. 63351 E 32°.34244	N” 15°.7094830, E” 32°.5392930

Phyisco-Chemical Parameters

The water samples were collected from selected sites during morning hours in two liters polythene bottles for physico-chemical parameters between 7:00 A.M. to 11:00 A.M. Water temperature (Thermometer), transparency (Sacci disk), pH, NO_2-N, NO_3-N, NH_3-N and PO_4 were determined by using standard methods of APHA, (2005).

Sampling and Collection of Plankton

For the plankton analysis, the samples were collected by filtering 40 liters of water filtered through plankton net of 20µ pore size filtering cloth and concentrated up to 100 ml. The concentrated plankton samples were preserved immediately with the help of 2 ml of formalin solution (10%) (Edmondson, 1959). The samples were observed under the microscope and identified phytoplankton using standard keys and published literature. The phytoplankton species have been identified by using keys Edmondson (1974). Counting was made by putting one drop of concentrate on a slide and observing the content under inverted microscope (Metzer). Results were expressed in No. /ml.

Diversity index Shannon -Weaver (1949) and correlation coefficient were also calculated. Shannon Weaver diversity index (H') was calculated using the following formula:

Shannon - Wiener Index (H) = Σni/N In ni/N ………………. (1)

Where:

H = Shannon -Weaver index of diversity;

ni = total numbers of individuals of species,

N = total number of individual of all species.

Data Analysis

1. Spatial and Temporal Distribution

One aspect of the dynamics of phytoplankton is the spatial and temporal distribution of PO_4, NO_3 and density of phytoplankton. Spatial aspects than is location, i.e. White Nile, Blue Nile and River Nile, while the temporal aspect is the dry. The analysis used two way multivariate analysis of variance (Johnson and Wichern, 1992).

If the parameters of a functional relationship between the dependent variable with more than one independent variable estimated, then the regression analysis with respect to the regression (multiple regression). To determine the relationship between (X_1), (X_2) and (X_3), to perform structural equation modeling and diagram using SPSS® (V. 16), then the general multiple linear regression model as:

$$Y = \beta 0 + \beta 1X_{1i} + \beta 2X_{2i} + \ldots\ldots + \beta k\ Xki + \varepsilon i \ldots\ldots\ldots\ldots \quad (2)$$

Where:

Y = observation to i on the dependent variable

Xik = Observations to i on the independent variables

β0 = intercept parameter

β1, β2, .. .βk = parameter regression coefficient independent variable

εi = observations to the i variable error

2. Functional Relationship between Plankton and Abiotic Factors

Plankton functional relationship with the abiotic environment was done to form multiple regression approach:

$$\int \text{Plankton} = f(Transperancy\, ;\, PO_4 - P\, ;\, No_3 - N) \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$Y_{plankton} = f(X\,Trans\,;\ X\,PO_4 - P\,; X\,No_3 - N) \ldots\ldots\ldots\ldots \quad (4)$$

Linear Multiple Regression

Results

Physico-chemical Parameters

The measurements of these characteristics provide valuable information about the aquatic environment. Some of the important physicochemical factors of the research stations (White Nile, Blue Nile and River Nile) have been analyzed as in (Table 2 and Figure 1).

Table 2. The average of physico-chemical parameters in water during the period of this study

	White Nile	**Blue Nile**	**River Nile**
Temperature (°C)	22.00±1.00	21.00±0.00	21.00±0.00
pH	8.47±0.31	7.6.00±0.5	8.07±0.12
NO_2 (mg L^{-1})	0.00±0.01	0.00±0.00	0.00±0.00
NO_3 (mg L^{-1})	0.00±0.01	0.00±0.00	0.00±0.00
NH_3 (mg L^{-1})	0.00±0.00	0.00±0.00	0.00±0.00
PO_4 (mg L^{-1})	1.33±0.01	0.00±0.00	0.00±0.00
Transperancy (cm)	34.67±11.06	85.33±4.16	47.00±8.54

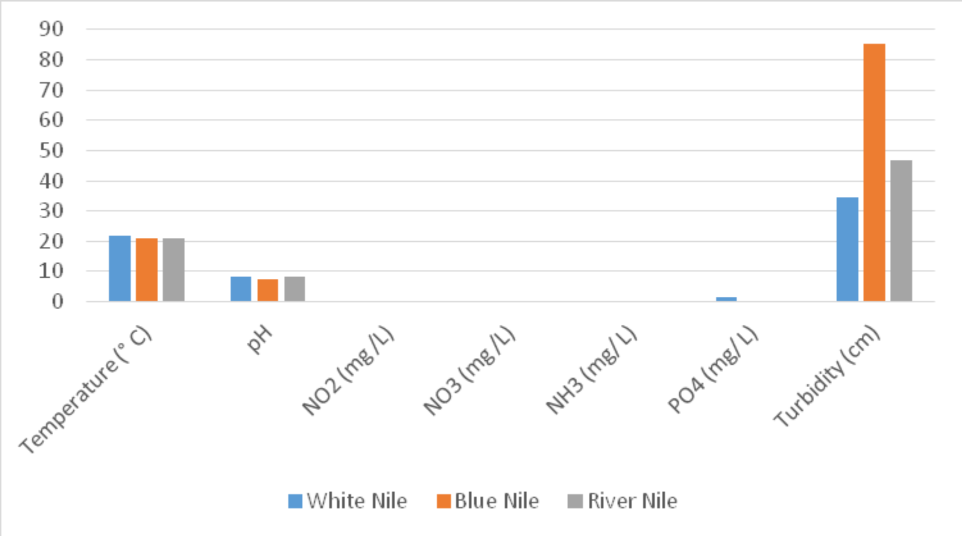


Figure 1. Physico-chemical Parameters during this study

Phytoplankton

Species composition of phytoplankton it's varied during this research that is depend on the location. The results showed that, the total number of phytoplankton classes were 6 in nine different stations studied which comprises 18 different genera, the genus are represented by 4 genus Chlorophyceae, 5 genus Bacillariophyceae, 3 genus Cyanophyceae, 1 genus Coscinodiscophyceae, 2 genus Xanthophyceae and 3 genus Zygnematophyceae (Table 3; and Figure.2).

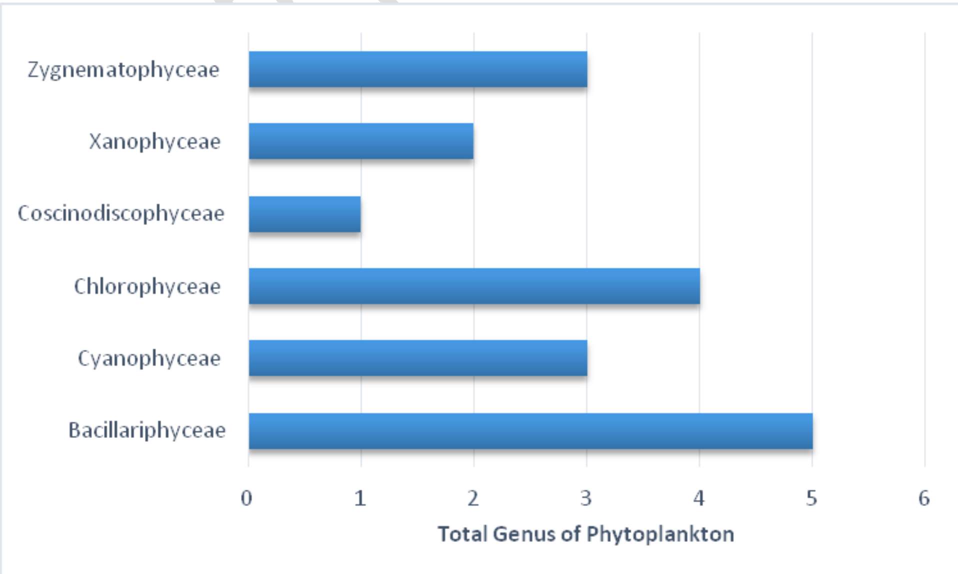


Figure 2. Total genus of phytoplankton during the study

The environmental variation in the species diversity index (H') have been calculated and presented in (Figure 3) for all the nine stations. The abundance of phytoplankton during this study ranged from 73, 101 and 210 Cell L^{-1} for White Nile, Blue Nile and River Nile respectivley.

Table 3. The average of phytoplankton during the period of this study in three different locations

Phytoplankton	White Nile	Blue Nile	River Nile	Total
Bacillariphyceae				
Navicula sp	1	2	-	**3**
Fragilaria robusta	-	2	2	**4**
Synedra sp	-	4	-	**4**
Bacillaria paradoxa	1	-	-	**1**
Diatoma sp	1	-	-	**1**
Cyanophyceae				
Phormidium sp	24	37	104	**165**
Oscillatoria sp	1	2	6	**9**
Chamaesiphon sp	7	6	12	**25**
Chlorophyceae				
Chaetophora sp	14	7	8	**29**
Scenedesmus sp	-	4	-	**4**
Pediastrum boryanum	1	1	-	**2**
Eudorina sp	-	1	-	**1**
Coscinodiscophyceae				
Melosira sp	7	26	17	**50**
Xanophyceae				
Tribonema sp	6	6	51	**63**
Euglena sp	5	-	3	**8**
Zygnematophyceae				
Spondylosium sp	1	2	-	**3**
Euastrum sp	4	-	3	**7**
Cosmarium sp	-	1	4	**5**
Total	**73**	**101**	**210**	**384**
Simpson Index (D)	**0.24**	**0.22**	**0.59**	
Shannon wiener index (H)	**4.2**	**4.6**	**1.7**	

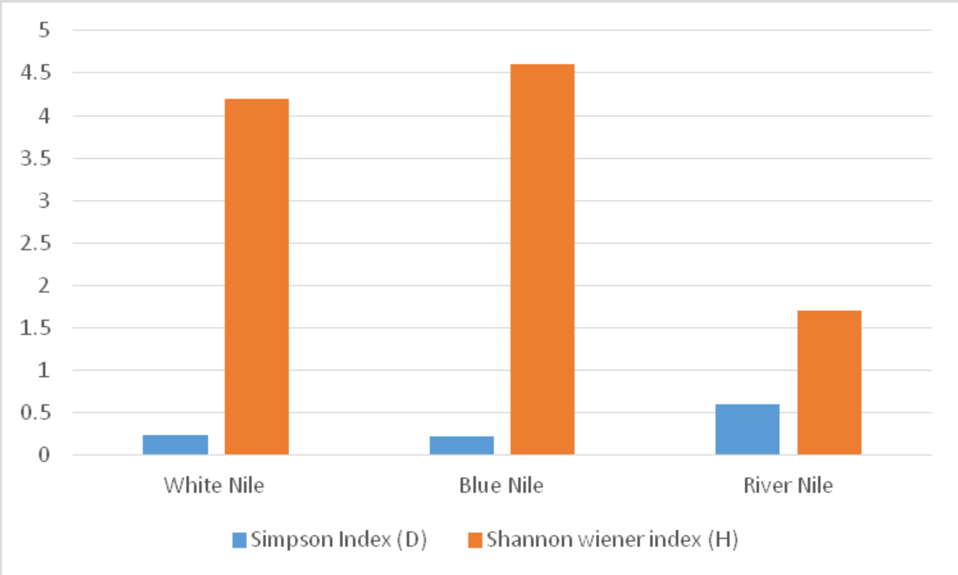


Figure 3. Phytoplankton diversity index during this study

Zooplankton

The results showed that, the total number of zooplankton classes were 9 in nine different stations studied in White Nile, Blue Nile and River Nile, which comprises 18 different genera, the genus are represented by 6 genus Rotifera, 2 genus for (Crustacea, Rhizopoda, Lobosea and Eurotatoria), 1 genus for (Adenophorea, Phylactolemata, Secernetea and Ciliata) (Table 3 and Figure.4). Simpson (D) and diversity index (H') have been calculated and presented in (Table 4; Figure 5) for all the nine stations. The abundance of zooplankton during this study were 125, 97 and 202 (ind./L) for White Nile, Blue Nile and River Nile respectivley (Figure 5).

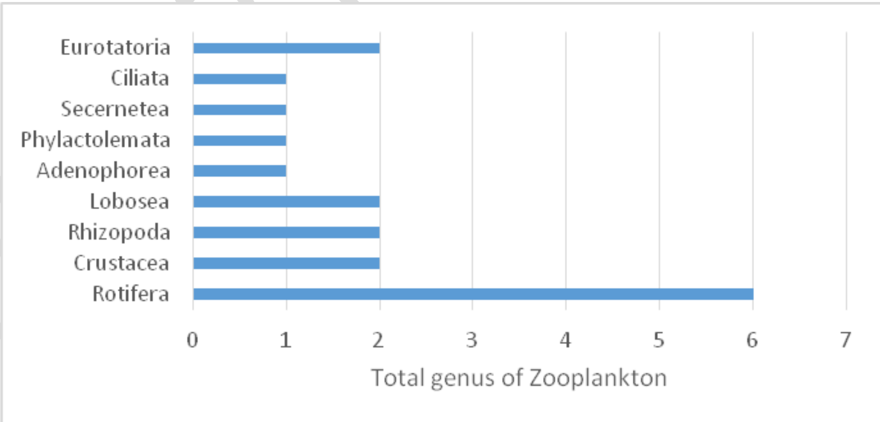


Figure 4. Total genus of zooplankton during the study

Table 4. The average of phytoplankton during the period of this study in three different locations

Zooplankton	White Nile	Blue Nile	River Nile	Total
Rotifera				
Brachionus sp	1	-	-	**1**

Brachionus bidentate	-	-	3	**3**
Brachionus falcatus	-	1	-	**1**
Notholca sp	-	4	1	**5**
Philodina sp	17	13	13	**43**
Keratella sp	1	4	-	**5**
Crustacea				
Cyclops sp	-	2	1	**3**
Moina sp	-	3	1	**4**
Rhizopoda				
Arcella sp	25	3	25	**53**
Difflugia sp	12	8	41	**61**
Lobosea				
Centropyxis sp	19	9	11	**39**
Centropyxis aculeate	5	6	23	**34**
Adenophorea				
Rhabdolaimus sp	8	10	35	**53**
Phylactolemata				
Plumatella sp	11	4	4	**19**
Secernetea				
Panagrolaimus sp	5	4	3	**12**
Ciliata				
Epistylis sp	9	16	17	**42**
Eurotatoria				
Rotaria sp	10	6	15	**31**
Monostyla sp	2	4	9	**15**
Total	**125**	**97**	**202**	**424**
Simpson Index (D)	**0.18**	**0.1**	**0.16**	
Shannon wiener index	**5.7**	**10**	**6.1**	

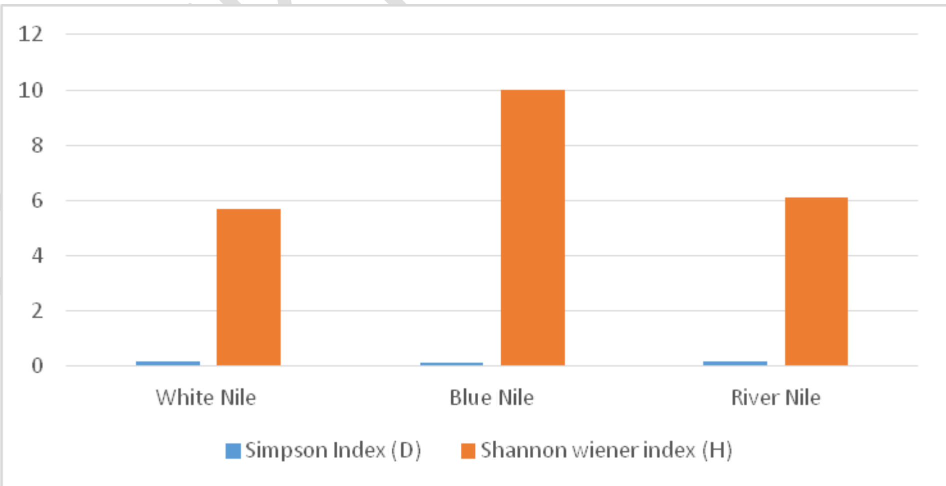


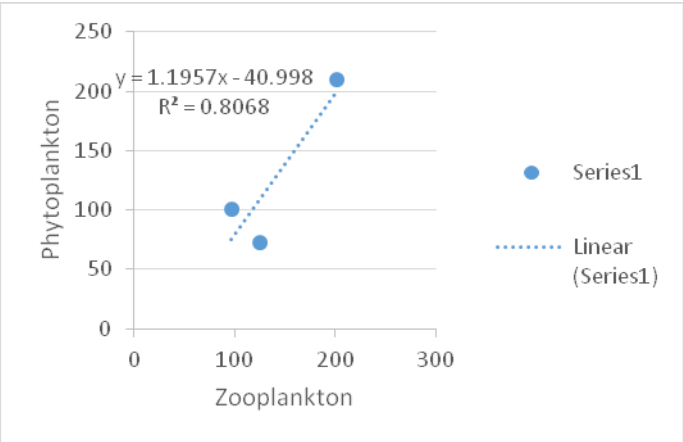
Figure 5. Zooplankton diversity index during this study

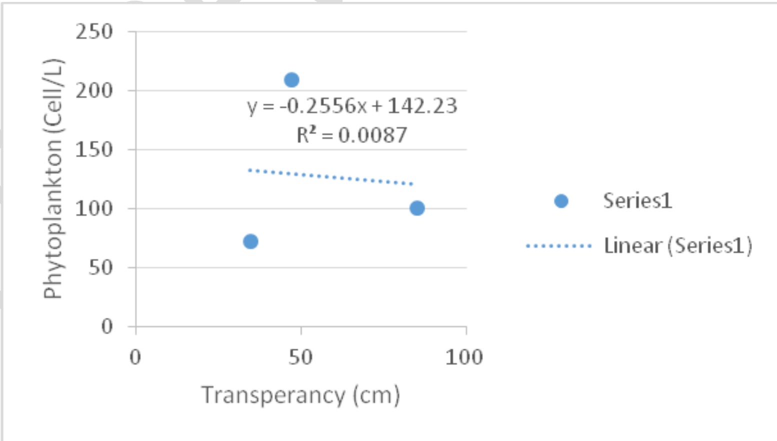
Table 5. The Equation of Regression Relationship between Biotic and Abiotic Components

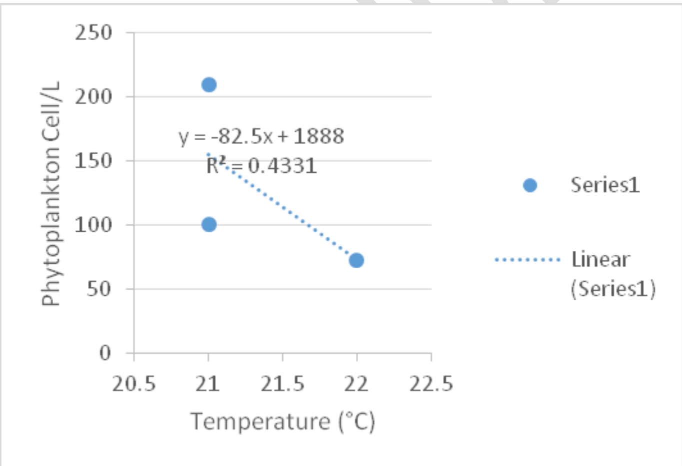
Parameter	Regression equations	df	$r_{calcu.}$	r_{table}	L.S

Properties				0.01	0.05	
Phyto – Zoo	$y=1{,}1957.e^{-40{,}998X}$	10	0.81	0.50	0.48	**
Phyo-Trans.	$y = -0{,}2556.e^{142{,}23X}$	10	0.01	0.50	0.48	NS
Phyto-Temp.	$y = -82{,}5.e^{1888X}$	10	0.43	0.50	0.48	*
Phyto-PO_4	$y = -62{,}03.e^{155{,}5X}$	10	0.43	0.50	0.48	*
Phyto – pH	$y = -24{,}547.e^{325{,}52X}$	10	0.02	0.50	0.48	NS
Zoo-Trans.	$y = -1{,}0731.e^{201{,}07X}$	10	0.27	0.50	0.48	*
Zoo –Temp.	$y = -24{,}5.e^{664X}$	10	0.07	0.50	0.48	NS
Zoo-PO_4	$y = -18{,}421.e^{149{,}5X}$	10	0.07	0.50	0.48	NS
Zoo –pH	$y = 37{,}713.e^{-162{,}13X}$	10	0.09	0.50	0.48	NS

Table (5) and Figures (6) showed significat result between phytoplankton and zooplankton (r^2 = 0.81) and with water temperature and PO4 (r^2 =0.43); non-significant different with transperancy (r^2 = 0.01); for zooplankton the results showed that the positive relation between zooplankton and transperancy (r^2 =0.27) and non-significat with other parameters







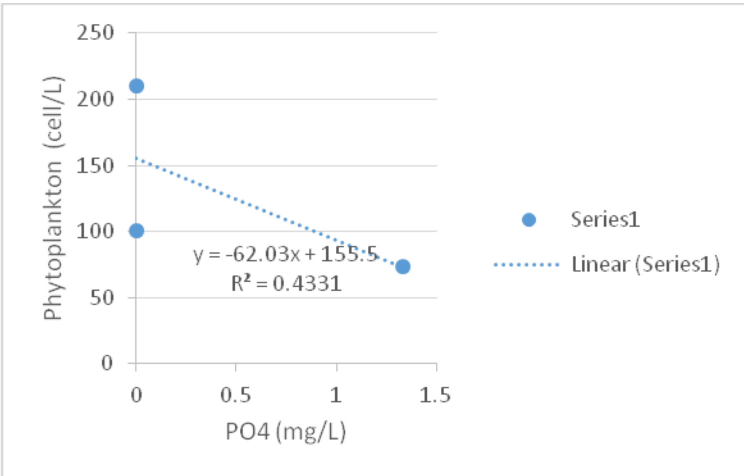


Figure 6. Regression Relationship between Biotic and Abiotic Components

Discussion

The ecological studies in fresh water involve a choice between two types of approaches, one connected with a knowledge of the dynamics of aquatic species in a given area and the other relating to a knowledge of water body and its physical and chemical characteristics. In order to define a particular freshwater body, it is important to analyze accurately as many physical and chemical characteristics of water as possible before preceding the biological studies. The measurements of these characteristics provide valuable information about the aquatic environment. Some of the important physicochemical factors of the research stations (White Nile, Blue Nile and River Nile) have been analyzed and the water temperature (°C) were (22.00±1.00, 21.00±0.00, 21.00±0.00), pH (8.47±0.31, 7.6.00±0.35 and 8.07±0.12) and Transperancy (cm) (34.67±11.06, 85.33±4.16 and 47.00±8.54) for White Nile, Blue Nile and River Nile repectivley.

The pH of water affects the solubility of many toxic and nutritive chemicals; therefore, the availability of these substances to aquatic organisms is affected. According to Mosley et al. (2004), water with a pH > 8.5 indicates that the water is hard. Most metals become more water soluble and more toxic with increase in acidity. Toxicity of cyanides and sulfides also increases with a decrease in pH (increase in acidity). The content of toxic forms of ammonia to the untoxic form also depends on pH dynamics.

Transparency The light in water is a factor of profound importance for its role in the photosynthetic processes of all chlorophyll bearing aquatic plants and thus for the primary production. It is often a limiting factor in the distribution of organisms in water particularly the plankton. The transparency values are given in (Table 2 and Figure 1) for the nine stations.

There are many sources of P addition to aquatic systems. In heavily fertilized agricultural regions, and also from municipal and industrial wastes is also an important source of phosphorus precipitation, P bound to soil particles enters aquatic systems by way of runoff and is a major source of P to surface waters. Applications of fertilizers and certain land management practices modify and generally increase the amount of nutrients in runoff. The addition of P to water from municipal and industrial wastes is also an important source (Wetzel, 2001). Phosphorus is accumulating in the world's agricultural soils. A consistent feature of intensive agriculture is that it operates with a P surplus, with more P entering the system than leaves in agricultural product (Heaney et al., 2001).

Increased PO_4 inputs can have many negative effects on aquatic ecosystems including: increased biomass of phytoplankton; shifts in phytoplankton to bloom forming species such as cyanobacteria, that may be toxic or inedible; increased biomass of benthic and epiphytic algae; changes in macrophyte species composition and biomass; decreases in water transparency; oxygen depletion; and, decreases in perceived esthetic value of the water body (Carpenter et al., 1998). Increased growth of algae and aquatic weeds interferes with use of the water for fisheries, recreation, industry, agriculture, and drinking.

Succession of phytoplankton communities is affected by strong seasonal influence, the population slowly declines till at all stations. This may be due to the changes in temperature. The high biomass in dry season could be the result of higher temperature and quantity of essential nutrients. Changes in the composition of plankton biomass perhaps are affected by predation and grazing which complicates the interpretation of population dynamics of phytoplankton in the White Nile, Blue Nile and River Nile.

Shannon-Wiener diversity index (H') were calculated by using the data on phytoplankton species and numerical abundance (cell number). Changes in phytoplankton cell numbers and diversity indices are shown in (Table 3). The highest values were 4.6 (in Blue Nile). It was shown that abundance of phytoplankton during the dry season in waters is negatively correlated with nutrient concentration (Polat and Isik, 2002; Yousif et al., 2017). This is attributed to a depletion of nutrients as these were utilized by the phytoplankton for photosynthesis increasing their population size.

Zooplankton is a good indicator of changes in water quality because it is strongly affected by environmental conditions and responds quickly to changes in environmental quality and also considered to be the ecological indicators of water bodies (Gajbhiye and Desai, 1981). Factors such as light intensity, food availability, dissolved oxygen and predation effect the population dynamics of zooplankton. Low pH can reduce their diversity and density (Horne and Goldman, 1994: Yousif et al., 2018).

Conclusion

The findings of this study revealed that phytoplankton and zooplankton could be considered as bio-indicators of water quality in several areas subjected to anthropogenic disturbance. The study showed that the physiochemical (inputs of sewage discharge, urban and agricultural run-off) and natural parameter (rainfall) are significant sources of variation and fluctuations in densities of phytoplankton and zooplankton genera, these biota are considered suitable bio-indicators for environmental changes which may threaten the White Nile, Blue Nile and River Nile. The composition and relative abundance of phytoplankton are determined by environmental factors especially nutrients and light conditions.

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