International Journal of Applied and Natural Sciences (IJANS)
ISSN (P): 2319-4014; ISSN (E): 2319-4022
Vol. 7, Issue 1, Dec– Jan 2018; 1-6

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

DETERMINATION OF WATER QUALITY INDEX AND IRRIGATION SUITABILITY OF GROUNDWATER SOURCES IN PARTS OF COASTAL AQUIFERS OF EASTERN NIGER DELTA, NIGERIA

Akakuru, O.C., & Akudinobi, B.E.B

Department of Geological Sciences, Nnamdi Azikiwe University, Awka, Nigeria

ABSTRACT

Determination of water quality index and suitability of groundwater sources in parts of Coastal Aquifers of Eastern Niger Delta Nigeria has been done to ascertain the suitability of the groundwater sources for domestic and agricultural (irrigation) purposes. Forty five (45) water samples were collected within the study area and were subjected to chemical analyses. The results of the investigation revealed that Calcium concentration (mg/l) ranged between 0-0.22, Magnesium concentration (mg/l) ranged between 0.2-4.6, Sodium concentration (mg/l) ranged between 1.2-7.3, Chlorine concentration (mg/l) ranged between 6.0-17.0, Bicarbonate concentration (mg/l) ranged between 17.9-56.3, Arsenic concentration (mg/l) ranged between 0-1.35, Copper concentration (mg/l) ranged between 0 - 0. 95, Iron concentration (mg/l) ranged between 0-0.09, Mercury concentration (mg/l) ranged between 0-0.014, while Lead concentration (mg/l) ranged between 0-0.4. The Water Quality Index (WQI) in the study area was calculated using eight (8) parameters, and it gave an overall WQI value of 509.9,impling that the samples in this study were grossly unsuitable for drinking purposes, based on the WQI standard. From the result of the Sodium Absorption Ratio (SAR), the values of the entire water samples were below 3.5meq/l, indicating predominance of excellent water for irrigation purposes. This study therefore, recommends that the groundwater sources in the study area require treatment before use for domestic purposes, but is suitable for irrigation purposes.

KEYWORDS: *Water Quality Index, Suitability, Sodium Absorption Ratio, Groundwater, Irrigation*

Article History

Received: *8 Dec 2017* **|** ***Revised:*** *13 Dec 2017* **|** ***Accepted:*** *19 Dec 2017*

INTRODUCTION

Groundwater is one of earth's most vital renewable and widely distributed resources, as well as an important source of water supply throughout the world. According to Sodde and Barrocu, (2005) groundwater, accounts for about 98% of the world's fresh water and it is fairly well distributed throughout the world. About two billion people (approximately one- third of the world's population) depend on groundwater supplies, withdrawing about 20% of global water (600 – 700km^3) annually, much of which is from shallow aquifers (Foster *et al.,* 2005). Water quality is of vital concern to mankind, since it is directly linked with human welfare (Balkrishnan *et al.,* 2011). It is regrettable that, rapid urbanization, improper waste disposal and landfill, excessive application of fertilizers and unsanitary conditions have

threatened groundwater quality (Akakuru, *et al.*, 2015). Consequently, human health in many parts of the world has been endangered, by naturally occurring pollutants and anthropogenic pollutants (Akporido, 2008).

Location of the Study Area

The study area comprises parts of Osisioma Ngwa, Isiala Ngwa, Obio Ngwa, Aba North, Omumma LGAs (all in Abia State), Etche LGA (in Rivers State) and Ngor Okpala LGA (in Imo State). It lies between latitudes $5^{o}07^{1}$ to $5^{o}15^{1}$N, and longitudes $7^{o}14^{1}$ to $7^{o}22^{1}$E (Figure 1). It is densely populated, with an average population density of 3500 inhabitants per square kilometer (Adindu *et al.*, 2012). $7^{o}22^{1}$E covering an area of about 169km^{2}. It is densely populated, with an average population density of five thousand, five hundred (5,500) inhabitants (Adindu *et al.*, 2012). The area is a major settlement and commercial centre, in a region that is surrounded by small villages and towns. The indigenous people of the area are well known for its craftsmen.

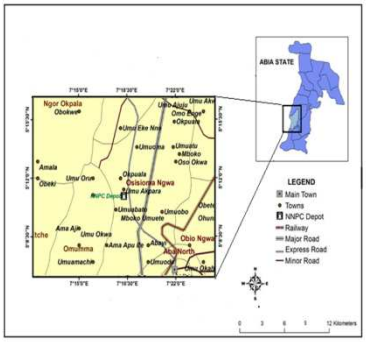

Figure 1: Location Map of the Study Area

Geology and Hydrogeology of the Study Area

The study area is underlain by the Benin Formation (the Coastal Plain-Sands). The major rock types include sands, sandstone, and gravel with clay occurring as lenses. The sand and sandstone are coarse to fine grained partly unconsolidated, with thickness ranging from 0-2100m. The sediments represent upper Deltaic Plain Deposits. The shales are few and they may represent Deltaic Plain Deposits. Nwankwoala, and Ngah (2014) observed that, the Benin Formation is composed mainly of high resistant fresh water bearing continental sands and gravels, with clay and shale intercalations. Akakuru et al., (2013) maintained that, the sandy unit (which constitutes about 95% of the rock in the area) is composed of over 96% of quartz. The porous and permeable sand and inter fingering sandy clay and gravels of the Benin Formation forms a multi-aquifer system in the study area.

Evapo-transpiration is 1000mm, leaving an effective rainfall of 2000 mm. of this effective rainfall, 37% or 750 mm is known to recharge the subsurface aquifers, while the remaining 1250 mm flows directly into the streams (Akpokodje *et al.*, 2005). This recharge which is 75% of the total precipitation is on the high side of the range, commonly reported for unconsolidated sediments (Nwankwoala, and Ngah, 2014). This therefore ensures that, the region is adequately supplied with water. Besides, rain may fall at any time of the year, even during the peak of the dry season, further ensuring an all year round water input into the region.

Methods of Investigation

Water sample collections were done in line with the guidelines of American Public Health Association (1995). To reduce the risk of sample contamination, all water samples were collected in fresh sample containers

(polyethylene plastic cans), which were acid – washed to reduce the effect of interferences between containers and sample. This was done by washing each container with a detergent and rinsing with tap water; re-rinsing with 1:1 nitric acid solution; rinsing with deionised water and air-dried. Before collection, each container was rinsed with the sample to be collected. Samples were labelled and transported to the laboratory in ice-pack cooler kit; samples collected were analyzed within 24 hours of collection. Forty five (45) groundwater samples within the study area were collected. Anions analysed included: Chloride, Bicarbonate, and Sulphate. Cations analyzed included: Calcium, Sodium, Potassium, and Magnesium. Heavy metals analyzed included: Arsenic, Copper, Iron, Mercury, and Lead. Heavy metal analyses were conducted using Varian AA240 Atomic Absorption Spectrophometer, according to the method of APHA, (1995).

RESULTS AND DISCUSSIONS

Water Quality Index (WQI)

The Water Quality Index (WQI) was calculated using the weighted arithmetic index method. The quality rating scale for each parameter (qi) was calculated as:

$$q_i = \frac{C_i}{S_i} \text{x} \frac{100}{1} \quad \textbf{(1)}$$

A quality rating scale (q_i) for each parameter is assigned by dividing its concentration (C_i) in each water sample by its respective standard (S_i) and the result multiplied by 100. Relative weight (Wi) was calculated, by a value inversely proportional to the recommended standard (Si) of the corresponding parameter:

$$\text{Wi} = \frac{1}{S_i} \quad \textbf{(2)}$$

The Water Quality Index (WQI) was calculated by aggregating the quality rating (q_i) with unit weight (W_i) linearly.

$$\text{WQI} = \sum q_i W_i \quad \textbf{(3)}$$

Where: q_i: the quality of the ith parameter, w_i: the unit weight of the ith parameter and

$$\text{Overall WQI} = \frac{\sum q_i W_i}{\sum W_i} \quad \textbf{(4)}$$

For this study, the WQI was calculated using eight (8) important parameters (table 1). It was calculated by using the standards of drinking water quality, recommended by the World Health Organization (WHO, 2003), the result are presented in table 1.

Table 1: Computed WQI Values For the Study Area

Parameter	Ci	Si	qi	wi	qiwi
As	0.137388	0.01	1373.88	100	137388
Ca	0.041862	200	0.020931	0.005	0.000105
Cu	0.026698	2	1.3349	0.5	0.66745
Mg	1.252595	150	0.835063	0.006667	0.005567
Hg	0.00056	0.006	9.333333	166.6667	1555.556
Pb	0.048379	0.01	483.79	100	48379
Cl	9.25	5	185	0.2	37
HCO_3	37.64569	100	37.64569	0.01	0.376457
Summary	**48.40317**	**457.026**	**2091.84**	**367.3883**	**187360.6**

The overall WQI was calculated using equation 4,

Overall WQI = $\frac{187360.6}{367.3883}$ = 509.9

The overall WQI in this study reveals that the groundwater samples are unsuitable for drinking based on the WQI standard (Table 2).

Table 2: Standard Water Quality Classification Scheme Based on WQI Value (Minakshi and Dulal, 2017)

WQI Values	Water Quality Status	Possible Usage
0-25	Excellent	Dinking, Irrigation and Industrial
26-50	Good	Dinking, Irrigation and Industrial
51-75	Poor	Irrigation and Industrial
76-100	Very poor	Irrigation
>100	Unsuitable for drinking	Proper treatment required before use

The percentage of sodium to calcium and magnesium in a soil is thus a measure of the suitability of the soil for irrigation. Sodium Adsorption Ratio (as described by the Richards, 1954; Akakuru *et al.*, 2015), has been evaluated for this study using the relevant chemical parameters analyzed. The distribution of the SAR in the study area is presented in Figure. 2

$$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^{2+}] + [Mg^{2+}]}{2}}} \quad \textbf{(5)}$$

where: $[Na^+]$= sodium concentration (in meq/l)

$[Ca^{2+}]$ = calcium concentration (in meq/l)

$[Mg^{2+}]$ = magnesium concentration (in meq/l)

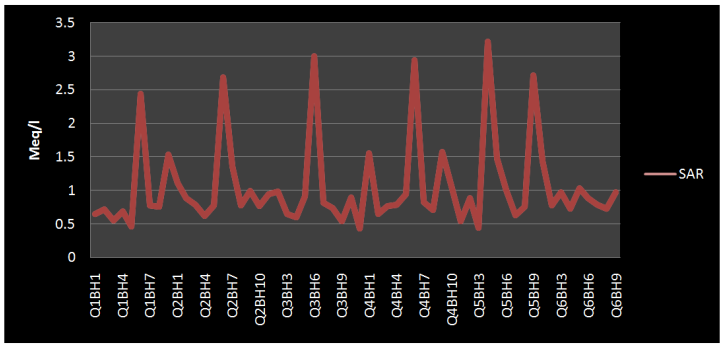

Figure 2: Sodium Absorption Ratio (SAR) Values in the Water Samples

From the result as presented in Figure 2, the values of the entire water samples were below 3.5meq/l, indicating predominance of excellent water for irrigation purposes in accordance with recommended standard (Table 3).

Table 3: Recommended Irrigation Water Classification (Offodile, 2002)

SAR	Water Class
<10	Excellent, No Problem
10-18	Good (Medium) Increasing Problems
18-26	Poor (High) Sever Problem

CONCLUSIONS

Determination of water quality index and suitability of groundwater sources in parts of Coastal Aquifers of Eastern Niger Delta Nigeria has been done. The results of the investigation reveal certain attributes; the concentrations of Calcium, Magnesium, Sodium, and Potassium in the study area are below the WHO (2011) standard and also, they are not of health concern at levels found in drinking water. Bicarbonate and Sulphate concentrations in the study area are below the WHO (2011) standard, while Chlorine was above the recommended standard, but are not of health concern at levels it was found in drinking water. Arsenic, Copper, Mercury and Lead concentrations in the study area are above the WHO (2011) standard and require pre-use treatment before use, because of the associated health concerns. The overall WQI in the study area is 509.9. This implies that the samples in the in this study are grossly unsuitable for drinking based on the WQI standard. From the result of the SAR, the entire water samples fell below 3.5meq/l, indicating predominance of excellent water for irrigation purposes in accordance with recommended standard. This suggests that the groundwater sources in the study area require treatment before use for domestic purposes, also that the groundwater is very good for irrigation purposes.

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