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Studies on Hydrobiological Features of Koka Reservoir and Awash River in Ethiopia

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ABSTRACT
The physico-chemical parameters of the water and phytoplankton of the Koka Reservoir and Awash River were investigated for a period of one year. The water temperature in the study sites showed temporal variations which followed the local atmospheric temperature during the wet and dry season. The pH of the river water was comparatively lower than that of reservoir due to the influx of sewage and industrial pollutants. The dissolved oxygen and free carbon dioxide in the reservoir water varied considerably due to the occurrence of algal bloom and flooding of the catchment area during rainy season. The phytoplankton constituted mainly of green algae and diatoms in the riverside site and their abundance was controlled by the massive growth of the macrophyte, *Eicchornia crassipes* especially during the dry season. In the reservoir the diatoms and green algae predominated after the cessation of the rain. However, during the high temperature months the blue green algae predominated in the shallow near shore regions in the reservoir. The possible reasons for the alteration in physico-chemical and biological features in the two study sites are discussed in this paper.

Keywords: Phytoplankton, Macrophytes, *Eicchornia crassipes,* Diatoms.

1. Introduction

Aquatic ecosystems are often viewed as highly productive biological systems; they provide important resources for life and life management systems of mankind, such as water for consumption, fishing, irrigation, power generation, transportation and recreation. Ethiopia is gifted with a variety of aquatic ecosystems, which are of great scientific interest and economic importance. The reservoirs provide various services to people, such as irrigation and drinking water, flood protection, fisheries and tourism [1]. Most of the Ethiopian reservoirs and lakes are very productive, inhabited by indigenous and exotic populations of edible fish and supporting a variety of aquatic and terrestrial wildlife. The physical regimes and the levels of lakes are governed by many natural and anthropogenic factors [2, 3]. Closed terminal lakes fluctuate significantly in response to climatic changes but tend to maintain equilibrium between input and output [4]. Wood and Talling [5] have reviewed the hydrology, chemical characteristics and algal distribution in Ethiopian lakes. Several studies made on Ethiopian lakes have indicate that the alterations in water quality due to human impact, such as urbanization and industrialization [6, 7] occur in the rift valley zone. There are reports on salinization of irrigated lands and ultimately lake level changes in the Rift and adjacent highlands [8] due to increased rates of irrigation. Soil erosion is very common in Ethiopia, and some of the lakes are affected by the consequences of sedimentation and increased turbidity. One such phenomenon is the increase of algal blooms [9] and damages scused to the breeding grounds of fish species that spawn in shallower parts of the lake [10]. A large number of studies have been made on the community structure and primary production of phytoplankton in various East African Lakes [5, 11].

In Ethiopia, the Koka Reservoir is built for hydro-electric power generation, to which Awash (major) and Modjo (minor) rivers flow. Koka Reservoir supports commercially important fish species such as *Oreochromis niloticus, Cyprinus carpio, Clarias gariepinus* and *Labeobarbus intermedius* [12]. Seyoum Letta *et al*. [13] observed pollution due to Chromium, Sulfide and Ammonia in the Modjo River, which eventually flows into Koka Reservoir. In the light of recent observations on the hydrobiological and chemical composition of the major lakes and reservoirs in the Rift valley, it is understood that an environmental status assessment of Koka Reservoir is very much needed. Hence the present study was conducted to investigate the physico-chemical and biological characters of Koka reservoir and Awash River.

2. Material and Methods

The Koka Reservoir, also known as Lake Gelila, is situated in south-central Ethiopia in the Misraq Shewa Zone of the Oromia Region, approximately 100 km southeast of Addis Ababa. The reservoir has an area of 180 square kilometers. For the present investigation two sampling sites were chosen. Station I is located in the Awash River before it joins with the reservoir for the collection water and plankton sample were taken during June 2010-May 2011. Station II is fixed inside the reservoir (Fig. 1). In the present study the surface water temperature was measured by using a centigrade mercury thermometer soon after collection. The pH of the water was measured in the laboratory using a digital pH meter (Hanna model) after calibrating with buffer solution. The dissolved oxygen (DO) was estimated following the modified Winkler method [14]. The Carbon dioxide content was estimated using a phenolphthaline indicator followed by titration against sodium hydroxide solution and recorded as mg/l of water [14]. The hardness of water was determined by making use of Ammonia buffer and the indicator Eriochrome Black T and titrating with EDTA solution in the laboratory [15]. The Total Alkalinity was determined titrimetrically using the indicators Phenolphthalein and Methyl orange [15].

The qualitative and quantitative analyses of phytoplankton were done in the samples collected by using plankton net (No. 21). The species were enumerated and identified to genus level [13, 16, 17].

3. Results

The results on the physico-chemical parameters of water collected from the Stations I and II are presented in the Table 1 and 2.

Table 1: Physico-Chemical parameters of Reservoir water

Parameters	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Temperature (°C)	26	21.5	22	25	21	22	25	24.5	23	25	24	25
pH	6.29	7	7.4	7.9	7.64	7.26	7.96	6.13	8.3	8.6	7.47	7.84
DO (mg/l)	6.4	6.2	6.1	5.8	7	5.6	4	11.6	10.4	7.2	5.6	6.3
CO_2 (mg/l)	6.6	3.2	1.6	0.6	0.4	0.2	0.8	0.8	0.2	0.2	0.8	0.9
Alkalinity (mg/l)	20	40	28	14	6.4	4	6	5	56	8	20	16
Chloride (mg/l)	32	14.2	11	7.2	9	2.9	3.4	2.8	5	5.8	7.2	5.3

Table 2: Physico-Chemical parameters of River water

Parameters	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Temperature (°C)	24	20	21	19	23	20	19	24	24.5	22	24	24
pH	6.0	6.8	7.1	6.8	7.2	7.3	7.9	4.6	7.2	5.3	6.8	6.6
DO(mg/l)	4	5.2	6.7	6.3	5.8	6.4	4	7.8	6	8.6	7	5
CO_2 (mg/l)	0.3	0.4	3.3	1.6	0.6	0.8	0.8	0.8	0.8	1	0.8	1.2
Alkalinity (mg/l)	16	40	36	24	12	8	20	2	8	10	10	48
Chloride (mg/l)	28	26	16	11	6	16	2.9	1.4	7	7.5	8	8.2

The data on water temperature at the reservoir station showed wide temporal variation during the study period. The temperature varied from 21-26^{o} C. The highest temperature (26 $^{\circ}$C) was recorded in June and the lowest (21 $^{\circ}$C) during the rainy season (October 2010). In the river, the water temperature recorded was maximum 24.5^{o}C and the minimum 19 $^{\circ}$C. Generally during the dry season the water temperature was comparatively high. However, the range of variations between months was insignificant. The pH of reservoir water showed the highest value (8.6) during March 2011 and the minimum (6.13) in January in the same year. Whereas, in the river, the pH value was comparatively lowers it also varied from 4.6 (January) to 7.9 (December). The amount of dissolved oxygen in the surface water showed considerable variations between the months in the two sampling sites. In the reservoir it varied between 11.6 mg/l (January) to 4 mg/l in December 2010. The dissolved oxygen in the river water ranged from 4mg/l (June & December) and 8.6mg/l in March 2011. The fluctuation in DO in the reservoir was more pronounced than in the river. The dissolved carbon dioxide in the reservoir showed variations between months. The highest value measured was 6.6 mg/l in June and the lowest 0.2 mg/l during November. During September to November and also during February and March in 2011 carbon dioxide was below detectable levels in the reservoir. In the river water the carbon dioxide values fluctuated from a low value of 0.3mg/l (June) to 3.3mg/l (August). The alkalinity in the reservoir showed maximum value (56 mg $CaCO^3$/l) and minimum (4mg $CaCO^3$/l) in February and November respectively. The value in the river was highest (48 mg $CaCO^3$/l) in May2011 and lowest in January (2mg $CaCO^3$/l). The amount of chloride in the reservoir varied from 2.9mg/l to 32 mg/l. The highest value was registered during June 2010 and the minimum in November. In the river site the chloride value recorded was maximum 28 mg/l (June) and minimum 1.4 mg/l in January.

The phytoplankton composition of reservoir and river showed a total of 18 and 09 genera respectively (Table 3 and 4). In general the phytoplankton was composed of diatoms, green algae and blue-green algae in the study sites. In the reservoir, diatoms noticed were *Pleurosigma*, *Bacillaria*, *Fragilaria*, *Synedra*, *Tabellaria and Navicula*. The green algae recorded were *Chlorella*, *Desmidium*, *Cosmarium*, *Closterium*, *Arthrodesmus*, *Selenastrum* and *Staurastrum.* The blue green algae recorded were *Oscillatoria*, *Merismopedia*, *Anabaena*, *Nostoc and Microcystis*.

Table 3: Phytoplankton in the Reservoir site

Genera	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Pleurosigma				2.47	2.77	2.3						
Navicula	2.3	2.3	2.55	2.6	2.77	2.69	2.3					
Bacillaria				2.69	2.84	3.04	3.07	2.9				
Fragilaria	2.47	2.69	2.77	2.69	2.3							
Synedra				2.47	2.77	3	2.47					
Tabellaria				2	2.3	2.6	2.47	2.77				
Merismopedia							2.9	3.11	3.3	3.5	3.25	2.69
Oscillatoria							3.11	3.25	3.36	3.44	3.07	
Anabaena							3	3.38	3.47	3.41	3.07	
Nostoc								3.07	3.25	3.41	3.44	3.14
Microcystis						2.3	2.9	3.38	3.52	3.2	3.07	3
Selenastrum					2	2.3	2.3					
Arthrodesmus		2	2	2.3	2.77	3						
Closterium				2.47	2.69	2.84	3.07					
Cosmarium			2.3	2.69	2.84	3.04	3	2.6				
Staurastrum				2.3	2.3	2.3	2.69					
Desmidium			2	2	2.6	2.9						
Chlorella				2.69	2.77	2.9	2.47					

Table 4: Phytoplankton in River site

	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Pleurosigma	2.3	2.34	2.55	2.6	2.69	2.69	3	2.9	2.77	2.3	2.47	3.2
Navicula				2.3	2	2.31	2.47	2.77	2.3	2.3	3	
Bacillaria			2.77	2.69	3	3.17	3.11	2.6	2.3	2	2.47	2.47
Fragilaria			2.69	2.47	2.84	3.14	3.07	3			2.6	2.3
Tabellaria					2.3	2.9						
Surirella			2.47	2.47	2.77							
Microcystis								2.84	3	2.84	2.9	
Ankistrodesmus			2.47	2.47	2.84	3	3.04	2.47				
Closterium	2.3	2.47	2.47		2.69	2.69	2.77	2.84	3	2.77		

During the rainy months, the plankton were reduced in number as well as species. In the reservoir the diatoms were predominant after the rainy season, from September to December. The diatoms, *Navicula* and *Fragilaria* were noticed during the rainy season. However, their density was very low. The cell counts of green algae were found high from October to December. The blue-green algae invariably showed high density during the dry season, especially during February and March.

In the river site the number of species of phytoplankton as well as their cell counts were less than in the reservoir. Generally, the desmids were more common. The diatoms recorded from the station were few in numbers. The population of the diatoms was found to increase during the dry season when the water temperature increased.

4. Discussion

The surface water temperature in the study sites showed highest values in March during the dry season when the influx of river water was at a minimum. Comparatively lower temperatures were observed in the rainy season. The monthly variations in temperature between the study sites could be related to the time of sampling. The values were found to be higher than those reported from Lake Gudera and Tana [18]. The surface water temperature variations are closely related to the atmospheric temperature. The temperature dissipation into the water column is regulated by factors such as the clarity of the water, wind and the nature of the sky over the water body. The study area is comparatively shallow and hence the water temperature increased in the non- rainy period and this is closely associated with the reduction in water levels in the reservoir. Elizabeth and Amha Belay [19] observed that low temperatures were associated with cold air temperature, and cool rain water influx in to Lake Awassa. The decrease in water level affects the ionic composition of the water. When large quantities of water is extracted for irrigation purposes by agriculture and floriculture activities during the dry season, the water level goes down facilitating a high rate of evaporation of the surface water due the prevailing high temperature.

The pH of the Reservoir and River Awash was found to be slightly alkaline in nature even though it decreased during the non-rainy season. This might be due to the influx of river water which brings sewage and industrial effluents discharged from a nearby town and the agricultural land drains with dissolved fertilizers [20]. Harrison and Hynes [21] stated that human activities in the form of washing cloths and other cleaning with detergents were responsible for increasing the pH of water. Based on investigations, Ayenew [10] opined that salination is most critical in the Awash valley due to irrigation water logging.

The dissolved oxygen in the reservoir was maximum during January but declined considerably in the subsequent months. Several investigators have recently addressed the limnological changes by comparing their data on dissolved oxygen and water transparency [22, 23].

In the present investigation, the chloride concentration was found to be high in June and the value further decreased gradually up to February 2011. In addition the values increased slightly in the subsequent months. Omer and Cooper [24] noticed higher level of chloride when the water level went down. There is no regular seasonal variation in the chloride values at this station. In the river land drainage and the presence of the effluents from the tanneries and other industries may be responsible for the high chloride content. Ayenew [10] observed that the chemistry of some of the Rift Valley lakes has changed drastically. The literature on alkalinity indicates that the values reported in the present study are very low when compared to those observed in lake Abhijata. Positive correlations of sodium ion, alkalinity and total ions with salinity in most Ethiopian lakes have been reported [5].

Phytoplankton production is regarded as a good predictor of fish yield in lakes and reservoirs. The species composition and their biomass estimations are followed in the assessment of water quality and productivity measurements in farmed and natural systems. In the present study, from the two study sites, 20 species of plankton were identified. However, earlier reports from other lakes indicate more species of plankton. A total of 100species with 48% chlorophyceae, 30% blue green algae and 11% diatoms and the rest constituted of dinoflagellates were described from lake Awassa [19]. The present study revealed seasonal variation in the plankton succession in the reservoir and river. Similar results were recorded in other African lakes, such as Kariba, Malawi, Tanganyika and Victoria, where blue-green algae dominate during summer stratification and diatoms tend to dominate in winter at turn-over, when stratification breaks down [19]. The composition and abundance of phytoplankton often reflect the nutrient status of African lakes which is an indicative of low organic pollution [25]. In Koka Reservoir there was regular occurrence of blue-green algal bloom during the high temperature period. The consequences of flooding in the cultivated catchment areas in the two study sites were obvious in the form of prolonged algal bloom and invasive growth of the water hyacinth *Eichhornia crassipes* as reported by Zinabu Geberemariam [26] and Zinabu *et al.* [27]. Golterman [28] stated that an increase in temperature may upshot the net growth of phytoplankton, positively or negatively depending on the type of species. In the present study, excessive growth of phytoplankton and formation of scum at the surface prevents the dissolution of oxygen into the water column. In the present study the green algae dominated after the rains when the temperature was moderate with abundant supply of dissolved nutrients in the water. Similar observations were made by Elizabeth and Amha [19] in lake Awassa. In the present investigation the number of diatoms was comparatively lower than green algae and blue green algae. This might be due to the influence of temperature, light intensity and nutrients [29, 30]. In the present study, the phytoplankton density in the river and reservoir was influenced by the excessive growth of the floating macrophytes like *Eichhornia crassipes, Lemna sp. and Azolla* during the warmer months

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