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Full Length Research Paper

Seasonal variation in the physicochemistry of a small tropical reservoir (Aiba Reservoir, Iwo, Osun, Nigeria)

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Aiba Reservoir was sampled between March, 2004 and February, 2005 for physico-chemical studies. Air temperatures ranged from 20.00 – 30.50°C (mean ± s.e: 26.33 ± 0.26°C), water temperature ranged from 25.00 – 35.00°C (mean ± s.e: 29.26 ± 0.19°C), pH ranged from 5.53 - 9.48 (mean ± s.e: 7.98 ± 0.11), dissolved oxygen ranged from 1.75 – 11.20 mgO_2/l (mean ± s.e: 7.23 ± 0.20 mgO_2/l), alkalinity ranged from 42.50 – 85.00 mg/l (mean ± s.e: 65.20 ± 0.85 mg/l), total hardness ranged from 12.00–59.00 $mg/lCaCO_3$ (mean ± s.e: 45.13 ± 0.90 $mg/lCaCO_3$), conductivity ranged from 6.80 – 126.40 mV (mean ± s.e: 67.03 ± 4.04 mV), and turbidity ranged from 12.50 – 143.75 FTU (mean ± s.e: 40.74 ± 3.60 FTU). The physico-chemistry of Aiba Reservoir exhibited spatio-temporal variation. Two-way analysis of variance of physico -chemical parameters showed obvious seasonality for pH, conductivity and turbidity, suggesting that these parameters play major roles in the limnology of the reservoir. Factor analysis shows pH, conductivity, temperature and dissolved oxygen as important parameters contributing to the annual variability. Dissolved oxygen is a more important parameter during the wet season, while alkalinity is more important during the dry season for the reservoir. Hardness and alkalinity values suggest that the reservoir water is good for aquaculture.

Key words: Reservoir, physicochemical parameters, seasonality, factor analysis, limnology.

INTRODUCTION

Freshwater ecosystems have been used for the investigation of factors controlling the distribution and abundance of aquatic organisms. The physical and chemical characteristics of water bodies affect the species composition, abundance, productivity and physiological conditions of aquatic organisms (Bagenal, 1978). Economic development and population growth require stable water and hydroelectric power supplies. However, because of the relative scarcity of natural lakes, it will be expected that tropical countries will construct reservoirs in parallel with their economic development, thereby making reservoirs the predominant lake type in many regions (Lewis, 2000). This leads to the conclusion that in the tropics as a whole, limnology must be strongly oriented towards reservoir than it has been at temperate latitudes. Lakes and reservoirs around the globe are critical components in the ecological system.

They provide habitat, sanctuary and food for many spe-cies of fish and wildlife and are also a source of process water to a myriad of industries (Dinar et al., 1995). The number of small natural and man-made lakes, ponds and reservoirs is probably in the millions. These bodies of water (although they do not make a significant contri-bution to the global surface area) offer the same range of important services to nearby urban and rural populations as large lakes but unfortunately are more susceptible to pollution than large lakes (Wetzel, 1992; Dinar et al., 1995). Where lakes have been profoundly altered and have lost much of their value, the scientific understanding of lakes is being used in prescribing restoration methods (Lewis, 2000).

Nigeria is abundantly blessed with a vast expanse of inland waters. The total surface area of water bodies in Nigeria is estimated to be about 14,991,900 hectares (149,919 km^2) and this constitutes about 15.9% of the total area of Nigeria (Ita, 1993). These include both natural and man-made lakes, reservoirs, floodplains and cattle ponds, rivers and streams; but exclude deltas, estuaries and miscellaneous wetlands suitable for rice

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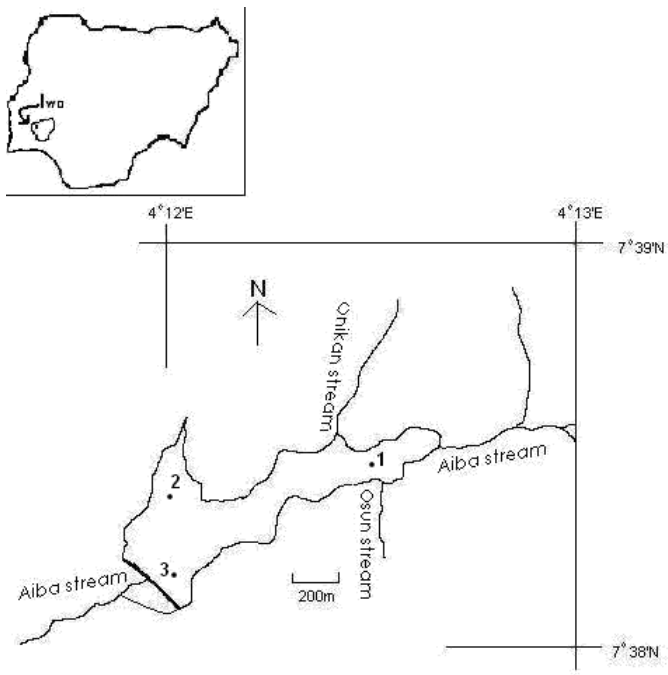


Figure 1. Map of Aiba Reservoir showing water sampling stations for physicochemical analysis.

cultivation. The inland waters of Nigeria consist of water bodies that support a wide array of aquatic organisms, which include phytoplankters, zooplankters, nektonic aquatic invertebrates and vertebrates and benthic organisms. The species composition and density of these will be influenced not only by geographical locations but also by the water quality of their aquatic habitats, which in turn can be adversely affected by human activities (Oben, 2000). More so, in recent times, there has been rising concerns about the state of our environment. Many researchers are carrying out studies into the extent and impact of human activities and the implication for our aquatic resources. Investigations into the physico-chemistry of Nigerian freshwater bodies especially in the southwest includes those of Egborge (1970) on River Oshun, Adebisi (1981) on upper River Ogun, Oke (1998) on Owena Reservoir, Oben (2000) on three man-made lakes in Ibadan, Akin-Oriola (2003) on Ogunpa and Ona rivers, Ikenweiwe and Otubusin (2005) on Oyan Lake, Idowu and Ugwumba (2005) on Eleiyele Reservoir. Ayoade et al. (2006) made comparative studies on the physicochemical features of Oyan and Asejire Lakes.

In tropical systems, marked variations in temperature and rainfall between seasons influence the physical and chemical characteristics of water bodies (Adebisi, 1981). Research conducted for over two decades on the physicochemistry of Awba reservoir shows that there is deterioration in water quality due to effluent discharge and eutrophication (Akin-Oriola, 2003). This study investigates seasonal variation in physical and chemical parameters of Aiba Reservoir. It is also an opportunity to providing necessary information and highlighting the peculiar features of Aiba Reservoir.

MATERIALS AND METHODS

Study area

Aiba Reservoir is a man-made lake located in Iwo city in the southwestern part of Nigeria. The reservoir lies between longitude 4° 11' to 4° 13' East of the Greenwich and latitude 7° 38' to 7° 39' North of the Equator (Figure 1). The reservoir has a catchments area of 54.39 km^2 and a surface area of about 0.32 km^2 (32 hectares). The reservoir was constructed primarily to serve as a source of portable water supply to the Iwo community; however, it provides a daily source of fish and livelihood to the surrounding community. The reservoir drains the Aiba, Osun and Onikan streams and later flows into the Oba River, which is a tributary of River Oshun.

Sampling

Three sampling stations, 1, 2 and 3, were chosen for physico-chemical studies. Station 1 is positioned at the northeastern part where the Aiba stream enters the reservoir. Apart from fishing, there is little or no human activity at this portion of the reservoir. Station 2 is located at the northern part of the reservoir. Human activities around this station include washing of clothes and automobiles, and fetching of water for domestic and construction purposes. Station 3 is located at the southwestern part of the reservoir. The water outlet is at this portion of the reservoir to prevent overflow during the wet season. The major human activity at this station involves mainly domestic activities especially during the dry season. Water samples were collected fortnightly from March, 2004 to February, 2005 between 800 and 1000 h. The following physical and chemical properties were determined: air temperature, water temperature, hydrogen ion concentration (pH), dissolved oxygen (DO), total alkalinity, total hardness, conductivity and turbidity. Apart from air and water temperature, all parameters were determined in the laboratory. Water samples were collected in plastic containers after being rinsed with ambient water from each station.

Air and water temperatures were taken using a centigrade mercury-in-glass thermometer and were expressed in degrees celsius (^{o}C). The hydrogen ion concentration (pH) and conductivity were determined using the electronic method as recommended by APHA (1995). Conductivity was measured at 25^{o}C and expressed as millivolts (mV). The dissolved oxygen concentration was determined using the azide modification of the iodometric method (APHA, 1995) and expressed as mgO_2/l. Alkalinity was determined by titration method and expressed as mg $CaCO_3/l$. Ethylenediamine tetra acetic acid (EDTA) titrimetric method was used in the determination of total hardness, which was expressed as $mgCaCO_3/l$. Turbidity was carried out by the formazin turbidity unit method using a spectrophotometer after the preparation of a calibration curve (Department of the Environment, 1972) and expressed as formazin turbidity unit (FTU).

Statistical analysis

To summarise the data and express the observed variables by a smaller number of factors (or components), a factor analysis was carried out using the software SPSS for Windows, Release 10.0.1 (27 October, 1999). Factors were extracted using the Varimax rotated principal component method. Two-way analysis of variance was used to test for significant differences between stations and sites for physico-chemical parameters using Genstat 5 Release 3.2

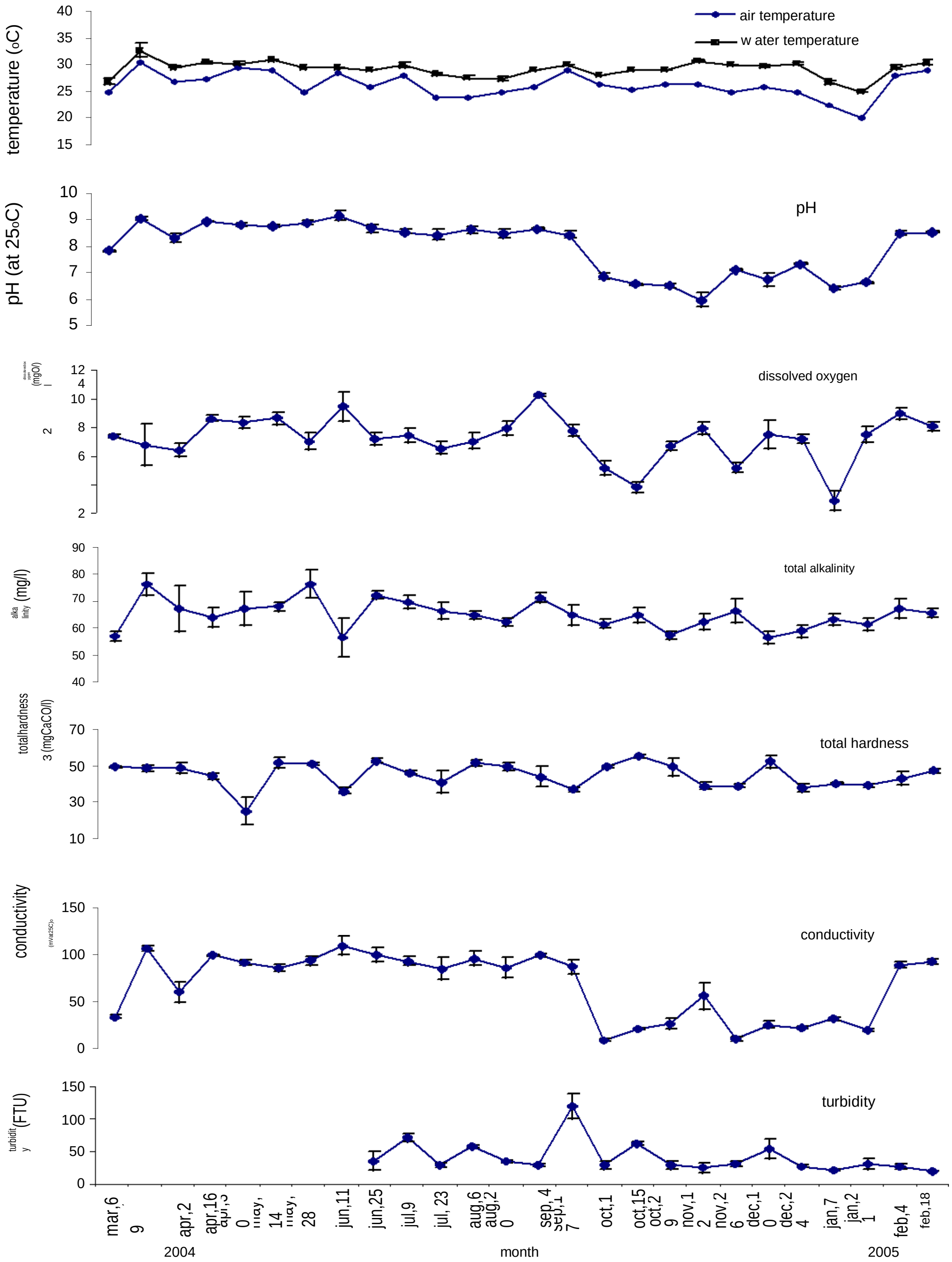


Figure 2. Variation in the mean values of physico-chemical variables during the study period.

software (1996), Lawes Agricultural Trust (IACR – Rothamsted).

RESULTS

Figure 2 shows the variation in the mean values of physico-chemical parameters measured for the study period. Table 1 shows the results of the physico-chemical parameters measured for stations expressed as mean values, standard error and range. Table 2 shows the seasonal mean values and coefficient of variation (%) of physico-chemical parameters and Table 3 shows the calculated F-values of two-way analysis of variance of physico-chemical parameters measured at Aiba Reser-

Table 1. Physico-chemical parameters measured at the three stations of Aiba Reservoir, Iwo.

Station parameter	Station 1	Station 2	Station 3	Overall range
Air temperature (°C)	26.33 ± 0.46*	26.33 ± 0.46	26.33 ± 0.46	20.00-30.50
Water temperature(°C)	29.44 ± 0.38	29.19 ± 0.32	29.15 ± 0.28	25.00-35.00
pH	8.00 ± 0.21	7.96 ± 0.20	7.99 ± 0.19	5.53-9.48
Dissolved oxygen (mgO$_2$/l)	7.10 ± 0.30	7.13 ± 0.35	7.47 ± 0.39	1.75-11.20
Alkalinity (mg/l)	67.70 ± 1.48	65.25 ± 1.48	62.64 ± 1.34	42.50-85.00
Total hardness (mg/l CaCO$_3$)	46.02 ± 1.44	44.23 ± 1.47	45.16 ± 1.79	12.00-59.00
Conductivity (mV)	70.34 ± 7.16	65.91 ± 6.95	64.85 ± 7.08	6.80-126.40
Turbidity (FTU)	43.06 ± 6.72	39.24 ± 5.41	39.93 ± 6.78	12.50-143.75

*Values are mean ± standard error.

Table 2. Mean, standard error and coefficient of variation (%) of physical and chemical parameters measured at Aiba Reservoir, Iwo for the dry and wet seasons.

Parameter	Wet Season		Dry Season		Overall	
	Mean ± SE	Coefficient of variation (%)	Mean ± SE	Coefficient of variation (%)	Mean ± SE	Coefficient of variation (%)
Air temperature (°C)	26.69 ± 0.25	6.49	25.75 ± 0.54	11.46	26.33 ± 0.26	8.76
Water temperature (°C)	29.25 ± 0.15	3.54	29.28 ± 0.43	8.04	29.26 ± 0.19	5.66
pH	8.32 ± 0.12	10.17	7.44 ± 0.19	13.65	7.98 ± 0.11	12.60
Dissolved oxygen (mgO$_2$/l)	7.40 ± 0.24	22.65	6.95 ± 0.35	27.57	7.23 ± 0.20	24.55
Alkalinity (mg/l)	66.15 ± 1.11	11.67	63.68 ± 1.29	11.07	65.20 ± 0.85	11.53
Total hardness (mg/l CaCO$_3$)	46.03 ± 1.30	19.52	43.71 ± 1.07	13.36	45.13 ± 0.90	17.64
Conductivity (mV)	78.09 ± 4.63	41.07	49.35 ± 6.27	69.91	67.03 ± 4.04	53.17
Turbidity (FTU)	49.79 ± 5.55	61.00	29.43 ± 2.93	48.71	40.74 ± 3.60	64.86

Table 3. Calculated F-values of two-way analysis of variance of physico-chemical parameters measured at Aiba Reservoir during the study period.

Parameter	Season	Station	Season*Station
Air temperature (°C)	2.97	0.00	0.00
Water temperature (°C)	0.01	0.22	0.04
pH	16.22***	0.01	0.15
Dissolved oxygen (mgO$_2$/l)	1.18	0.35	0.50
Alkalinity (mg/l)	2.07	3.07*	0.06
Total hardness (mg/l CaCO$_3$)	1.50	0.31	0.02
Conductivity (mV)	13.39**	0.19	0.04
Turbidity (FTU)	11.81***	0.19	0.27

* = significant at p 0.05; ** = significant at p 0.01; *** = significant at p 0.001.

voir during the study period.

Air temperature ranged from 20.00°C to 30.50°C with a mean of 26.33 ± 0.26°C. The lowest air temperature (20.00°C) was recorded in late January while the highest air temperature (30.50°C) was recorded in mid-March. The mean air temperature for the wet season 26.69 ± 0.25°C was higher than the dry season value 25.75 ± 0.54°C. The coefficient of variation for the study period was low (8.76%), however the coefficient of variation for the wet season (6.49%) was lower than that of the dry season (11.46%). Water temperature ranged from 25.00 to 35.50°C. The overall mean water temperature for the study period was 29.26 ± 0.19°C. The lowest mean water temperature (25.00 ± 0.00°C) was recorded in late January while the highest temperature (32.83 ± 1.36°C) was recorded in mid-March. The mean water temperature for the wet season (29.25 ± 0.15°C) was slightly lower than the dry season value (29.28 ± 0.43°C). The coefficient of variation for the study period (5.66%) was low, however, the wet season recorded a lower coefficient of variation (3.54%) compared to the dry season (8.04%). Hydrogen ion concentration (pH) ranged from 5.53 to 9.48. The overall mean pH for the study period was 7.98 ± 0.11. The lowest mean pH (6.00 ± 0.24) was recorded in mid-November while the highest pH (9.19 ± 0.18) was recorded in mid-June, 2004. The coefficient of variation for the study period (12.60%) was low, however, the wet season recorded a lower coefficient of variation (10.17%) compared to the dry season (13.65%). The mean pH for the wet season (8.32 ± 0.12) was significantly higher ($F= 16.22$, $p < 0.001$) than the mean pH for the dry season (7.44 ± 0.19). The dissolved oxygen values ranged from 1.75 to 11.20 mgO_2/l. The overall mean dissolved oxygen for the study period was 7.23 ± 0.20 mgO_2/l. The lowest (3.83 ± 0.39 mgO_2/l) and highest (10.27 ± 0.13 mgO_2/l) mean dissolved oxygen values were recorded in mid October and early September respectively. The coefficient of variation for the study period was 24.55%; the wet season recorded a lower coefficient of variation (22.65%) compared to the dry season (27.57%). Alkalinity values ranged from 42.50 to 85.00 mg/l. The overall mean alkalinity value for the study period was 65.20 ± 0.85 mg/l. The lowest mean alkalinity value (56.67 ± 7.12 mg/l) was recorded in mid-June while the highest (76.67 ± 5.07 mg/l) was recorded in late May. The coefficient of variation for the study period (11.53%) was low; the wet season recorded a slightly higher coefficient of variation (11.67%) com-pared to the dry season (11.07%). There was a marginal significant difference ($F= 3.07$, $p= 0.05$) in the mean alkalinity values between the stations. Least Significant Difference (LSD) shows that the mean alkalinity value for Station 1 (67.70 ± 1.43 mg/l) was significantly higher ($0.01>p>0.05$) than the mean value for Station 3 (62.64 ± 1.43 mg/l). Total hardness ranged from 12.00 mg/l $CaCO_3$ to 59.00 mg/l $CaCO_3$. The overall mean total hardness value for the study period was 45.13 ± 0.90 mg/l $CaCO_3$. The lowest mean total hardness (25.33 ± 7.51 mg/l $CaCO_3$) was recorded in late April while the highest value (55.33 ± 0.88 mg/l $CaCO_3$) was recorded in mid-October 2004. The coefficient of variation for the study period was low (17.64%); the coefficient of variation for the wet season (19.52%) was higher than that of the dry season (13.36%). Conductivity values ranged from 6.80 to 126.40 mV. The overall mean conductivity value was 67.03 ± 4.04 mV. The lowest mean conductivity (8.97 ± 1.18 mV) was recorded in early October while the highest value (109.70 ± 10.17 mV) was recorded in mid-June. The coefficient of variation for the study period was high (53.17%); the coefficient of variation for the wet season (41.07%) was lower than that of the dry season (69.61%). The mean conductivity value for the wet season (78.09 ± 4.63 mV) was significantly higher ($F= 13.39$, $p<0.01$) than the mean value for the dry season (49.35 ± 6.27 mV). Turbidity values ranged from 12.50 to 143.75 FTU. The overall mean turbidity value was 40.74 ± 3.60 FTU. The lowest mean turbidity (25.00 ± 7.22 FTU) was recorded in early November while the highest value (118.75 ± 19.09 FTU) was recorded in mid-September. The coefficient of variation for the study period was high (64.86%); the coefficient of variation for the wet season (61.00%) was higher than that of the dry season (48.71%). The mean turbidity value for the wet season (49.79 ± 5.55 FTU) was significantly higher ($F= 11.81$, $p<0.001$) than the mean value for the dry season (29.43 ± 2.93 FTU).

Interrelationship between physico-chemical variables

Air temperature significantly correlated positively with water temperature, pH, conductivity, dissolved oxygen and turbidity at $p<0.05$ (Table 4). Water temperature significantly correlated positively with air temperature, pH, conductivity and alkalinity at $p<0.01$. Hydrogen ion concentration (pH) and conductivity significantly corre-lated positively ($p<0.01$) with all the measured physico-chemical parameters except total hardness and turbidity. Alkalinity significantly correlated positively with water temperature, pH and conductivity at $p<0.01$. Dissolved oxygen showed positive significant correlation ($p<0.05$) with pH, conductivity and air temperature. Total hardness did not show any significant correlation with any of the measured physico-chemical parameters but however, correlated negatively with all measured parameters ex-cept for alkalinity and turbidity. Turbidity did not show any significant correlation with any of the measured physico-chemical parameters except with air temperature ($p<0.05$).

Factor analysis of physico-chemical parameters

The first two components for the wet season accounted for 62.60% of the total variation. The first component accounted for 32.78% of the explained variance. Conduc-tivity, pH and dissolved oxygen recorded high positive loadings of 0.951, 0.939 and 0.819, respectively (Figure 3a). The second component accounted for 29.82% of the explained variance. Air temperature and water tempera-ture recorded high positive loadings of 0.934 and 0.826, respectively while turbidity recorded a positive loading of 0.614. The first two components for the dry season accounted for 66.90% of the total variation. The first component accounted for 44.25% of the explained variance. Air temperature, conductivity, pH, water tempe-rature and alkalinity recorded high loadings of 0.916, 0.898, 0.787, 0.754 and 0.706, respectively (Figure 3b). The second component accounted for 22.65% of the explained variance. Turbidity and total hardness recorded high positive loadings of 0.776 and 0.771, respectively. The first two components for the annual variability accounted for 57.04% of the total variation. The first com-ponent accounted for 39.69% of the explained variance. Conductivity, pH, air temperature and water temperature recorded high positive loadings of 0.819, 0.815, 0.815

Table 4. Two-tailed correlation coefficient (r) for physico-chemical parameters measured at Aiba Reservoir.

	Air temp.	Water temp.	pH	Conductivity	Alkalinity	Dissolved oxygen	Total hardness
Water temp.	0.789**						
pH	0.513**	0.325**					
Conductivity	0.507**	0.362**	0.862**				
Alkalinity	0.191	0.300**	0.338**	0.338**			
Dissolved oxygen	0.363*	0.171	0.556**	0.572**	-0.087		
Total hardness	-0.066	-0.043	-0.033	-0.050	0.112	-0.196	
Turbidity	0.307*	0.154	0.249	0.206	0.101	0.082	0.061

* = significant at $p<0.05$; **** = significant at $p<0.01$. n = 78 except for turbidity where n = 54.

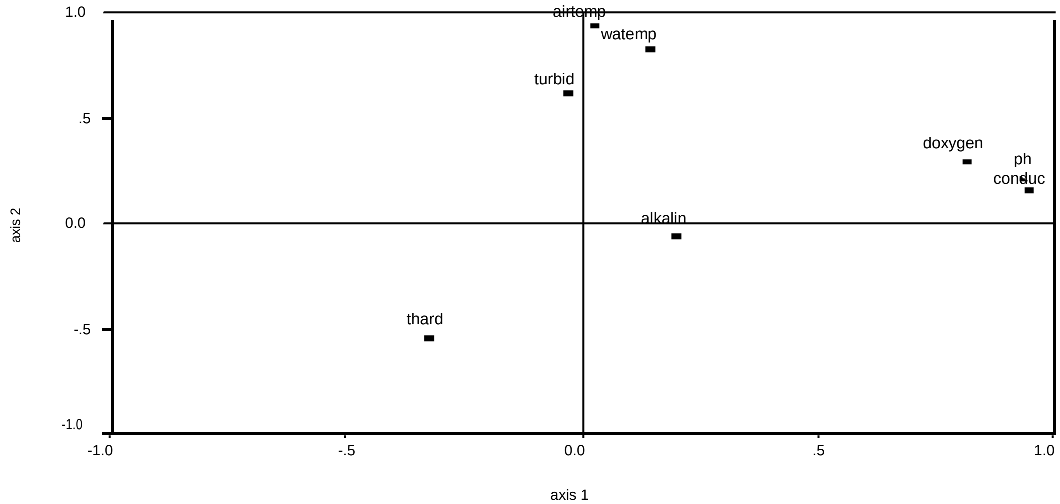
and 0.729, respectively (Figure 3c). The second component accounted for 17.35% of the explained variance and dissolved oxygen recorded a high positive loading of 0.728.

DISCUSSION

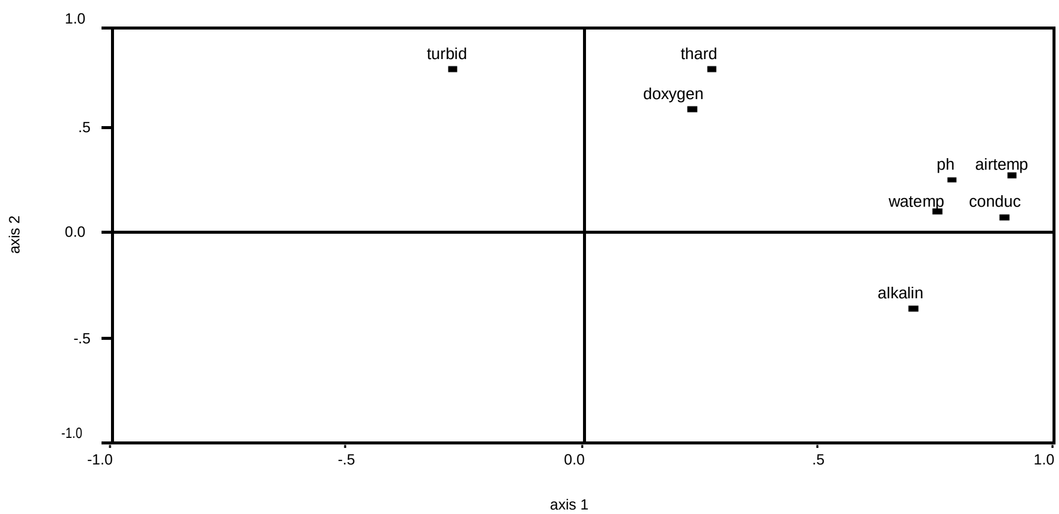
The physico-chemical parameters in water bodies vary in composition and concentration on a seasonal, diurnal or even hourly basis. These variations may be related to patterns of water use and rainfall (Abel, 1996; Ayoade et al., 2006). The patterns of spatial distribution of physico-chemical parameters measured for the reservoir were generally similar except for alkalinity which showed a marginal significant difference for the three stations. Temperature is an important factor that influences primary production in reservoirs (Lewis, 2000). It depends on the climate, sunlight and depth and does not undergo drastic changes during the year in lacustrine environments (Egborge, 1970; Gupta and Gupta, 2006; Akinyemi and Nwankwo, 2006) as compared to fluviatile environments. Temperatures were relatively lower during the wet season than during the dry season. Water temperature values, although higher, followed closely the changes in air temperatures. This might be attributed to the sampling time, which was between 800 and 1000 h, when the water is warmer than air. Air and water temperature showed a strong positive correlation for the reservoir. The positive correlation between air and water temperatures is well documented (Holden and Green, 1960; Egborge, 1970: Egborge, 1974). Lower temperature recorded during December and January was attributed to the effect of harmattan wind while the highest temperature recorded during March was attributed to the peak of the dry season when insolation was at its highest. Similar reports have been made for Owena Reservoir (Oke, 1998), Oyan and Asejire Lakes (Ayoade et al., 2006). The minimum and maximum temperatures (25.00 and 35.50^{o}C, respectively) are normal for tropical waters and are required for the normal growth of aquatic organisms. Okayi (2003) recorded a minimum and a maximum temperature of 24 and 31^{o}C, respectively while for Ikenweiwe and Otubusin (2005), temperature ranged from 26.8 – 31.7^{o}C with a mean value of 28.6 ± 1.3^{o}C. The higher variability recorded during the dry season is attributable to the effect of the harmattan during the dry season when cooler tempe-rature was recorded.

The mean pH (7.98 ± 0.11) of the reservoir water tends towards alkalinity. Idowu and Ugwumba (2005) recorded pH values ranging from 6.9 – 9.6, while Ayoade et al. (2006) reported a pH range of 6.2 – 8.5. This suggests that the reservoir water is good for fish production. Accumulation of free carbon dioxide due to little photosynthetic activities of phytoplankton will lower the pH value of the water while intense photosynthetic activities of phytoplankton will reduce the free carbon dioxide content resulting in increased pH values (Egborge, 1994; Gupta and Gupta, 2006). Adebisi (1981) stated that pH decreases with rainfall. This may suggest why significant lower mean pH was recorded during the dry season. There was a sharp decrease in the pH of Aiba Reservoir in September during late wet season. This can be attributed to the increased organic matter brought in by rain as a result of runoff during peak wet season that tends to reduce dissolved oxygen through utilization of organic dehydration giving rise to a fall in pH. A similar observation was made by Ogueri (2004).

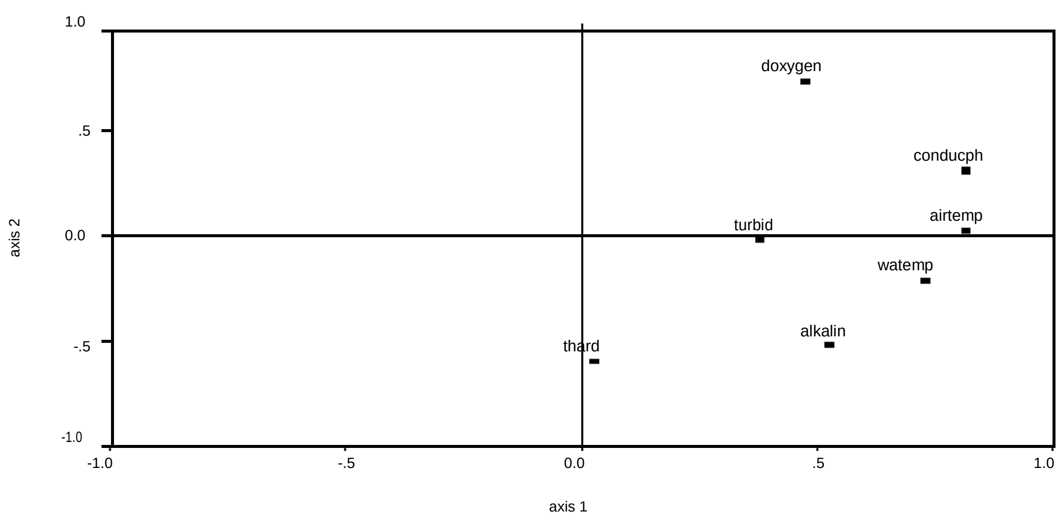
Sources of dissolved oxygen in the aquatic environment include the atmosphere and photosynthesis, and depend on its solubility while losses of oxygen include respiration, decay by aerobic bacteria and decomposition of dead decaying sediments (Gupta and Gupta, 2006). The dissolved oxygen for the reservoir ranged from 1.75 to 11.20 mgO_2/l, with a mean of 7.23 ± 0.20 mgO_2/l. Oke (1998) reported that Owena Reservoir had a dissolved oxygen concentration that varied from 0 to 5 mg/l. Ikenweiwe and Otubusin (2005) recorded a mean value of 6.40 ± 0.3 mg/l. Idowu and Ugwumba (2005) recorded dissolved oxygen concentrations ranging from 6.3 – 8.3 mg/l. The latter authors attributed the high concentrations of dis-solved oxygen to low organic enrichment. At alkaline pH



(a) wet season



(b) dry season



(c) combined seasons

Figure 3. Principal Components Analysis (PCA) plots of physico-chemical variables for Aiba Reservoir.

values, photosynthetic activities would be high and should result in high oxygen content. Hydrogen ion concentration (pH) showed a strong positive correlation with dissolved oxygen. Increasing levels of dissolved oxygen in aquatic systems are usually associated with eutrophic and productive water bodies (Egborge, 1994). The decrease in dissolved oxygen observed in September during late wet season could be due to phytoplankton bloom and decomposition of allochthonous organic materials taking place at this time of the year. A similar report was recorded by Okayi (2003). Any observed depression in dissolved oxygen could be due to chemical and biological oxidation process in the water. Lewis (2000) regarded factors that work against oxygen retention in tropical waters as the poorer ability of water to hold oxygen at higher temperature than at lower temperature and to the higher rates of microbial metabolism at higher temperature. Although there is usually an inverse relationship between temperature and dissolved oxygen, exceptions do exist (Oben, 2000). Temperature showed a positive correlation with dissolved oxygen for the reservoir. Lewis (2000) opined that oxygen conservation is an important management principle for tropical lakes.

Water bodies of the tropics usually show a wide range of fluctuations in total alkalinity, the values depending on the location, season, plankton population and nature of bottom deposits. Highly productive waters have alkalinity values above 100 ppm and for freshwater aquaculture the values should be between 40-200 ppm. Alkalinity values above 300 ppm have been reported to adversely affect the spawning and hatching of freshwater fish (Gupta and Gupta, 2006). Hard waters usually have con-centrations greater than 200 mg/l while soft waters are usually less than 75 mg/l (Hunter, 1997). Waters having hardness values of 15 ppm or above are satisfactory for the growth of fish while values less than 5 ppm $CaCO_3$ equivalent cause slow growth, distress and eventual death of fish (Gupta and Gupta, 2006). Idowu and Ugwumba (2005) reported high alkalinity values during the dry season. The mean alkalinity of 65.20 ± 0.85 mg/l (range: 42.50 to 85.00 mg/l), and mean total hardness of 45.13 ± 0.90 mg/l$CaCO_3$ (range: 12.00 to 59.00 mg/l$CaCO_3$) suggest that Aiba Reservoir could be consi-dered good for aquaculture.

The conductivity range (6.80 to 123.40 mV) and mean value (67.03 ± 4.04 mV) for the reservoir during the study can be regarded as low to intermediate according to the classification by Adeleke (1982). Conductivity levels below 50 µmhos/cm are regarded as low; those between 50 – 600 µmhos/cm are medium while those above 600 µmhos/cm are high conductivity levels. For many Nigerian inland water bodies the conductivities are much less than 500 µS/cm at the peak of the dry season and much less than 100 µS/cm during the rainy season (Egborge, 1994). Akin-Oriola (2003) therefore opined that the conductivity of Awba reservoir could be regarded as being intermediate (mean and standard deviation of 239.65 ± 74.31 µS/cm and a range of 48.93 – 954.33 µS/cm). Ikenweiwe and Otubusin (2005) recorded a range and mean of conductivity values of 64.9 – 100.1 µmhos/cm and 82.5 ± 0.6 µmhos/cm. The general trend in this study was that conductivity tended to decrease in the dry season compared with the wet season. Increased conductivities could result from low precipitation, higher atmospheric temperatures resulting in higher evapotranspiration rates and higher total ionic concentration, and saline intrusions from underground sources. It could also be due to a high rate of decomposition and mineralisation by microbes and nutrient regeneration from bottom sediments (Egborge, 1994). Oben (2000) reported an increase in conductivity values during the dry season and attributed this to evaporation. The author also suggested that decrease in conductivity values during the rainy season may be due to dilution by rain water. The significantly higher conductivity value recorded for Aiba Reservoir during the wet season suggests that allochthonous materials brought in by streams draining the catchments area plays a major role in the limnology of the reservoir. The lower conductivity values recorded for the dry season may be due to the utilization of such allochthonous materials by the phytoplanktonic organisms of the reservoir. High conductivity values have been reported to be indicative of an increase in the amount of polluting particles (Oben, 2000).

The significantly higher turbidity recorded during the wet season compared to the dry season may be due to heavy rainfall leading to an increase in phytoplankton abundance and decay of organic matter in suspension in addition to surface runoff from adjacent streams carrying heavy sand and silt into the water. Lewis (1978) opined that phytoplankton biomass influences water transparency, and therefore turbidity. The author also reported a positive correlation between turbulence and nutrient availability. This increase in suspended solids impeded light thereby increasing turbidity. The adverse effects of turbidity on freshwaters include decreased penetration of light hence reduced primary and secondary production, adsorptions of nutrient elements to suspended materials making them unavailable for plankton production, oxygen deficiency, clogging of filter feeding apparatus and digestive organs of planktonic organisms and may greatly affect the hatching of larvae (Gupta and Gupta, 2006). Lower coefficients of variability were recorded during the wet season compared to the dry season for air temperature, water temperature, pH, conductivity and dissolved oxygen. Low amplitudes of variation of physico-chemical parameters of water bodies suggest that high fluctuations of these parameters do not occur and this implies stability. Alkalinity, total hardness and turbidity, however, recorded higher coefficient of variability during the wet season compared to the dry season. All the parameters except conductivity and turbidity recorded coefficient of variability greater than 30% for both wet and dry seasons.

The lower coefficient of variability of water temperature compared to air temperature despite being strongly correlated confirms the importance of the specific heat capacity of water. The lower coefficient of variability of pH compared to conductivity despite being strongly correlated suggests that the water body has a strong buffering capacity. Oben (2000) reported low coefficients of variation for temperature, alkalinity, pH and conductivity. Akin-Oriola (2003) reported that wide variations in dissolved oxygen content, pH and conductivity may be due to the fact that the sampling took place during the late dry/rainy season period and reported three major components influencing the physico-chemistry of Awba reservoir, which are trace metals, dissolved oxygen and ionic composition.

Reservoirs often receive water from large areas (river drainages) relative to their size and are therefore especially vulnerable to changes in the hydrology or water quality of rivers (Lewis, 2000). Factor analysis of physico-chemical parameters studied for Aiba Reservoir shows differences in the most important factor for the two seasons. For the wet season, conductivity, pH and dissolved oxygen recorded high positive loadings on the first component. The first and most important factor for the wet could be regarded as nutrient-dissolved oxygen factor or chemical factor. However, air temperature, water temperature and turbidity recorded positive loadings on the second component. This component can therefore be referred to as temperature-suspended matter factor or physical factor. Therefore, factor analysis for the wet season was able to separate the physical from the chemical variables suggesting that chemical variables are more important than physical variables during the wet season for the reservoir. For the dry season, temperature, conductivity, pH and alkalinity recorded high loadings on the first component, which could therefore be regarded as temperature-ionic factor. However, turbidity and total hardness recorded high loadings on the second component and therefore could be regarded as suspended matter-carbonate factor. Oduwole (1997) attributed significant differences in parameters between seasons as indicative of changes in water quality. For annual variability, conductivity, pH and temperature recorded high loadings on the first component and could be regarded as the temperature-ionic/nutrient factor. However, dissolved oxygen recorded a high loading on the second component and could be regarded as oxygen factor. Therefore, pH, conductivity, temperature and dissolved oxygen are important annual variables for the reservoir. Dissolved oxygen, however was a more important factor during the wet season compared to the dry while alkalinity was a more important factor during the dry season compared to the wet. HCO_3^- and CO_3^{2-} in very alkaline waters are of special importance in relation to the availability of carbon dioxide for photosynthesis, and their relative concentrations are linked with the concentrations of hydrogen ions (Beadle, 1974).

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