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Original Article

SUITABILITY OF BOSSO LAKES MINNA, FOR MEETING DOMESTIC AND AGRICULTURAL HUMAN NEEDS

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ABSTRACT

The need for informed management practices and sustainable exploitation of Bosso lakes Minna, Nigeria, were the reasons for this study which elucidated the phsico-chemical properties and hence, fitness of water from these lakes for drinking, domestic and agricultural purposes. Weekly collection of water samples were carried out during the rainy season of 2009 and analyzed for water quality following standard techniques. The results showed that while the concentration of values of temperature, pH, Potassium Hardness, Mg^{2+}, DO and TDS were not significantly different ($P > 0.05$) between the two lakes, the other physico-chemical parameters varied significantly ($P > 0.05$). Also, Electrical Conductivity, Turbidity, Nitrates, Sodium ion and COD were significantly ($P < 0.05$) higher in Gabas lake while, Alkalinity, Calcium ion and BOD, were significantly ($P < 0.05$) higher in Pyata lake. These results indicated varying degrees of pollution of the lakes which was attributed to the different human activities around the lakes. Assessment of water from the two lakes for suitability for human and agricultural needs revealed that while the mean concentration of the nutrient salts (i.e., NO_3, range = 3.08±2.83 to 6.72±7.90 mg/l; SO_4, ranged = 2.44 ± 0.38 to 4.57 ± 0.50mg/l; and PO_4, range = 2.51 ± 0.37 to 4.63 ± 0.26mg/l), pH (range = 6.664±0.45 to 7.33±1.34), Dissolved Oxygen (ranged = 24.56±15.72 to 24.63±16.73mg/l), Total Hardness (ranged = 33.86±35.85 to 29.00±38.09 mg/l), were within the international tolerance limits; Sodium and TDS (range = 3.14± 2.05 to 6.07± 4.20 mg/l and 1041.50±2406.66 to 1296.11±3017.17mg/l) were outside the limits. The public health implications of these results were discussed and concluded that, on the whole, water from Pyata and Gabas lakes, Minna, Nigeria are suitable for drinking (if treated), domestic uses, irrigational agriculture and fish stocking s most of the physico-chemical concentration ranges were below WHO maximum tolerance limits.

Keywords: Physico-chemical properties, Mineral salts, Water quality.
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INTRODUCTION

The aquatic ecosystem is the most diverse in the world, as water is the most vital factor for the existence of all living organisms. Aquatic habitats provide the food, water, shelter and space, essential for the survival of aquatic organisms and hence, humans depend heavily on them for direct water supply and aquatic resources. Though the oceans meet these needs to a large extent, inland human settlements rely on freshwater ecosystems for these resources (Karleskint *et al.*, 2006).

However unlike the oceans, inland water bodies are very much limited temporally and spatially. This, coupled with intense human demands for aquatic resources due to increasing population explosion, make inland water bodies prone to abuse, that manifest as Physico-chemical properties of such water bodies sliding in to ranges intolerable to aquatic organisms, as well as, grossly unsuitable for human domestic and agricultural needs (Garrison, 2005). Important physico-chemical characteristics that influence the fitness of inland waters for human use include pH, temperature, Dissolved Oxygen, Mineral salts, transparency, conductivity; and to this end, they have been variously investigated in Nigeria (Akpah, 2008), but rarely related to the suitability of the water bodies for human needs. Minna, typical of Nigerian urban centers, faces acute shortage of water and thus, relies heavily on Bosso lakes for water supply. Water supply from Bosso lakes, via the Niger State Water Works Department, may be safe for human consumption and other domestic uses, as such water is claimed to have been analyzed, treated and made to conform with recommended standards, before been pumped to the populace; the same, however, may not be true of the large numbers of people seen, during pre-study observations, thronging the lake-sides to fetch raw water directly for domestic uses, perhaps, without any form of treatment. Yet, studies have shown that lakes not protected against uncontrolled arbitrary human and animal interference, are often polluted and their water having physico-chemical properties outside the range recommended for human/animal consumption and other domestic uses, with attendant serious public health risks (Chandrasekhar *et al.*, 2003). It was against the backdrop of the urgent need to protect Bosso lakes from pollution and deterioration, and to ascertain if the quality of water from the lakes is suitable for domestic and agricultural uses, that this study was carried out to elucidate the physio-chemical properties of the lakes *vis-a-vis* internationally recommended permissible limits.

MATERIALS AND METHODS

Description of Study Area and Study Sites

The study was carried out in Minna, the capital city of Niger state, North Central Nigeria. Minna, is located within longitude 6° 33'E and latitude 9° 37'N, covering a land area of 88 km^2 with an estimated human population of 1.2 million. (The Nigerian Congress, 2009).The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30.2°C, 61.00% and 1334.00mm, respectively. The climate presents two distinct seasons: a rainy season between May and October, and a dry season (November - April). The vegetation in the area is typically grass dominated savannah with scattered trees. Though, a heterogeneous community, residency in Minna is dominated by three major tribes namely, Gwari, Nupe and Hausa, with reasonable presence of Yorubas and Igbos. Water supply in the area is grossly inadequate, characterized by sources such as wells, boreholes, streams/rivers, pipe-borne, etc. The people are mostly engaged in agriculture, trading, artisanship and civil service for living.

Selection of Sampling Station and Collection of Water Samples

Ten sampling points were randomly selected in each lake, in a way that the water samples represented the entire lake. The sampling program was carried out during the rainy season of 2009, between the months of May and

September. Biweekly water samples were collected at about 15cm below the surface, using sterile polythene bottles, between the hours of 0800 and 0900. The water samples were fixed *in situ* according to APHA (1998), and transported to the laboratory where they were stored in a refrigerator at 4°C.

Physico-chemical Analysis of Water Samples

The pH of the water samples was determined using a portable pH meter. The pH meter was calibrated with buffer solution and the probe was immersed in the well-stirred water sample and readings were noted (Ramteke and Moghe, 1988). Water temperature was determined using a mercury thermometer, by inserting the bulb about 5cm below the surface and the readings in degree centigrade noted. This exercise was repeated 5 times within a sampling station, and the average of the 5 readings was calculated and recorded as water temperature per station. Electrical conductivity (EC in µs/cm), of the water samples was measured using electrical conductivity meter (Model N0. LF 90 (0.N0 300210)), by inserting the electrodes in a well-stirred sample (Ranteke and Moghe, 1988). Total Dissolved Solids (TDS) was worked out according to (Ranteke and Moghe, 1988). Turbidity was determined with the Secchi disc depth measurement (Chandrasekhar *et al.*, 2003). Determination of Dissolved Oxygen (DO) was performed according to the technique of APHA (1998). Standard titration methods of APHA (1998) were used to determine alkalinity and hardness.

The water samples were analyzed for mineral nutrients namely, Nitrates (NO_3), Sulphates (SO_4) and Phosphates (PO_4), according to the Standard methods of APHA (1998). Sodium and Potassium concentrations of the water samples were determined using the techniques of Ramteke and Moghe (1988). Determination of Calcium ion (Ca^{2+}), Magnesium ion (Mg^{2+}), Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD), were according to the techniques of APHA (1998).

Statistical Analysis

The data collected from the two lakes were processed and analyzed using SPSS version 16.0. Mean values ± SD for the individual Physico-chemical parameter was calculated for each lake and, thereafter, differences in data collected between the two lakes were examined using the Chi-square test, at 0.05 level of significance. The extent of correlations in individual Physico-chemical properties between the two lakes was determined using linear coefficient correlations.

RESULTS AND DISCUSSION

The results of the physico-chemical analyses of water samples from the lakes are given in Table 1. While the concentration values of temperature, pH, Potassium Hadrness, Mg^{2+}, DO and TDS, were not significantly different ($P > 0.05$) between the two lakes, the other physico-chemical parameters varied significantly ($P < 0.05$). The results indicated that Electrical Conductivity, Turbidity, Nitrates, Sulphates, Phosphates, Sodium ion and COD were significantly ($P < 0.05$) higher in Gabas lake while, Alkalinity, Calcium ion and BOD, were significantly ($P < 0.05$) higher in Pyata lake.

All things been equal, the distribution of physico-chemical parameters in Pyata and Gabas lakes ought not to differ significantly, as both lakes are located in the same area and hence, influenced by similar climatic and Edaphic factors; an assertion supported by the

insignificantly different temperatures (i.e., 26.86±2.45°C and 27.21±2.16°C, in Pyata and Gabas lakes, respectively) and TDS (i.e., 1041.00±2406.66mg/l and 1296.11±3017.00mg/l, respectively), factors respectively, influenced by climate and Edaphic conditions. Therefore, the significant variations observed in certain physico-chemical parameters, especially, those influenced mainly by human activities such as mineral salts and BOD in the 2 lakes, suggest unwholesome human interference but, perhaps, to different degrees. In Bangalore, Chandrasekhar *et al.* (2003) blamed the pollution of Bellandur Lake on higher values of alkalinity, BOD and COD which was attributed to the urbanization of surrounding areas that led to the discharge of domestic and industrial effluents into the lake. The results of this study showed that most of the physico-chemical parameters that varied significantly between the lakes had higher values in Gabas lake and indicate that this lake is more polluted than its counterpart.

The mean concentrations of Sodium in Pyata and Gabas lakes were 3.14±2.05 and 6.07±4.02 mg/l, respectively, values significantly lower than the maximum limit of 200mg/l recommended for drinking, domestic and agricultural waters (WHO,1992). According to Ramachandra *et al.* (2006), the Sodium content of lake water depends on runoff from agricultural fields and concentration of chemical constituents present in the lake water. High concentrations of Sodium and Potassium in water make it unsuitable for irrigational agriculture, as it may cause damages to the crops by interfering with water uptake. The levels of mineral salts, i.e., Nitrates (range = 3.08±2.83 to 6.72±7.90 mg/l), Sulphates (range = 2.44 ± 0.38 to 4.57 ± 0.50mg/l) and Phosphates (range = 2.51 ± 0.37 to 4.63 ± 0.26 mg/l) in the two lakes were below the tolerance limits. While who (1993) and who (2007) respectively recommended maximum tolerance limit of 250mg/l for sulphate and 50mg/l for nitrates , maximum limits for phosphates has been put at 5.omg/l according to the European union standards (who,1993). Therefore, from this view point, the water of Bosso lakes is suitable for irrigation, drinking, if treated, and for the growth of aquatic organisms and stocking of fish. The Total Dissolved Solids in the two lakes were relatively high (i.e mean= 1041.50±2406.66 and 1296.11±3017.17 mg/l in Pyata and Gabas lakes, respectively). The recommended permissible limits are 500mg/l for drinking and 2100mg/l for irrigation water (Chandrasekhar *et al.*, 2003). Thus, water from these lakes is not suitable for drinking without standard pretreatment though, may be adequate for fisheries and irrigation.

Table 1: Physico-chemical properties of Pyata and Gabas lakes, Bosso Minna, Niger State.

Parameters	Pyata Lake	Gabas Lake	Correlation
Temperature (oC)	26.86 ± 2.45[a]	27.21 ± 2.16[a]	0.9407
Dissolved Oxygen (mg/l)	24.56 ± 15.72[a]	24.63 ± 16.73[a]	0.9774
Electrical Conductivity (µs/Cm)	84.71 ± 20.55[a]	99.57 ± 45.47[b]	0.9267
Turbidity (NTU)	18.61 ± 4.80[a]	28.51 ± 10.90[b]	0.9434
pH	6.64 ± 0.45[a]	7.33 ± 1.34[a]	-0.4149
Nitrates (mg/l)	3.08 ± 2.83[a]	6.72 ± 7.90[b]	0.7405
Sulphates (mg/l)	2.44 ± 0.38[a]	4.57 ± 0.50[b]	0.8602
Phosphates (mg/l)	2.51 ± 0.37[a]	4.63 ± 0.26[b]	0.7245
Sodium (mg/l)	3.14 ± 2.05[a]	6.07 ± 4.20[b]	0.9958
Potassium (mg/l)	2.63 ± 0.44[a]	1.58 ± 0.79[a]	-0.5347
Alkalinity (mg/l)	182.14 ± 121.46[b]	167.14 ± 152.35[a]	0.8891
Chemical Oxygen Demand (mg/l)	43.00 ± 27.36[a]	208.25 ± 60.49[b]	0.9307
Calcium ion (mg/l)	13.97 ± 4.44[b]	7.94 ± 2.38[a]	0.1973*
Calcium Hardness (mg/l)	47.33 ± 51.27[a]	41.50 ± 57.63[a]	0.9932
Total Hardness (mg/l)	33.86 ± 35.85[a]	29.00 ± 38.09[a]	0.9898
Magnesium Hardness (mg/l)	3.87 ± 7.12[a]	1.49 ± 1.89[a]	0.8452
Magnesium ion (mg/l)	3.87 ± 1.67[a]	3.49 ± 2.24[a]	0.6692
Ammonia (mg/l)	0.23 ± 0.41[a]	1.88 ± 1.75[b]	0.5452*
Fluorine (mg/l)	0.00 ± 0.00[a]	0.00 ± 0.00[a]	1.0000
Biochemical Oxygen demand (mg/l)	329.33 ±22.19[b]	190.32 ± 64.29[a]	0.0935*
Total Dissolved Solids (mg/l)	1041.50 ± 2406.66[a]	1296.11 ± 3017.17[a]	1.0000

Values followed by same superscript alphabets in a row are not significantly different at P = 0.05.
*Insignificant correlations

pH values from 7.2 to 8.7 are suitable for aquatic organisms (klein, 1973), while the recommended pH values of water for domestic purposes range from 6.0 to 9.0 (Mishra and Yadar 1978); and for drinking in Nigeria lies between 6.5 to

8.50. Therefore, the pH value of 7.33±1.34 recorded in Gabas lake, makes its water suitable for drinking and domestic uses, as well as, as for the survival of aquatic organisms. However, while the water of Pyata lake (with pH of 6.64±0.45) is suitable for drinking and other domestic uses, it will be acidic for aquatic organisms. The amount of Dissolved Oxygen (DO) in the two lakes (mean = 24.56±15.72 and 24.63±16.73mg/l, respectively) are relatively high, as much lower values were reported in India (Ramachandra *et al.*, 2006). This finding suggests that water from the two lakes is suitable for aquatic biota. According to Kumar et al. (2004), exposure to DO values less than 2.0mg/l for few days may kill most of the biota in aquatic ecosystems while, minimum values of 5.0 to 6.0mg/l support thriving populations of most fish species. The high DO recorded in the lakes, perhaps, explains the low nutrient salts (i.e., Nitrates, Sulphates and Phosphates), as an inverse relationship exists between these variables; these salts promote algal growth which leads to eutrophication which, in turn, depletes free oxygen in water (Ramachandra *et al.*, 2006).

Total hardness in the two lakes is relatively high (range = 29.00 ± 38.09 to 33.86 ± 35.85mg/l), indicating that their water is not suitable for domestic washing purposes. According to Ramachandra *et al.* (2006), water with hardness range of 0 to 6 mg/l is classed as soft, and reacts well with washing soaps.

CONCLUSION

Different intensities of human activities around Gabas and Pyata Lakes, Minna, have resulted in increased pollution of the former, as reflected by its higher values of important physico-chemical parameters. However on the whole, the physico-chemical parameters of the two lakes are within international recommended tolerance limits hence, their water is suitable for drinking (if treated), domestic uses, irrigational agriculture and fish stocking; though, there is need for comprehensive monitoring, in order good for management decisions to be taken to ensure sustainable exploitation of the lakes.

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