Physicochemical limnology of Lake Kubanni, Zaria-Nigeria

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THE QUALITY OF any water body is governed by its physicochemical factors. The monitoring of physicochemical characteristics of a water body is vital for both long term and short analysis (Wood, 1995). Distribution and productivity levels of organisms are largely determined by physicochemical factors (Ashton and Schoeman, 1983; Adakole *et al.*, 1998).

The direct effect of interactions of many frequently measured water quality parameters with biotic components that affect productive potentials of fish species have been demonstrated (Kemidirin, 1993; Adakole et al., 1998; Adakole, 2002).

Kubanni lake, constructed primarily for domestic water supply, receives various domestic and agricultural effluents through its major tributary (Samaru stream) and this could affect the water quality. Variations in physicochemical parameters of a water body could significantly influence the water's treatment processes, portability of the water supply as well as have long term effects on the biota in the aquatic environment(WHO,1971; Adakole *et al.*,1998). The objective of the present study is therefore to investigate the physicochemical variations of lake kubanni and its tributaries.

Materials and methods

Study area and sampling stations

Kubanni lake, also called Ahmadu Bello University dam, is constructed on river Kubanni and supplies water to the University community. The lake (reservoir) catchment's area is 57Km², its width is 122 meters (400 feet), and the mean depth is 6 meters. The lake is located approximately within latitude 11°11'N and longitude 7°38'E in Samaru-Zaria, Kaduna state. It is located within the premises of Ahmadu Bello University, main campus. The lake's two major tributaries are the Kampagi and Samaru streams. Kampagi stream, which originates from a rural settlement, has a seasonal flow whereas Samaru stream that originates from a semi-urban settlement has an all-year-round flow due to its sustenance by urban runoffs and seepages.

Five sampling stations were chosen for the study, two on each stream at 500m apart before discharging into the Lake. The fifth station was located below the dam's dyke.

Physicochemical analysis

Surface water samples were collected in plastic bottles biweekly from each station for a period of 4 months (April to July, 1999) for determination of those physicochemical parameters that could not be determined on the field. The temperatures of the air (2m above water level), surface water (1cm below water surface) and water depth (1m below water surface) were determined in the field using a mercury thermometer. Transparency was determined using a Secchi disc. Hydrogen ion concentration (pH) and electrical conductivity by using Kent Eil 7055 pH meter and Jenway 4010 conductivity meter models respectively. Total dissolved matter was analyzed as described by Lind,(1979). Dissolved oxygen, BOD, total alkalinity and total hardness were determined by burette titration (APHA, 1985).

The statistical analysis was carried out using the Gensat release 4.03 package. Statistical procedures used include summary statistics and analysis of variance (ANOVA).

Results

The atmospheric, water surface and water depth temperatures, ranges were 24 – 30°C, 24 – 28°C and 22.50 – 27.0°C respectively (Table 1). Analysis of variance for all the temperatures revealed that there were high significant variations ($P < 0.01$) among the weekly means, however, among the stations, the variations were not significant ($P > 0.05$). The mean transparency of the lake was 27.27±18.40cm, with the Lake water mean showing a higher transparency values throughout the study period. There was a significant variation ($P < 0.05$) among the weekly values while a highly significant variation ($P < 0.01$) exists between the stations. The least total dissolved matter (65.00mg/l) was recorded in station 1 in week 1, whereas the highest value (293.80mg/l) was recorded in station 3 in week 4. The variations in both biweekly and station means of total dissolved matter values were highly significant ($P < 0.01$). The electrical conductance of the sampling stations is in this order of increasing magnitude: station 1 < station 2 < station 5 < station 4 < station 3. The fluctuations in electrical conductivity correlate positively with the total dissolved matter

During the study period, the biweekly mean pH values revealed acidic conditions (pH6.6 to 6.91), whereas the station mean range was circumneutral (pH6.34 to 7.12. There was no significant variation ($P > 0.05$) among the biweekly means. However, a high significant variation ($P < 0.01$) was observed among the station means. The mean dissolved oxygen for Kubanni lake was 7.04±1.80mg/l. Both the least (2.70mg/l) and highest (9.40mg/l) dissolved oxygen concentrations were recorded in station 5 in weeks 1 and 5 respectively. The biweekly mean ranges between 3.30 to 9.10mg/l There were high significant variation ($P <$

Table 1. Statistical summary of results obtained for kubanni lake and its tributaries

Parameters	Grand Mean	Standard Deviation	Standard Error	Minimum	Maximum	Median
Atmospheric temperature (^{O}C)	26.63	1.53	0.24	24.00	30.00	26.00
Water surface temperature (^{O}C)	25.91	1.17	0.19	24.00	28.00	26.00
Water depth temperature (^{O}C)	25.32	0.94	0.15	22.50	27.00	25.00
Transparency (Cm)	27.27	18.40	2.90	5.00	65.00	20.00
Total dissolved matter (mg/l)	165.10	69.21	11.00	65.00	293.80	149.73
Electrical conductivity ($\mu S/cm$)	256.80	107.80	17.00	100.00	452.00	236.50
pH	6.78	0.30	0.05	6.16	7.50	6.80
Dissolved oxygen (mg/l)	7.04	1.80	0.29	2.70	9.40	7.85
Biochemical oxygen demand (mg/l)	2.14	0.64	0.10	1.00	3.80	2.10
Total hardness (mg/l.$CaCO_3$)	172.50	61.18	19.70	72.00	288.00	180.50
Total alkalinity (mg/l.$CaCO_3$)	78.90	34.00	5.40	19.00	179.00	83.50

0.01) in both station and biweekly means of dissolved oxygen. The station mean biochemical oxygen demand ranged between 1.00 to 3.90mg/l. The mean biweekly total hardness ranged from 95.20 to 210.40mg/l.$CaCO_3$ in weeks 1 and 5 respectively while the station mean value range from 118.90 212.80mg/l. $CaCO_3$ for stations 1 and 3 respectively. The peak total alkalinity (180.00mg/l.$CaCO_3$) was recorded in station 3. All the other station values were generally below 130.00mg/l.$CaCO_3$.

Discussion

Fluctuations in surface and water depth temperatures closely follow air temperatures in all the sampling stations. Certain taste and odor producing organism grow more readily at a temperature range of 16 to 20°C. Hence recommendation for any acceptable limit should be guided by the temperature requirement at a specific locality necessary to preserve normal species diversity and prevent undesirable growth of nuisance organism (WHO, 1971; Patra and Azadi, 1985; Umeham,1989; Jonnalagadda and Mhere, 2001). The measured temperature of the water reflected the rainy season, which undoubtedly affected the temperature probably by lowering the solar radiation during the cloudy rainy months. The significant correlation in both the biweekly and station means of transparency showed that the materials that determined the transparency level of the lake originated from the disturbance of the lakes basin. The persistent high transparency of

station 5 is attributed to its depth, large water volume and low velocity. Turbidity caused by the hydrous oxides of Fe and Mn is objectionable in domestic water and may require special treatment for removal (Krenkel, 1974). Turbidity is not necessarily harmful to fish (Ayodele and Ajani, 1991); however, the resulting reduction of sunlight intensity in the water decreases the productivity of a water body. The higher dissolved matter loading of Samaru stream (stations 3 and 4) than Kampagi stream (stations 1 and 2) is due to the discharge of various domestic and agricultural effluents into Samaru stream in contrast to Kampagi stream that passes through relatively undisturbed vegetation. The variations in electrical conductivity and total dissolved matter were similar.). The electrical conductance of Kampagi stream (126.88 ± 6.82mS/cm) was lower than that of Samaru stream (330.31± 31.37mS/cm). At low levels of electrical conductance, major ions may determine the nature of the fauna (Moss, 1993).

The lake's mean pH (6.78 ± 0.03) makes the lake water quite suitable for fish production and for domestic uses. Freshwaters with a pH range of 6.0 to 9.0 have been noted to be productive and thus recommended for fish culture (Adeniji, 1986). Outside this range water may have sour taste and could be corrosive to metals. Unpolluted water bodies normally show a near neutral or slightly alkaline pH. Dissolved oxygen increases the palatability of water because of its ability to remove undesirable taste. A dissolved oxygen concentration of not less than 5.0mg/l is required to sustain

fish and other aquatic life in water bodies (Adeniji, 1986; Ayodele and Ajani, 1991; Adakole, 2000). Thus the 7.04 ± 1.80mg/l dissolved oxygen concentration of the Kubanni lake points to the relatively clean condition of its water quality. Presence of dissolved oxygen in good quantity in water bodies have the tendency of improving the water quality by oxidizing poisonous gases such as hydrogen sulphide and ammonium into their non poisonous forms. BOD values indicate the extent of organic pollution in an aquatic system, which adversely affect the water quality (Jonnalagadda and Mhere, 2001). The BOD of unpolluted waters is less than 1.00mg/l; moderately polluted (BOD 2.0 – 9.0mg/l) while heavily polluted waters have BOD more than 10.0mg/l(Adakole, 2000). Consequently Kubanni lake and its tributaries is regarded to be moderately polluted during the study period. Pollution by organic maters is very complex as it involves not only the deoxygenation of the water but also the addition of suspended solids, the organic matter itself and poisons such as ammonia (Adakole, 2000; Jonnalagadda and Mhere, 2001). Based on water hardness classification by Lind (1979), the waters of the lake (119.75 ± 13.87mg/l.CaCO$_3$) and those entering the lake from Samaru stream (171.56 ± 28.26mg/l.CaCO$_3$) and Kampagi stream (147.50 ± 54.49mg/l.CaCO$_3$) were all moderately hard. The mean alkalinity obtained for Kubanni lake (78.90 ± 5.40mg/l.CaCO$_3$) compares unfavorably with the mean(212.67±37.69mg/l.CaCO$_3$) recorded by Umeham(1989). Since it is recognized that in-lake processes can generate more alkalinity in dilute, oligotrophic lakes than can be supplied from the lake's catchments (Psenner, 1988; Schindler, 1988), the low alkalinity recorded during this study may be attributed to size and temperature difference of the two lakes. Alkalinity in excess of alkaline earth metal concentrations is significant in determining the suitability of water for irrigation while an alkalinity range of 20 – 40 mg/l.CaCO$_3$ is recommended for domestic purposes (WHO, 1971; Dillon *et al*., 1997)

Conclusion

Kubanni lake water quality is influenced by its tributaries. The lake water quality is suitable for irrigational, aqua cultural and domestic purposes in terms of most of the physico-chemical parameters analyzed. However, considering that the lake is a source of drinking water, the pollution potential of the tributaries gains significance. Hence, there is need for an effective pollution control program of the tributaries.

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