Effect of Selected Limnological Factors on Phytoplankton in Section of the River Nile

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ABSTRACT

Effects of pH, dissolved oxygen, temperature and water transparency on phytoplankton communities were investigated in section of the River Nile at Nimule, South Sudan. The Mean ± SE water pH, DO mgO2/L, water temperature (^{0}C), transparency (cm) and total phytoplankton abundance (cells L^{-1}) were in the order: 6.41± 0.23, 6.41± 0.23, 2±0.05, 27± 0.05, 62 ± 3.60 and 144 ± 24, respectively. Three phytoplankton peaks were encountered; the first peak was 285cells/L at pH 7.08, DO 1.8 mgO_2/L, temperature 27.1 ^{0}C and transparency 50 cm, the second one was 223cells/L at pH 5.98mg/L, DO 2.21mg/L, temperature 27.1 ^{0}C and transparency of 60 cm, and the third peak was 210 cells/L at pH 6.8, DO 1.95 mgO_2/L, temperature 27.1 ^{0}C and transparency of 60cm, recorded in September and October respectively. Two low peaks of 57cells/L at pH 6.91, DO 2.23 mgO_2/L, temperature 26.6 ^{0}C and water transparency of 60cm and 66cell/L at pH 7.09, DO1.8mg/L, temperature 27.1 ^{0}C and water transparency of 50cm occurred in August and October respectively. The algae component was found to consist of Chlorophceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae. Green algae was dominated by *Closteriumsp*, *Ulthrixspp* and *Chlorella spp* while blue-green algae was represented by *Merispomedia spp* and *Lyngbya spp*. Diatom was dominated by *Melosira spp* and *Tabellria spp* and Euglenophceae was represented by *Euglena spp*, The DO concentration was lower than the average concentration (5mgO_2/L) while the pH range between acidic and neutral (5, 98 - 7.09). The difference between high and low temperature was small (1^{0}C) but phytoplankton abundance corresponded with the high temperature. The total phytoplanktons was found to be more or less inversely proportional to transparency and the water was more or less neutral, transparent and less saturated.

Keywords: Phytoplankton, Climate Change, River Nile, Nimule South Sudan.

INTRODUCTION

The River Nile is the longest river in the world. It starts from its remotest headstream, the Luvironza River in Burundi, to the delta on the Mediterranean Sea, north east Egypt covering a distance of 6,695 km. The Nile flows northward and drains 2,850,000sq.km, about one tenth of Africa, including parts of Burundi, Tanzania, Democratic Republic of Congo, Uganda, Kenya, South Sudan, Eritrea, Ethiopia, Sudan and Egypt (Ibrahim, 1984).The Nile basin covers an area of over 3.12 million km^2, and being the longest in the world, the basin extends from 4ºS to 31º N, stretching over different geographical, climatological and topographical regions. In spite of its great length and large drainage basin about 10% of Africa, and affecting 10 nations, it carries relatively little water

The general desire to protect fresh water fisheries has led to an expansion of research into the water quality requirements, such as pH, temperature, dissolved oxygen, transparency, total alkalinity, total hardness, electrical conductivity, total dissolved matter. These factors serve as a basis for the richness or otherwise biological productivity of any aquatic environment (Unanam and Akpan, 2006). Review of researches on primary productivity revealed that it is important to assess the ecology of freshwater bodies in general (Hakanson, 2004). Several reasons may lead to vigorous and varied developments of planktonic algae in regions of the Nile system. Firstly, there are large headwater lakes in which lacustrine phytoplankton can develop, and possibly travel down their outflows as potential 'inocula' for renewed growth downstream. Secondly, the retention of water in the reservoirs within the Sudan and Egypt provides the additional time favourable for phytoplankton development to which marginal retentions also contribute. Thirdly, the great length of the river and its component stretches increase the time of travel of any water-mass and so the opportunities for planktonic growth (Talling *et. al.*, (2009), Phytoplankton is widely but unevenly developed in regions of the Nile system. The phytoplankton community composition is mostly dominated by diatoms (e.g. *Aulacoseira granulata*) and Cyanobacteria (e.g. *Anabaena flos-aquae f. spiroides*), but there are also many species of green algae and some flagellates such as Pediastrum and Volvox (Hammad and Ibrahim, 2012). In Aswan reservoir the major classes are Bacillariophyceae, Cyanophyceae, Chlorophyceae, Dinophyceae and Eugelnophceae. The dominant diatoms are *Cyclotella spp*, *Aulacoseira* and *Melosira spp*, while blue-greens are dominated by *Lyngbya spp*, *Oscillatoria spp* and *Anabaenopsis cunningtonii*. Green algae are dominated by *Ankistrodesmus spp* and *Closterium spp* (Salem, 2011). The biomass of micro-algae is a good source of nutrients, biologically active ingredients and considered the primary producers in the aquatic environment. Any change in their type, distribution and concentration would affect all organisms living in the Nile water, accordingly and for this reason, estimation of algal biomass is very crucial (Shehata *et. al.*, 2008).

The major factor limiting phytoplankton abundance and distribution is the transparency of water; this is due to the limitation of the production zone to relatively thin layer

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of about (2-3) near the surface. Transparency affects the distribution and seasonal variation of phytoplankton in rivers and to some extent, primary production of running water depends on its turbidity on one hand. On the other hand, water temperature is of enormous significance as it regulates various abiotic as well as biotic activities of an aquatic system. However, dissolved oxygen has been used as a most reliable parameter of lake eutrophication.

Despite the fact that the River Nile in Nimule holds some fish fauna, few studies have been done to identify its flora and fauna. Therefore this work aims at identifying the main algal assemblages and determines their variations with physicochemical parameters of the water. The finding of this work is expected to be a baseline towards setting up a future management plan for community fishery and aquaculture in the area as phytoplankton constitutes an important link in the food web of fish.

MATERIALS AND METHODS

Site description

Nimule Payam is located 120 km south east of Juba, the national capital of South Sudan. It is situated between latitudes 33^0 5.3' N and 34^0 7.2' N and longitudes 31^0E 49.3' E and 32^0E 2.2' E. at elevation of 750 m above sea level. The average annual temperature and rainfall are 26.5^{0}C and 1,101mm respectively. It is borderd in the north by Kaya River; the Eastern part is bordered by the River Nile while the southern part is bordered byUganda and the western part is bordered by Illungwa Mountain. Nimule National Park is situated within Nimule Payam. The park, established as a game reserve in 1935 and later was proclaimed as a national park in 1984, has an area that varies between 251km^2 and 410km^2.

Sampling

Boat was used for sampling phytoplankton and physio-chemical factors. Using GPS, 10 different sites were randomly selected, marked and plotted on a map using ArcGIS (Figure 1.).

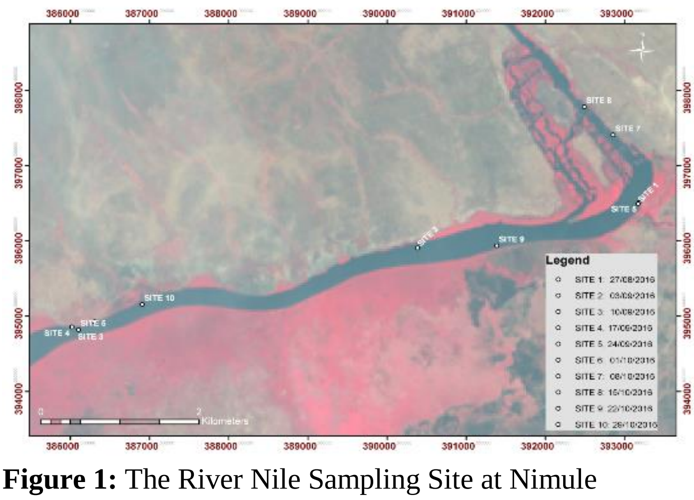

Figure 1: The River Nile Sampling Site at Nimule Payam and Pansalla District

Samples were taken weekly. The study covers the period from August 2016 to October 2016.

Phytoplanktons

Phytoplanktons were collected every 2 week using phytoplankton net (35 micron) at landing sites in Nimule Payam and Pansalla, Uganda - South Sudan border. The net was towed for an interval of 5 minutes using a boat. The content was then emptied into a sampling bottle and preserved in 4% formalin and allowed to stand for 24hr in order to settle. The supernatant water was then siphoned off leaving a concentration between (5-10ml). A drop from the siphoned water was mounted on a slide covered with cover glass and observed under binocular microscope, first using x10 magnification and then x40 magnification, for algal cells and filaments. The phytoplanktons encountered were recorded in their genera.

Transparency, temperature and pH

Water transparency was measured using a secchi disc 20 cm in diameter. The secchi disc is lowered into the water until the black and white colours on the disc unified. The mark made by water was recorded in cm. Water surface temperatures were recorded in degree centigrade (^{0}C) using an ordinary thermometer. The pH was measured using a pH meter (Model 25, Fisher Scientific).

Chemical analysis and data normalization

Water samples for chemical factors were analyzed in chemistry laboratory at University of Juba. The instruments used for the chemical analysis were calibrated before analysis. pH was measured with pH meter (Model 25, Fisher Scientific) and dissolved oxygen (DO) was measured in mgO_2/l using a digital oxygen meter (Model YSI 55). The total phytoplankton and water transparency were log normalized as follow:

Total phytoplankton = *log(total phytoplankton+1)*
Transparency = *log(transparency+1)*.

Data analysis

The data were analysised using SPSS Statistical Package. The phytoplankton were correlated with the limnological factors using graph and histogram.

RESULTS AND DISCUSSION

Phytoplankton abundance, and physic-chemical variables of water

The minimum pH , mean ± SE and the maximum levels recorded, were in the order of 4.42,6.41± 0.23 and 7.09; DO concentration (mg/l):1.8, 2±0.05 and 2.23; Temperature (^{0}C): 26.6,27± 0.05 and 27.1; Transparency (cm): 50,62 ± 3.60 and 80; Phytoplankton (cell/l):57,144 ± 24and 285 (Table 1).

Total phytoplankton abundance (cells L^{-1})

Three peaks of the total phytoplanktons were recorded during the study period. The first peak was a total of 285 phytoplankton cells/L which corresponded to the log (total phytoplankton+1) of 2.46 cells/L) that occurred on September 3rd. The second was a peak of 223 cells/L which corresponded to the log normalized phytoplankton of 2.35 cells/L which was observed on October 8th, and the third peak (210 cell/L^{-1}) that correspond to log (total phytoplankton+1) of 2.32 cells/L) was observed on October 29th. Low peaks of 57 and 66 cells/L which corresponded to log normalized total phytoplankton of 1.76 and 1.83cells/L occurred on August 27th and October 22nd, respectively (Figure 1). These variations could be due to increase in transparency which is related to the decrease in algal growth, phytoplankton species composition and diversity. Depth affected the behaviour of the algal associations (ÊW-Dantas, 2012).

Table1: Phytoplankton abundance and physical - chemical variables of water

Parameter	Minimum	Mean ± SE	Maximum
pH	4.42	6.4 ± 0.23	7.09
DO (mgO_2/l)	1.80	2 ± 0.05	2.23
Temperature (^0C)	26.60	27 ± 0.05	27.1
Transparency(cm)	50.00	62 ± 3.60	80
Phytoplankton(cell/l)	57.00	144 ± 24	285

SE, Standard error

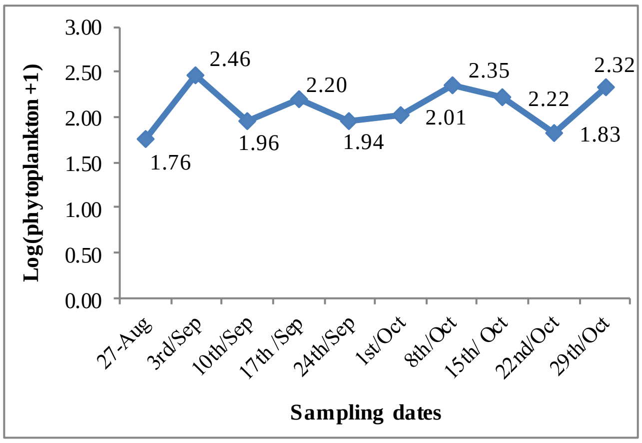

Figure 1: General trend of total phytoplankton

Nile section in Nimule consisted of the members of Chlorophceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae (Figure 2) of which the green algae were dominanted by *Closteriumsp*, *Ulthrixspp* and *Chlorella spp* while blue-green algae were represented by *Merispomedia spp* and *Lyngbya spp*. Diatom were dominated by *Melosira spp* and *Tabellria spp* on one hand. On the other hand, Euglenophceae was represented by *Euglena spp*, a finding in agreement with the work of Salem (2012) as quoted by Biswas and Tortajada (2012) who also found a similar composition which belong to Bacillariophyceae, Cyanophyceae, Chlorophyceae, Dinophyceae and Eugelenophceae. The dominant genera compositions were however more or less the same: diatoms were dominated by *Cyclotella spp.*, *Aulacoseira* and *Melosira spp.*, while blue-greens were dominated by *Lyngbya spp.*, *Oscillatoria spp.* and *Anabaenopsis cunningtonii*. Green algae were dominated by *Ankistrodesmus spp*. and *Closterium spp.*

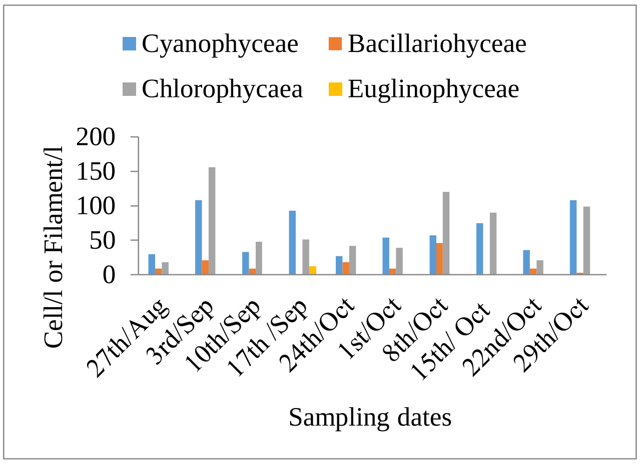

Figure 2: Evolution of phytoplankton classes encountered

Evolution of the total phytoplankton with dissolve oxygen (DO) and pH

The first peak of the total phytoplanktons was recorded at DO concentration and pH levels of 1.8 mgO_2/L and 7.08 respectively while the second peak occurred at DO concentration and pH levels of 2.21 mgO_2/L and 5.98 respectively, and the third peak was registered when the DO concentration and pH levels were 1.95 mgO_2/L and 6.88 respectively . The two low peaks occurred at pH concentrations and DO levels of 6.91,2.23mgO_2/L and 7.09, 1.8mgO_2/L respectively (Figure 3).

The pH of the reservoir was more or less alkaline and the DO concentration was lower than the average concentration (5mgO_2/L). However yet three peaks of total phytoplanktons were recorded. This could be due to the decomposition, turbidity and high water temperature. The decrease in DO might be due to the increase in water temperature and the increase in oxidative processes of organic matter (Abdel-Satar and Elewa, 2001). Anon (2007) also found high concentration of DO during cold season compared with the hot season in summer. The pH of water in present study ranged between acidic and neutral (5, 98 - 7.09). This result is in line with the finding of Toufeek and Korium (2009) who reported that the pH of Nile water slightly fluctuated between acidic and neutral in the range 5.7-7.1 during rainy season (August and September).

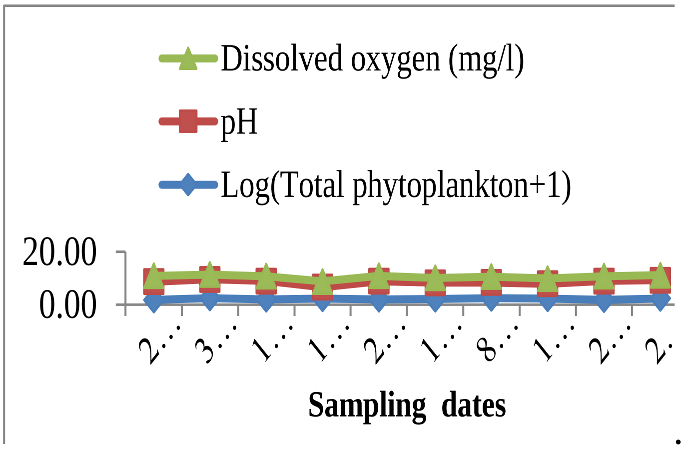

Figure 2: Evolution of total phytoplankton with Do and pH

Evolution of the total phytoplankton with water temperature

The first, second and third peaks of total phytoplankton were recorded at water temperature of 27.1 ^{0}C while the lowest peak was recorded at temperature of 26.6 ^{0}C (Figure 3).This finding shows that the phytoplanktons grow best in high temperature. The decrease or increase in the Nile water temperature depend mainly on the climatic condition ,sampling time, and the duration of sunshine as well as characteristic of water environment such as turbidity, wind direction, plant cover and humidity. Yacoub *et.al.* (2008) and Abdel-Satar (2005) indicated that water temperature of River Nile plays an important role in the heat budget of the Nile water, and a key factor in regulating River Nile phytoplankton population.

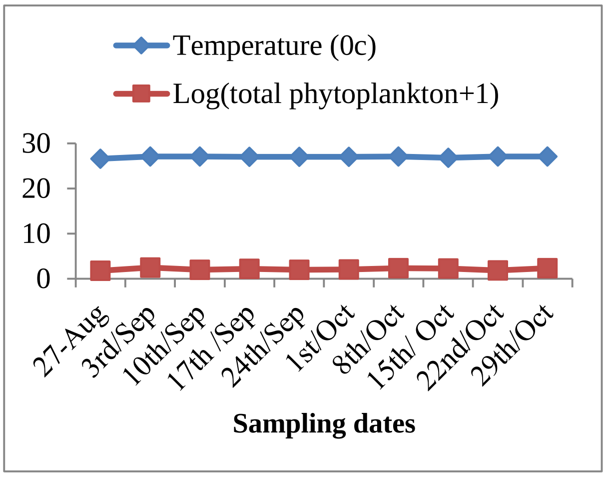

Figure 3: Evolution of total phytoplankton with water Temperature

Evolution of the total phytoplankton with water transparency

Total phytoplankton first, second and third peaks were recorded at water transparencies of 50cm which correspond to log (trans +1) =2cm, while the lowest total phytoplankton was observed at 60cmwhich also correspond to log (trans +1) =2cm (Figure4). This implies that the correlation between total phytoplankton and transparency is more or less inversely proportional relationship. Abdel-Satar and Elewa (2001) and Abdel-satar, (2005) attributed the high values of transparency to the increase in the uptake of suspended matter by phytoplankton and increased solar radiation penetrating the surface water as well as settling out of suspended particles to the bottom sediment especially during summer. However, increase in water level in addition to the decrease in the concentration of total suspended matter could lead to increase in transparency.

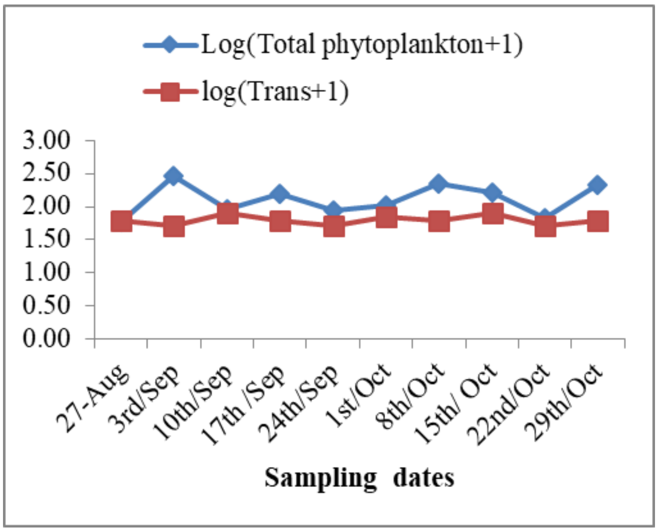

Figure 4: Evolution of total phytoplankton with transparency

CONCLUSION

The algae component of River Nile section around Nimule in South Sudan consists of the members of Chlorophceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae. Green algae was dominated by *Closterium sp*, *Ulthrix spp* and *Chlorella spp* while blue-green algae was represented by *Merispomedia spp* and *Lyngbya spp*. Diatom was dominated by *Melosira spp* and *Tabellria spp* and Euglenophceae was represented by *Euglena spp.* DO concentration was lower than the average concentration (5mgO_2/L)while the pH range was between acidic and neutral. The phytoplankton was found to grow best in high temperature. The River Nile section around Nimule was not much saturated, more or less neutral and transparent, yet it favours the growth of algae. The change in water quality of the River Nile sector around Nimule payam might have been attributed to fluctuations of rainfall a factor which should be considered in the next work.

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