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ASPECTS OF METEOROLOGICAL FACTORS AND TEMPERATURE REGIME OF ASA LAKE, ILORIN NIGERIA

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Abstract
The temperatures of Asa lake were studied for 12 months at three sites along the lake between the early morning and afternoon hours. Surface water temperatures were generally higher than the air temperatures during the afternoon hours except in the months of January to March when air temperatures were high (28.1 to 28.7°C) due to the low relative humidity (39 to 70 %). In the morning hours, surface water temperatures (25.5 to 26.3°C) became higher than the air temperatures (25.2 to 26.0°C) from May to December when relative humidity values were also high (50 to 88 %). The difference ($P < 0.05$) in the surface and bottom water temperatures were generally higher (0.7 to 3.1°C) in the afternoon than in the morning hours (0.2 to 0.8°C) due to the effect of sunlight. Also the temperature difference ($P < 0.05$) in the surface and bottom waters were usually higher at the dry season than the wet season for similar reasons. Thermally stratified conditions were more pronounced in the afternoon than in the morning hours especially from January to August. These conditions were not clearly defined as from October / November when water temperatures from surface to about 9 meters deep were almost uniform (mean =26.5°C) due to the mixing effect. Minimum and maximum water temperatures were significantly different ($P < 0.05$) for both surface and bottom waters. However there were no marked variations in the temperature pattern along the three sampling sites. It was concluded that the fish species distribution with respect to the temperatures along the lake may show little or no variation.

Key words: *Temperatures, Asa lake, meteorological factor, relative humidity, Thermal stratifications*

Introduction

Temperature has significant impact on distribution and physiological processes of the floral and fauna of the aquatic environment. In fishes, temperature is an important external factor in the early life stages because it has direct influence on the timing of ontogenetic events (Bagenal, 1978). The demand for oxygen increases continuously during embryogenesis and is influenced by temperature, therefore both temperature and oxygen supply of the environment may accelerate or retard the morphogenetic process of development (Balon, 1975; Bagenal, 1978). Movement of plankton and fish is influenced by water temperature and this is usually more pronounced especially in the temperate regions where there is wide variation in the seasonal changes of temperature.

Changes in temperature and other biological factors including succession contributed to the elimination of some aquatic plants in Jebba lake (Adeniji *et al*, 1984). Seasonal changes in temperature reflect on the growth pattern in fishes. This information has been used in the study of distribution, age and growth of fishes by Fagade (1974), Van Der Waal and Schoonbee (1975), Ikusemiju (1976), Araoye, (2002). Temperature affects directly or indirectly other limnological parameters such as transparency, viscosity, dissolved gases, pH, Total dissolved solids, conductivity (Whitney, 1942); all of which constitute the very important limnological parameters that form the basis for an enlightened fisheries and water resources management. Although different fish species tolerate different levels of adverse environmental conditions, it is important to maintain stable environmental conditions for fishes (Kolndadacha, *et al*, 2004)

There are literatures on the temperature pattern of some Nigerian inland waters, these include those provided by Hill and Webb (1958) on Lagoon waters, Imevbore (1975) on Kainji lake, Adebisi (1981) on Upper Ogun river and Adeniji (1991) on Jebba lake. However this work which also examines the meteorological factors along with the temperature regime of Asa lake in Ilorin is the most recent in the history of the dam. The temperature regime of the lake is worthy of investigation because the lake now constitutes another source of fresh water fish supply to Ilorin and its environs to complement the supply from other sources including Kainji, Jebba and Moro lakes.

Materials and Methods

The lake is about 302 hectares in surface area (Ita et al 1985) and it is located at 5 kilometers south of Ilorin across river Asa. The three sampling sites were Odore, Laduba and Afon (Fig. 1). Odore was close to the dam where maximum depth at high water levels did not exceed 14 meters. Laduba and Afon located towards the river source have the depth of 11 meters at high water levels. These sites were reached through a paddled canoe during the sampling trips.

Water samples were collected bimonthly for twelve months (March 2002 to February 2003) in the morning hours between 06.00 and 07.00 a.m. and the afternoon hours between 12.00 and 1.00 p.m. Samples were collected from the surface to the bottom (13.0 meters) at different depths interval of 2 meters using the Kemmer water sampler attached to a graduated nylon rope. Samples were taken randomly from three places in each of the sampling sites to determine the mean temperatures. Water temperature was taken to the nearest 0.1 ^{0}c using a thermometer with a range of 0 ^{0}c to 100 ^{0}c. Transparency levels were also determined using secchi disc with a calibrated rope attached. This was lowered into the water until it disappeared and then brought up gently until it appeared. The mean of these two depths was recorded as the depth of the transparency level. Monthly mean rainfall, relative humidity (R.H.) and air temperatures around the dam were obtained from Ilorin International Airport that is just about two kilometers away. Monthly water levels were also recorded from the water level gauge installed at the dam by the state utility board. The data were subjected to statistical analysis including t-test and correlation coefficient.

Result

Mean surface water temperatures were generally higher (26.0 to 27.0 ^{0}c) than air temperatures (25.9 to 28.7 ^{0}c) in the afternoon hours except for few months (January to March) when mean air temperatures were above 28 ^{0}c. Air and surface water temperatures were almost uniform in the months of October / November but most peculiarly in the morning hours. Monthly variations of water temperatures (Surface and bottom) are shown in Tables 1 and 2 and the thermal stratification of the lake is illustrated in Fig. 2. The maximum depth that could be reached at low water levels was 11 meters. The temperatures of the surface and bottom waters were significantly different (P <0.05) during the morning hours of the dry seasons (November to April). Thermally stratified conditions were prominent during the afternoon hours of January to August in all the sampling sites (Fig. 2). These hours also recorded higher temperature difference between the surface and bottom waters (Table 1). Stratified conditions were not clearly defined as from September to November when the temperature differences between the surface and bottom waters were relatively low. Similar stratification was not clearly defined in the morning hours. Air and water temperatures that were recorded in the morning hours were lower than those recorded in the afternoon hours. Monthly variation of relative humidity, rainfall, water and transparency levels is also presented in Tables 1 and 2. There were little or no rainfalls in December to February. Relative humidity was high as

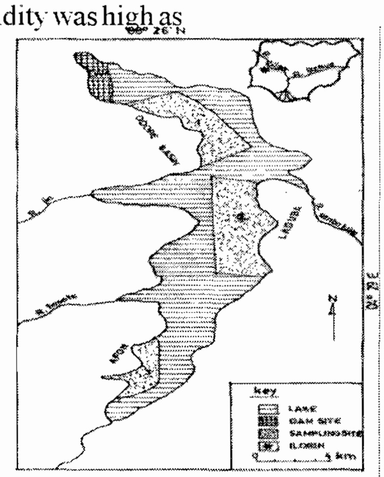

Fig. 1: Sketch map of Asa Lake showing The fishing sampling sites

From May to October and low in December to March (Table 1).

The mean transparency levels that were usually high at dry season dropped as from August to October corresponding with the period of flood around the lake, during which air and water temperatures were relatively low. Transparency levels in the morning and afternoon hours did not show any remarkable variation except in October and November when transparency levels were slightly lower in the morning hours (mean = 0.4 m) Transparency and water levels were negatively correlated (-0.79). Similarly, water temperatures and relative humidity were negatively correlated (-0.42) but air and water temperatures (Table 3) were positively correlated (0.52). There were no marked variations in the meteorological and the temperature profile along the three sampling sites.

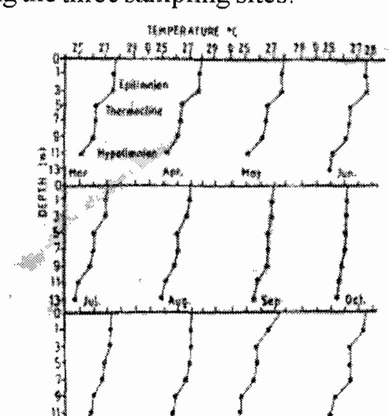

Fig. 2. Monthly changes in temperature with depth. Note the thermal stratification in January to August. (TimeL 12.00 noon - 1.00 p.m.)

Discussion

The positive correlation between air and surface water temperatures was due to the close contact between the air temperatures and the temperatures of the epilimnion (Parks, et al 1975). Higher surface water temperatures in the afternoon hours were attributed to the less humid atmospheric air in the afternoon than the morning hours. Also low surface water temperatures during the wet seasons (May to October) were due to the more humid atmosphere and lower rate of evaporation.

Table 1: Mean monthly value of meteorological parameters, transparency levels and water temperatures in Asa dam, March 2002 – February 2003 (Time: 12.00 noon-1.00 p.m.)

Month	Surface water ToC)	Bottom water (ToC)	Temperature difference (oC)	Air Temp. (ToC)	RH (%)	RF (cm)	Water level (m)	Transp. (cm)
Mar	28.9	26.3	2.6	33.6	70	2.8	11.1	1.7
Apr	28.8	26.2	2.6	31.5	75	1.1	11.1	1.8
May	28.9	26.1	2.8	31.5	74	4.6	11.4	1.6
Jun	28.7	26.1	2.6	29.4	79	9.7	11.9	1.5
Jul	28.3	26.0	2.3	27.6	86	16.0	12.2	1.4
Aug	29.0	25.9	3.1	26.7	88	25.8	12.4	1.0
Sept	27.5	26.7	0.8	28.0	84	9.3	12.5	0.6
Oct	27.5	26.5	1.0	29.2	85	15.5	12.4	0.6
Nov	28.4	26.3	2.1	32.4	76	5.9	12.0	0.9
Dec	28.4	26.3	2.1	31.9	50	0.0	11.9	1.3
Jan	28.5	25.5	3.0	28.4	39	0.7	11.4	1.5
Feb	28.7	25.7	3.0	33.3	57	0.0	11.2	1.7

Table 2: Mean monthly value of meteorological parameters, transparency levels and water temperatures in Asa dam, January – December 2002 (Time: 06.00 – 7.00a.m.)

Month	Surface water (ToC)	Bottom water (ToC)	Temperature difference (oC)	RF (cm)	Water level (m)	Transp. level (cm)
Mar	27.3	26.7	0.6	2.8	11.1	1.7
Apr	27.4	26.6	0.8	1.1	11.1	1.7
May	27.3	26.6	0.7	4.6	11.4	1.6
Jun	27.0	26.3	0.7	9.7	11.9	1.5
Jul	27.0	26.6	0.4	16.0	12.2	1.3
Aug	27.0	26.6	0.4	25.8	12.4	0.6
Sept	26.8	26.4	0.4	9.3	12.5	0.5
Oct	26.4	26.2	0.2	15.5	12.4	0.4
Nov	26.5	25.3	0.2	5.9	12.0	1.2
Dec	26.5	25.2	0.2	0.0	11.9	1.3
Jan	27.4	26.7	0.7	7.2	11.4	1.6
Feb	27.4	26.8	0.6	0.0	11.2	1.7

These changes in air and surface water temperatures were normal phenomena similar to the observations of Hill and Webb (1958) on the Lagos lagoon, Egborge (1970) on the river Osun, Imevbore (1975) on Kainji lake and Adeniji (1991) on Jebba lake. The impact of flood around the lake in October and November enhanced the mixing of the surface waters resulting in temperature uniformity at the air – water interface in those months particularly in the morning hours. The flooding of the lake resulting in high water levels three months after the commencement of the rains caused mixing, turbidity and low transparency levels. Similar observation was reported in some other tropical lakes (Biswas, 1973; Olaniyan, 1975).

Table 3: Correlation coefficient ® values between temperatures, rainfall, water levels, relative humidity and transparency in Asa lake (6.00 am and 1.00 pm).

	Rainfall	Water levels	Air Temp. 6.00 am	Air Temp. 1.00 pm	Water Temp. 6.00 am	Water Temp. 1.00 pm	R.H. 6.00 am	R.H. 1.00 pm	Transp
Rainfall									
Water levels	0.54*								
Air temp. (6.00 am)	-0.41	-0.42							
Air temp. (1.00 pm)	-0.57	-0.23	-0.34						
Water temp. (6.00 am)	-0.23	0.22	0.37	0.52*					
Water temp. (1.00 pm)	0.20	0.35	0.30	0.52*	0.52*				
R.H 6.00am	0.67*	0.50*	-0.65*	-0.57*	-0.53*	-0.42			
R.H. 1.00 pm	0.47*	0.50*	-0.52*	-0.53*	-0.42	-0.50*	0.10		
Transp.	0.21	-0.79*	0.42	0.60*	0.33	0,55*	-0.60*	-0.51*	

* Significant correlation coefficient values ($P < 0.05$)

Since heat is absorbed more rapidly at the surface of a water body, the warm surface waters are less dense than the cool bottom waters; hence the body of water may stratified thermally (Boyd, 1979). This is also a normal phenomenon which explains the stratified conditions in Asa lake during the months of January to August in the afternoon hours when the difference between the surface and bottom water temperatures were higher (1.0 to 3.1 °C). Periodic stratification of temperature in many tropical lakes has been reported by many authors including Viner, 1968); Beadle, 1974); Adeniji, 1978 and 1991). However the period of stratification varies depending on the prevailing hydrological and meteorological conditions. In Asa lake for example periodic stratification was reported as from January to August (Araoye, 1997) but in this present report stratification of this lake commenced in December to July because the lake began to experience its annual flood in August. This periodic change in the commencement of lake stratification can be attributed to the changes in the commencement of rains which also has effect on the time of flood and temperature regime around the lake. De-stratification which commenced as from August in this report became well pronounced in October (Fig. 2). Hutchinson (1957), Odum (1971) and Wetzel (1975) described the classical pattern of thermal stratification of lakes. This classical pattern can also be seen in this report as from March to June when the epilimnion and hypolimnion zones of the lake were properly demarcated and the thermocline formation in-between them (Fig. 2).

Distortion of the thermally stratified conditions in Asa lake between August to November was due to the mixing effect caused by high water current around the lake from the adjoining rivers after the rains. Also the high relative humidity that became pronounced from August to October can also reduce the surface water temperatures resulting in higher density of surface waters, hence there was overturn. Stratified conditions can also be distorted due to drop in atmospheric temperature at night (Olaniyan, 1975). Therefore the less pronounced stratified conditions of Asa lake in the morning hours could have resulted from the distortion that probably occurred during the night. Over turn in some tropical lakes may be useful to fish because of the bottom nutrients that were brought up especially for non bottom dwelling fishes e.g. Clupeids and detritus feeders such as *Tilapia melanotheron* (Fagade, 1974). Over turn in Asa lake could also be of advantage to some fishes that feed on detritus such as *Synodontis schall* (Araoye and Jeje, 1999). It may also influence the spatial distribution of such fishes because the need to move towards the bottom habitat at this period to feed on detritus may not be required (Araoye, 1999). However fish mortality have been observed in some temperate fish ponds due to overturn and it was explained that mixing of the large volumes of oxygen deficient hypolimnetic with waters of the epilimnion resulted in dissolved oxygen depletion (Boyd, 1979). Low transparency in August to October was due to turbidity of the lake at this period which is an usual occurrence in the tropical lakes.

Water level was significantly correlated with the transparency. The negative value of 'r' is an indication that generally the transparency is low when water level is high and vice versa (Adebisi, 1981). It was noted that the maximum transparency (3.0 m) recorded in Kainji dam by Henderson (1975) was higher than what is now recorded for Asa dam (1.8 m). This indicates that the flood and turbidity were more pronounced in Asa lake than in Kainji lake probably due to the small size of Asa dam compared with Kainji dam which has a higher depth and a larger surface area of impounding the incoming floods. There is tendency for light to penetrate more in a deeper lake than a shallow lake. Hence the higher the transparency level in Kainji lake. The relatively small size of Asa lake was also responsible for the temperature similarities along the sampling sites. Hence the fish species distribution with respect to the temperatures along the lake may exhibit little or no variation, unlike what was reported in Kainji lake (Willoughby, 1974) and Jebba lake (Adeniji, *et al* 1984). The slight increase in surface water temperatures at Afon during the months of February to March was probably due to the narrow and shallow structure of the lake towards the river source.

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