

Water Quality Index for the Assessment of Selected Borehole Water Quality in Rivers State

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ABSTRACT

Water quality of different locations in River state, Nigeria was evaluated using Water Quality Index (WQI) approach to assess the suitability of water from three local government areas in Rivers State. The study revealed that WQI was determined by the following parameters: pH, Temp, EC, BOD, Chloride, Sulphate, Calcium, Magnesium, Phosphate, Total Hardness, Nitrate, Pb Calcium, Cd, Cu, and Fe. The result obtained indicated that the water quality index of borehole water exceeded the status of water quality in all sampling locations due to groundwater contamination, making the water unsafe for human and animal consumption. Residents within the State should be enlightened on the adverse effect of drinking polluted water and the need for water treatment before consumption.

Keywords: Groundwater, Quality Water Index.

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I. INTRODUCTION

There are two zones in the underground waters, the vadose and ground water zones, not all underground water are ground water. Ground water whose pressure is less than atmospheric is vadose water while underground water whose pressure is greater than atmospheric is groundwater [11]. Ground water is the major source of drinking water, irrigation, and other domestic activities such as washing, bathing etc. in the Niger Delta region of Nigeria. Groundwater is of abundance and readily available in the abovementioned part of Nigeria, however, the quality of borehole water cannot be visually ascertained unless it is analyzed in the laboratory and compared with relevant standards like WHO and NSDWQ. The activities of human beings can alter the underground water quality during any of the stages of hydrologic or water cycle which comprises of precipitation, surface run-off, infiltration, percolation, evaporation, and transpiration. Infiltration of water through underground rocks, soil may pick- up natural contaminants even with no human activity or pollution in the area. Improper waste management such as indiscriminate dumping of hazardous waste (chemicals, used batteries, paints etc.) in an un-engineered landfill can deter the quality of borehole water. Increase in population density results in rapid increase in the volume of waste generated which may cause serious pollution of underground water [13].

The importance of water cannot be over-emphasized as it plays a significant role in enhancing human life, animal, and

plants but if polluted it can be detrimental posing adverse health effect. The study aimed at assessing the selected borehole water in Rivers state using water quality index (WQI) approach [4].

II. MATERIAL AND METHODS

A. Study Area

Obio/Akpor, Etche and Omuma local government areas are located in Rivers State, Nigeria. The sampling location coordinates are given below in Table 1. The average annual Temperature of the study area was 26.4 °C.

TABLE 1: GEOGRAPHICAL COORDINATES OF THE STUDY LOCATIONS

Sampling Locations	Latitude	Longitude
Obio/Akpor (EC1)	4.876556 °N	6.920874°E
Etche (EC2)	5.0382°N	7.050636°E
Omuma (EC3)	5.087575°N	7.231772°E

B. Sample Collection

Borehole water samples were taken from different locations within Rivers State. The physical. Chemical and heavy metals were analyzed in line with American Public Health Association [3].

C. Water Quality Index Calculation

The WQI was calculated using standards of drinking water quality recommended by the World Health Organization (WHO) and Nigeria Standard of Drinking Water Quality (NSDWQ). The weighted Arithmetic index

method [4] was used for the calculation of WQI in this study. Further, quality rating or sub index was calculated using the following expression.

$$q_n = 100[V_n - V_i]/[S_n - V_i] \quad (1)$$

(Let there be n water quality parameters and quality rating (q_n) corresponding to n th parameter is a number reflecting relative value of this parameter in the polluted water with respect to its standard permissible value).

q_n – Quality rating for the n th water quality parameter.

V_n – Estimated value of the n th parameter at a given water sampling station.

S_n – Standard permissible value of the n th parameter

V_i – Ideal value of n th parameter in pure water (i.e., 0 for all other parameters except the parameters pH and Dissolve oxygen [7.0 and 14.6 mg/l respectively]).

The unit weight was calculated by a value inversely proportional to the recommended standard value S_n of the corresponding parameter.

$$W_n = k / S_n \quad (2)$$

where

W_n – unit weight for n th parameter.

S_n – standard permissible value for n th parameter.

k – proportionality constant ($K=1.85445$).

The overall WQI is calculated by the following equation.

$$WQI = \sum q_n W_n / \sum W_n \quad (3)$$

III. RESULTS AND DISCUSSION

Borehole water samples were analyzed to ascertain the extent of ground water pollution. Results were compared with Nigeria Standard for Drinking Water Quality [8] and World Health Organization [14] to determine if it is good for human consumption. The most important physicochemical and heavy metals parameters such as pH, Temperature, Turbidity, Electrical Conductivity (EC), Biological Oxygen Demand (BOD), Chloride, Sulphate, Calcium, Magnesium, Phosphate, Total Hardness, Nitrate, Lead (Pb), Cadmium (Cd), Copper (Cu), and Iron (Fe). borehole water samples were taken at three sampling locations within Rivers State (Obio-Akpor (EC1), Etche (EC2) and Omuma (EC3) Local Government Areas).

A. pH and Temperature

Water samples in all locations were acidic with pH values not within the WHO and NSDWQ permissible range. Results from the study area reveals that Temperature for all sampling locations exceeded the acceptable limit of 25 °C for domestic water, which indicated the presence of foreign bodies like an active micro-organism [9], [1].

B. Copper

Values obtained showed that copper concentration are less than 0.2 mg/l were observed in all the locations, however, all the values were below the permissible limit as specified by WHO and NSDWQ. The presence of excess

copper in water can result to gastrointestinal disorder when exposed to it for long period.

C. Lead

Among the heavy metals, lead is the most significant because it is very toxic and harmful even in small concentration [9], it can harbor in the body tissue causing harm to humans such as cancer, brain damage, mental deficiencies, even death [5]. Concentrations of lead were 0.001mg/l in all locations, which indicated that all samples did not exceed the permissive range of 0.01mg/l according to WHO and NSDWQ.

D. Iron

Iron is known as dark-grey in coloration when in pure form and exists in groundwater as ferric Hydroxide [7]. The concentration of iron in the results obtained were less than 0.1 mg/l for all locations, which is within the permissible limit of 0.3mg/l as specified by WHO. Concentration above the permissible range may be as a result of weathering of minerals and rocks of Iron in the soil, and dissolution of iron natural deposit in groundwater bodies through leaching. Consumption of water containing high concentration of Fe can cause diabetes, mellitus, liver damage, arteriosclerosis, and other diseases [12] and its toxic even at lower concentration.

E. Cadmium

The presence of cadmium in ground water occurred when it comes in contact with soil contaminate with discharges from fertilizer industries, paint, petroleum hydrocarbon through leaching. High level of cadmium results to agonistic and antagonistic effects on hormones and enzymes causing several health problems such as kidney failure, cancer etc. [6], [9]. The concentration of Cd in the study areas are within the WHO and NSDWQ acceptable range.

F. Electrical Conductivity

EC is the ability of a substance to conduct electric current. This ability depends on the presence of ions, their total concentration mobility, valence, relative concentration and on the temperature. Pure water is not a good conductor of electric current, increase in ion concentration enhances the electrical conductivity of water. The amount of dissolved solids in water determines electrical conductivity. The result indicated the EC value were 114.0 μ /cm, 9 μ /cm and 7.9 μ /cm for EC1, EC2 and EC3 respectively, this result clearly indicates that water in the study area was not considerably ionized and has lower level of ionic concentration activities.

G. Nitrate

Nitrate is one of the importance diseases causing parameters of water quality. The sources of nitrate are nitrogen cycle, industrial waste, nitrogenous fertilizer etc. The maximum WHO drinking water limit for nitrate is 10mg/l, results from the study areas reveals that the concentration of nitrate in the study areas are 0.631 mg/l, 0.895 mg/l and 1.58 mg/l for EC1, EC2 and EC3, respectively. Values indicated that the Nitrate concentration is within the WHO permissive range.

H. Chloride

Chloride is also an important parameter surface water bodies often have low concentration of chloride as compared to groundwater. High concentration of chloride damages metallic pipes and structures, as well causes harm to growing plant through irrigation. Concentration of chloride should not exceed 250 mg/l. Chloride values are 3.04 mg/l, 8.11 mg/l and 5.22 mg/l, which indicated that the concentration of Chloride is within the WHO and NSDWQ Permissible range.

I. Total Hardness

Total hardness of water is determined by the presence of soluble salts of calcium, magnesium and other heavy metals dissolved in it. Values obtained are within WHO permissive range of 300 mg/l.

J. Turbidity

Turbidity in drinking water is caused by particulate matter that may be present from sources of water as a result of filtration or from resuspension of sediment in the distribution system. The study revealed that turbidity values of EC1, EC2 and EC3 are within the permissible range of drinking water standard.

K. TDS

The presence of TDS is an indication of saline water which can be as a result of discharge from industrial treatment plants causing soil contamination leaching effect [2]. The implication of high TDS is reduction in performance of pipes, filters, and valves due to scale accumulation. Values obtained showed that TDS in all locations are 6.003 mg/l, 76.04 mg/l and 42.06 mg/l, which indicated that TDS values are within the WHO and NSDWQ permissible range of 500 mg/l.

L. BOD

BOD gives a measure of oxygen requirement for biodegradation of carbonaceous matter in water

Sample. The BOD values for all sample point are within the acceptable range of 10 mg/l.

M. DO

Dissolved oxygen values for all samples exceeded the WHO and NSDWQ permissible range of 2 mg/l and 5 mg/l respectively, the increase of DO may be due to the degree of pollution by organic substance as well as self-purification capacity of the water body.

N. Phosphate and Sulphate

The concentration of phosphate in all samples was within the permissible range. Phosphates are mostly from fertilizer, industrial cleaning, pesticides while the natural sources include Phosphate containing rock and solid or liquid wastes. Natural water contains sulphate ions and most of these ions are soluble in water. Sulphate concentration in all samples lies within the acceptable limit.

O. Magnesium and Calcium

Magnesium is usually associated with calcium in all kinds of water, Magnesium is essential for Chlorophyll growth and acts as a limiting factor for the growth of phytoplankton,

the depletion of Magnesium reduces the number phytoplankton's population. The amount of calcium in natural water depends on the type of rock. Little concentration of calcium is beneficial in reducing the corrosion in water pipes, the concentration of magnesium in all samples are within the permissible range 75 mg/l while concentration of calcium in EC1 and EC2 samples exceeded the acceptable standard of WHO and NSDWQ as shown in Table 2.

TABLE 2: THE PHYSICO-CHEMICAL PARAMETERS OF SELECTED BOREHOLE WATER SAMPLES AT THREE LOCATIONS

Parameters	EC1	EC2	EC3	WHO, 2011	NSDWQ, 2015
pH	4.1	4.8	4.7	6.5-8.5	6.5-8.5
Temp	28.5	28.4	27.8	25	-
Turbidity	0	1.63	0.5	5	5
EC	9	114	79	1000	1000
TDS	6.003	74.04	42.06	500	500
DO	6.5	7.5	7.4	2	5
BOD	4.9	4.06	5.02	10	-
Chloride	3.04	8.11	5.22	250	250
Sulphate	0.001	0.001	0.001	100	100
Calcium	0	192	90	75	75
Magnesium	0	8	23	30	-
Phosphate	0.001	0.001	0.001	0.1	-
Total Hardness	0	200	184	300	-
Total Alkalinity	4	18	7	200	-
Nitrate	0.631	0.895	1.58	50	50
Pb	0.001	0.001	0.001	0.01	0.01
Cd	0.001	0.001	0.001	0.003	0.003
Cu	0.099	0.12	0.53	2	-
Fe	0.001	0.001	0.042	0.3	-

P. Total Alkalinity

Alkalinity is a measure of the buffering capacity to assess the water quality [10]. Results obtained in the study areas are within the WHO permissible range of 200 mg/l.

TABLE 3: CALCULATED WATER QUALITY RATING (QN) OF SELECTED BOREHOLE WATER AT THREE LOCATIONS

Parameters	EC1	EC2	EC3
pH	173.33	146.67	153.33
Temperature	114	113.6	111.2
Turbidity	0	32.6	10
EC	0.9	11.4	7.9
TDS	1.2	15.21	8.41
DO	64.28	56.35	57.14
BOD	49	40.6	50.2
Chloride	1.22	3.24	2.09
Sulphate	0.003	0.003	0.003
Calcium	0	256	120
Magnesium	0	26.7	76.7
Phosphate	1	1	1
Total Hardness	0	66.67	61.33
Total Alkalinity	2	9	3.5
Nitrate	1.26	1.79	3.16
Pb	10	10	10
Cd	33.3	33.3	33.3
Cu	4.95	6	26.5
Fe	0.33	0.33	14

TABLE 4: CALCULATED UNIT WEIGHT (WN) OF BOREHOLE WATER SAMPLE AT THREE LOCATIONS

Parameters	WHO,2011	NSDWQ,2015	Unit Weight (WN)
pH	6.5-8.5	6.5-8.5	0.218
Temperature	25	-	0.074
Turbidity	5	5	0.371
EC	1000	1000	0.002
TDS	500	500	0.004
DO	2	5	0.927
BOD	10	-	0.185
Chloride	250	250	0.007
Sulphate	100	100	0.019
Calcium	75	75	0.025
Magnesium	30	-	0.062
Phosphate	0.1	-	18.54
Total Hardness	300	-	0.006
Total Alkalinity	200	-	0.009
Nitrate	50	50	0.037
Pb	0.01	0.01	185.445
Cd	0.003	0.003	618.15
Cu	2	-	0.927
Fe	0.3	-	6.181

TABLE 5: CALCULATED WATER QUALITY INDEX (WQI) FOR BOREHOLE WATER SAMPLES AT THREE SAMPLING LOCATIONS

Sampling Locations	Water Quality Index
EC1	456.773
EC2	830.463
EC3	749.763

TABLE 6: STATUS OF WATER QUALITY BASED ON WQI [15]

Water Quality Index	Status
0-25	Excellent
26-50	Good
51-75	Bad
76-100	Very Bad
100 and above	Unfit

IV. CONCLUSION

The study revealed that borehole water samples collected at three sampling locations EC1, EC2, and EC3 were unsafe for human and animal consumption. Water samples in all sampling locations were acidic with pH.

Dissolved oxygen, temperature, and calcium values not within WHO and NSDWQ permissible range of drinking water standard which demeaned the quality of the water while Turbidity, TDS, BOD, Chloride, Sulphate,

Magnesium, Phosphate, Total Hardness, Total Alkalinity, Nitrate, Pb, Cd, Cu and Fe were within the WHO and NSDWQ permissible limit. The study revealed that water quality index values were above the status of water for human and animal consumption. Residence of Rivers state should be enlightened on the adverse effect of drinking polluted water and the need for water treatment before consumption.

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