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LIMNOLOGICAL INVESTIGATION OF A FRESHWATER IMPOUNDMENT – IKPOBA RESERVOIR – IN BENIN CITY, EDO STATE

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ABSTRACT
The water quality assessment of the Ikpoba Reservoir was carried out between April and August, 2012. Water samples were collected for physical and chemical analysis coupled with phytoplankton collection by towing a 55µm mesh size plankton net, and periphyton were obtained from submerged aquatic macrophytes, after which they were preserved with 4% formalin. The Ikpoba Reservoir is oligotrophic and acidic to neutral (6.0 - 7.27) in pH. From the physico – chemical parameters analyzed, it can be inferred that the Ikpoba Reservoir is fit for domestic and other human uses. The phytoplankton/periphyton flora of the Ikpoba Reservoir consisted of 27 taxa belonging to 3 divisions, 5 orders, 11 families and 11 genera. Chlorophyta accounted for 77.8% (mostly dominated by desmids) followed by Bacillariophyta 18.5% and Euglenophyta 3.7%. Station 2 had the highest species composition, followed by station 3. The divisions, Cyanophyta and Rhodophyta were not represented during the study period.

KEYWORDS: *Ikpoba Reservoir, Water quality, Phytoplankton, Periphyton*, *Benin City*

INTRODUCTION

Water, commonly known as the universal solvent because of its ability to dissolve many chemical substances, has from time immemorial been a valued natural resource to man, animals and plants, besides other organisms that tied their existence to the essence of its presence. Water covers about seventy per cent of the Earth's surface, and is the most abundant chemical in the human body, where it plays a central role in the regulation of nutrient transport, toxic waste removal, thermal regulation, digestion and organ functioning. Management of the quality of this vital resource is therefore, of great importance, hence the study of water quality.

Water quality is a measure of the conditions of water, relative to the requirements of one or more biotic species and to any human need or purpose (Johnson *et al.,* 1997). A water quality criterion is a quantity usually developed through scientific experiments upon which a judgment can be based (Ikhile, 2012). A criterion may be based on physical, chemical and biotic characteristics. The criterion may be related to techniques employed in removing the substances from water or based on people's visual preference (Ikhile, 2012).

Expanding human population, brought about by the opportunities of good water supply, irrigation, fish production, recreation and navigation offered by reservoirs, has put enormous pressure and stress on the quality of water impounded by the reservoir. The impact of human activities in and around the reservoir is felt on the unique physical and chemical properties of water on which the sustenance of fish that inhabit the reservoir is built as well as to the functions of the reservoir. Water quality is determined by the physical and chemical limnology of a reservoir (Sidnei *et al*., 1992).

The use of the physico - chemical properties of water to assess water quality gives a good impression of the status, productivity and sustainability of such water body (Djukic *et al*., 1994). The changes in physical characteristics like temperature, transparency, and chemical elements of water such as Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Nitrate and Phosphate provide valuable information on the quality of the water, the source(s) of the variations and their impacts on the functions and biodiversity of the reservoir (Djukic *et al.,* 1994).

Water quality deterioration in reservoirs usually comes from excessive nutrient inputs, eutrophication, acidification, heavy metal contaminations, organic pollution and obnoxious fishing practices (Tripathi and Shukla, 1991). These do not only affect the socio-economic functions of the reservoirs negatively, but also bring about loss of structural biodiversity of the reservoir (Tripathi and Shukla, 1991). In the discharge areas, microbial decomposition of these wastes exerts high Biochemical Oxygen Demand (BOD) and creates anaerobic conditions, bacteria and pathogens are introduced into waters, and eutrophication-stimulating nutrients like nitrates and phosphates are also introduced (Tripathi and Shukla, 1991; Ademoroti, 1996). When this happens, aquatic life suffers, resulting in a loss of productivity of the natural waters and a deterioration of water quality (Ogbeibu and Ezeunara, 2002).

Water quality criteria include pH, Chemical Oxygen Demand, Biochemical Oxygen, Total Dissolved Solids (TDS) and electrical conductivity (EC) and there are guidelines for different uses of water. Water quality guidelines are acceptable concentrations of substances that can be consumed by people, and concentrations above these are considered dangerous to human life (WHO, 2006). Guidelines for assessing water quality were provided by WHO (2006), in which it was stated that parameters like Ca (mg/l), Mg (mg/l) or Na(mg/l) of any water met for drinking should not be greater than 200, Pb (mg/l) should not exceed 0.01, Cu (mg/l) should be 2.0, while Fe (mg/l) and Zn (mg/l) should not be greater than 0.3 and 3 respectively, and that the pH should be in the range of 6.5-8.15. In the light of this, if a reservoir contains dissolved substances above the acceptable required concentrations as stipulated by health agencies such as the WHO, such a reservoir would be deemed detrimental to human life and unfit for drinking.

A dam is a barrier that blocks the flow of water and produces a reservoir. Natural dams can include the beaver dams, lava flows or landslides. Artificial dams are built for water storage or flood control or to generate electricity (Jackson, 2009). Reservoirs are lentic i.e. stagnant water bodies, although some may be slow flowing, consisting of mainly fresh waters. They are primarily created by excavating a large portion of the Earth's surface, or by damming the flow of a river rift.

Artificial dam such as the Ikpoba Reservoir, has long been an important water storage reservoir to the inhabitants of the community in which it is situated, in as much as it serves as a site for fishing activities, bathing, swimming, washing, aquaculture and irrigation, to mention but a few. Water enters this reservoir from groundwater seepage and runoff from a mixed land-use watershed. This watershed contains diverse nutrient sources (e.g. dairy farms, agricultural fields, brewery and septic systems) that could accelerate the eutrophication process.

Algae constitute one of the known parameters with which the quality of a water body can be assessed and ascertained. Algae are the source of oxygen in aquatic systems and are the main autochthonous primary producers. They also serve as indicators of pollution in any water body, as primary producers and as such, could be used in determining water pollution level (Akomeah *et al*., 2010). Phytoplankton are microscopic algae which float in water, and are carried about passively by wind and water current. They differ from periphyton which is a complex mixture of algae, cyanobacteria, heterotrophic microbes and detritus that attached to submerged surfaces in most aquatic ecosystems (Azim *et al*., 2006). Some periphyton are sensitive indicators of water quality assessment and produce the early warning signal of water pollution (Browder *et al*., 1998). Periphyton are an essential component of the aquatic food chain. They are the primary producers in freshwater bodies including lakes where different forms are present in various locations viz: epilithic (rock), episamic (sand), epiphytic (plant), epipelic (mud) and epizoic (animals) forms (Kadiri, 2002).

This study was undertaken to ascertain the water quality and floristic composition of the Ikpoba Reservoir in relation to stipulated regulatory standards.

Study Area

The study was carried out at Ikpoba Reservoir in Benin City, Edo State, Southern Nigeria. The Ikpoba Reservoir is located between 6º 20′ and 6º 22′ N and 5º 38′ and 5º 40′ E. The Ikpoba Reservoir was constructed when the Ikpoba River was impounded in 1977. The reservoir is situated some 3.75 km South – East of the University of Benin. The water supply per day is 150,000 L with a minimum discharge of 9m^3/s and a maximum discharge of 310 Cu m/s. The reservoir at full capacity is 3.25 km long and 600 m wide with a crest level of 36.8m. This study area is surrounded by arable farmland which is about 2.5 km in length along the reservoir (Oronsaye *et al*., 2010).

The Ikpoba Reservoir covers an area of 107.5 hectares and has a maximum water capacity level of 36.8 m. The reservoir, which has a storage capacity of 1.5 million m^3, was originally intended as an infrastructure for municipal water supply, fisheries and recreation, although none of these has been functional. The substratum is muddy and subject to sedimentation (Ogbeibu and Oribhabor, 2002).

The climate of Benin City, Southern Nigeria is mostly humid and is characterized by heavy rainfall between March through to October and dry season from November to February with a cold harmattan spell from mid-December to late January.

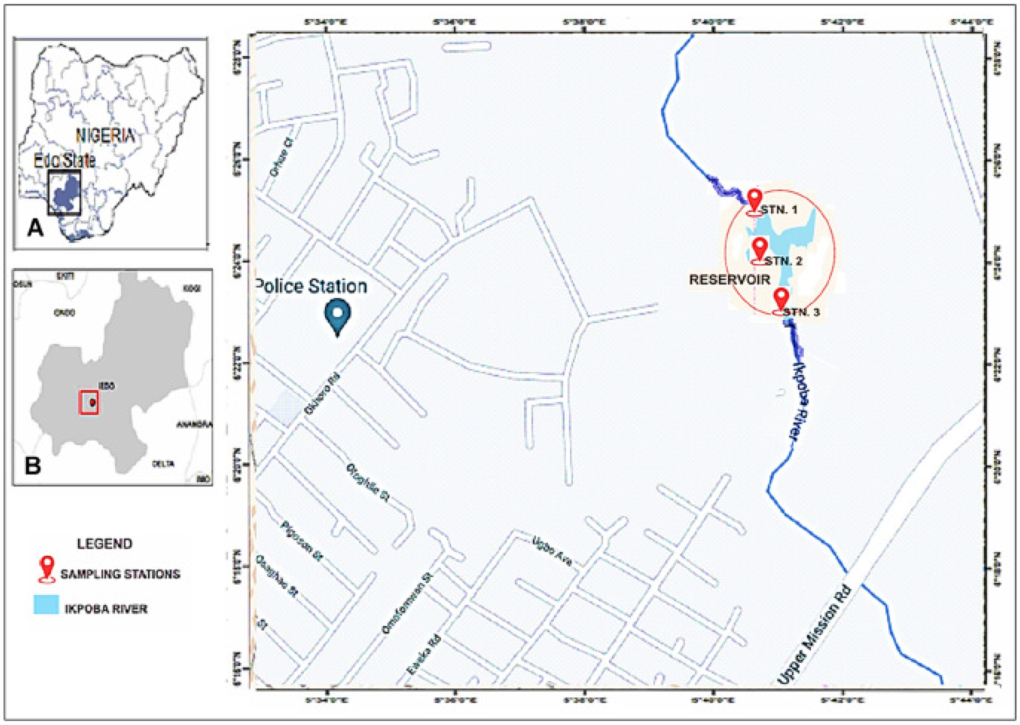

Fig. 1: Study Area

The Ikpoba Reservoir is an open and expanse storage artificial or man–made lake surrounded by a fringing vegetation composed of shrubs, grasses and trees such as *Mangifera indica*, *Carica papaya*, *Cocos nucifera*, the Indian bamboo (*Bambusa* sp.), palm trees (*Elaeis guineensis*) etc. The natural forest of the bank has been destroyed and the reservoir is surrounded by arable farmlands. The dominant macrophytes is *Nymphaea lotus*, and other macrophytes are *Azolla* sp., *Utricularia* sp., *Spirodella* sp. and *Salvina* sp. (Ogbeibu and Oribhabor, 2002). The grasses commonly found in the ambience of this reservoir include the ones of *Panicum maximum*, *Cyperus ambulate*, *Axonopus compressus*, *Pennisetum purpurium*, *Imperieta cylindrica* etc.

Geologically, the substratum of the reservoir is composed of fine sand, laterite, small gravel, red clay and silt. The Benin rock formation consists generally of red laterite soil with some clay patches in some areas. The soil has a moderate water retention capacity and the topography of the area is generally of a sloppy type (Edema *et al*., 2002). The Benin soil formation is located on top of the Agbada formation system which is composed basically of sand stone and coarse sand (Fufeyin, 1994). The Benin soil formation is made up of top reddish clayed sand capping highly porous fresh water bearing loose pebble sands, and sandstone with local thin clays and shale interbeds which are considered to be of braided stream origin. Sands, sandstones and clays vary in colour from reddish brown to pinkish yellow on weathered surfaces to white in the deeper fresh surface (Patrick *et al*., 2002).

Station 1

Station 1 (Plate 1) is an open area with less vegetation when compared with the other stations, whose water is slow flowing. There are many human activities like bathing, laundry, swimming, washing etc. here, as it is easily accessible. Despite these human activities, the water is still quite clear and clean. It is devoid of trees except few macrophytes attached to underlying rocks and small gravels. The substratum is made of sands and coarse stones.

Station 2

Station 2 (Plate 2) is also an open area with many standing water grasses and shrubs. The water here is fast flowing but not as clear and clean as station 1 and is a bit darker and dirtier. Most of the activities here are swimming, washing and fishing. The substratum is basically made of silt, soft mud and reddish clay with some stands of medium-sized gravels.

Station 3

This station is mostly enclosed to some extent by shrubs and grasses. The water here is a bit turbid and stable with no much flow. There are no human activities here. The substratum is composed mainly of reddish clay and soft mud with no sand.

MATERIALS AND METHODS

Collection of Samples

Water Samples

Water samples were collected monthly from the Ikpoba Reservoir between 7:30-8:30 a.m. from the months of April to August, 2012 from three different stations. Samples were collected into one litre plastic containers for physical and chemical analysis. Air and water temperatures were recorded *in-situ* using using a calibrated centigrade (^oC) mercury-in-glass thermometer. Dissolved Oxygen Biological Oxygen Demand (BOD) were fixed in the field following the Winkler method. The physicochemical parameters investigated include pH, electrical conductivity, total alkalinity, hardness, total hardness, chloride, calcium and magnesium.

Sample Analysis

The physicochemical parameters were analysed in the laboratory using standard methods according to (APHA, 1998).

Phytoplankton

Phytoplankton samples were collected using a round - mouthed bolting silk net with 55µm mesh aperture and towed for 5 minutes. The phytoplankton samples were preserved with 4% formalin. They were viewed and identified with the aid of the Olympus microscope of model CX40 using texts (Prescott, 1970) after which photographs were taken by a digital camera. Their respective names and families were noted and recorded.

Periphyton

Periphyton samples were also collected from submerged substratum of floating macrophytes of the three different stations, and preserved respectively with 4% formalin, after which they were also identified, and photographs taken by a digital camera.

RESULTS AND DISCUSSION

Table 1 shows the variations in the physicochemical properties of the Ikpoba reservoir in Benin City during the study period.

Table 1: Summary of physical and chemical variables

Parameter	Min	Max	Range	Mean	Standard deviation
Temperature ºC (water)	26	28	26- 28	27.2	1.01
Temperature °C (air)	29	31	29- 31	30.1	0.74
pH	6.0	7.27	6.0 -7.27	6.48	0.34
Total Alkalinity	25	50	25- 50	42.7	9.61
Total Hardness	0.4	0.9	0.4- 0.9	0.69	0.16
TDS	7	83	7- 83	15.3	18.9
Chloride	9.9	32.9	9.9- 32.9	20.4	5.76
Conductivity (µS/cm)	16.0	175.9	16.0 –175.9	32.3	40.1
Calcium	0.05	0.3	0.05- 0.3	0.17	0.08
DO	20	30	20 -30	24.2	3.11
BOD	4.2	8.2	4.2 -8.2	6.7	1.30
Magnesium	0.2	0.75	0.2- 0.75	0.48	0.16

Table 2: Phytoplankton Distribution in Ikpoba Reservoir

Division	Class	Order	Family	Genera	Total number of taxa	% Taxa composition of flora
Chlorophyta	Chlorophyceae	3	7	7	10	71.43 %
Bacillariophyta	Bacillariophyceae	2	2	2	3	21.428 %
Euglenophyta	Euglenophyceae	1	1	1	1	7.143 %
Total		6	10	10	14	

Checklist of Phytoplankton/Periphyton in Ikpoba Reservoir

Division Bacillariophyta
Fragilaria construens
Eunotia lineolate
Coscinodiscus sp.
Division Chlorophyta
Pleurotaenium gloriosum
Pleurotaenium trabecula
Spirogyra dubia
Closterium acerosum
Closterium coronatum
Closterium cynthia
Closterium kuetsingii
Oedogonium crassum
Microspora sp.
Netrium digitus
Division Euglenophyta
Euglena allorgei

DISCUSSION

The physical and chemical factors investigated in this research have been used to assess the water quality of some African reservoirs (Nhiwatiwa and Marshal, 2007). Recorded air and water temperatures did not vary much throughout the studied period. The air temperatures which ranged from 28^{o}C to 31^{o}C were found to be higher than water temperatures (26^{o}C – 29^{o}C). This has been found to be a major characteristic of most tropical regions. The low water temperature in comparison with air temperature may be due to flood influx into the reservoir as sampling was done in the wet season. Low water temperature in the wet months might have been caused by increased cloud cover conditions and reduced solar isolation (Onyema and Nwankwo, 2006).

Total dissolved solids of the three sampling stations were relatively low and ranged from 7 mg/L to 83 mg/L. The observed extremely increased total dissolved solids value of 83 mg/L at station 3 in July, which is the peak of rainfall in this southern region of the country may have been instigated by increased influx of allochthonous substances via acid rain and storm water as a result of increased water run-off from rainfall. The general lower concentration levels of total dissolved solids connote that human discharge activity in the Ikpoba Reservoir, if at all present, is very minimal.

pH is the degree of acidity or alkalinity of a water body. The mean pH value recorded for the Ikpoba Reservoir was 6.48, which is an indicative that the reservoir is acidic. This is probably as a result of high carbon- dioxide concentration from organic decomposition (Mustapha, 2008). The acidic nature of the reservoir could also be attributed to the surrounding laterite soil that may have leached into it (Kadiri, 2000). The difference in pH among stations and sampled months was relatively minimal. The pH values recorded for the three stations during the period of study remained within the acceptable limits of 6.5 – 8.5 for inland waters by W.H.O. The extremely high value of electrical conductivity observed at station 3 in July can be attributed to evaporation of water, leaving a higher concentration of salt within a small volume of water (Olele and Ekelemu, 2008). The increased value of conductivity could also be as a result of inflow of city effluent and run-off from the watershed during the rains (Akpan, 1995).

Alkalinity, which is a measure of the bicarbonates and hydroxides presence in a natural water varies only slightly in the Ikpoba Reservoir, and can be linked to variation in Ca^{2+} and Mg^{2+}. The low values of total alkalinity observed in July and August were due to dilution by rain water (Akpan, 1995). The low alkalinity also indicates low productivity, low input of calcium carbonate and bicarbonates ions.

Dissolved oxygen is vital for existence of all life forms in any aquatic ecosystem. High values of DO in the reservoir may be ascribed to increased primary production by phytoplankton and low of organic suspended matter. The result compares with Odukuma and Okpokwasili (1997), who reported that DO is generally higher in the wet seasons in tropical waters. Organic pollution and decomposition by bacteria deplete oxygen concentration. Biochemical oxygen demand (BOD_5) indicates the concentration of dissolved oxygen that will be depleted from water during biological assimilation of organic pollutant. High BOD in the reservoir during the wet season is attributed to municipal effluents made up of sewage and other domestic and industrial wastes brought into it by run-off.

The relatively low value of total hardness in the Ikpoba Reservoir is attributable to dilution effects by rainfall during the study period in the wet season. These low values therefore suggest that the water is soft with reduced buffering solution, since its values were less than 50 mg/L $CaCO_3$. Thus, the water does not waste soap as it easily lathers when used.

The increase in calcium Ca^{2+} and magnesium Mg^{2+} during the wet season is attributed to increased rainfall and subsequent increased soil erosion, surface run - off, thus adding nutrients to the reservoir. The low concentration of chloride in the Ikpoba. Reservoir can best be explained based on the underground lithology and adjoining soil profile composition (Kadiri, 1999). Thus, the composition of different element in the reservoir, is a direct reflection of the nutrient poor sandy soil with lateritic sandy soil in the drainage area.

The low phytoplankton / periphyton density and composition in the Ikpoba Reservoir during the wet season can be attributed to low nutrient level flushing out by high water level, which was mostly noticed in April – June of the wet season. It could also be linked to the low water clarity which reduces the amount of light available to the planktonic algal component for photosynthesis (Onyema, 2008).

CONCLUSION

The Ikpoba Reservoir was with low species diversity coupled with low nutrient status. The pH range of the reservoir during the study period was 6.0 - 7.27. This indicated that the reservoir was highly acidic with a slight gravitation towards neutrality. There were high dissolved oxygen content and low calcium and magnesium concentration. The water was well aerated. Thus, the water can be termed "soft water". The green algae which belong to the division Chlorophyta were most abundant among the phytoplankton and periphyton population and were dominated by desmids, which are great indicators of low nutrient status. This attests to the fact that the reservoir was both oligotrophic and acidic. Next to the Chlorophyta was the Bacillariophyta followed by the Euglenophyta whose only representative was *Euglena allorgei*. In the phytoplankton composition, 71.43 % of Chlorophyta was recorded followed by Bacillariophyta (21.428 %) and Euglenophyta (7.143 %). The periphyton population was dominated by the Chlorophytes (84.615 %) followed by the Bacillariophytes (15.385 %).

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