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Full Length Research Paper

A preliminary study on limnological stock assessment, productivity and potential fish yield of Omi Dam, Nigeria

Solomon Iboko Ovie, Richard Lema Bwala* and Olarewaju Ajayi

National Institute for Freshwater Fisheries Research (NIFFR), P. M. B. 6006, New Bussa, Niger State, Nigeria.

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This study examined the water quality, primary productivity, plankton and the potential fish yield of Omi dam for management purposes. Among the physico-chemical parameters analyzed, Ca^{2+} and HCO_3, were found to be above permissible limits ((3.90 ± 0.68, 24.50 ± 7.33, respectively). A total of 24 species of phytoplankton belonging to three major taxa were recorded. Most species were of the class chlorophyta, followed by chrysophyta then cyanophyta. The highest density of phytoplankton was in January (740 No. ml^{-1}), while the lowest (300 No. ml^{-1}) was recorded in April all in station 3. The mean density recorded for each month was 555, 333 and 410 No. ml^{-1} for January, April and June respectively. A total of 23 zooplankton species was recorded predominated by rotifera, followed by cladocerans and copepod respectively. Density was highest (5.00 ind.L^{-1}) in station 1 in April, while it was lowest (0.32 ind.l^{-1}) in station 2 in June. Mean density for each month was 0.92, 2.95 and 0.57 (ind.L^{-1}) for January, April and June respectively for the three stations sampled. Sorenson's index of similarity for zooplankton species between the months showed that there was similarity throughout the period of the study. There was also similarity in the phytoplankton except between the months of January and June. Mean gross pelagic primary productivity (GPP) was high (19.58 g O_2 $m^{-2}d^{-1}$) when compared to other water bodies. Mean potential fish yield (PFY) of 34.77 kg ha^{-1} was calculated based on the morpho edaphic index (MEI). Observations are discussed and recommendations are made.

Key words: Physico-chemical, assessment, phytoplankton, zooplankton, Sorenson.

INTRODUCTION

Limnological studies should evaluate optimum water quality, identify and isolate specific factors affecting water quality for the purpose of suggesting the most sustainable way of utilizing the water systems. The critical importance of ensuring an optimum environmental quality of any fishery is a major factor in obtaining good productivity and ultimately high fish yield. However, in recent times, serious challenges have been posed to Nigerian freshwater ecosystems and other water bodies the world over through growing populations, intensification of agricultural practices, industrial and urban pollution, forest and wetland destruction among others. According to Roy and Mazumdar (2005), the use of water in the world has increased by more than 35 times over the past three centuries and recent estimate shows 3240 km^3 of freshwater is withdrawn globally on an annual basis. A major portion of this (69%) is used for agriculture, 23% for industry and the remaining 8% for domestic use. Owing to inadequate management of wastes, freshwater potential has been reduced due to widespread pollution. Studies have shown deterioration of water quality and low faunal abundance and diversity caused by stress imposed by effluents from land based sources (Chukwu and Nwankwo, 2005; Mir et al., 2005). If left unchecked, these ecosystems will cause a serious threat to aquatic life and as well man due to continuous depletion to extinction of fish species catch. This therefore calls for a continuous investigation into the processes that occur in our water systems. The present paper is a preliminary study of one of the significantly potential water bodies in the North-central ecological zone of Nigeria, with the aim of checking the status of the

*Corresponding author. E-mail: richardl669@gmail.com.

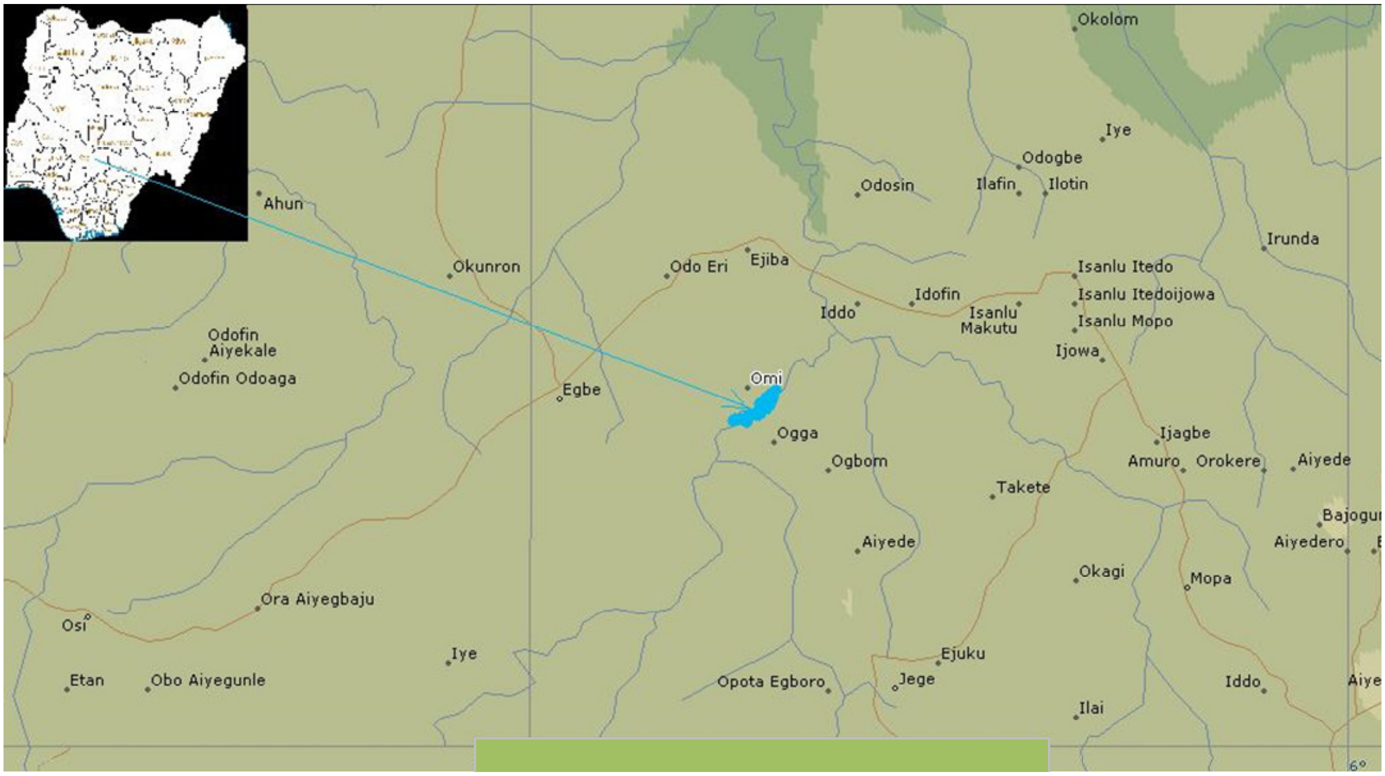

Figure 1. Map showing Omi reservoir (Inset: Map of Nigeria).

water quality, primary productivity, species and abundance of plankton and the potential fish yield of the reservoir. The results will establish baseline information for future studies and management purposes.

MATERIALS AND METHODS

Study area

Araoye et al. (2004) described the dam as located on latitude 8°13'N and longitude 5°38'E in west Yagba Local Government Area of Kogi State, Nigeria. It was constructed in 1999 and has a reservoir capacity of about 250 million cubic meters of water. Other features and specifications of the dam include: Height of dam = 42 m, length of embankment = 1,920 m, length of spill way = 250 m, length of the main canal = 39 m, reservoir area = 2,570 ha and net irrigation area = 4,100 ha. The dam was primarily constructed to promote agriculture through irrigation activities involving more than 5000 farming households within and outside Yagba Local Government Authority. There are many settlers particularly fishermen along the lake and this indicates the enormous fisheries potential of the dam. These farmers and fishermen have not only depended on farm produce and fish for their livelihood, they also depend on the water body for drinking and for domestic activities. Figure 1 is a map locating Omi Dam.

Sampling

Samples were collected from three stations namely stations 1, 2 and 3 from January to June (2009). Physico-chemical parameters (Dissolved oxygen, temperature, pH, BOD, colour, conductivity, transparency, NO_3, PO_4, NH_3, Ca^{2+}, Mg^{2+}, Na^+, K^+, CO_2^-, SO_4^-, Cl^- and HCO_3) were analysed using methods as described in the APHA (1998). Primary productivity was measured using the light and dark bottle method as described in The Regents of the University of Michigan (2005) and Rhode's (1965) formula as described by Karlman (1973):

$$\sum_a = Z_{0.1} \text{ jmpc} \times a_{max}$$

Where: $\sum_a$ = gross pelagic primary productivity per unit area, and $Z_{0.1}$ = depth (m) of the 10% light transmission level for the most **jmpc** penetrating component.

Samples of plankton were collected using No. 20 silk bolting zooplankton net with mesh sieve of 76 µm and mouth diameter of 12.50 cm. samples were preserved in 4% formalin and were allowed to stand undisturbed for over 24 h on a flat surface. Thereafter, the sample volume was reduced to about 25 ml by siphoning with a pipette fitted with a flexible rubber tubing of 5 mm diameter. The tip of the pipette also fitted with a 76 µm mesh size zooplankton net to prevent accidental loss of organisms during siphoning (Ovie, 1997). Phytoplankton samples were collected by obtaining one litre of the reservoir water to which two drops of Rose Bengal stain was added. The samples were then preserved in 4% formalin (Zabbey et al., 2008). Qualitative and quantitative evaluations were done following methods described in Jeje and Fernando, (1986) and APHA (1998). Sorenson's index of similarity was computed using the equation:

$$S = \left[\frac{2c}{a + b}\right] 100$$

Table 1. Ranges of physico-chemical characteristics of Omi dam.

Parameter	Range
Air temp. (°C)	27.00 - 34.50
Water temp. (°C)	25.00 - 34.50
Transparency (m)	1.40 - 3.00
Dissolved oxygen (mg L^{-1})	0.40 - 8.60
pH (unit)	6.80 - 7.60
Conductivity (µmhos/cm)	60.00 - 600.00
BOD (mg L^{-1})	1.40 - 7.80
NO_3 (mg L^{-1})	0.00 - 24.70
NH_3 (mg L^{-1})	0.00 - 5.60
K^+ (mg L^{-1})	1.34- 2.01
Na^+ (mg L^{-1})	2.50 throughout
Mg^{2+} (mg L^{-1})	1.22 - 1.95
Ca^{2+} (mg L^{-1})	3.20 - 4.80
SO_4^- (mg L^{-1})	0.00 - 2.50
CO^{2-} (mg L^{-1})	0.00 throughout
Cl^- (mg L^{-1})	18.00 - 33.00
HCO_3 (mg L^{-1})	14.00 - 31.00
Colour	Light yellow

where: a = total number of species in one ecosystem; b = total number of species in the second ecosystem, and c = total number of species common to both ecosystem being compared (Ovie, 1995).

Potential fish yield (PFY) was estimated using the morpho edaphic index (MEI) method given by the equation:

$$\log Y = 0.9420 + 0.3813 \log X$$

where Y = fish yield in kg ha^{-1}, and X = MEI = Conductivity in µmhoscm^{-1} at 20°C / mean depth in meters.

RESULTS AND DISCUSSION

Physico-chemical status of the reservoir

Table 1 shows the ranges of physico-chemical parameters measured while Figure 2 is a representation of mean values analyzed. The water temperature recorded in this dam (30.50°C) is slightly above the optimum for warm water fish because they grow best in temperatures between 25 to 30°C. However, it can still be considered as good for growth and body metabolism of the fishes in the water body; this is because intensity of metabolism of warm water fish is closely associated with water temperature, that is, the higher the temperature, the higher the metabolic rate.

Mean transparency or Secchi disc depth measurement (2.00 m) recorded can be considered as that of ultra clear water. This may be good for optimum phytoplankton growth thereby raising the level of productivity of the water.

The concentration of organic substances in water and their capacity of taking oxygen from water are evaluated by means of biochemical oxygen demand (BOD). Although optimum levels differ for different fishes, the mean value obtained here (6.37 mg L^{-1}) is not too high to deplete the required value of dissolved oxygen (5 mg L^{-1}). The mean dissolved oxygen recorded in this study is 5.12 mg L^{-1}. Although the range (0.4 to 8.60) shows there were periods of anoxia, however, Boyd and Lichtkoppler (1985) reported that the condition can only be lethal when fish exposure is prolonged.

The optimum pH levels for fish range from 6.50 to 8.50. The range recorded in this study is 6.80 to 7.60 with a mean value of 7.25. Depending on species, fish can generally be vulnerable or resistant to high or low pH. However, the value recorded here can be said to be good for fish production.

Conductivity gives the indirect measure of total dissolved solids (TDS) in water bodies. It therefore follow that the more ions in solution, the higher the conductivity. The four major cations and four major anions analysed were in the proportion: Ca>Na>K>Mg and $Cl>HCO_3>SO_4>CO_3$ as compared to the normal Ca>Mg>Na>K and $CO_3>SO_4>Cl$ for cations and anions respectively. In freshwater, the most dominant are the Ca^{2+} and HCO_3^-. Although the proportions of the various ions were not exactly the same as the normal, Ca^{2+} and HCO_3^- still maintained their dominance. The irregularities in the proportions of the ions can be said to be the cause of the high conductivity (229.43 mg L^{-1}) recorded. Ovie et al. (2004) reported low level of conductivity in some Nigerian inland waters which showed nutrient-poor systems. Omi dam however can be regarded as rich in nutrient due to its high conductivity. In terms of their availability for usage by biota, the concentrations of Cl^-, Na^+, K^+, Ca^{2+} and SO_4^- recorded may agree with the assertion by (Omoregie, personal communication, 2003a) that Mg^{2+}, Na^+, K^+ and Cl^- are usually high in concentration but they are conservative, as only very little is used by biota while Ca^{2+}, CO_3^- and SO_4^- are lower in concentration but are dynamic and are strongly influenced by biotic metabolism. High concentration of Ca^{2+} and Mg^{2+} ions is responsible for hardiness and they are usually associated with high levels of bicarbonates. In the present study, Ca^{2+} had the highest concentration among the cation while HCO_3 was the second highest among the anions, this shows that the water in Omi dam may be hard.

The non dissociated form of ammonia is usually toxic to fish. The LC_{50} value, determined in an acute toxicity test as shown by (E. Omoregie, personal communication, 2003b) ranges between 1 and 1.5 mg of NH_3 L^{-1} in cyprinids and about 0.8 mg L^{-1} for salmonids. However, when dissolved oxygen is high in water, it reduces the toxicity of ammonia hence reducing fish kill. This may explain why despite the seemingly high concentration of ammonia (2.33 mg L^{-1}); it was not injurious to the fish.

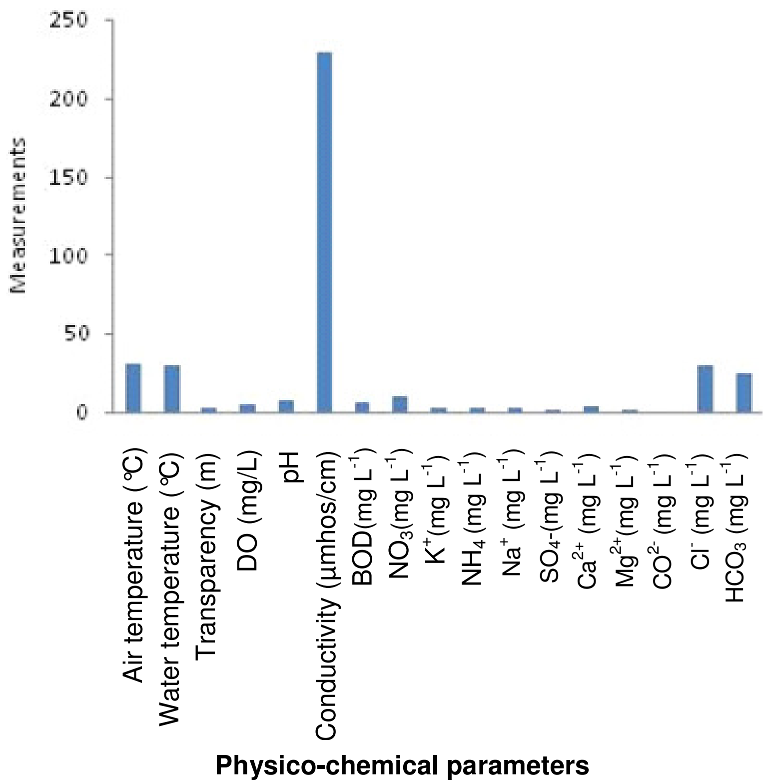

Figure 2. Mean value of physic-chemical parameters analysed in Omi Reservior.

Table 2. Mean gross pelagic primary productivity (GPP) of Omi Dam.

Productivity	January 2009	April 2009	June 2009
Minimum production (mgO_2 L^{-1})	4.80	120.00	2.60
Maximum production (mgO_2 L^{-1})	9.40	2.00	3.20
GPP (g$O_2$$m^{-2}$$day^{-1}$)	27.81	9.79	19.58
Mean GPP (g$O_2$$m^{-2}$$d^{-1}$)		19.58	

Nitrate is only toxic to fish at concentrations above 1000 mg L^{-1}. The mean value recorded here (10.32 mg L^{-1}) is far below the toxicity level as such it is safe for fish survival.

Biological status

Primary productivity

Gross pelagic primary productivity was calculated as 19.58 g O_2 $m^{-2}day^{-1}$ (Table 2). Karlman (1973) in his classification reported that high values are usually > 3.0 g O_2 $m^{-2}day^{-1}$, the current value can be regarded as very high when compared with other water bodies: Kainji (2.19), Jebba (5.53), Victoria (3.98), Volta (2.55), Dadin kowa (0.16), Kiri (0.08), Oguta (6.75), Ojirami (0.63) and Abadaba (2.67) (Karlman, 1973; Adeniji, 1990; Talling, 1969; Boswas, 1978) in Ovie et al. (2004). This may not be unconnected with the high transparency in the water body and also the nutrient rich status of the water as indicated by the high level of conductivity and nitrate concentration which may have caused significant productivity in the water system.

Plankton species composition and density

Tables 3 and 4 provides preliminary checklist, indicating presence and absence of phytoplankton and zooplankton assemblages respectively. Seasonal patterns were not considered in this study due to time frame. However, distribution and the abundance of the plankton within the months under study and between the stations are shown in Figures 3 and 4. Phytoplankton density was high in January with the highest 740 No. ml^{-1} in station 3, while

Table 3. Checklist of phytoplankton and Sorenson's index of similarity of Omi Dam.

Class/species	January	April	June
Chorophyta			
Pediastrum simplex	+	+	-
Closterium kuetzingii	+	-	-
Hydrodictyon sp.	-	-	+
Microcystis flos-aquae	+	+	+
Chlorella ellipsoidea	+	+	+
Anabaena spiroides	+	+	+
Staurastrum rotula	+	+	+
Volvox tertius	+	-	-
Scenedesmus quadricauda	-	+	+
Spirogyra sp.	-	+	-
Hormidium sp.	-	+	+
Athrospira sp.	-	+	-
Ulothrix spe		+	-
Microspora sp.	-	-	+
Staurastrum cornuta	-	-	+
Synedra sp	-	-	+
Scenedesmus bijuga	+	-	-
Centronella reichelti	+	-	-
Chrysophyta			
Melosira granulate	-	+	+
Navicula digitoradiata	-	+	+
Nitzchia sp.	-	-	+
Synedra sp.	-	-	+
Fragillaria sp.	-	-	+
Cyanophyta			
Aphanocapsa elachista	+	+	+
Sorenson's index of similarity			
January vs April		52.17	
January vs June		38.46	
April vs June		62.07	

+ Signifies present; - signifies absent.

the lowest 300 No. ml^{-1} was recorded in April and also in station 3. The mean density recorded for each month was 555, 333, 410 (No. ml^{-1}) for January, April and June respectively. A total of 24 species of phytoplankton belonging to three major taxa were recorded. Most species were of the class chlorophyta, followed by chrysophyta then cyanophyta. Zooplankton was highest (5.00 ind. L^{-1}) in station 1 in April, while it was lowest (0.32 ind. L^{-1}) in station 2 in June. Mean density for each month were 0.92, 2.95 and 0.57 (all values in ind. L^{-1}) for January, April and June respectively. This generally shows low density per liter of water analyzed. A total of 23 species were recorded with rotifera dominant, followed by cladocerans and copepod respectively.

Although, Sorenson's index of similarity is usually used to evaluate the degree of similarity of plankton between water bodies as described by Sorenson (1948), Green (1967, 1971), Robinson and Robinson (1971) (Ovie, 1995); it was used here to test similarity of plankton between months of the study (Tables 3 and 4). Since similarity values are only significant when they are greater than 50%, it can be said that the zooplankton community were all similar between the months with the highest value 74.07 recorded between January and April. There was also similarity in phytoplankton species with the exception of those that occurred in January with

Table 4. Checklist of zooplankton and Sorenson's index of similarity of Omi dam.

Class/species	January 2009	April 2009	June 2009
	Rotifera		
Trichocerca cylindrica	+	+	+
Keratella cochlearis	+	+	+
Keratella tropica	+	+	-
Trichocerca elongata	+	-	-
Asplanchna sp	+	+	+
Brachionus calyciflorus	+	+	+
Polyarthra vulgaris	+	-	-
Filinia opoliensis	-	+	+
Polyarthra delicoptera	-	-	+
Lecane decipiens	-	-	+
Brachionus angularis	-	-	+
Brachionus falcatus	-	-	+
Ptygra melicenta	-	-	+
Cladocerans			
Diaphanosoma exisum	+	+	+
Bosmina longirostris	+	-	+
Ceriodaphnia cornuta	+	+	+
Moina micrura	+	+	+
Daphnia longispina	-	-	+
Nuplii	-	+	+
Copepoda			
Cyclopoid sp	+	+	+
Calanoid sp	+	-	+
Copepodites	+	+	+
Sorenson's Index of similarity			
January vs April	74.07		
January vs June	68.57		
April vs June	68.75		

.+ Signifies present; - Signifies absent.

those in June (38.46).

Potential fish yield

Mean potential fish yield of 34.77 kg ha^{-1} was recorded (Table 5). This was calculated on the basis of the morpho edaphic index of the different stations. The value obtained in Omi dam could be said to compare favourably with other reservoirs studied by Ovie et al. (2009) and Ovie and Ajayi (2000). Such reservoirs include Ojirami (49.60), Dadin Kowa (30.20) and Kiri (42.70).

CONCLUSION AND RECOMMENDATIONS

The water quality was found to be adequate for survival and growth of fish. Productivity of the water was also high which ideally should result to high fish yield, however, the MEI computed in this study was not compared with the catch assessment survey (CAS) of the same reservoir as the latter was not available at the time of compiling this report. Therefore, the status of the utilization of the reservoir could not be ascertained. It is recommended that such comparison be made in further studies.

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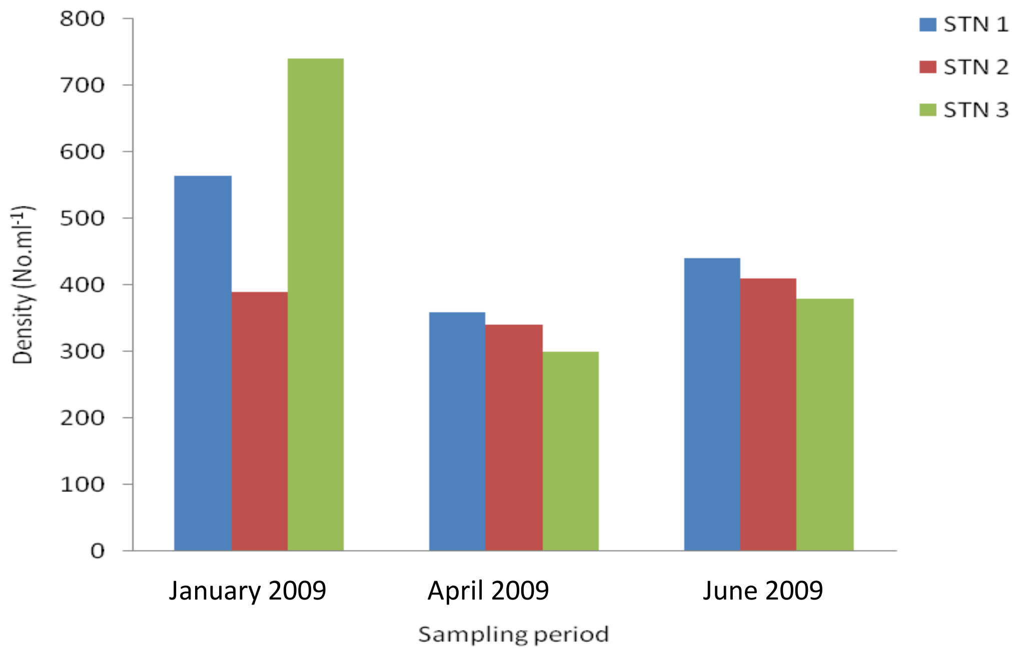

Figure 3. Phytoplankton abundance of the sampling stations of the sampling stations in Omi Dam.

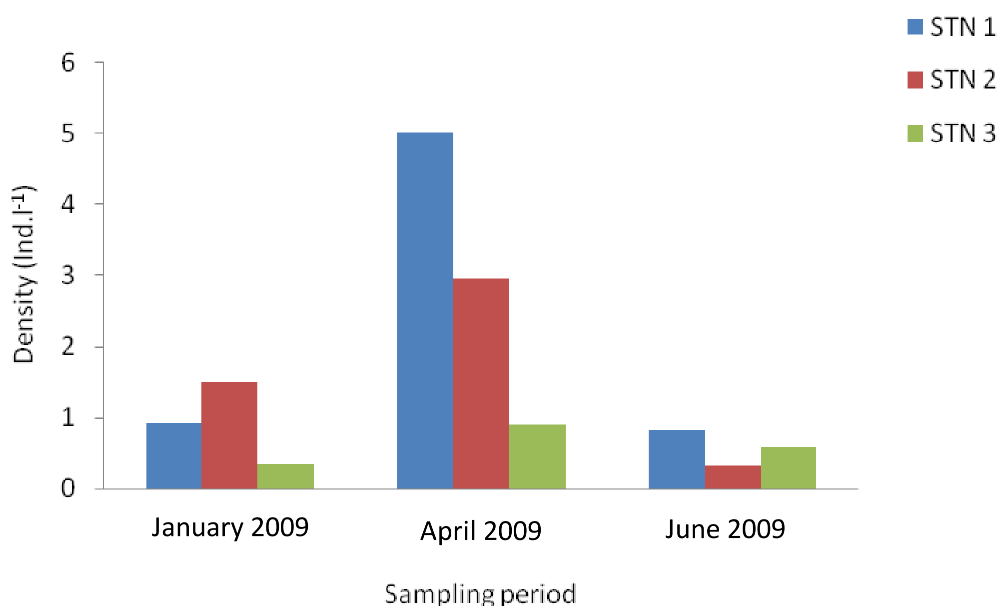

Figure 4. Zooplannkton abundance of sampling stations in Omi Dam.

Table 5. Morpho edaphic indexes (MEI) and mean potential fish yield (PFY) of Omi Dam.

Period (month)	MEI	PFY (Kg ha^{-1})
January	32.68	33.11
April	25.19	30.20
June	91.58	49.00
∑PFY		112.31
Mean PFY		37.44

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