Variations in the Physico-Chemical Parameters of a Natural, Tropical, Rainforest Lake

Eyo, J E., Odoh, G. E. and Achife, A.
Department of Zoology, University of Nigeria, Nsukka.

Corresponding Author: Eyo, J. E. Department of Zoology, University of Nigeria, Nsukka. Email: divinelovejoe@yahoo.com Phone: 234-8054563188

Abstract

A study of the physico-chemical parameters of Agulu Lake was made from January to December 2003. Except for surface temperature, the other parameters were markedly season-dependent. Conductivity, total residue, DO, alkalinity, turbidity, calcium, N-NO_3, P-PO_4 values were higher in the rainy than the dry season. Conversely, pH, visibility and free CO_2 were higher in the dry season. There was no significant seasonality in surface temperature.

Keywords: Physico-chemical parameters, Agulu Lake

Introduction

Although lakes occupy a small fraction of the aquatic environment, their ecological and economic importances are tremendous. They provide water for domestic and agricultural use, support subsistence and artisanal fisheries, receive run-off from its catchment's areas, recharge ground water aquifers, regulate stream flow, moderate drought and provide habitat for plants and animals, including vectors of many diseases of human and veterinary importance. The growing human and environmental influences impact strongly on the quantity and quality of water available in any lake system. Several studies have been made on the hydrological regimes of Nigerian ponds and lakes (Azionu, 1983; Chidobem and Ejike, 1985; Adeniji, 1989; Abobweyere, 1990; Daddy *et al.,* 1991). Studies on water quality parameters provide base line information for subsequent assessment of the environmental impact of man-made perturbations. There are tens of natural lakes of various sizes in the rainforest landscape of Anambra State, Nigeria. Of these, only in Agulu lake has several base line hydrobiological studies been undertaken (Emejulu *et al.,* 1994; Ekwunife and Okafor, 2004; Inyang and Ezenwaji, 2004). This is because the lake is easily accessible but, more important; the Anambra State Government is planning to develop it into a tourist centre. This study presents the first report on the lake's temporal and seasonal physico-chemical status.

Materials and Methods

The study was carried out in the six-armed Agulu Lake, Anambra State (Fig. 1). It is a natural lake and the area is underlain by the Eocene (Tertiary) shallow marine to continental Ameki formation, which is dominantly sandy with purple, white, grey, pink, clay-shale-silt bands (Offodile, 2002). The lake lies in a valley and the surrounding slopes are used for subsistence farming of various crops, particularly yam, cassava and vegetables. The local population uses the lake for washing, fishing (mainly using traps and set gill nets), ritual sacrifices and domestic water supply. Other features of the lake have been reported by Inyang and Ezenwaji (2004). Monthly sampling for twelve physico-chemical parameters was conducted in each of the six arms of the lake, which constitute the six stations of this study (Fig. 1), from January to December 2003. Thus, the sampling schedule covered both the rainy (April to September/October) and dry (October/November to March) seasons. All samples were collected between 9 a.m. and 10 a.m., except dissolved oxygen, which was collected using 500 ml Nessler bottles at about 12 noon. Surface temperature was measured in situ by 2 min. immersion of mercury thermometer and the visibility by a 25 cm (diameter) Secchi disc. The pH and conductivity were determined using consort P107 digital pH meter and consort K120 digital conductivity meter. Measurement of other parameters was based on methods described in APHA (1989).

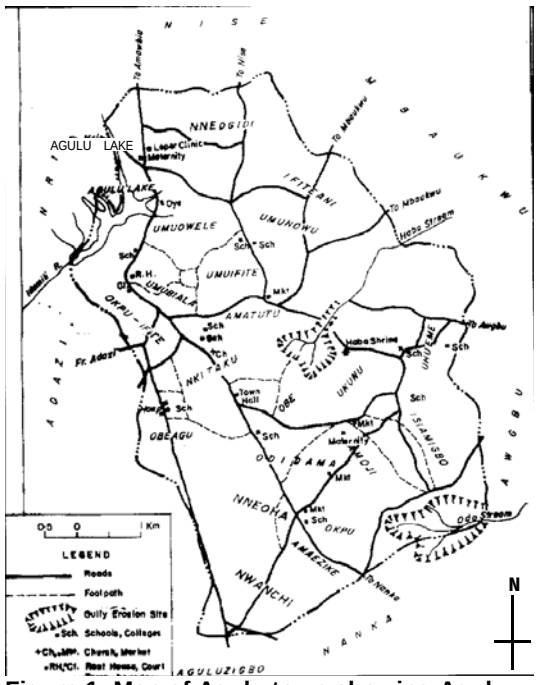

Figure 1: Map of Agulu town showing Agulu lake

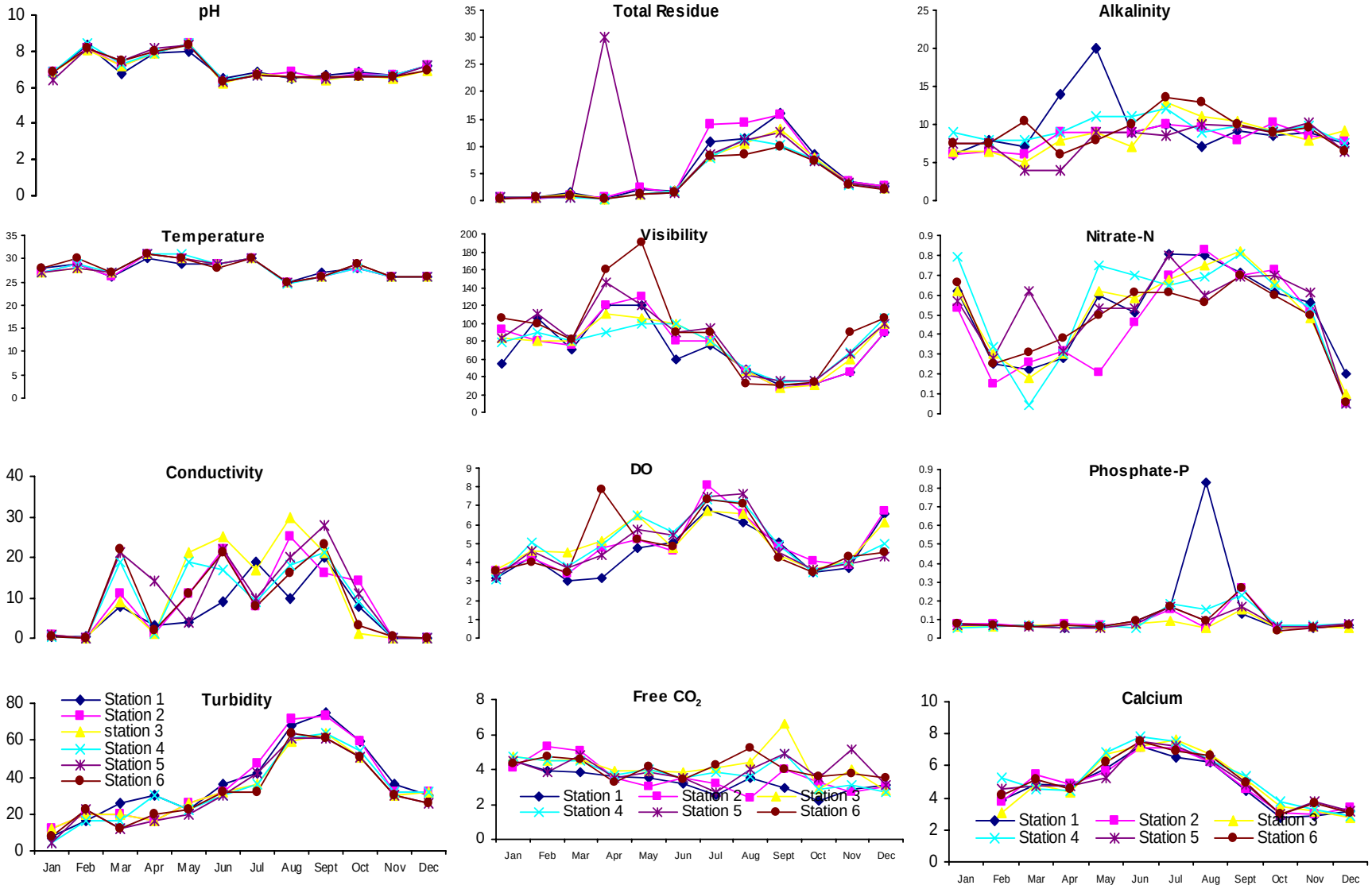

Figure 2: Monthly variation in the studied physico-chemical parameters of Agulu lake, Nigeria

Results

Apart from turbidity, transparency and free CO_2 with values in station 1 differing significantly from those of other stations, the values of all the other parameters were similar in all stations ($P < 0.05$) (Fig. 2).The pH of the lake ranged from 6.26 in June to 8.45 in May. Mean monthly pH was lowest in June (6.34 ± 0.09) and highest in May 8.31 ± 0.18) but this was not different from the value in February (8.21 ± 0.12). The dry season recorded a higher mean pH value (7.18 ± 0.23) than the rainy season (7.03 ± 0.28). The mean annual pH was 7.09 ± 0.03 showing the lake to be slightly alkaline (Fig. 2).

The temperature varied from 24.50 in August to 31 ^{0}C in April. Mean monthly temperature was lowest in August (24.92 ± 0.20) and highest in April (30.83 ± 0.41). The annual mean temperature of the lake was 27.84 ± 0.09 ^{o}C. There was no significant difference between the wet (28.46 ± 2.38) and dry (26.97 ± 1.18) season temperatures (Fig. 2).

The conductivity value was highest in August 19.83 ± μscm-1 and lowest in February significant 0.10 ± μscm-1. There mean turbidity ranged from 8.00 ± 1.46 NTU in January to 66.33 ± 2.50 NTU in September. The wet season mean turbidity (39.36 ± 7.03 NTU) was higher than the dry season (26.16 ± 7.95 NTU). The total residue ranged from 0.24 to 30.00 g during the study period. The annual average value for total residue was 4.80 ± 0.99g; the highest monthly mean of 12.94 ± 1.08 g was recorded in September and the lowest mean value of 0.55 ± 0.04 g in February. There was a significant difference between the mean visibility values of the dry and wet season at 83.15 ± 6.4 cm and 75.67 ± 15.45 cm respectively. The visibility was highest in May (127.50 ±13.28 cm) and lowest in September (31.00 1.34 cm) (Fig. 2). The highest mean DO for the stations was 5.06 mg/l and the lowest was 4.62 mg/l; there was no significant difference between the stations ($P > 0.05$). The highest value for DO was recorded in July (7.29 ± 0.21 mg/l) (Fig. 2).

Free CO_2 ranged from 2.17 to 6.65 CO_2/l; the annual mean free CO_2 value was 3.82 ±0.30 mg CO_2/l. The wet season mean was 3.67± 0.18 mg CO_2/l, while the dry season mean was 4.02 ± 0.30 mg CO_2/l. Alkalinity values were low and varied from 4.00 to 20.00 mg $CaCO_3$/l during the study period. The dry season value of 7.57 ± 0.42 mg $CaCO_3$/l was markedly different from the wet season value of 9.76± 0.39 mg $CaCO_3$/l (Fig. 2). The concentrations of phosphate-phosphorus (PO_4-P) were low during the study period (mean 0.10 ± 0.02; range 0.05 to 0.21). Nitrate-Nitrogen (NO3-N) ranged from 0.04 to 0.83 mg/l; the highest monthly mean (0.74 ± 0.23) was in September, whereas the lowest (0.09 ±.012) was in December (Fig. 2).

Calcium varied from 2.80 to 7.83 mg/l. The wet season calcium value of 5.68 ± 0.57 mg/l was higher than the dry season value of 3.86 ± 0.42 mg/l. There was no significant difference between the stations ($P > 0.05$) (Fig. 2).

Discussion

Agulu Lake has low nutrient load and is, therefore, an oligotrophic lake. The low nutrient level observed maybe attributed to the poor turnover rate of the lake sediment. The lake is usually still with occasional multidirectional wind action on the surface. The wind action observed during the course of the study was not strong enough to cause the complete mixing of the lake. The non-seasonality of temperature is consistent with reports on natural tropical ponds and small to medium-sized lakes and fell within the normal temperature range (25 – 35 ^{0}C) for natural tropical waters (Alabaster and Lloyd, 1980), if the lower limit of 24.5 ^{0}C is approximated to 25 ^{0}C. In tropical systems, marked variations in temperature and rainfall between seasons influence the physico-chemical characteristics of water bodies (Beadle, 1981). The slightly higher mean pH in the dry season agrees with the reports of Azionu (1983) and Adebisi (1981). The highest pH of 8.31 in May might be due to the complete decay of organic material and the low water level just before the onset of full rains.

The conductivity of lakes depends largely on that of inflowing rivers, turnover rates and the soil of the catchment's area (Boyd, 1979); thus the conductivity data for Agulu lake showed strong seasonal variation. The rainfall and subsequent surface runoff into the lake (the surrounding soil dominated by sand and silt) might have raised the lake's concentration of ions; thus, the mean conductivity in the rainy (wet) season was higher than that of the dry season. Similarly, particles brought from the catchment area during the rains and not in the dry season may explain the seasonality pattern in the optical properties of total residue and visibility. This is consistent with the findings of Olusanya (1988) in Opa reservoir. The DO concentration of Agulu lake showed monthly variations. The 4.9 mg/l annual mean DO was similar to that of Jebba lake 4.8 mg/l (Adeniji, 1985). Complete oxygen depletion was not observed in the lake.

The alkalinity and free CO_2 values recorded were low. The higher mean alkalinity in the rainy season is at variance with that in Opa reservoir (Olusanya, 1988) and some tropical rivers (Wright, 1982), which are typified by higher alkalinity during the dry season. The concentrations of NO_3-N and PO_4-P were low in Agulu lake. Odiete (1999) noted that a characteristic feature of most tropical waters is low rate which results in rapid utilization of nutrients. The marked seasonality in calcium concentration might be due to increased leaching due to rains. This results in a higher value for wet than dry season. The low nutrient level of the lake can be overcome by nutrient enrichment. But this can only be done in an integrative manner taking other biological, environmental and economic factors into consideration.

Conclusion: The non-seasonality of temperature (25 – 35 ^{0}C) is consistent with reports on other natural tropical small to medium-sized lakes. In the lake, slightly higher mean pH is observed during the dry season.

The conductivity data for Agulu lake showed strong seasonal variation. The rainfall and subsequent surface runoff into the lake raised the lake's concentration of ions; thus, the mean conductivity in the rainy (wet) season was higher than that of the dry season. Complete oxygen depletion was not observed in the lake, and the alkalinity and free CO_2 values for the lake was low. The marked seasonality in calcium concentration might be due to increased leaching due to rains. Agulu Lake has low nutrient load and is, therefore, an oligotrophic lake.

References

Abobweyere, P.O. (1990). Study of limnological parameters and potential fish yield in Kigera Reservoir (extensive system) in Kainji, New Bussa. *Journal of Aquatic Sciences,* 5: 53 - 58.

Adebisi, A. A. (1981). The physico-chemical hydrology of a tropical river Ogun. *Hydrobiologia,* 79: 157 - 165.

Adeniji, H. A. (1985). A pre-impounded fisheries limnological study of the river Nigeria in the proposed Jebba Area. Pages 45 – 50. *In: Kainji Lake Research Annual Report,* New Bussa.

Adeniji, H. A. (1989). Limnological characteristics of man-made lakes in Nigeria. Pages 224-232. *In: The proceedings of the national conference of two decades of research on Lake Kainji Nigerian.* Freshwater and Fisheries Research Institute Report, New Bussa.

Alabaster, J. S. and Lloyd R. (1980). *Water quality criteria for fresh water fish.* 2nd edition, Butterworth, London 361 pp.

APHA (1989). *Standard Methods for the examination of water and waste waters.* 18th edition, American Public Health Association Washington D.C. 1134 pp.

Azionu, B. S. (1983). *Spatial and dial variation in some hydrological features of the Shen reservoir, Plateau State.* MSc. Thesis, University of Jos. 152 pp.

Beadle, L.C., (1981). *The inland waters of Tropical Africa: An Introduction to Tropical Limnology*. Longman, New York. 475 pp

Boyd, E. C. (1979). *Water quality in warm water fish pond. Cr*aft Master Print Incorporation, Auburn, Alabama 353 pp

Chidobem, I. J. and Ejike, J. C. (1985). An evaluation of the trophic status of the Shen Reservoir by an analysis of phytoplankton composition and water characteristics. Pages 175 - 178. *In: Proceedings of the 4th Annual Conference of Fisheries Society of Nigeria (FISON),* Port- Harcourt, 26-29th Nov. 1985.

Daddy, F., Awojobi. R. I. and Abubakar, A. (1991). An evaluation of fisheries resources of Tatabu lake, Mogero, Niger State, Nigeria. Pages 50 - 58. *In: Nigerian Freshwater and Fisheries Institute Annual Report.* Nigerian Institute of Freshwater and Fisheries Research, New Bussa.

Emejulu, C. A., Alabaronye, F. F., Ezenwaji, H. M. G. and Okafor, F. C. (1994). Investigation into the prevalence of urinary schistosomiasis in the Agulu lake area of Anambra State, Nigeria. *Journal of Helminthology,* 68: 119 – 123.

Ekwunife, C. A. and Okafor, F. C. (2004). Schistosomiasis infection in primary schools in Agulu town of Anambra State, Nigeria. *Animal Research International,* 1(3): 203 – 207.

Inyang, N. M. and Ezenwaji, H. M. G. (2004). Size length-weight relationships, reproduction and trophic biology of Chrysichthys nigrodigitatus and Chrysichthys auratus (Siluriformes: Bagridae) in a natural West African lake. *Bio-Research,* 2(1): 47 - 58.

Odiete W. O. (1999). *Environmental Physiology, Animals, and Pollution.* Diversities Publishing Limited, Lagos. 261 pp.

Offodile, M. E. (2002). *Ground Water Study and Development in Nigeria.* Mecon Services, Jos. 453 pp.

Olusanya, A.O. (1988). *The studies of the physico-chemical factors and diatom flora of Opa Reservoir.* MSc. Thesis, Obafemi Awolowo University, Ile Ife, Nigeria. 183 pp.

Wright, R. (1982). Seasonal variations in water quality of a West African river (R. Jong in Sierra Leone). *Rev. Hydrobiol. Trop.,* 15(3): 193 – 199.