Fish Community Structure, Richness and Diversity in Relation to Water Quality in Taungthaman Lake

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Abstract

Water quality and fish species are studied in four stations of Taungthaman Lake during the period from August 2014 to February 2015. A total of 31 fish species were recorded in this study. The mean values of Marglef's richness index ranged from (3.357) in December to (1.372) in February. The mean values of Shannon-Weaver index ranged from (2.223) in November to (1.093) in September. Dissolved oxygen (DO) range from 0.01mg/L in station I to 6.8 mg/L in station IV. pH ranged between 7.1 to 8.5 and biological oxygen demand (BOD) ranged between 8.6 mg/L to 22.58 mg/L. There was a relation between the numbers and abundance of fish species and dissolved oxygen. This study also presents measures for the sustainable management of the lake environment, its quality and fisheries.

Keywords: Water quality, Marglef's richness index, Shannon-Weaver index, DO, BOD.

Introduction

Taungthaman Lake is one of the important sources in Upper Myanmar for a variety of fishes and small prawns for local consumption of Mandalay environs. During the rainy season, the area of the lake is about 607 ha with the depth of 8 to 15 feet and is about 324 ha with the depth of 3 to 6 feet during hot dry season. Taungthaman Lake is the natural flood-plain, during the rainy season. It supports a traditional flood plain fishery production about 1680 tons of fish annually (Smith *et al*., 2002).The water body of the lake is drained by two major rivers (Dokhtawady and Ayeyarwaddy River). Dokhtawady River flows to the south of it and Ayeyarwaddy River flows to the west. Taungthaman Lake is a large floodplain transformed into a permanent lake by the construction of water

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control at Tadarphyu sluice gate in the year 1993 disrupts the natural flow of the lake. There are some agriculturally productive areas at the east bank of lake with use of agro-chemicals. Urban and industrial development around Myothit area is the point source of pollution since the waste discharges directly through Payandaw Chaung into the Lake.

The Ayeyarwaddy River and its floodplains are important aquatic resources in Myanmar. The floodplain lakes of the Ayeyarwaddy River are in the ecology of the river system. The floodplain lake fauna includes a diverse and productive fish community, provides an important food source for villages along the river. Floodwater usually enters the lake in June, after which the water level rises rapidly. During the rainy season, temporal connection between river and the lakes facilitates movement of spawner, which appear predominantly during this period. Such river ecosystem with flood dependent cycles of the fish is mainly found in tropical regions (Lowe. Mc Connell, 1987).

Floodplain lakes support a lucrative fishery in Myanmar and are considered as the most important inland fisheries resources of the country. These water bodies are not only rich in fin fish biodiversity but also support a rich source of zooplankton, phytoplankton and macro invertebrate species (Khan, 1998). The productivity of a water body depends on its ecological conditions. Productivity can be increased for obtaining maximum sustainable yield of fish and maintenance of environmental and social stability through constant monitoring of water quality. The water quality parameters like temperature, hardness, pH, dissolved gases (oxygen and CO_2), alkalinity etc. must be watched regularly, individually or synergistically to keep the aquatic habitat favorable for existence of fish.

Fish distribution and abundance in different habitats is related to availability and abundance of food and substrate types. In addition fishes are not evenly distributed throughout a water body (Balirwa, 1998; cited by Muyodi *et al*., 2011). The physical habitat and the presence of other organisms and plants influence the distribution of fish, particularly those used for food and shelter. Many fish species or developmental stages of a species can only survive within a certain range of abiotic conditions such as temperature, oxygen, pH and water currents (Fryer, 1973).

Different fish species have different requirements for the concentration of oxygen dissolved in water. The oxygen requirement of fish also depends on a number of other factors, including the temperature, pH

and CO_2 level of water and the metabolic rate of the fish (Svobodova *et al*. 1993; cited by Htay Htay Sein).

The specific objectives of the study were:

-to identify the fish species composition, abundance and distribution within the Taungthaman Lake

-to determine the levels of water quality parameters (physicochemical)

-to investigate the effect of water quality on the composition and occurrence of fish species in Taungthaman Lake.

Materials and Methods

Study Area and Study Period

Thaungthaman Lake is situated in Amarapura Township, Mandalay Region, and Central Myanmar. It lies between 21° 53′ N to 21˚54′ N latitude and 96˚ 03′ E to 96° 05′ longitude. Monthly sampling was conducted for a period of seven months from August 2014 to February 2015.

Four different stations were selected in lake for sampling of fish and water. The first station was located near the connection of lake with the Payanddaw Chaung, the second in the northern part of the U Pain bridge, the third in the southern part of the U Pain bridge and the fourth station at the connection of lake with the river mouth. Samplings were done every month from August 2014 to February 2015.

Collection, Preservation and Identification of the Specimens

Collection of specimens was made at the stations caught by fishermen. The physical appearance of fish was noted down and the photo was also taken immediately after capturing the fish. Small specimens were preserved in 10% formalin and then transferred to 5% formalin. The medium-sized specimens were injected with 10% formalin on the side of abdomen for total fixation before they were preserved.

The random samples of fish were take with cast net of 5 to 10 cm stretched mesh size in different stations to determine the total number of species, total number of individuals in a sample and total number of

individuals of a species in lake every month. Same frequency of catching or trapping rate e.g. two times per site per trip was maintained through the studied period. Genus and species were identified according to Day (1878), Jayaram (1981), Talwar and Jhingram (1991) and Ferraris (1998). The identified specimens were arranged and presented according to the system of classification given by Jayaram (2013).

Collection of Water Sample

For water quality analysis, random samples of water were collected from four different stations in the morning of the first week of every month during August 2014 to February 2015. Water samples were carried out in the laboratory of water supply and sanitation department, Mandalay city development council. Dissolved oxygen (DO), biological oxygen demand (BOD) and pH were determined using standard methods (APHA, 1995). The surface water temperature was measured by mercury thermometer in the field for each station.

3.4 Data Analysis

Margalef's species richness index (Margalef, 1958), (Shannon-Weaver) (S-W) species diversity index (Shannon and Weaver, 1963), Evenness index (Pielou, 1966) and index of dominance (Simpson, 1949) were used in the data analysis.

Observations and Results

Fish Composition, Distribution and Abundance

A total of 31 fish species belonging to 22 genera and 13 families under 6 orders were recorded from the four stations in Taungthaman Lake during the field study period from August 2014 to February 2015. Although the total numbers of species varied from a low of 9 at station I to 29 at station III, second highest number of species were 26 at station II and followed by station IV with (20) species (Fig.2). *Oreochromis niloticus* (25.48%) were numerically the most dominant followed by the *Parambassis ranga* (21.63%). In Lake, station III had the highest number of fishes (899), followed by station II with (587), station IV with (568) and station I recorded the lowest number of fish (291) (Fig.1). The largest total number of species and specimens were 22 and 266 respectively in the

November at station III and the lowest 2 and 24 in February and December at station I.

Fish species were graded according to their abundance. Four grades were recognized as group I, those species that occur at all stations in high occurrences (above 15 recorded), group II, those species that occur at station in medium occurrences (between 11-15 recorded), group III, those species that occur at station in low occurrences (between 6-10 recorded) and group IV, those species that occur at station in presence (between 0-5 recorded) (Table .1).

Species Richness (d) and Diversity

Monthly values of Margalef's richness index (MRI), Shannon-Weaver index (SWI), evenness index (EI) and index of dominance (ID) of fish species in respective study sites and mean value of these parameter for the whole area are shown in (Table.2).

Monthly species richness in the whole study areas were recorded the highest value 3.36 in December and the lowest value 1.37 in February. The highest diversity value SWI was 2.22 in November and the lowest value was 1.09 in September. Similarly, the highest value of EI was 0.81 in November and the lowest value was 0.59 in September. The highest value ID was 0.45 in September and the lowest value was 0.19 in November.

Water Quality parameter

Physical parameter

i. Water Temperature

During study period, water temperature values ranging between 22^oC – 36^oC were recorded. However, highest values of water temperature 36^oC were observed in September at station III and lowest values 22^oC were recorded in February at station II (Fig.3).The pattern of variation of the water temperature parameter was almost similar at different four stations.

ii. pH

The pH of all the study sites ranged from 7.1 to 8.5. The highest value 8.5 was recorded in February at station III while the lowest value 7.1 was recorded in September at station I (Fig.4). The results indicated not conspicuous variation of the pH value at stations during study period.

Chemical Parameter

i. Dissolved Oxygen

Dissolved oxygen content varied from 0.01 to 6.80 during study period. Dissolved oxygen values were found to have a maximum of 6.80 in November at station IV and a minimum of 0.01 in December at station I. The conspicuous seasonal variation of DO parameters is shown in (Fig.5).

ii. Biological Oxygen Demand (BOD)

During the study period, BOD value was found to be between 8.60 and 22.58. The lowest value 8.60 was recorded in November at station II. The highest value 22.58 was found in December at station I (Fig.6).

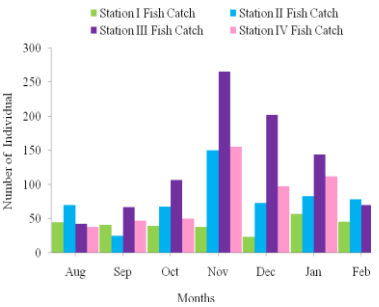

Fig .1 Composition of individual fish in four stations during August 2014 to February 2015

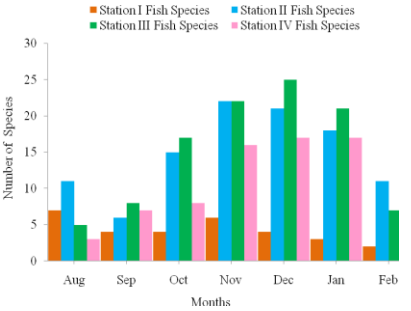

Fig.(2) Composition of fish species in four stations during August 2014 to February 2015

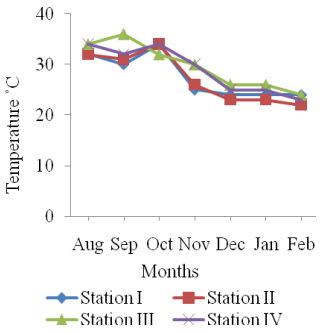

Fig.(3) Time plot of monthly observed data of temperature from four stations in Taungthaman Lake

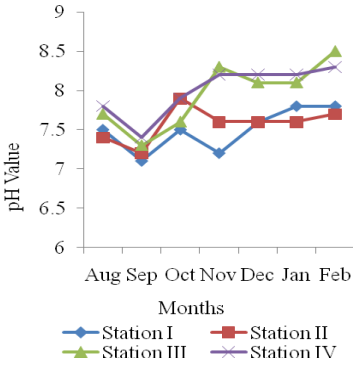

Fig.(4) Time plot of monthly observed data of pH from four stations in Taungthaman Lake

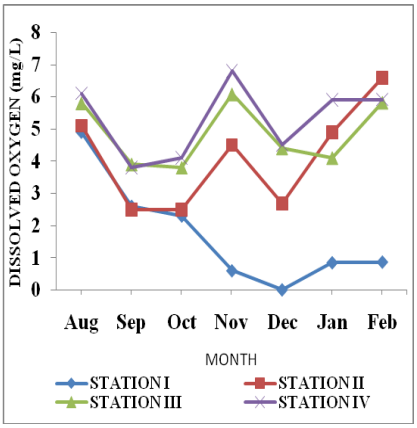

Fig.(5) Time plot of monthly observed data of DO from four stations in Taungthaman Lake

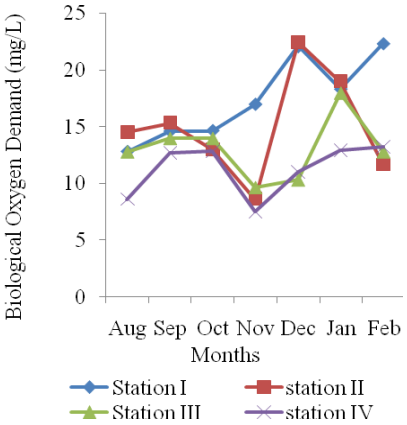

Fig.(6) Time plot of monthly observed data of BOD from four stations in Taungthaman Lake

Table 1. Stationwise distribution of abundance of fish species recorded from Taungthaman Lake during August 2014 to February 2015

Group I	Group II	Group III	Group IV	Group I
O. belangeri	*G. variegata*	*N. notopterus*	*R. guttatus*	*O. belangeri*
O. cotio	*P. gonionotus*	*H. ilisha*	*E. altus*	*O. cotio*
P. chola	*L. rohita*	*A. atkinsonii*	*H. molitrix*	*P. chola*
P. sarana	*G. giuris*	*A. mola*	*C. mrigala*	*P. sarana*
P. ranga		*M. bleekeri*	*C. catla*	*P. ranga*
O. niloticus		*M. cavasius*	*L. calabasu*	*O. niloticus*
T. pectoralis		*M. pulcher*	*L. berdmorei*	*T. pectoralis*
			W. attu	
			C. batrachus	
			X. cancila	
			C. marulius	
			C. puntatus	
			C. striatus	

Table 2. Monthly species richness and diversity indices determined for four stations of Taungthaman lake during August 2014 to February 2015

Month	Index	Station	Station	Station	Station	Overallmean
Aug	MRI (d)	1.576	2.354	1.063	0.549	1.386
	SWI	1.423	2.105	0.916	1.079	1.381
	EI(J)	0.731	0.878	0.569	0.983	0.79
	ID	0.35	0.143	0.487	0.346	0.332
Sep	MRI (d)	0.808	1.553	1.665	2	1.461
	SWI(H')	0.593	1.305	1.093	1.38	1.093
	EI (J)	0.428	0.728	0.526	0.665	0.587
	ID	0.704	0.344	0.416	0.326	0.448
Oct	MRI (d)	0.813	3.318	3.424	1.789	2.336
	SWI	1.18	2.205	2.227	1.473	1.771
	EI (J)	0.852	0.814	0.786	0.709	0.79
	ID	0.354	0.141	0.149	0.314	0.24
Nov	MRI (d)	1.375	4.079	3.761	2.97	3.046
	SWI	1.155	2.703	2.658	2.374	2.223
	EI (J)	0.645	0.875	0.86	0.856	0.809
	ID	0.461	0.091	0.093	0.132	0.194
Dec	MRI (d)	0.944	4.662	4.333	3.489	3.357
	SWI	1.072	2.551	2.519	2.109	2.063
	EI (J)	0.773	0.838	0.792	0.745	0.787
	ID	0.413	0.119	0.119	0.204	0.214
Jan	MRI (d)	0.495	3.691	3.823	3.391	2.85
	SWI	0.809	2.512	2.472	1.999	1.948
	EI (J)	0.737	0.869	0.825	0.706	0.784
	ID	0.501	0.11	0.134	0.217	0.241
Feb	MRI (d)	0.261	2.288	1.512	1.427	1.372
	SWI	0.462	1.873	1.398	1.629	1.341
	EI (J)	0.667	0.781	0.718	0.837	0.751
	ID	0.713	0.206	0.284	0.232	0.359

Discussion

A total of 2345 fish representing 31 species belonging to 22 genera and 13 families under 6 orders were recorded from the four stations during the period from August 2014 to February 2015.

A fish community is a group of fish that inhabit the same area of a stream and interact with each other. The structure of a fish community is determined by the species present, their relative abundances, their life stages and size distributions, and their distributions in space and time (Meador *et al*, 1993 a).

The recorded species in this work belong to 6 orders, Osteoglossiformes (1 species), Clupeiformes (2 species), Cypriniformes (15 species), Siluriformes (5 species), Cyprinodontiformes (1 species) and Perciformes (7 species).

The freshwater fish faunas of East and South East Asia are dominated by cyprinids (Rainboth, 1991). Similarly, Myanmar cyprinids are dominant among the fish fauna in the study sites. Cypriniformes recorded the most species accounting for 48.39% while Perciformes had 22.58%. *Oreochromis niloticus* and *Parambassis ranga* dominated overall catch, constituting 25.41% and 21.74%.

The station III had greater numbers of fish (266) in November and higher species (25) in December. The station I had lower numbers of fish (24) in December and fewer species (2) in February.

Species number thus increased during November–December rendering an increase in Marglef's species richness index, the Shannon–Weaver index and evenness index at the stations. This was due to gradual reduction in number of individuals of the dominant species captured in the stations, resulting in a gradual reduction of index of dominance.

Dissolved oxygen is essential for a healthy aquatic ecosystem. Fish and aquatic animals need the oxygen dissolved in the water to survive. Dissolved oxygen should be maintained above 3.0 mg/l and 5.00 mg/l for warm and cold water fish respectively (Buttner, 1993).

Khin Than Htwe was observed that from May 2006 to 2007 February, the DO level of the surface water was the highest (11.86 mg/L) in January and the lowest was 7.3 in December. (Khin Than Htwe, 2007).

During study period, the value of DO ranged between (0.01 mg/L in December- 6.8 mg/L in November). The station I had the lowest values (0.01 mg/L- 4.9 mg/L) followed by station II (2.7 mg/L-6.58 mg/L) and station III (2.5 mg/L-6.08 mg/L) while station IV had the highest values (3.8 mg/L-6.8 mg/L).

The high concentration of dissolved oxygen at station III, the high was the fish species in station III. The low the concentration of dissolved oxygen at station I, the lower was the fish species in station I.

Biological oxygen demand (BOD) is a measure of oxygen used by microorganisms to decompose the waste. The permissible limit of BOD in the inland surface water is 20 mg/L (Mahapatro and Padhy, 2001). In the present study, BOD ranged from 7.5 – 22.58 mg/L and maximum BOD value was recorded in December at station I. In study stations, BOD values were inversely related number and abundance of fish species, fish species increased with decrease in biological oxygen demand (BOD) value.

During the study period, the temperature values ranged between $22^{o}C$ – $36^{o}C$. There was not wide different in the surface water temperature parameters between the four stations during studying each month. Thus, temperature values were found to be no significant effect on fish catches and species composition at four stations in Lake.

The pH is an important variable in water quality. The pH of most natural water is between 6.0 and 9. In the present study, pH ranged between 7.1 and 8.5. The pH of the Taungthaman Lake is normal.

Therefore it was concluded that, some water quality parameters showed some relation with number and abundance of fish species, although this was not as strong and direct as that expressed by dissolved oxygen concentrations and biological oxygen demand.

Out of water parameters, DO level was found to be significant effect on fish catches and species composition in lake. There are the lowest DO level (0.01 mg/L) and the lowest numbers of fish (24) at station I in December. The water quality of the present time was slightly degraded than the past time (2004-2007). The number of natural fish and commercial fish are significantly reduced in the lake. But the small fish (*Parambassis ranga*) and Tilapia (*Oreochromis niloticus*) dominated overall catch of lake in the present study.

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