

*Full Length Research Paper*

# Dynamics of limnological features of two man-made lakes in relation to fish production

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Limnological features of Oyan and Asejire lakes, South-Western Nigeria, were investigated between July 2000 and December 2001. Rainy season (April-October) mean monthly rainfall values of  $120.3 \pm 52.4$  mm and  $15.9 \pm 10.3$  were recorded for Oyan and Asejire lakes respectively, while corresponding dry season (November-March) values were  $18.2 \pm 34.7$  and  $4.2 \pm 3.81$  mm, respectively.. The mean surface water temperature, transparency, dissolved oxygen content and pH were  $29.9 \pm 2.34^\circ\text{C}$ ,  $1.5 \pm 0.19$  m,  $7.1 \pm 0.96$  mg/L and  $7.4 \pm 0.43$ , respectively, in Oyan lake and for Asejire lake the values were  $28.5 \pm 1.91^\circ\text{C}$ ,  $1.3 \pm 0.35$  m,  $6.9 \pm 1.33$  mg/L and  $7.4 \pm 0.54$ , respectively. The physicochemical properties of the two lakes vary with seasonal changes in the rainfall of the drainage area. Oyan and Asejire lakes exhibited features that are typical of tropical environment. The high dissolved oxygen content values indicate that the water bodies can successfully support aquatic life including fish.

**Key words:** Limnological factors, Asejire, Oyan, fish, production.

## INTRODUCTION

A comprehensive knowledge of the limnological features of a lake or any environment in which fish live is imperative for accessing its productivity and suitability for rearing fish. The literature available on limnology of lakes, rivers and streams in Nigeria is vast (Holden and Green, 1960; Green, 1963; Imevbore, 1964, 1970; Egborge, 1970, 1971, 1972a, 1978a, 1978c, 1979b, 1986; Egborge and Fagade, 1979; and Adebisi, 1981). However there has been no previous attempt of comparative studies to monitor changes in physico-chemical features of two tropical lakes simultaneously. This will better illustrate effect of differences in environmental condition on fish production.

This paper constitutes the first record of an investigation into the dynamics of limnological features of Asejire and Oyan lakes in Southwestern Nigeria, in relation to fish production (Table 1).

## GEOGRAPHY AND TOPOGRAPHY OF STUDY SITES

Oyan and Asejire lakes are located in Southwestern Nigeria (Figure 1) and there is a horizontal distance of about 100 km between them. Lake Asejire is a man-made lake constructed on River Oshun in 1972. River Oshun is one of the series of West African rivers which do not drain into Niger system but discharge into coastal lagoons and creeks bordering the Atlantic Ocean. The lake is Y-shaped with two unequal arms of the Y. From the data supplied by the Oyo State Water Corporation, the catchment area above the dam is  $7,800 \text{ km}^2$  and the impounded area is 2,342 hectares. The dam has a normal pool elevation (water level) of 150 m and maximum flood elevation of 152.4 m. The lake has an approximate gross storage of 7,403 million liters.

Oyan Lake (Figure 1) is constructed on Oyan River and it started to fill with the closing of the gates of the dam on the 30th of October 1984 and took  $2\frac{1}{2}$  months to fill. The average annual flow at the dam site is estimated at 1,770 million  $\text{m}^3$  and the dam provides a normal level reservoir

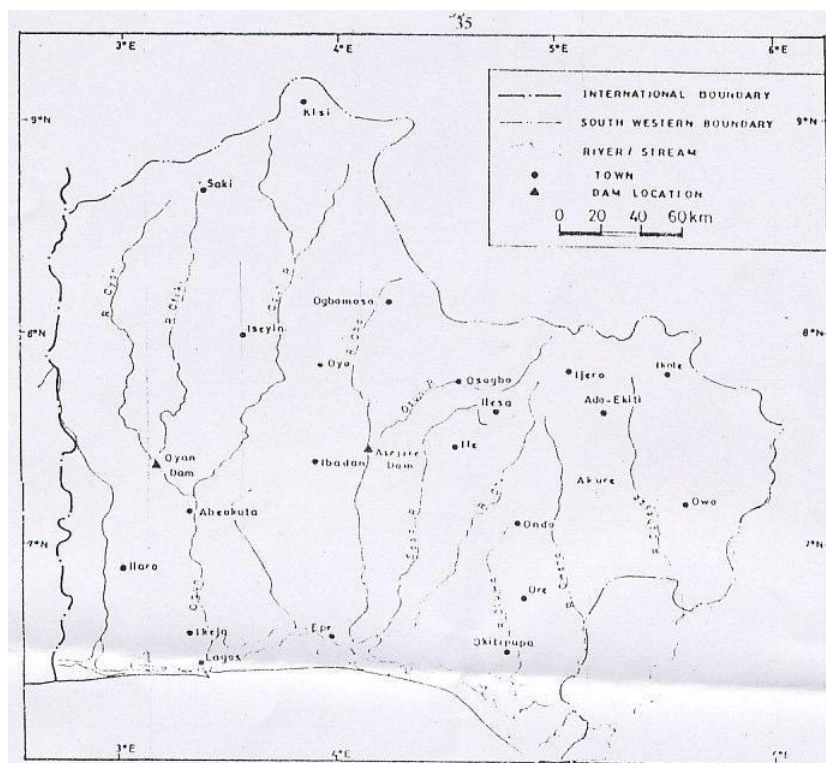
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**Table 1.** Features of Oyan and Asejire lakes.

Parameter	Oyan lake	Asejire lake
Location	20 km Northwest of Abeokuta	30 km East of Ibadan
Latitude	07°15' and 07°26'N	07°21'N
Longitude	03°6' and 3°16'E	04°07'E
Elevation	0 and 150 m above sea level	137 m
Geology	Precambrian metamorphic and plutonic rocks	Precambrian metamorphic rocks
Vegetation	Forest savanna mosaic	
Climate	Dry season: November to April Rainy season: May to October	Dry season: November to April Rainy season: May to October
Maximum length	27 km	-
Maximum width	6 km	-
Maximum depth	63 km	-
* Mean temperature	24.3°C	27.3°C
* Mean rainfall	102.6 mm	14.7 mm
* Mean humidity	77.4%	79%

**Source:** Elliot (1986) and Olurin (1994).

\*From present investigation.

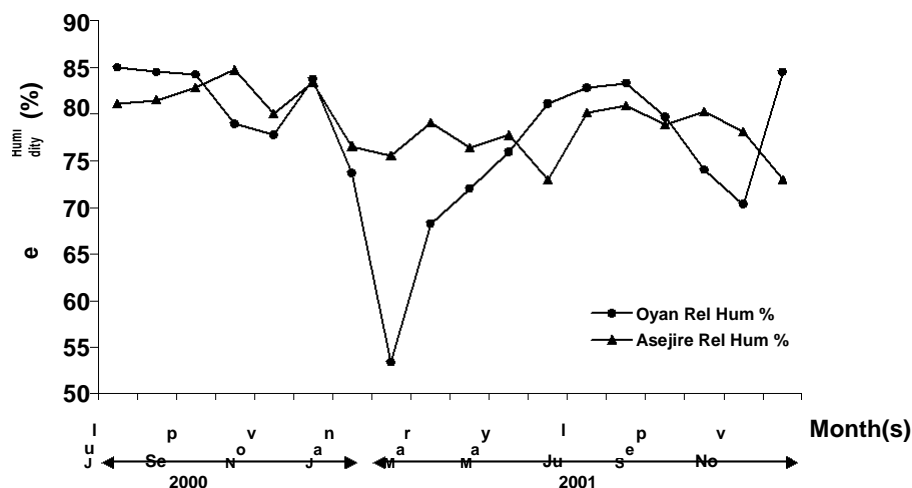


**Figure 1.** Map of South Western Nigeria showing the location of Oyan and Asejire dams

capacity of 270 million m<sup>3</sup>. The climate of Oyan Lake is influenced by the NE- SW movement of a zone of surface discontinuity between maritime (Atlantic) air masses and dry continental (Sahara) air masses.

## MATERIALS AND METHODS

Physico-chemical characteristics were monitored monthly between July 2000 to December 2001 on Oyan and Asejire lakes. Measurements of parameters occurred between 13.00 and 15.00



**Figure 2.** Monthly changes in relative humidity at Oyan and Asejire lakes, Southwestern Nigeria. (Source: Oyan Dam Meteorological Department and Department of Geography, University of Ibadan) (July 2000 – December 2001).

hrs and 10.00 and 12.00 hrs for Oyan and Asejire lakes, respectively.

Surface water temperature was measured to the nearest 0.1°C with mercury in glass thermometer at about 10 cm below the water surface. Transparency was measured with a 15 cm diameter white and black Secchi disc to the nearest 0.1 m as described by Ruttner (1965). Samples of the surface water were collected for chemical analyses. The pH of the samples was determined in the laboratory using Kent pH meter 7020. The dissolved oxygen concentration (DO<sub>2</sub>) determinations were by titrimetric methods described by Mackereth (1963).

Records of monthly total rainfall, relative humidity and maximum, minimum and mean air temperatures were collected for the period of July 2000 to December 2001 from Oyan Meteorological Department for Oyan Lake and from Department of Geography, University of Ibadan for Asejire Lake.

## RESULTS

### Relative humidity

Monthly variation in relative humidity around Oyan and Asejire lakes is shown in Figure 2. Between January to April 2001, the relative humidity were 53.4 to 73.7% (mean =  $66.8 \pm 9.24\%$ ) and 73.4 to 79.1% (mean =  $75.7 \pm 2.43\%$ ) for Oyan and Asejire lakes, respectively. The relative humidity was higher between July to October 2000 with range of 78.9 to 85% (mean =  $83.2 \pm 23.21$ ) and 81.1 to 84.7% (mean =  $82.5 \pm 1.63\%$ ) for Oyan and Asejire lakes, respectively. Between June and October 2001, the relative humidity were 79.7 to 83.3% (mean =  $81.7 \pm 1.62\%$ ) and 78.3 to 84% (mean =  $81.7 \pm 2.39\%$ ) for Oyan and Asejire lakes, respectively. In Oyan Lake, highest relative humidity was recorded in July 2000 (85%), while it was in October 2000 (84.8%) for Asejire Lake. Lowest relative humidity occurred in February 2001

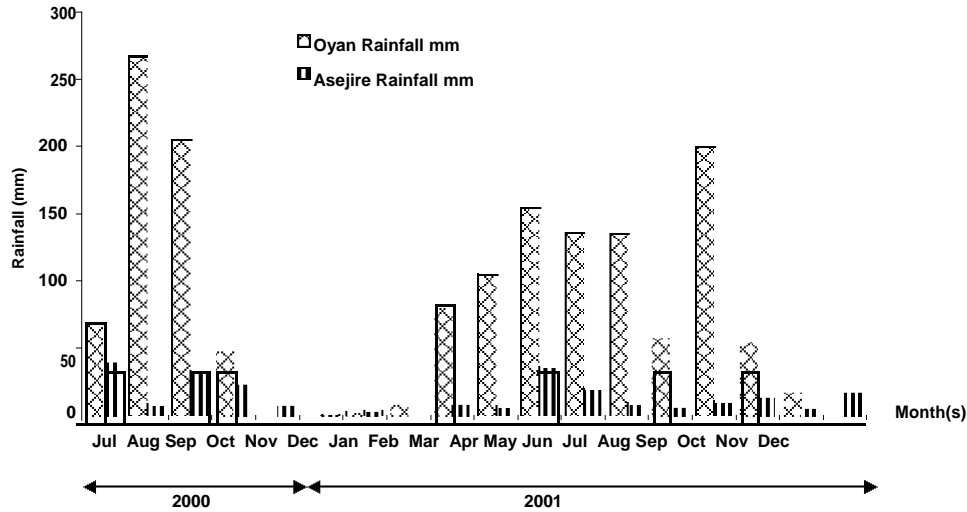
(53.4%) and December 2001 (72.9%) for Oyan and Asejire lakes, respectively.

### Rainfall

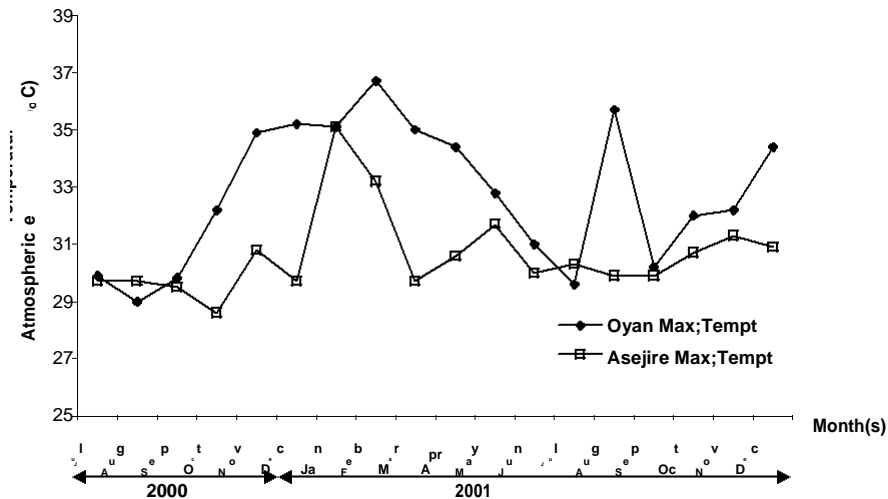
The mean monthly variation in rainfall in the two lakes from July 2000 to December 2001 is shown in Figure 3. The data shows that amount of rainfall recorded was lower between November 2000 to April 2001 (range = 0.0 to 8.6 mm, mean =  $5.6\text{mm} \pm 0.06$  and 0.0 to 8.6 mm, mean =  $4.52 \pm 3.52$  for Oyan and Asejire lakes, respectively). Between March to December 2001, the monthly rainfall reading was between 5.74 and 199.3 mm (mean =  $123.9 \pm 44.07$  mm) and 6.1 to 35.5 mm (mean =  $14.9 \pm 9.69$  mm) for Oyan and Asejire lakes, respectively. For Oyan Lake, the periods of heaviest rainfall recorded were the months of August (267.1 mm) and September (204.1 mm) 2000 and the data shows that rain fell in most months during the period of study. For Asejire lake, higher rainfall was recorded in July and September 2000 and May 2001, with values of 39.5, 32.7 and 35.5 mm, respectively.

### Atmospheric temperatures

From November 2000 through May 2001, the maximum air temperature ranged from 34.9 to 36.7°C (mean =  $35.4 \pm 0.75^\circ\text{C}$ ) and 29.7 to 35.1°C (mean =  $31.6 \pm 1.95^\circ\text{C}$ ) for Oyan and Asejire lakes, respectively (Figure 4). The maximum atmospheric temperature were generally lower during rainy season months of May to October 2001 (range of 29.6 to 35.7°C (mean =  $31.9 \pm 2.2^\circ\text{C}$ ) and range of 2.99 to 30.7°C (mean =  $30.1 \pm 0.35^\circ\text{C}$ ) for Oyan



**Figure 3.** Monthly variation in rainfall at Oyan and Asejire lakes, Southwestern Nigeria. (Source: Oyan dam Meteorological Department and Department of Geography, University of Ibadan) (July 2000 – December 2001).



**Figure 4.** Variations in maximum atmospheric temperature in Oyan and Asejire lakes, southwestern Nigeria. (Source: Oyan Dam Meteorological Department and Department of Geography, University of Ibadan) (July 2000 – December 2001).

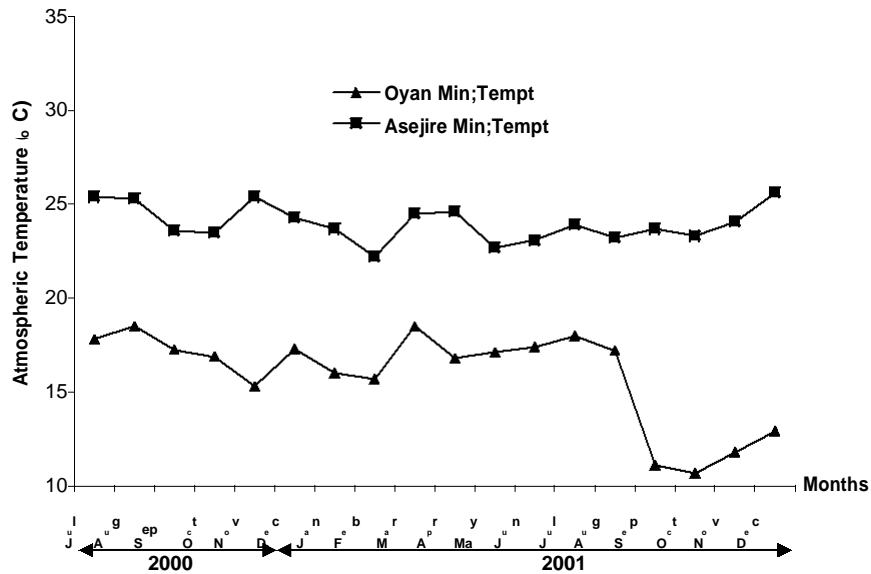
and Asejire lakes, respectively.

For Oyan lake, lower minimum air temperature were recorded in months of September through December 2001 (range = 10.7 to 12.9°C; mean = 11.6 ± 0.98°C). From July 2000 to August 2001, there were little variations in minimum air temperature (range = 15.3 to 18.5°C; mean = 17.1 ± 0.96°C) and highest minimum air temperature was recorded in March 2001 (18.5°C). In Asejire lake, higher minimum air temperature were recorded between November 2000 to April 2001 (range = 22.2 to 25.4°C; mean = 24.1 ± 1.08°C) and February (22.2°C) was the coldest month. Lower minimum air

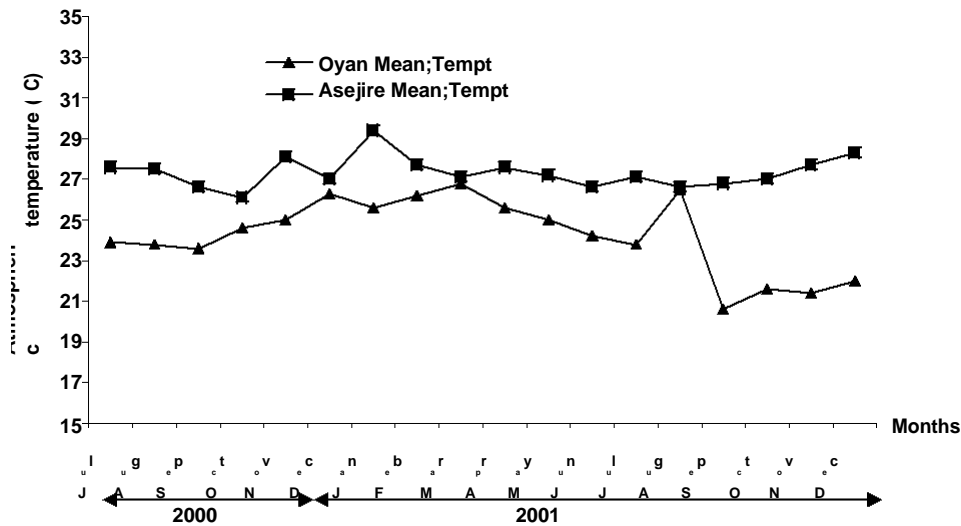
temperature were recorded between May and October 2001 (22.7 to 23.9°C; mean = 23.3 ± 0.41°C) (Figures 5 and 6).

### Surface water temperature

The variation in monthly surface water temperature of Oyan and Asejire lakes is illustrated in Figure 7. The monthly surface water temperature ranged from 24 to 31.5°C (mean = 28.5 ± 1.91°C) and 26.7 to 33°C (mean = 29.9 ± 2.34°C) for Asejire and Oyan lakes, respectively.



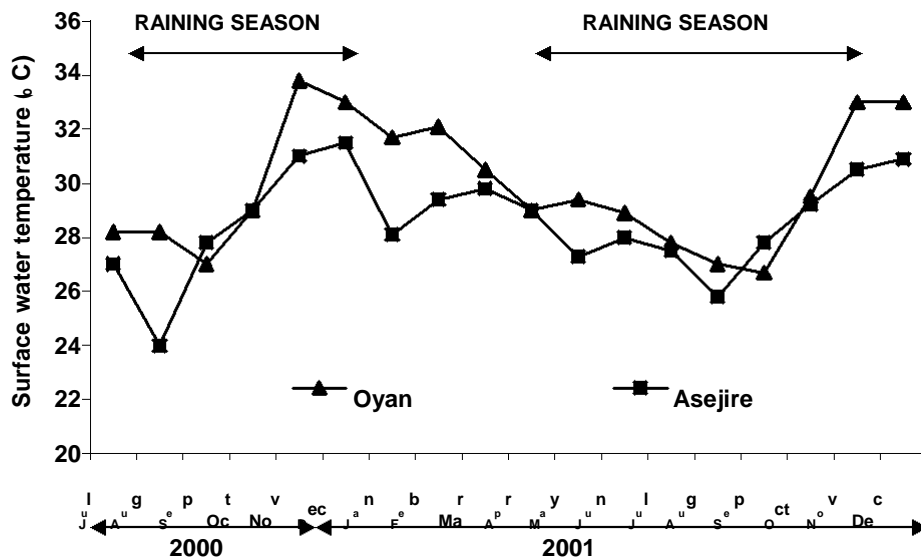
**Figure 5.** Variations in minimum atmospheric temperature in Oyan and Asejire lakes, Southwestern Nigeria. (Source: Oyan Dam Meteorological Department and Department of Geography, University of Ibadan) (July2000 - December2001).



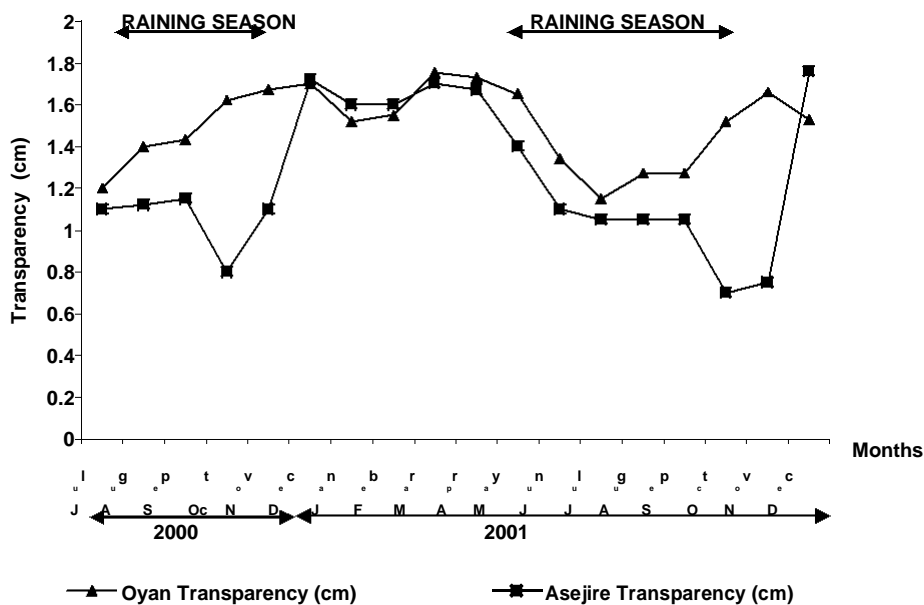
**Figure 6.** Variations in mean atmospheric temperature in Oyan and Asejire lakes, Southwestern Nigeria. (Source: Oyan Dam Meteorological Department and Department of Geography, University of Ibadan) (July 2000 – December 2001).

In Asejire and Oyan lakes, lower water temperature (range = 24 to 27.8°C; mean =  $26.3 \pm 1.23^\circ\text{C}$  and range 27 to 29 °C; mean =  $28.7 \pm 0.82^\circ\text{C}$ , respectively) were recorded from July to October 2000. Higher surface water temperatures were recorded between October 2000 and April 2001. It varied from 2.9 to 31.5°C (mean =  $29.7 \pm 1.22^\circ\text{C}$ ) and 30.5 to 33.8°C (mean =  $32.2 \pm 1.26^\circ\text{C}$ ) for Asejire and Oyan lakes, respectively. From April to

September 2001, lower surface water temperatures were recorded in both lakes. For Asejire lake, it ranged from 25.8 to 28°C (mean =  $27.3 \pm 0.87^\circ\text{C}$ ), while for Oyan lake, it ranged from 26.7 to 29.4°C (mean =  $28.1 \pm 1.27^\circ\text{C}$ ). From October to December 2001, the temperature increased gradually from 29.2 to 30.9°C (mean =  $30.2 \pm 0.89^\circ\text{C}$ ) for Asejire lake and from 29.5 to 33°C (mean =  $31.8 \pm 1.26^\circ\text{C}$ ) for Oyan lake.



**Figure 7.** Monthly variations in surface water temperature in Oyan and Asejire lakes, Southwestern Nigeria.



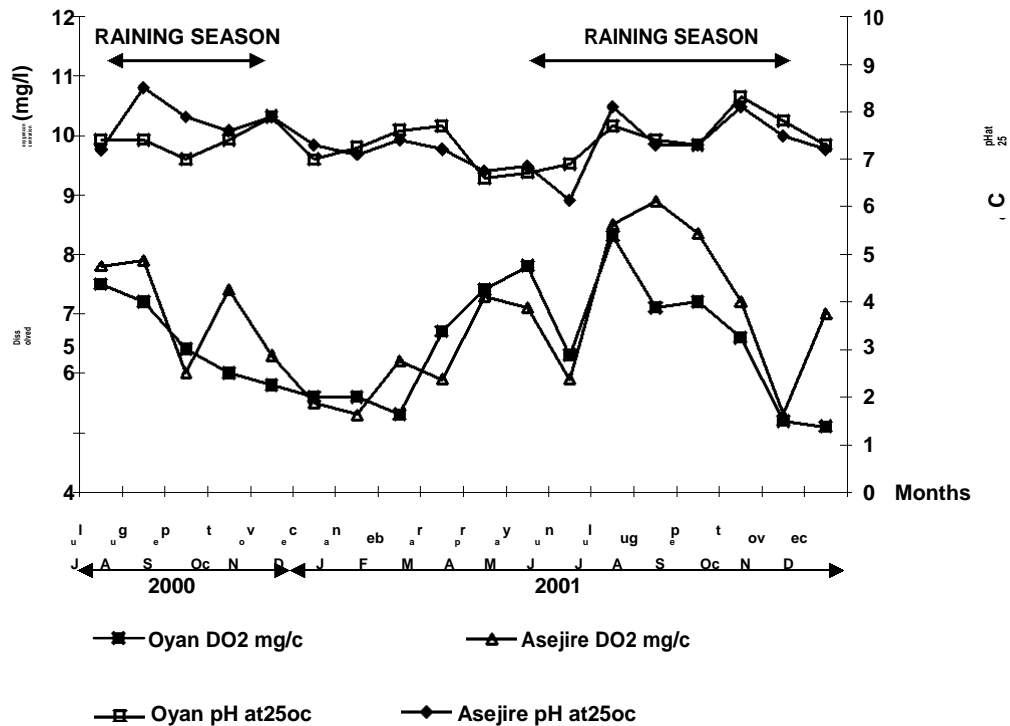
**Figure 8.** Temporal variations in transparency of Oyan and Asejire lakes, Southwestern Nigeria.

### Transparency

In Asejire lake, Secchi disc transparency of the water ranged from 0.7 to 1.72 m (mean =  $1.25 \pm 0.35$  m). Between July to November 2000, the transparency ranged from 0.8 to 1.2 m (mean =  $1.15 \pm 0.16$  m). Higher Secchi disc transparency occurred from December 2000 to May 2001 (range = 1.4 to 1.72 m; mean  $1.52 \pm 0.12$  m) (Figure 8). Decrease in transparency occurred between

June to November 2001 (range = 0.7 to 1.1 m; mean =  $0.98 \pm 0.17$  m).

For Oyan lake, Secchi disc transparency of the water ranged from 1.15 to 1.75 m (mean =  $1.5 \pm 0.19$  m). Transparency was lowest in July 2000 and 2001 at 1.2 m and increased steadily to its highest value in March 2001, when the Secchi disc was visible at 1.8 m and then decreased gradually until September 2001, and afterward there was increase in transparency of the water (Figure 8).



**Figure 9.** Monthly changes in dissolved oxygen concentration and pH of Oyan and Asejire lakes, Southwestern Nigeria.

### Dissolved oxygen content (DO<sub>2</sub>)

The dissolved oxygen content of the water varied between 5.3 and 8.9 mg/L, (mean =  $6.9 \pm 1.33$  mg/L) and 5.1 to 8.3 mg/L, (mean =  $7.1 \pm 0.96$  mg/L) for Asejire and Oyan lakes, respectively (Figure 9). From July to October 2000, the dissolved oxygen content ranged from 6.0 to 7.9 mg/L, (mean =  $7.3 \pm 0.88$  mg/L) and 6.4 to 7.5 mg/L (mean =  $7.0 \pm 0.57$  mg/L) for Asejire and Oyan lakes, respectively. The oxygen content of the water was lower between October 2000 and March 2001, with range of 5.3 to 6.3 mg/L (mean =  $5.84 \pm 0.19$  mg/L) and range of 5.3 to 6.0 mg/L (mean =  $5.7 \pm 0.26$  mg/L) for Asejire and Oyan lakes, respectively. In both lakes, high dissolved oxygen content were recorded between March to October 2001 and it ranged from 5.9 to 8.1 mg/L (mean =  $7.6 \pm 1.09$  mg/L) for Asejire lake and range of 6.6 to 8.3 mg/L (mean =  $7.2 \pm 0.66$  mg/L) for Oyan lake. Afterward there was decrease in oxygen content of the water.

### pH

In Asejire lake, during the period of study, the pH of the water ranged between 6.2 and 8.5 (mean =  $7.4 \pm 0.54$ ), while in Oyan lake it was 6.6 to 8.3 (mean =  $7.4 \pm 0.43$ ). The water was more acidic between April and June 2001 than at any other time during the year, range of 6.2 to 6.9

(mean =  $6.6 \pm 0.38$ ) and 6.6 to 6.9 (mean =  $6.7 \pm 0.96$ ) for Asejire and Oyan lakes, respectively.

### DISCUSSION

In both study sites, there are two distinct seasons, rainy and dry seasons. More rainfall was recorded during the rainy season months (April to October) than dry season months (November to March). Rains were generally heavier in Oyan Lake than Asejire Lake during this study period. Highest rainfall was recorded in Oyan Lake in August 2000 (267.1 mm), while in Asejire Lake; it was in July 2000 (39.5 mm). One month (February 2001) had no rain in Asejire while three months had no rains in Oyan during the study period. These show that apart from variation in quantity of rainfall between the two locations, the persistence of rainfall also differed. Carter (1960) stated that in the tropics, where the different seasons are not clearly demarcated, the amount and type of rainfall may play a significant part in regulating the various seasonal biological rhythms. The variations in chemical conditions of freshwater ponds have generally been found to be due to effects of rainfall (Vaas, 1954; Chow, 1958; Tucker, 1958). Rainfall also influences the amount of discharge into river and consequently into the lake. It has been pointed out that rainfall affect water quality of Asejire Lake and Warri River (Anatekhai, 1986; Egborge,

1994). Thus, due to the effects of rainfall on water level and physicochemical parameters of lakes, the differences observed in amount and duration of rainfall between both locations may likely cause differences in physicochemical parameters which will affect fish growth and production. Lower atmospheric temperatures were recorded in the rainy season in both locations. This may be associated with rainfall and relative humidity which were higher during rainy season, thus lowering the atmospheric temperature. However, lower atmospheric temperatures were observed in November (21.4°C) and December (22°C) in Oyan lake and this is likely to be due to harmattan.

In both reservoirs, relative humidity was lower in dry season. This could be associated to the thicker cloud cover during rainy season. Elliot (1986) also reported relative humidity was lower in dry season and higher in rainy season around Asejire Lake.

The average surface water temperature of 28.5 and 29.9°C observed in Asejire and Oyan lakes, respectively, lie within the optimum temperature range of 25 to 30°C required for survival of tropical fish. The higher mean temperature value in Oyan Lake could be due to the fact that most of the temperature readings were taken in the afternoon (13-15 hrs) in this location. Lower water temperatures were recorded in rainy season months of July to September in Asejire and Oyan lakes. This could be due to the thicker cloud cover which had a reducing effect on the solar radiation and in addition, the effect of the high concentration of suspended particles in absorbing and scattering heat rays (Egborge, 1970). This high temperature observed in dry season was probably associated with high atmospheric temperature, low relative humidity and reduction in the amount of suspended particles. Similar observations were made by Egborge (1977) and Anetekhai (1986).

The average Secchi disc transparency of Asejire Lake (1.3 m) and Oyan lake (1.5 m) fall within the range considered suitable for fish growth. However, Oyan Lake had a higher light extinction coefficient, thus penetration of sunlight is more likely and sunlight energy is important in photosynthesis. It has been well documented that high transparency correlates with high productivity. The lower transparency observed in both lakes during rainy season could be attributed to influx or turbid flood from the rivers and runoffs into the lakes thereby decreasing light penetration. It could also be due to decrease in sunlight intensity due to presence of heavy cloud in the atmosphere which in turn reduced the quantity of light reaching the water. Hassan (1974), Adebisi (1981), Anetekhai (1986) and Ugwumba (1990) working on Nigerian waters made similar observations.

The pH of water in Asejire and Oyan lakes ranged between 6.2 to 8.5 and 6.6 to 8.3, respectively. Thus, these waters are good for fish production, since Boyd (1979) reported waters with a pH range of 5.5 to 9.0 as most suitable for fish production.

The dissolved oxygen content of surface water of Asejire lake (range = 5.3 to 5.9 mg/L; mean =  $6.9 \pm 1.3$  mg/L) and that of Oyan lake (range 5.1 to 8.3 mg/L; mean =  $7.1 \pm 0.96$  mg/L) were found satisfactory for fish production. The higher value of DO<sub>2</sub> in Oyan Lake than Asejire Lake may be attributed to higher transparency of the Oyan Lake, thus, causing photosynthetic activity to be higher, leading to release of more O<sub>2</sub> into water body. Seasonal variations observed in DO<sub>2</sub> content in both reservoirs with higher values in rainy season could be due to low water temperature and increased aeration because of heavy rainfall. Elliot (1986) also reported the dissolved oxygen concentration at Asejire Lake attained its peak at the height of rainy season.

In conclusion, the Oyan and Asejire lakes exhibited features that are typical of tropical environment. The physicochemical parameters that were observed for both water bodies fall within the range that can support aquatic life including fish, thus, both lakes were productive.

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