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Species Composition and Abundance of Phytoplankton Communities in relation to Physico Chemical Parameters of Lake Tana at Gulf of Bahir Dar, Ethiopia

Flipos Engdaw and C. Subramanian*

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Abstract

The species composition and its abundance of phytoplankton community were studied in the shore of Lake Tana at Bahir Dar during Janurary, 2014. For physico chemical parameters such as Temperature (T), pH, Dissolved Oxygen (DO), transparency and turbidity on site measurements were made from four different sites. Each parameter was measured in five replicates by using standard methods. The other factors such as Euphotic zone and vertical attenuation coefficient were also determined. A total of thirty four phytoplankton genera / species belonging to four higher taxa were identified. The Chlorophyta dominated the phytoplankton community and contributed 38.2 % with 13 species followed by Bascillariophyta, Cyanophyta and Euglenophyta. However, the Cyanophyta found to be the most abundant (88 % of occurrence accounted 54.6 % of the total abundance) followed by Chlorophyta, Bascillariophyta and Euglenophyta. The one way ANOVA results indicates that the dissolved oxygen and transparency, showed significant variations between sites ($p < 0.05$) while others not showing any significant variations ($p > 0.05$).

Key words: Lake Tana, Physico chemical parameters, Phytoplankton and Species composition

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Present Address

Department of Applied Biology, College of Natural and Computational Sciences, University of Gondar, Ethiopia

Corresponding Author Email:
*Email: wlbsasu@gmail.com

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1. Introduction

Algae play a vital role in aquatic ecosystems by providing food and energy for organisms. They respond more rapidly to environmental changes, which have been traditionally used as indicators of water quality. Algae used in the pollution assessment and monitoring studies in various ways which include change in community structure, species diversity, species preference and biological toxicants. It affects the water properties such as water color, odor, taste and chemical composition (Santhi *et al*., 2013). Thus, the use of algae for ecological bio-monitoring of the water bodies helps in the analysis of water quality trends, development of cause effect relationships between water quality and environmental data and judgments of the adequacy of water quality for various uses.

In recent decades, freshwater biodiversity has declined faster than terrestrial or marine biodiversity (Bordoloi *et al*., 2013). Lake Tana is the largest lake in Ethiopia, its geography and catchment area has been described in various publications (Wudneh, 1998; Dejen *et al*., 2004; Wondie, *et al*., 2006).

Studies of the spatial and temporal variations in the physico-chemical properties of waters in relation to the periodicity of primary and secondary producers, and secondary consumers are essential for an evaluation of the trophic nature and community structure. These components are also important in determining the fisheries potential of the lake and for monitoring changes taking place as a consequence of human developmental activities and encroachment on the lake wetlands. Any changes in the physical and chemical variables can affect aquatic biota in a variety of ways.

This paper aims to provide a preliminary report on the phytoplankton assemblage and physico-chemical conditions in the Bahir Dar gulf of Lake Tana with a view to document the species composition and abundance of phytoplankton community in relation to the physicochemical parameters. There is a need to document these features of the Lake Tana at large and specifically, the Bahir Dar gulf with its peculiar biodiversity and the increasing threats of expanding urban habitation and attendant effect on the wetlands.

2. Material and Methods

2.1 Study area

Lake Tana is an oligo mesotrophic lake located in north west portion of Ethiopia on a mountaneous plain (Wudneh, 1998). It straddles the provinces of Gojjam and Gondar of Amara Regional State at a distance of 650 km from the capital city Addis Ababa with the latitude between 11^0 30' and 12^0 15' N and longitude of 37^0 15' to 37^0 35' E. The average elevation of this lake is 1800 masl and the surface area extent aproximately 3150 km^2 with the mean depth of 8.9 meters (Dejen *et al*., 2002).

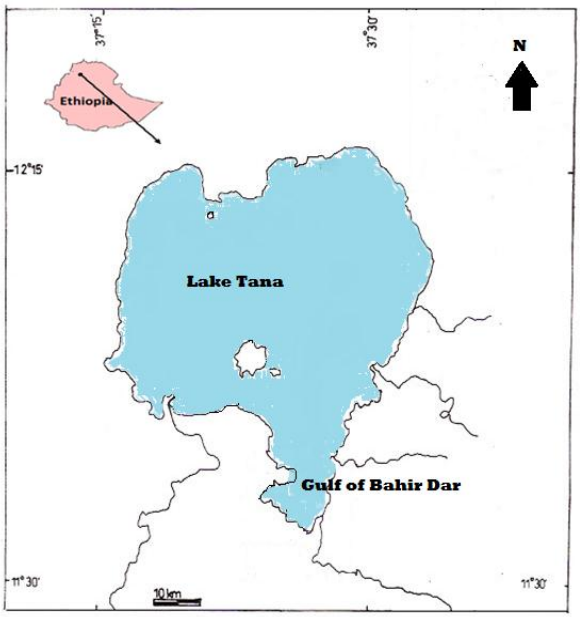

Figure 1: Map of Lake Tana showing the study area

2.2 Sampling and Measurements

For the physico chemical parameters such as Temperature (T), pH, Dissolved Oxygen (DO), transparency and turbidity on site measurements were made at the sampling sites. Each parameter was measured in five replicates from four different sites and measurements were made using standard centigrade thermometer, pH pen, Standard Oxygen Meter (SM600) and Secchi disc respectively. While others such as Euphotic zone and vertical attenuation coefficient were determined by following standard methods of (APHA, 1999; IAAB, 2006).

2.3 Phytoplankton Identification

Water samples were collected from the shore of Lake Tana at Bahir Dar by using washed bottles. The collected samples were homogenized and preserved by using 5% formalin solution to keep the phytoplankton from decomposition. For the identifications and enumeration of phytoplankton species, three methods were employed. 1. Filtration: Preserved samples were taken and filtered by using Whatman's filter paper (number 540/110 mm diameter). The filtrate was discarded and the solid residue was taken for algae identification. 2. Centrifugation: The samples were centrifuged at 100 rpm for 10 minutes by using Eltek

TC 450A model centrifuge. The supernatant was discarded and the residue was taken for identification (Siba and Jayanti, 1992). 3. Flocculation: For the auto flocculation, the samples was allowed to sediment by itself for 24 hrs and for chemical flocculation lugol's Iodine solution was added on the preserved sample so as to allow it for sedimentation (Wondmagene *et al*., 2012) and the sediments were used for the identification.

All the collected samples were examined under Olympus compound microscope (CX21FS1) at University of Gondar Biology department laboratory.

2.4 Data Analysis

The data generated from physico chemical parameter and phytoplankton identification study was analyzed by using descriptive statistics, such as mean, frequency of occurrence, percentage composition and standard deviation and SPSS version 16.0 software was used for one way ANOVA.

3. Results and Discussion

a. Physicochemical Properties

All the physico-chemical parameters were comparable except Dissolved oxygen and transparency which range from 4.4 to 7.32 mg/l and 27.5 to 41cm respectively. Transparency which is the measure of clarity of the water was relatively high at site 2. Presence of calm water or it may be due to the absence of clay, slit, finely divided organic and inorganic matter, soluble colored organic compounds and suspended materials. Water transparency was mainly controlled by the concentrations of suspended sediment particles rather than by phytoplankton. However, at site 1 more visible suspended solids from terrestrial environment contributed to the reductions of transparency of the water. The turbidity caused by suspended solids has an effect on the extinction of light in the water through reductions of visual depth (Bera and Akbar, 2012).

Temperature ranges from 18 to 22 ^{0}C with a mean of 20.75 ± 0.966 ^{0} C; whereas, the pH remains almost same in all sites as 6.8 ± 0.01. According to the result of present study, the pH is neutral in shore of Lake Tana water at gulf of Bahir Dar. Since aquatic organisms are extremely sensitive to high or low pH conditions that affect their metabolic activities, neutral pH is recommended to have a healthy environment. Thus according to the prescribed standards of WHO, (2004) as well as other literature values (Arain *et al*., 2008) the pH range between 6.5 to 8.5 is optimum for both potable water as well as for survival of aquatic organisms. Therefore the present finding of neutral pH range within the limit is positively in agreement with other findings who have reported results within the boundary (Radhakrihnan, *et al*., 2007; Bera and Akbar, 2012).

The level of dissolved oxygen (5.98 ± 0.88 mg/l), Transparency (36.5 ± 4.18 cm) euphotic zone (91.3 ± 20.9 cm) and vertical attenuation coefficient (0.61 ± 0.08 cm) shows variations. High level of DO was recorded at site 4 and it was low at site 1. The one way ANOVA results indicates that only dissolved oxygen ($p < 0.001$) and transparency ($p < 0.013$), showed significant variations between sites, while others not showing any significant variations ($p > 0.05$). One of the most important critical parameter in aquatic environments is the amount of oxygen dissolved in water regulated by consumption of aquatic organisms, natural aeration, amount of organic matter and water temperature (Mengesha, 2010).

Table- 1: Values of physico-chemical parameters recorded during this study

Parameter	Mean ±SD				
	Site 1	Site 2	Site 3	Site 4	Mean
T° (^{0}C)	19.8 ± 1.09	21.4 ± 0.89	21 ± 0.71	20.8±0.45	20.75±0.97
pH	6.80 ± 0.01	6.81 ± 0.1	6.82 ± 0.01	6.79 ± 0.01	6.8 ± 0.01
DO (mg/l)	4.91± 0.39	5.83 ± 0.69	6.08 ± 0.14	7.09 ± 0.20	5.98 ± 0.88
SDT (cm)	32 ± 2.23	39.5 ± 2.03	38.1 ± 2.81	36.5 ± 5.13	36.5 ± 4.18
EZ (cm)	80 ± 5.59	98.7 ± 5.08	95.2 ± 7.03	91.2 ± 12.8	91.3 ± 20.9
VAC (cm)	0.69 ± 0.05	0.56 ± 0.03	0.58 ± 0.04	0.61 ± 0.10	0.61 ± 0.08

Table -2: The phytoplankton species recorded with their occurrence and abundance

Taxa	Genera or species	Occurrence (%)	Abundance (%)
Cyanophyceae	*Anabaena*	20.6	1.4
	Aphanocapsa	11.8	1.7
(Blue green	*Chreococus*	58.8	8.8
algae)	*Coelospharium*	79.4	10.8
	Cylinderospermosis	35.3	3.1
	Lyngbya	68.1	7.3
	Microcystis	88.2	15.4
	Oocystis	14.7	0.9
	Planktolyngbya	52.9	5.2
Chlorophyceae	*Ankistrodesmus*	8.8	1.2
	Botryococus	58.8	4.7
	Chlamydomonas	17.6	1.7
(Green algae)	*Chlorela*	23.5	2.4
	Closterium	23.5	2.1
	Cosmarium	8.8	1.5
	Crucigenia	44.1	3.1
	Oscilatoria	17.6	1.9
	Pediastrum	2.9	0.5
	Spirogyra	26.5	2.4
	Ulotherix	2.9	0.7
	Volvox	38.2	3.3
	Zoochlorela	5.9	0.4
Bascilariophyceae	*Anomoneies*	26.6	3.1
	Cyclotella	67.6	3.9
(Diatoms)	*Cymbella*	11.8	1.0
	Fraglaria	14.7	1.1
	Melosira	17.6	2.8
	Naviculla	11.8	0.5
	Nitzschia	14.7	1.4
	Pinularia	17.6	2.2
	Sururella	11.8	0.7
	Synedra	2.9	0.5
Euglenophyceae	*Phacus*	14.7	1.6

Euglena	8.8	0.7

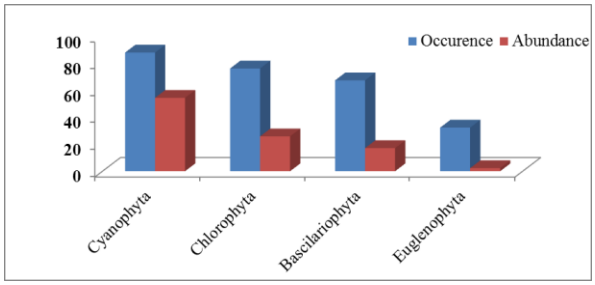

Figure 2: Abundance and Occurrence of phytoplankton

The least concentration of DO in the present study was found at site 1 as 4.4 mg/l while the maximum was 7.36 at site 4. It might be due to over exploitation through bacterial decomposition in site 1 (high BOD) caused by the presence of high organic matter at the shore regions of the lake which indicates high pollution load in the water or presence of suspended particles that cause turbidity. The other possible justification for low DO may be over production of algae (Eutrophication) which cause high rate of respiration or may favor other animals to flourish, as well at the time of death high DO required for decomposition by aerobic microorganisms.
The study of Radhakrihnan *et al*., (2007) reported the decomposition and oxidation of organic matter reduce the solubility of oxygen in water. On the reverse high concentrations of DO at site 4 may be due to the photosynthetic activities of phytoplankton or it may be the good mixation of water. This result is in agreement with the findings of Lokhande *et al*., (2011) and Radhakrihnan *et al*., (2007).

3.2 Phytoplankton

A total of 34 phytoplankton genera/species belonging to 4 higher taxonomic groups such as Cyanophyta (blue green), Chlorophyta (green algae), Bascilariophyta (diatom) and Euglenophyta were identified. Of all taxonomic genera, members of Chlorophyta were found to be the most abundant groups constituting 13 species (38.2%) of the total phytoplankton recognized followed by Bascillariophyta which comprise 10 species (29.4%) and Cyanophyta embrace 9 species (26.5%). However, Euglenophyta was found to be the least abundant group that constitutes the remaining 2 species (5.9%).

In the present study, the identified 34 species belonging to 4 different genera on the shore of Lake Tana were relatively diverse. As compared to reports from Ethiopian inland water bodies (Wondmagegne *et al*., 2012; Hadgembes, 2007; Adane, 2006) who has reported the presence of common phytoplankton species dominated by same genera and species composition. Phytoplankton in Lake Tana shore was found to be almost similar. Both studies disclose the dominancy of green algae in terms of species composition by number. However in this study diatom was the second dominant than blue green in the above study.

On the other hand members of the Division Cyanophyceae were found to be the most abundant species which occurred in many of the slides examined showing 88% occurrence that accounted 54.6% of the total abundance. Blue greens were dominated by colonial *Microcystis* which was found to be the most abundant and frequently occurring species with 15.4%. *Coelospharium* was the second most abundant species followed by *Chreococus* by accounting 10.8% and 8.8% correspondingly. Filamentous members of the group such as *Lyngbya*, *Planktolyngbya* and *Cylinderospermosis* have constituted 7.3%, 5.2% and 3.1% in the same order. As compared to the others, the abundance as well as occurrences of *Ahanocapsa*, *Anabaena* and *Oocystis* was established to be diminutive.

The most diverse but the second abundant division was Chlorophyta, which comprised 25.9% and occurred in 76.4% of the slides inspected. Within green algae, *Botryococus*, *Crucigenia* and *Volvox* were relatively dominant on the shore line region of Lake Tana occurring 58.8%, 44.1% and 38.2% as well as contributing 4.7%, 3.7% and 3.3% to the total abundance of the group respectively. Some of the common members of green algae such as *Chlorela* and *Closterium* showed average abundance (2.4% and 2.1%) and occurrence as all accounted 23.5% whereas *Spirogyra* was observed in 26.5% of the samples with 2.4% contribution to the total abundance of phytoplankton in the lake. Both least occurrence and abundance were recorded by the remaining members of the division including *Oscilatoria* and *Clamydomonas* (17.6%), *Cosmarium* and *Ankistrodesmus* (8.8%). However, the occurrence and abundance of *Ulotherix* and *Pediastrum* is negligible as compared to others.

The species compositions of algae vary from one to another as more species can co exist in one lake for long period of time. The difference in dominance of diverse algae genera may be due to changes in a yearly cycle known as algal succession. Reports on the diversity and compositions of phytoplankton from different inland waters of Ethiopia can be a good example. 46 species of phytoplankton belonging to 6 genera were also reported from Gefersa reservoirs. Based on their dominance it is in consensus with the present study as Chlorophyceae, followed by Bacillariophyceae and Cyanophyceae (Nigatu, 2010).

Natural succession of phytoplankton in aquatic environment happens due to their response to changes in season, temperature, wind, precipitation patterns, and nutrient cycles. Growth and development of algae is limited by availability of solar radiations, high nutrient load and absence of zooplanktons or filter feeders which are dependent on grazing them (Moore and Thornton 1988).

The third diverse division with 67.6% occurrence and 17.2% abundance was Bascilariophyta, which was represented by dominant *Cyclotella* and *Anomoenies* that occurred in 67.6% and 20.6% of the samples examined with abundance of 3.9% and 3.1% in that order. *Melosira* and *Pinularia* accounted 2.8% and 2.2% abundance has showed similar occurrence of 17.6% as *Nitzschia* and *Fraglaria* occurred 14.7% of the samples examined. While the occurrences of *Cymbella*, *Sururella*, *Navicula* and *Synedra* were very small. The last division was Euglenophyta that confirmed an occurrence of 32.4% was found to have the least contribution to the total abundance of the community. The division was represented by *Phacus* and *Euglena* in which both species has occurred 14.7% and 8.8% with abundance of 1.6% and 0.7% in the same order.

Abundance, distributions and richness of phytoplankton in a given water body depends on several factors including, availability of nutrients low turbidity which promote penetrations of solar radiation are the crucial once (Nigatu, 2010). As compared to other water bodies of Ethiopia, Lake Tana has the largest morphometry. However, the diversity of aquatic organisms especially of the phytoplankton was small. A study conducted by Girma, (2006) on the rift valley Lakes indicated the presence and dominancy of Chlorophyta, Cyanophyta and Bacillariophyta.

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