ASSESSMENT OF GROUNDWATER QUALITY AT THE NIGERIAN INSTITUTE FOR OCEANOGRAPHY AND MARINE RESEARCH: IMPLICATION FOR PRODUCTION OF AQUACULTURE

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ABSTRACT

This study was carried out to ascertain the suitability of the Nigerian Institute for Oceanography and Marine Research's groundwater resources for aquaculture purposes. The samples were subjected to physico-chemical analyses and the parameters analyzed are Iron, pH, Sulphide ion Total Ammonia, Dissolved Oxygen, Alkalinity, Hardness, Salinity, Colour, Electrical Conductivity, Turbidity, Temperature, Taste, Odour, Total Dissolved Solids, and Nitrate. The Total Iron content of the ground water ranges from 0.1 to 0.6 mg/l, pH ranges the from 6.0 to 7.8. The Dissolved Oxygen ranges from 1.0 to 2.0 mg/l, Total Hardness ranges from 58 to 68 mg/ l, Electrical Conductivity, ranges from 0.04 to 0.06 uScm^{-l} .Alkalinity ranges from 46 to 140 mg/l. Turbidity ranges from 40 to 68 mg/l . The quality assessment of the NIOMR waters in Lagos State indicate that all the parameters are within the acceptable range for aquacultural production except for iron content in one of the boreholes where the concentration is about 0.6 mg/l. The results generally show that the study area has enormous potential for aquaculture development.

KEYWORDS: Aquaculture, Groundwater, Physicochemical parameters.

INTRODUCTION

Among the key areas of research of the Nigerian Institute for Oceanography and Marine Research, Lagos is Aquaculture with the multifarious mandates of (a) genetic improvement of catfish through acquisition of germ plasm of promising strains from different ecological zones in Nigeria (b) development of mass techniques for fingerlings of Clarias gariepinus and the hybrid of clarias species and heterobranchus species.(c) successful culture of commercial important oyster, Crassotrea gasar. (d) development of fish feed for fish farm industry. (e) enterprise combination of fish with vegetables/livestock, and (f) development of pond construction techniques in different ecological zones in Nigeria for profitable farming. With these mandates, it is imperative that its ground water resources be evaluated to assess its suitability for aquaculture. Aquaculture development worldwide is growing rapidly due to increasing demand for its products. This is because there are limited supplies from inland and marine sources. Water is the most important element for aquaculture production therefore in selecting a site, the source of water and its suitability must be considered since water quality determines the ultimate success or failure of an aqua operation. Poor water quality may impair the development, growth or quality of fish products by tainting their flavor or causing bioaccumulation due to high concentration of some elements or toxic substances (Arabi et al. 2011). An experienced aquaculturist should put into consideration the physico-chemical status of the water source for the intended usage. There are two main categories of water supply for aquaculture purposes, ground and surface water (Arabi et al., 2011). Ground water often differs substantially from surface water in their characteristics. Ground water is commonly considered the most desirable water source for aquaculture because it is usually consistent in quantity and quality and free from toxic pollutants and contamination with predator or parasitic living organisms (Arabi et al 2011). The objective of this study is to evaluate the suitability of the NIOMR groundwater sources (borehole) for aquaculture purpose.

THE STUDY AREA

The study area which is within the barrier/lagoon complex lies between latitudes 06^{0}25'15.1'' to 06^{0}30'3.8''N and longitudes 03^{0}24'26.0'' to 03^{0}36'29.9''E (Fig1).The general evolution and morphology of the Barrier/Lagoon System was controlled by the deposition of fluvial sediments (Quaternary sands) in the coastal basins (Adegoke et al., 1975; Swift, 1975 and Zenkovitch, 1969). These Quaternary sands were reworked by currents and waves to form the barrier complex backed by the Lagos Lagoon (Ibe, 1988), The barrier bar is made up of beach ridges having at the front a very narrow beach with foreshore gradient averaging 1:50m. The topography ranges from 1 to 3m

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above sea level (Ibe and Awosika, 1988). Its drainage system is characterized by a maze of Lagoons and Waterways which constitute about 22% of the State's (Lagos) total landmass. The area is drained by rivers Ogun in the centre, Osun in the east and Yewa in the west, a sub-basin of the Ogun – Osun River Basin. The geology falls within the Benin Formation and consists of highly porous sands and gravels with thin shale/clay interface (Oteri and Atolagbe, 2003). The hydrogeology of the study area falls within the Dahomey Sedimentary Basin (Longe, 2011). The Dahomey Basin is bounded on the west by faults and tectonic structures while its eastern limit is marked by Benin hinge line. The aquifer within the Dahomey Sedimentary Basin extends from Accra in Ghana, through the Republic of Togo and Benin to Nigeria. The Dahomey Basin consists of the Abeokuta Group, Ewekoro Formation, Coastal Plain

Sands (CPS) and Recent Sediments. The Coastal Plain Sands is the most productive and most exploited aquifer in Lagos State. The Coastal Plain Sand is categorized into four types. The first aquifer comprises recent sediments while the second and third are the Upper and Lower Coastal Plain Sands aquifer respectively. The fourth aquifer is the Abeokuta Formation (Longe, 2011). The Upper Coastal Plain Sands aquifer has a water table whose depth ranges between 0.4 and 21m below ground level with annual fluctuation of less than 5m (Asiwaju and Oladeji, 2001). Water in this aquifer is usually tapped through hand dug wells and this is prone to pollution due to its nearness to the ground surface. The Lower Coastal Plain Sands aquifer however is tapped through the bore holes and serves as the basis for the establishment of mini water works in Lagos State (Longe, 2011 and Adepelumi,2008).
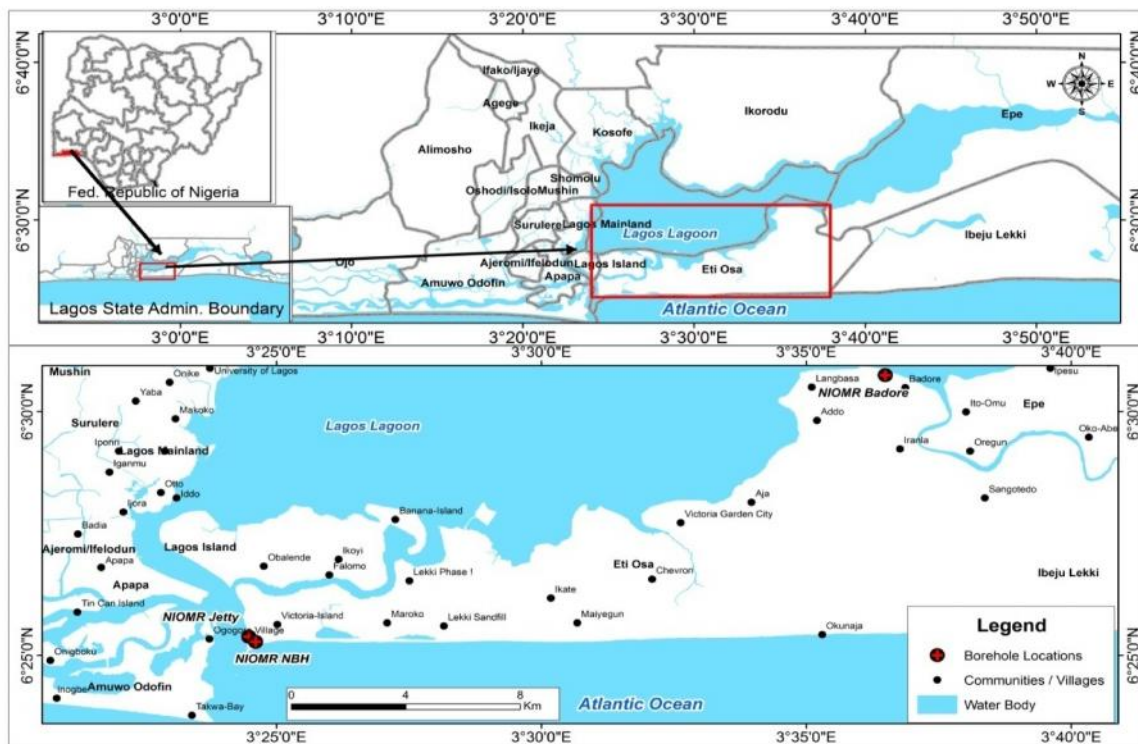

Figure 1: The Location Map of the Study Area Showing the NIOMR Boreholes

Method of Study
Ground water samples for this study were collected from three different locations within the study area. Two of the locations are within NIOMR headquarters in Victoria Island and the other location is in NIOMR outstation in Badore Lagos respectively. Table 1 below shows the various locations where the ground water samples were collected, their geographic coordinates and distances from the shoreline. It also shows the parameters analyzed. The groundwater samples were collected in high density polyethylene bottles prewashed with 1 N hydrochloric acid followed by distilled water and then rinsed two to three times with the sampled water. The collected water samples were transferred to the NIOMR Central Laboratory and kept at 5 °C for further analysis. The samples were filtered using 0.45 μm cellulose

membrane before the analysis. The water samples were subjected to physico-chemical analyses among which are: Iron, pH, Sulphide ion, Total Ammonia, Dissolved Oxygen, Alkalinity, Hardness, Salinity, Colour, Electrical Conductivity, Turbidity, Temperature, Taste, Odour, Total Dissolved Solids, and Nitrate (Table 2). Turbidity was measured with a HACP 400P turbidimeter. Temperature of the groundwater samples was determined using a common mercury thermometer, pH of all the samples were determined directly at the sources with pH meter. Hardness was analyzed by titration with EDTA. Iron was analyzed by AAS technique. The analytical procedures are as documented by the American Public Health Association (APHA 1995).

Table 1: Physico-Chemical Analysis Result of the Groundwater Samples

Water Quality parameter	Niomr-BH Headquarter Coordinates Lat. 06^0 25' 17.6"N Long. 03^0 24' 39.0"E Dist. from Shoreline 6002.84m	Niomr-BH Badore Coordinates Lat. 06^0 30' 3.8"N Long. 03^0 36' 29.9"E Dist. from Shoreline 9420m	Niomr- BH Jetty- Coordinates Lat. 06^0 25' 15.1"N Long. 03^0 24' 26.0"E Dist. from Shoreline 5002.84m	Min	Max	Mean	Std	WHO standard (1993)	Desirable range of water parameter for freshwater fish culture (Chapman, 1996)
Iron (mg/l)	0.2	0.1	0.6	0.1	0.6	0.3	0.22	0.3	<0.5mg/l
Sulphide ion (mg/l)	0.01	0.01	0.01					0.02	<0.1mg/l
P^H	6.0	7.8	6.6	6.0	7.8	6.8	0.75	6.8	6.5-8.5
Total Ammonia(mg/l)	0	0	0					-	<0.02mg/l
Nitrite(mg/l)	0	0	0					-	<0.025mg/l
Dissolved Oxygen(mg/l)	2.0	1.0	1.5	1.0	2.0	1.5	0.41	-	>4mg/l
Alkalinity(mg/l)	48	140	46	46	140	78	43.85	200mg/l	50-400mg/l
Hardness(mg/l)	54	58	68	54	68	60	5.89	100mg/l	50-400mg/l
Salinity(ppt)	0	0	0					0.1ppt	<1.0ppt
Colour	Slightly brownish	Colourless	Brownish					Colourless	Colourless
Electrical Conductivity uScm^{-1}	0.06	0.04	0.05	0.04	0.06	0.05	0.08	1.01 uScm^{-1}	<1500 uScm^{-1}
Turbidity(NTU)	54	40	68	40	68	54	11.43	-	40-80NTU
Temperature (^{o}c)	27	27	27					-	24-32°c
Taste	Tasteless	Tasteless	Tasteless					Tasteless	Tasteless
Odour	Odourless	Odourless	Odourless					Odourless	Odourless
Total suspended solid(mg/l)	8	8	8					10mg/l	80mg/l or less
Total dissolved solid(mg/l)	68	30	77	30	77	61	20.54	500mg/l	80mg/l or less
Nitrate (mg/l)	2	1	2	1	2	1.7	0.47	10	0-3mg/l

RESULTS AND DISCUSSION

Results

The physico-chemical parameters of the ground water samples (Table 1) shows that total Iron concentration ranges from 0.1 to 0.6 mg/l with mean of 0.3 mg/l. The highest value of 0.6 mg/l was recorded at the NIOMR borehole at the Jetty. Here the colour of the water is also brownish probably due to the high iron content. The pH values ranges from 6.0 to 7.8 with mean of 6.8 for the ground water samples.

The turbidity values for the ground water samples ranges from 40 to 68 NTU with mean value of 54 NTU.

Dissolved oxygen (DO) is by far the most important chemical parameter in aquaculture. The dissolved oxygen values for the water samples varied from 1.0 to 2.0 mg/l with a mean value of 1.5 mg/l. This is within the desirable range for fresh water fish culture.

The Electrical conductivity value in the analyzed ground water samples ranges from 0.04 to 0.06 uScm^{-1} with mean value of 0.05 uScm^{-1}.

Total hardness of the ground water samples ranges from 54 to 68 mg/L with mean value of 60mg/L. The sulphide ion values for the various sites are 0.01 mg/L and this is within acceptable range for fish production.

The Alkalinity value of the ground water samples ranges from 4.6 to 140 mEq/L (milliequivalent per liter) with mean value of 78 mEq/L.

The Temperature value for the ground waters is 27^0C and this falls within the desirable range required for fish culture in the tropics

DISCUSSION

Hardness - Water hardness is similar to alkalinity but represents different measurements. It refers to the concentration of divalent cations (calcium,

magnesium, and sodium). It is also expressed as the calcium carbonate equivalent concentration. Hardness may be an index of potential pond productivity. Hardness values of at least 20 ppm should be maintained for optimum growth of aquatic organisms. Low- hardness levels can be increased with the addition of ground agriculture lime. The values in the ground water samples are within the desirable range for fresh water fish culture.

pH. The negative logarithm of hydrogen-ions concentration – a way to measure acidity. It is the scale used and is from 0 to 14, where lower number reflects higher acidity & the higher number reflects higher alkalinity. Acid death point is around 4, alkaline death point is about 11 pH. Toxicity of ammonia to fish increases with an increase in pH. The pH values of all the ground water samples are all within the acceptable range of 6.5 to 8.5 and EU sets protection limit of 6 to 9 for fisheries and aquatic life (Chapman, 1996).

Colour. Waters adversely affected by abnormal concentration of iron tend to be brownish in colour. The colour was slightly brownish, brownish to colourless in the ground water samples respectively. Colour does not affect fish directly it restricts light penetration and reduces productivity especially for earthen pond culture. The high values imply that adequate treatment should be given to water against the abnormal concentration of iron before the water is supplied, though iron content can be treated especially for hatchery management.

The Turbidity values for the ground water samples are below the vlues where fishes show behavioral reaction as turbidity approached 20,000ppm (Gupta and Gupta, 2006).

The Sulphide ion values for the various sites are 0.01 mg/l and this is within acceptable range for fish production.

Dissolved oxygen (DO) is by far the most important chemical parameter in aquaculture. Low-dissolved oxygen levels are responsible for more fish kills, either directly or indirectly, than all other problems combined. Like humans, fish require oxygen for respiration. The amount of oxygen consumed by the fish is a function of its size, feeding rate, activity level, and temperature. Small fish consume more oxygen than do large fish because of their higher metabolic rate. The dissolved oxygen in the water samples is within the desirable range for fresh water fish culture.

Electrical conductivity (EC) is an indicator of the presence of ions and concentrations of dissolved components and has a direct relationship with salinity and TDS which are used for groundwater classification. The EC values in the ground water samples are within the desirable range for aquaculture practice (Table1)..

Alkalinity is the capacity of water to neutralize acids without an increase in pH. Consists of negatively charged bases – carbonates, bicarbonates, and hydroxides. It is expressed in equivalent concentrations of calcium carbonate. Alkalinity offers a buffering system to reduce pH swings. The carbonate buffering system is important to the fish farmer regardless of the production method used. In pond production, where photosynthesis is the primary natural source of oxygen, carbonates and bicarbonates are storage area for surplus carbon dioxide. By storing carbon dioxide in the buffering system. The values in the ground water samples are within the desirable range for fresh water fish culture.

Alikunhi (1957) reported that in highly productive waters, the alkalinity ought to be over 100 mEq/L. However, the range of alkalinity was 0.0 - 2.0 mEq/L for low production, 20 - 40mEq/L for medium production and 40 – 90 for high production (Pandey and Shukla, 2005).

Temperature. After oxygen, water temperature may be the single most important factor affecting the welfare of fish. Fish are cold-blooded organisms and assume approximately the same temperature as their surroundings. The temperature of the water affects the activity, behavior, feeding, growth, and reproduction of all fishes. Metabolic rates in fish double for each 18ºF rise in temperature. The water temperature is within 24-32°c recommended for freshwater fish culture (Chapman, 1996**).**

CONCLUSION

One of the goals of aquaculture is increased fish production within a pond, raceway, or tank. This research work has provided valuable information on the ground water quality status of NIOMR's ground water resources in NIOMR headquarters in Victoria Island and in Badore outstation with respect to their suitability for fish farming. It has also provided background information to the potential fish farmers in coastal Lagos on ground water quality with respect to aquaculture. The quality assessment of the NIOMR waters in Lagos State indicate that all the parameters are within the acceptable range for aquacultural production except for iron content in one of the boreholes where the concentration is about 0.6 mg/l. The high value implies that adequate treatment should be given to the water against the abnormal concentration of iron before the water is supplied.

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