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A Study on Phytoplankton Species Composition, and Primary Production in Fincha Reservoir, West Shoa Zone, Ethiopia

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Abstract
Fincha reservoir is a man-made freshwater body in Ethiopia constructed in 1973 in the course of *Chomen swamp* for power generation, irrigation and fishing. This reservoir is one of those water bodies which have not received attention in spite of its flourishing commercial fisheries. The phytoplankton species composition, biomass and primary productivity of this reservoir was carried out during the non rainy season for a period of six months. The samples were taken from two selected sites, s1 located near the shore where human interference in the form of washing clothes, cattle and fishing is high and S_2 an open area at the middle of the reservoir (less impacted area). The water in the shallow study site showed high level of total nitrogen, nitrate and total phosphorus than the deeper zone. The Three classes such as green algae, blue green algae and diatom were the major taxonomic group identified. The chlorophyceae comprising 39 species constituted 25-54% of the total plankton. The blue green algae such as *Cylindrospermopsis africana* and *Microcystis* sp. and dinoflagellates, *Peridinium gutanense*, were important in terms of abundance. The phytoplankton biomass measured as chlorophyll a pigment varied from 13.9 to 22.2 and from 12.3 to 23.7 mg/m^3 at near-shore and central stations respectively. A maximum gross primary production value (567 mg/cm^3/h) and the minimum (146 mg/cm^3/h) were recorded at 0.25 m and 1m depth in the near-shore station.
Keywords: Chlorophyll a, Euglenophyceae, Chlorophyceae, Cyanophyceae, Dinoflagellates.

INTRODUCTION
Ethiopia is gifted with a number of natural and manmade lakes that are of great scientific and economic importance. Reservoirs are manmade lakes formed by damming the course of rivers for conservation of water for agricultural or technological reasons such as the production of electricity, fisheries and tourism (Zwahlen, 2003). Fincha reservoir was constructed in 1973 has an estimated potential fish yield of 250 -300 tons per year (LDHMA, 2010). Several factors usually contribute to the establishment of phytoplankton communities in reservoir, among which are good water quality, presence of nutrients, physico-chemical factors of water and hydrological characteristics of the reservoirs. Phytoplankton not only serve as food for aquatic animals, but also play an important role in maintaining the biological balance and quality of water (Pandey *et al.,* 1998) and responsible for organic matter in aquatic ecosystem. Species composition and the temporal variations of these forms in freshwaters are dependent on the interactions between physical and chemical factors. Primary production may be the most important biological phenomenon in the nature on which the entire diverse array of life depends, either directly or indirectly. Henderson *et al*. (1973) and Ryder (1974) discussed the methods of relating fish yield to nutrient concentration and primary productivity of the aquatic systems. Melack (1976) and Oglesby (1977) provided linear regression equations relating fish yield and primary productivity. Fincha reservoir has not received attention in spite of its commercial fisheries potential in the recent times and there are no published data on the temporal dynamics of phytoplankton and primary productivity in relation to physico-chemical factors in this reservoir. This study mainly focuses on spatial and temporal variation of phytoplankton composition and primary production in the Fincha Reservoir in Ethiopia.

MATERIAL AND METHODS
STUDY SITE
The study was carried out at Abay Chomen Woreda located at between 09^o 33'.782'' N latitude and 037^o 21'.298'E longitude and altitude between 1350-3047 masl. The study site lies in the course of Fincha River, *a tributary of the Blue Nile, in the Chomen swamp.* The reservoir has a maximum and mean depth of 25 m and 5m, respectively, and covers an area of 1,318 km^2 as reported by Bezuayehu Tefera and Geert Sterk (2006). The reservoir has a number of seasonal and perennial tributaries like Agamsa, Fekere and Korkea rivers. Amerty and Neshe are the major perennial rivers that join Fincha reservoir in the lower valleys before the river joins the Blue Nile. The area is characterized by dry weather November through March. The average annual rainfall is 1709.2mm.

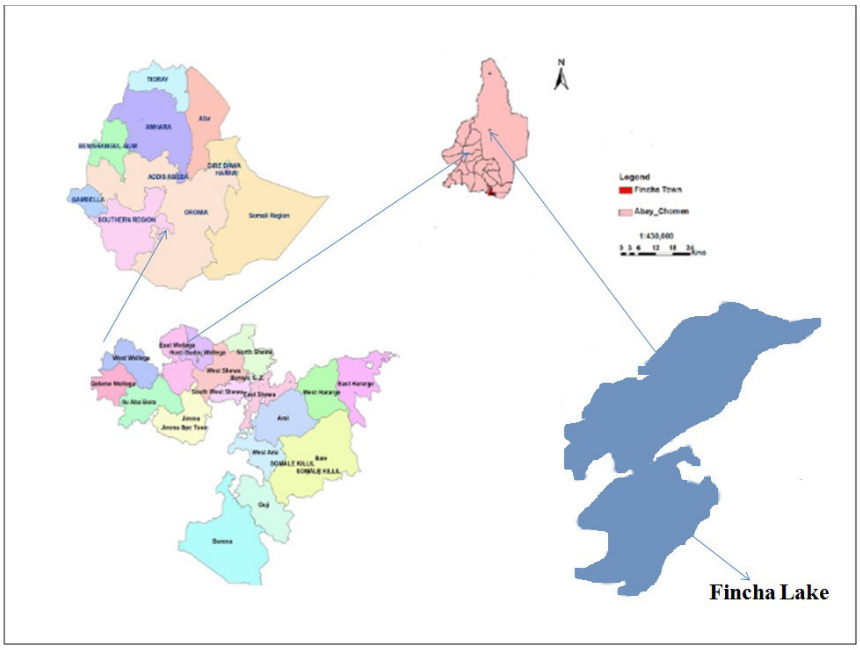

Figure 1: Map of the study area

The samples were taken from two sites; Station I is located in the shallow near-shore area where the local people use the water for washing cloths and Station II roughly in the center of the reservoir (100m) far from station I where there is relatively less human interference. Data on the various water quality parameters were collected from the two stations on monthly intervals. The water samples were collected using 1L Kemmerer sampler from different depths (0 .5, 0.75 and 1m) and composite samples were prepared for both stations (Talling and Lemoalle, 1998). Integrated composite samples were used for the estimation of chlorophyll a, phytoplankton, and primary productivity. The pH and conductivity were measured with a portable digital pH and conductivity meter (Hanna 9024). Transparency (vertical visibility) was estimated using the Secchi disc of 20cm diameter. Dissolved oxygen was determined by Winkler method (Azide modification) after fixing the oxygen in the field. Total Solids (TS), Total Alkalinity, Total Hardness, Nitrate and Phosphate were determined following standard methods (APHA, 1998; Wetzel and Likens, 2000). For the estimation of phytoplankton, composite water samples from each station were preserved with Lugol's iodine solution and allowed to settle. After a period of 72 hours, the upper 90% of the supernatant sample was siphoned leaving the phytoplankton concentrate from which subsamples were drawn for counting the plankton using a Sedgwick-Rafter cell (Hotzel and Croome, 1999 and Wetzel and Likens, 2000). Appropriate volumes of composite samples were filtered through Whatman filter paper (GF/F) and immersed in acetone for the extraction of chlorophyll pigments and measured spectrophotometrically at 665 and 750 nm (Strickland and Parsons, 1972). The primary productivity was measured by the Light and Dark Bottle Technique making use of the Winkler method of oxygen determination (APHA, 1998). To determine the relationship between physico-chemical factors and abundance of phytoplankton groups Pearson's correlation was used.

RESULTS AND DISCUSSION

Physico-Chemical parameters

Temperature is an important physical property of water because it regulates the amount of dissolved oxygen and photosynthesis by phytoplankton. Natural variations in water temperatures mainly occur in response to seasonal and regional climate. The water temperature in the reservoir varied from 19.5°C to 23.9°C at the near-shore and between 22 and 24°C at the central station during the non rainy period from October to March (Table1). Melaku, *et al.* (1988) reported 20.5°C as the lowest surface water temperature from the same reservoir. The water temperature recorded from this reservoir is generally lower than those of the Ethiopian Rift Valley Lakes(Girma Tilahun, 1988; Elizabeth Kebede *et al.,*1994; Eyasu Shumbulo, 2004).

The Secchi disk visibility provides an estimate of water transparency, and it is a standard indicator of water clarity, which is strongly correlated with biomass and annual productivity of suspended algae (Peck ham *et al.*, 2006). The Secchi depth (Z_{SD}) an estimator of transparency ranged from 0.68 to 1.05m and 0.57 to 1.03m in the central and near-shore stations respectively with comparatively lower values at the near-shore station(Table 1). The difference in Z_{SD} between the two stations, was not statistically significant ($t = -0.75$ $p = 0.47$). There is a high correlation between Secchi disc visibility and phytoplankton abundance ($r = -0.90$, $p = 0.001$).The low transparency value recorded in October, coincided with high quantity of suspended particle

due to influx of turbid water even after the cessation of the rainy period. The observed water transparency readings were greater than those reported for some rift valley lakes in Ethiopia (Elizabeth Kebede,1996; Yeshiemebet Major, 2006; Hadgembes Tesfaye, 2007). Euphotic depth (Z_{eu}), in this reservoir was approximated using the mathematical relationship of Z_{eu} and K_d suggested by (Kalff, 2002). The calculated euphotic depths ranged from 1.8 to 3.30 m and from 2.10 to 2.3 at the near-shore and central stations respectively (Table1). The euphotic depths recorded were almost similar to those for Lake Awassa, (Demeke Kifle and Amha Belay, 1990).
The dissolved oxygen varied between 4.9 to 8.1 and 4.8 to 9.3 mg/l in the near shore and central stations respectively (Table2). Dissolved oxygen level was higher at the surface and declined with increase in depth, which is related to the progressively lower oxygen contribution through photosynthesis as well as greater demand for oxygen for oxidative decomposition of organic matter by heterotrophy. The level of DO in the water was lower than the values reported from Koka reservoir (Handgembes Tesfaye, 2007).

The total alkalinity of the water fluctuated from 37.8 to 73.2 at mg/l in central station and from 29.5 to 54.0 mg/l in the near-shore station. pH value in the water varied from 6.0 to 6.8 in central station and from 5.6 to 6.6 in near-shore station (Table2). This minimum variation is linked with the water chemistry and biotic composition, which are considered as an index for suitability of the environment (Kaushik and Saksena,1999). A positive correlation has been observed between pH and alkalinity ($r= 0.69$, $p= 0.34$), as observed by Wood and Talling (1988) for Ethiopian lakes.

The total solids varied from 192 to 373 mg/l at central and 223 to 433 mg/l near-shore station(Table2). In the near shore station the waste water from water treatment plant and urban households enter into the reservoir. Besides, the remains of decomposed vegetation contributes a large quantity of suspended solids in the water column. The Electrical conductivity of the reservoir ranged from 86 to 99 µS/cm in the near shore shallow zone to 78 to 101µS/cm at the central station and the observed values are greater than the highest value reported earlier (Melaku et al., 1988).

The total nitrogen values in the central station was higher ranged from 30 mg/l to 37mg/l (Table3) than the near shore station(29.5 to 54 mg/l). Nitrate is the most stable form of inorganic nitrogen in oxygenated water. The concentration of Nitrate (NO_3-N) recorded low values in the low temperature period. The nitrate concentration varied from 3.0 mg/l to 7.1 mg/l in December, in the middle of the reservoir and from 4.7 mg/l to 9.5 mg/l in the shallow station. Phosphorus is known to be the main limiting nutrient for the growth of phytoplankton and chlorophyll a synthesis. Total phosphorus (TP), concentration ranged from a minimum value of 1.3 to a maximum value of 5.0 mg/l at central station and from 3.3 to 7.3 mg/l at the shallow station.

Table 1. Surface water temperature, Secchi disc (Z_{SD}) Mean vertical extinction coefficient (Kds) and Euphotic depths (Zeu) of Central and Near-shore stations

Month	Surface water temperature (^oC)		Z_{SD} (m)		Kd (units m)		Zeu (m)	
	NS	C	NS	C	NS	C	NS	C
October	19.5	22	0.57	0.68	2.52	2.18	1.8	2.11
November	21.6	21.9	0.75	0.76	1.92	1.89	2.39	2.43
December	23.5	23.2	0.80	0.96	1.8	1.49	2.55	3.08
January	20.4	23.6	1.03	0.99	1.39	1.45	3.3	3.17
February	22.2	24	0.90	1.05	1.60	1.35	2.87	3.35
March	23.9	23.5	0.97	0.99	1.48	1.45	3.10	3.17

Table 2. Average monthly variations of Dissolved oxygen, total alkalinity, pH, total hardness, total solids and Electrical conductivity.

	DO (mg/l)		TA (Meq/L)		PH		TH (Meq/L)		TS (mg/l)		EC (µS/cm)	
	NS	C	NS	C	NS	C	NS	C	NS	C	NS	C
29/10/2011	6.8	6.8	0.7.04	0.79	5.6	6.1	0.48	0.53	433	337.6	81.0	78.0
20/11/2011	7.8	5.6	0.59	0.75	6.0	6.3	1.2	0.72	360	331	76.0	87.0
18/12/2011	4.9	4.8	0.85	1.22	6.5	6.8	1.07	1.3	357	285	83	91.6
30/01/2012	7.6	9.3	0.86	1.19	6.4	6.7	0.8	0.8	227	338	84	79.6
20/02/2012	8.1	6.8	0.8	1.25	6.5	6.8	1.04	1.04	337.6	245.3	97.6	105
23/03/2012	7.1	7.2	1.088	1.46	6.6	6.8	0.91	0.84	223.9	192	99.3	97.3

Table3. Inorganic nutrients and Chlorophyll a concentration at the two stations

Month	TN mg/l		T-PO_4 mg/l		NO_3.N		Chl a (mg m^{-3})	
	NS	C	NS	C	NS	C	NS	C
October	35.2	33.553	5.0	5.0	4.4	9.59	13.973	12.3
November	29.5	32.5	6.2	4.9	5.4	7.0	15.39	14.1
December	42.6	30.0	7.3	3.6	7.1	5.1	17.35	18.4
January	43.1	37.0	7.1	4.2	6.6	4.7	15.48	23.7
February	40.8	31.4	4.2	2.9	3.0	6.6	22.1	19.0
March	54.0	30.8	3.3	1.3	4.7	4.7	20.2	21.3

Species composition and abundance of phytoplankton

A total of 39 phytoplankton species comprising 30 genera belonging to five algal classes were identified, in the composite samples collected from Fincha reservior. The identified phytoplankton belonged to classes Chlorophyceae, Cyanophyceae, Bacillariophyceae, Dinophyceae and Euglenophyceae. The number of species belonging to each class were in the order of Chlorophyceae (19) Cyanophyceae (8) Bacillariophyceae (7) Dinophyceae and (3) Euglenophyceae (2) in the study sites. The green algae, blue green algae and dinophyceae were the major algal (taxonomic) groups in terms of abundance. The Dinoflagellates and Euglenoids were poorly represented with a few species only.The distribution of the species at the two sites varied considerably during the study period. The Chlorophyceae was represented by 13 genera, of which*Pediastrum, Zygonema, Cosmarium, Scenedesmus, Arthrodesmus, Closterium are more common.* In general, Chlorophyceae was the richest group in terms of number of species and contributing 32 to 52% of the abundance at near-shore station and 32.4 to 54 % at central station, respectively in the total plankton. Kalff (2002) stated that in any normal water body between 70 to 200 species of phytoplankton or even as much as over 400 species occur. However in the tropics this number is expected to be low even in the long term observation. Melaku Mesfin et al.(1988) observed only 18 genera of phytoplankton from this reservoir. However the number of species in the present study was higher due to changes in the physico-chemical characteristics of the water, seasonal variation and sampling methods. The species composition and diversity of phytoplankton was found to be high in comparison with those of the Koka Reservoir (Hadgembes Tesfaye, 2007) and Legadadi (Adane Sirage, 2006). However, it was low when compared to those reported for Gefersa reservior. The green algae persisted with appreciable numbers throughout the period extending from November to February, although the abundance of the constituent species varied considerably. The reason for the dominance of the total species richness in tropical lakes by the Chlorophyceae has been attributed to their tolerance of the high light intensities found in the surface waters of

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tropical lakes but they share this characteristic with the Cyanophyceae and Dinophyceae (Sterner, 1989).

Cyanophyceae and Dinophyceae were the second and third most abundant algal groups that made up the phytoplankton community of Fincha reservoir. The dominance of these colonial and filamentous cyanobacteria may be attributed to the relative inedibility by the aquatic organisms especially fishes and nutrient availability.

Blue green algae, *Cylindrospermopsis africana and Microcystis sp were* commonly distributed at both stations of which *Cylindrospermopsis* was the most abundant species, consistently making up a large proportion of the total phytoplankton abundance. The abundance of blue-green algae peaked in January, which coincided with peak of total phytoplankton abundance. According to Harris and Baxter (1996), tropical lakes show cyanobacterial dominance during the dry and falling water level period. Cyanobacteria prefer stable water conditions with low inflows, light winds and minimum turbulence as buoyancy regulation and vertical positioning work best under stable water column conditions (Reynolds, 1984).

The Dinophyceae represented with 3 species of which, *Peridinium gatunense* and *Peridinium pusillum* becoming quantitatively important during March. This group formed 4.6 to 55 % and 14.3 to 39.9% at near-shore and central station respectively in the study period(Fig2&3). In March dinoflagelates contributed the greater proportion in numerical density than other phytoplankton groups and they contributed most in both sites during this month. The nutrient levels of this reservoir seem to have been at favorably high levels for dinoflagellates throughout the study period, however, these algal groups attained and maintained high population densities during the dry period of March. Although dinoflagellates prefer clean water column conditions, as they can always replenish their cells by nutrients obtained from deep parcels of water owing to their ability to migrate vertically and turbulence impedes cell division and disrupts cells (Fogg, 1991).

The Diatoms (Bacillariophyceae) and Euglenoids (Euglenophyceae) were of relatively low in species and their numerical abundance. A total of 7 species of diatoms occurred and their percentage contribution ranged between 2 to 14 % in the reservoir(Fig2). These wide variations may be due to the their ability exploit temporarily favourable conditions and build up their populations because of their intrinsically high growth rates (Reynolds, 1984).Diatoms, owing to their dense siliceous cellular envelope and lack of organelles of motility and the consequent inability to regulate their vertical position in lakes and reservoirs, are favored by turbulent water column conditions (Willen, 1991). Members of Euglenophyceae were poorly represented with very low contribution to the plankton population.

Wide variation of phytoplankton species diversity was evident during the study period at both stations, except November. In this month, phytoplankton abundance is low may be due to cloudy weather and low transparency associated with high concentration of total solids (TS) was observed during the month of October and November. The phytoplankton abundance increased gradually from December and declined after reaching its maximum in January(Fig2).

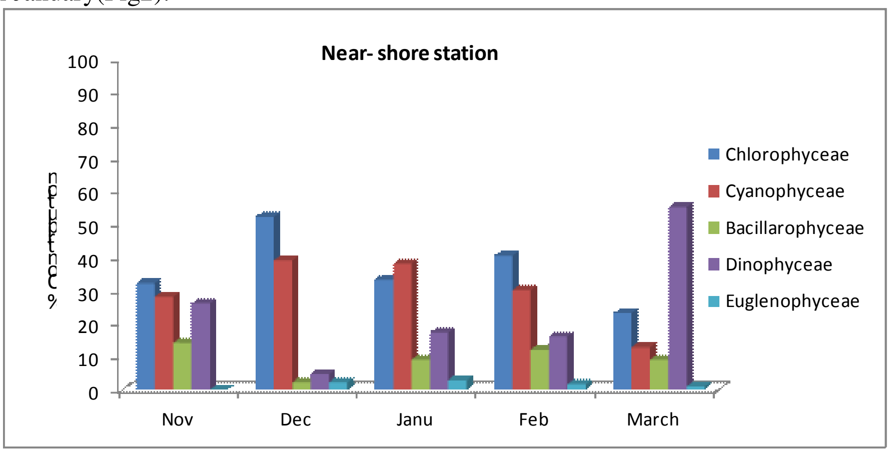

Figure 2. Percentage contribution of different taxonomic groups of phytoplankton

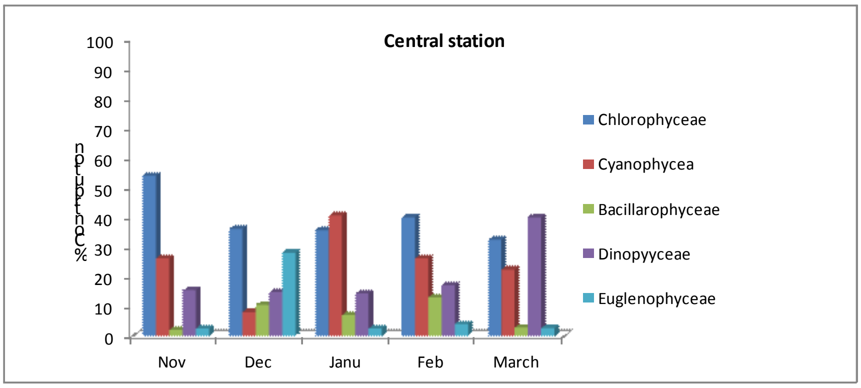

Figure 3: Percentage contribution of different taxonomic groups of phytoplankton

Phytoplankton biomass, measured as chlorophyll *a* concentration, at the central station varied from 12.3 to 23.7 (mean=18.1) mg/m^3 (Table3). In the near shore station chlorophyll a concentration ranged from 13.9 to 22.29 with (mean =17.4) mg/m^3. This seems to be associated with the generally higher transparency and concentration of nutrients of the water. Similar spatial trends were also reported for Lake Zeway and Babogaya in which the near-shore station had lower biomass than the open station (Getachew Beneberu, 2004), and (Yeshiemebet Major, 2006).There were a number of factors which affect the variations of phytoplankton chlorophyll content. Internal influences such as physiological differences among phytoplankton species give a specific form of phytoplankton growth. The results on the chlorophyll values are comparatively higher than the value recorded by Melaku *et al*. (1988) because his observation is only for the month of February. In general high levels of chlorophyll a observed between January, and February are associated with blue-green algal abundance especially *Cylindrospermopsis* and increased concentration of total nitrogen in the water. Talling, (1965) stated that nitrogen is the limiting nutrient in tropical African lakes, since nitrate levels were often very low, whereas phosphate levels were relatively high.

Table 4 Gross photosynthesis, Net Photosynthesis and Respiration rates

Month	Depth	Gp (MgC/m^3/hr)	Np (MgC/m3/hr)	Res (mg O_2/m^3/h)
	0.00	170.80	37.57	
	0.25	195.80	62.50	
	0.50	158.30	25.00	
Oct.	1.00	146.00	12.50	133.33
	0.00	520.90	287.50	
	0.25	483.30	250.00	
	0.50	345.80	112.50	
Nev.	1.00	270.80	37.50	233.00
	0.00	279.20	112.50	
	0.25	553.00	386.00	
	0.50	276.60	109.00	
Dec.	1.00	224.00	57.00	166.70
	0.00	488.00	388.00	
	0.25	462.50	362.50	
	0.50	337.50	237.50	
Jan.	1.00	262.50	162.50	100.00
	0.00	542.00	375.00	
	0.25	567.00	350.00	
	0.50	517.00	400.00	
Feb.	1.00	454.20	287.50	166.60
	0.00	372.50	263.00	
	0.25	298.00	188.00	
	0.50	235.00	125.00	
Mar.	1.00	197.50	87.50	110.00

The depth profile of gross photosynthesis per unit volume usually had maximum rates at a depth of 0.25m and gradually declined with increasing depth due to light limitation. The depth-profiles of gross photosynthesis exhibited reduced rates at the surface of the water column due to photoinhibition. Talling and Lemoalle (1998) argued that depression of production rates at a lake's surface is a common feature of profiles of photosynthesis in tropical waters as it is of temperate. The rate of gross productivity at 0.25m level was higher than the deep layer. It varied between 195 and 566.7 mg C/m3/hr, the maximum gross photosynthetic rate at sub-surface region of light-saturation which was observed in February coincided with a photosynthetic biomass of 22.16 Chl a mg m^{-3} while the lowest gross photosynthetic rate (195 mg C m^3h^{-1}) was observed in October was associated with a biomass of 13.97 Chl a mg m^{-3} (Table 4). During the study period, the depth-profiles of gross photosynthesis exhibited a maximum rate of gross photosynthesis at 0.25 m during sampling month. Many factors are well known to affect the primary production of the phytoplankton including nutrients loading, species composition, light and temperature. Invariably both gross and net productivity in the different depths was minimum in October, which is correlated with a lower chl *a* concentration(Table3). The gross primary productivity at the surface varied between 170.8 to 542 mgC/m^3/hr(Table4). Net primary production values however, showed wide fluctuations during the observation period. The net productivity at the surface was ranged from 37.57mgC/m^3/hr October to 388mgC/m3/hr January. The net of productivity rate showed the highest peak in January and February, which was the period of high algal density. The net productivity at 1m level was minimum. 12.5 mgC/m^3/hr in October and steadily increased to a maximum of 287 mgC/m^3hr in February. During March the Net productivity at all levels decreased significantly. The high primary productivity registered on the surface of Fincha reservoir may probably associated with essential nutrient availability for algae growth (nitrogen and phosphorus). Gross primary productivity of the present study was greater than lake Awassa (Demeke Kifle and Amha Belay,1990) and lake Babogaya, (Yeshiemebet Major, 2006) less than the present observation. In lake Chamo the rate of productivity recorded was 670.8mg/C/m3/hr (Eyasu Shumbulo, 2004), which is greater than the productivity recorded in Fincha reservoir. Kimmel et al. (1990) stated that phytoplankton primary productivity in reservoirs is mainly controlled by two factors such as light and nutrient availability, which are functions of the characteristics of the transport especially of suspended sediments, dissolved nutrients and the vertical-mix regime. Light generally decreases exponentially with depth. The decline of light with depth is determined by water molecules, by the concentration of dissolved matter, and by particles (such as phytoplankton). The low water temperatures registered in the period of October, can also be considered as possible causes for lower phytoplankton primary productivity values.

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