ASSESSMENT OF WATER QUALITY INDEX FOR BOREHOLES WATER FROM ISOKO NORTH LGA, DELTA STATE NIGERIA

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ABSTRACT

The assessment of the water quality index of boreholes water in the Isoko-North Local Government Area, Delta State, Nigeria, was carried using standard laboratory test procedures (ASTM). Assessed water quality parameters (pH, Electrical Conductivity, Turbidity, Total Dissolved Solids, Total Hardness, Bicarbonate, Carbonate, Chloride, Sulphate, Phosphate, Nitrate, Fluoride, Calcium, Magnesium, Sodium, Potassium, Iron and Total Coliform) were used to determine the water quality index values. The findings recorded indicated that the water quality index (WQI) at Ozoro1 were 34.90 (dry), and 35.3 (wet); Ozoro 2, 31.20 (dry), 43.90 (wet) and Ofagbe, 29.10 (dry), 41.90 (wet); were good and uninfluenced by season. Statistical analysis revealed no significant difference ($p>0.05$) in WQI values for both seasons. However, (WQI) values at Otibio, Erawah, Ovrode, and Otor-igho were largely influenced by season, hence decreasing the overall quality of water due to the influence of contaminants present in them. Statistical analysis revealed a significant difference ($p<0.05$) in WQI values for both seasons. Also it was observed that, the quality of borehole water is influenced by season, anthropogenic, and natural events within the study area. It is recommended that natural events such as floods should be properly managed to prevent groundwater pollution, while water from these boreholes should be subjected to primary water treatment processes before use.

Keywords: water quality index, Isoko-north, borehole water, groundwater

INTRODUCTION

The current state of affairs of the nation's deteriorated and non-availability of pipe-borne water in Nigeria, has left more than half the population with no other choice than being dependent on privately dug boreholes (many of which are improperly constructed) (Osinbajo and Majolagbe, 2012).
For many, including Adeyi and Majolagbe (2014), this trend is fostered by many factors including lack of proper urban planning by the government, inadequate and erratic water supply by the government water works as well as urbanization.
Water remains an essential component of life serving various human needs. As it regards human health, water is vital to ensuring healthy living (Adeyi and Majolagbe, 2014). Aside from human health, water is also needed for domestic and agricultural practices. However, current events of both natural and anthropogenic origin have impacted greatly on the water bodies causing some levels of groundwater contamination; owing to the leaching of contaminants (Mahananda *et al.*, 2010).

Results from these actions had been seen visually to caused changes to groundwater (boreholes) quality which is thoughtful as the most reliable source of drinking water.

In Delta state, specifically within the Isoko-North Local Government area where industrial activities as well as natural events such as flooding are rampant and liable to cause possible water quality damage. Inhabitants rely mainly on boreholes, vented water; and depending on the financial class, hand-dug wells as sources for drinking water and other domestic activities (Oko *et al.*, 2014).

Currently, there are no much industrial activities in and around the study area, but natural events including flooding, household wastes, and municipal sewage are likened as factors that may promote environmental pollution. Additionally, borehole water sources are susceptible to contamination due to rainfall washouts, slaughterhouse activities, pesticides, excreta, and various organic wastes. The quality of borehole water is vital. Amadi *et al.*, (2020) and Ishaku *et al.*, (2020) highlighted that groundwater quality plays a major role in the health of the receiving population. One sure way through which the quality of borehole water can be ascertained is through the study and adoption of a water quality index (Dwivedi and Pathak, 2007).

Water quality index is an arithmetic value that is used to depict the quality of water. It is obtained from the assessment of a large number of water quality parameters to report the current state of water within a place (Barti and Kartyal, 2011; Oko *et al.*, 2014).

To the best of our knowledge, there is absent proof that the water quality indexes exists in the study area creating a major doubt on water quality and its likely effect. Hence, it is important to apply the water quality index to understand the overall water quality status of borehole water resources (Olasoji *et al.*, 2019). The aim of this work is to determine the relevant physicochemical properties of the groundwater with the view to establish the base water quality indexes of boreholes water in the Isoko-North Local Government Area of Delta State, Nigeria.

MATERIALS AND METHODS

The study area is a local government area within Delta State and lies between latitude 5.5919^{O}N and longitude 6.2164^{O}E. Isoko-north is home to major towns including Ozoro, Ellu, Emevor, Otor-Owhe, Owhellegbo, Ofagbe, Ovrode, Otor-Igho, Igbuku-Owhe and Erawha characterized by two climatic seasons (wet and dry season). During the wet seasons (between April and October), this area usually experienced high water table levels and seasonal flooding in many of its villages.

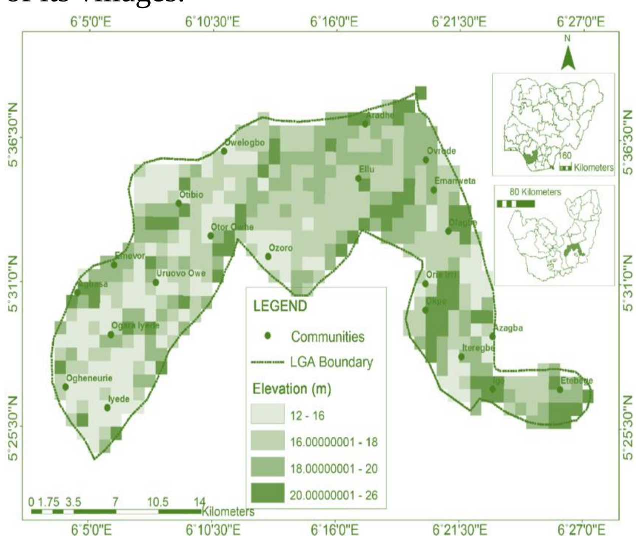

Fig 1: Map of the Study Area. Source: (Stockphoto 2023).

The water quality index of boreholes within the study area was obtained using water quality parameters including pH, Electrical Conductivity, Turbidity, Total Dissolved Solids, Total Hardness, Bicarbonate, Carbonate, Chloride, Sulphate, Phosphate, Nitrate, fluoride, Calcium, Magnesium, Sodium, Potassium, Iron and Total Coliform. These parameters were selected because of the availability of equipment for the test in the study area. This was done by collecting groundwater samples by the standard procedure mentioned in the Drinking Water Test Specification (DWTS), 2019). Boreholes water samples were assessed using standard test procedures. pH, Temperature, and Total iron concentration were determined using the American Society for Testing and Material method (ASTM-1293B and ASTM D6785). Turbidity, Total dissolved solids, and Electrical conductivity were measured using an appropriate digital laboratory meter. Carbonate, Bicarbonate, Total hardness, Magnesium, Sodium, Phosphate, Fluoride, Calcium, and Nitrate were by titration method. While Total coliform was determined using APHA 9222A1 (American Public Health Administration (APHA), 1992).

Calculation of Water Quality Index

The calculation of WQI is made by using the following equation.

$$Water\ Quality\ Index\ (\boldsymbol{WQI}) = \frac{\sum Q_i W_i}{\sum W_i}$$

Unit Weight (W_i); $W_i = \frac{k}{S_i}$

Where; $K = \frac{1}{\sum \frac{1}{S_i}}$

Water Quality Scale (Q_i); $Q_i = \frac{V_i - V_o}{S_i - V_o}$

V_i = Estimated concentration of the i^{th} parameter of interest in the analyzed water

V_o = The ideal value of the ith parameter in pure water

V_o = 0(except pH = 7.0 and Do = 14.6mg/l

S_i = Recommended standard value of the ith parameter

Source: Adeyi and Majolagbe (2014)

RESULTS AND DISCUSSIONS

Table 1a: Physicochemical properties of boreholes water in Isoko North

Parameters	Season	Ozoro1	Ozoro2	Otibio	Erawah	Ovrode
pH	Dry	3.76	4.27	4.35	5.3	3.76
	Wet	4.56	6.93	4.6	6.1	5.7
EC (uS/cm)	Dry	113	156	19	128	19
	Wet	289	438	68	147	59
Turbidity (NTU)	Dry	0.65	0.92	1.48	7.54	1.19
	Wet	0.78	0.83	2.84	6.54	1.19
TDS (mg/L)	Dry	116	132	44	187	33
	Wet	98	132	44	106	23
Total Hardness (mg/L)	Dry	18	21	8	46	5
	Wet	18	56	12	12	19
Bicarbonate (mg/L)	Dry	3.1	4.88	9.76	19.52	3.05
	Wet	21.24	12.2	11.95	17.08	19.52
Carbonate (mg/L)	Dry	0	0	0	0	0
	Wet	0	0	0	0	0
Chloride (mg/L)	Dry	37.75	39.7	11.9	61.54	9.93
	Wet	44.65	56.49	7.96	17.81	9
Sulphate (mg/L)	Dry	4.02	5.1	2.45	11.59	1.97
	Wet	2.24	5.62	0.85	2.42	1.45
Phosphate (mg/L)	Dry	0.002	0	0.001	0.007	0.003
	Wet	0.001	0.001	0.001	0.007	0.003
Nitrate (mg/L)	Dry	1.17	1.63	0.99	0.81	0.55
	Wet	0.61	1.04	0.19	0.53	0.11
Fluoride (mg/L)	Dry	0.07	0.12	0.04	0.15	0.008
	Wet	0.11	0.28	0.08	0.1	0.13
Calcium (mg/L)	Dry	4.93	6.75	2.39	12.33	1.49
	Wet	9.62	15.65	3.15	3.21	4.24
Magnesium (mg/L)	Dry	1.64	2.96	0.79	5.07	0.63
	Wet	3.11	4.02	1.11	1.11	1.34
Sodium (mg/L)	Dry	18.28	17.54	9.37	29.74	6.01
	Wet	35.58	53.31	5.88	14.63	8.12
Potassium (mg/L)	Dry	0.41	0.56	0.23	1.1	0.18
	Wet	1.93	1.48	0.12	0.87	0.37
Iron (mg/L)	Dry	0.21	0.18	0.19	0.18	0.16
	Wet	0.19	0.16	0.27	0.24	0.23
Total Coliform (mg/L)	Dry	0	0	0	0	0
	Wet	0	0	0	0	0

Table 1b: Physicochemical properties of boreholes water in Isoko North

Parameters	Season	Otor igho	Igbuku	Ofagbe	Owhe	Emevor	Ellu
pH	Dry	3.56	4.41	4.41	3.48	4.31	3.54
	Wet	5.8	5.4	5.6	5.12	4.92	4.88
EC (u S/cm)	Dry	28	23	40	27	28	23
	Wet	38	61	45	83	76	93
Turbidity(NTU)	Dry	2.83	1.29	0.67	0.77	0.94	0.68
	Wet	3.98	3.27	1.76	2.79	1.94	3.68
TDS (mg/L)	Dry	39	39	60	28	49	50
	Wet	26	31	56	23	50	50
Total Hardness (mg/L)	Dry	10	8	8	6	7	9
	Wet	10	11	11	20	23	12
Bicarbonate (mg/L)	Dry	10.4	9.76	2.3	4.25	4.9	6
	Wet	12.2	12.2	12.2	10.64	11.01	7.32
Carbonate (mg/L)	Dry	0	0	0	0	0	0
	Wet	0	0	0	0	0	0
Chloride (mg/L)	Dry	10.92	12.75	17.87	8.94	14.88	16.4
	Wet	7.51	8.45	7.84	18.5	23.2	21.76
Sulphate (mg/L)	Dry	1.29	1.73	3.29	1.49	2.81	2.45
	Wet	0.77	1.47	1.41	1.65	0.75	1.72
Phosphate (mg/L)	Dry	0.001	0.03	0.012	0.001	0.002	0.003
	Wet	0.005	0.03	0.01	0.003	0.004	0.005
Nitrate (mg/L)	Dry	0.3	0.15	0.59	0.2	0.38	0.42
	Wet	0.05	0.11	0.08	0.14	0.09	0.41
Fluoride (mg/L)	Dry	0.005	0.008	0.11	0.07	0.15	0.09
	Wet	0.01	0.06	0.01	0.04	0.1	0.14
Calcium (mg/L)	Dry	2.98	3.24	2.36	1.75	2.04	2.43
	Wet	3.01	3.21	3.02	4.22	3.2	4.01
Magnesium (mg/L)	Dry	1.07	1.27	0.89	0.59	0.66	0.81
	Wet	1.19	1.05	0.77	2.27	2.37	1.79
Sodium (mg/L)	Dry	6.87	7.71	10.11	5.56	9.68	10.92
	Wet	5.12	6.06	6.62	8.5	5.3	9.76
Potassium (mg/L)	Dry	0.2	0.25	0.31	0.16	0.15	0.27
	Wet	0.15	0.31	0.14	1.08	0.05	0.49
Iron (mg/L)	Dry	0.11	0.39	0.17	0.11	0.23	0.16
	Wet	0.24	0.22	0.22	0.14	0.11	0.14
Total Coliform (mg/L)	Dry	0	0	0	0	0	0
	Wet	0	0	0	0	0	0

Table 2. Water quality parameter for different seasons in Isoko-North

Parameters	Unit	Dry	Wet	WHO	SON
pH		4.10	5.42	6.5 - 8.5	6.5 - 8.6
EC	µS/cm	54.91	127.00	Ns	1000
Turbidity	NTU	1.72	2.69	5	5
TDS	mg/L	70.64	58.09	1000	500
Total Hardness	mg/L	13.27	18.55	500	150
Bicarbonate	mg/L	7.08	13.41	Ns	Ns
Carbonate	mg/L	0.00	0.00	Ns	Ns
Chloride	mg/L	22.05	20.29	250	250
Sulphate	mg/L	3.47	1.85	250	100
Phosphate	mg/L	0.01	0.01	Ns	Ns
Nitrate	mg/L	0.65	0.31	50	50
Fluoride	mg/L	0.07	0.10	1.50	1.50
Calcium	mg/L	3.88	5.14	Ns	75
Magnesium	mg/L	1.49	1.83	Ns	20
Sodium	mg/L	11.98	14.44	200	200
Potassium	mg/L	0.35	0.64	Ns	Ns
Iron	mg/L	0.19	0.20	0.3	0.3
Total Coliform	mg/L	Nd	Nd	Nd	Nd,
WQI		43.74	33.00		

Ns = Not stated

Nd = Not detected

pH value

The pH scale measures the concentration of hydrogen ions and it displays concentration levels ranging from 1 to 14. pH below 7 is regarded as an acidic point, pH 7 is the neutral point while pH above 7 is alkaline. The average pH of water samples in this study ranges between 4.1 in the dry season to 5.4 in the wet season, which indicates that the water is acidic and values are not within the WHO standard of (6.5-8.5). Statistical analysis reveals a significant difference (<0.05) between pH values for both seasons.

Electrical conductivity (EC):

Electrical conductivity measures the ability of water to conduct electric current. It is an indication of dissolved ions in the water. The obtained values of the water samples range from 54.91 µS/cm (dry season) to 127 µS/cm (wet season) respectively which is far lower than the WHO permissible limit, hence the water is safe for drinking and other domestic use considering only the EC.

Turbidity:

This measures the suspension of particles in a water sample that interferes with the passage of light. The obtained mean values of 1.72 NTU (dry season) and 2.69 NTU (wet season) which is within the WHO permissible limit. Hence, the water is safe for drinking.

Total dissolved solid:

The concentration level across all sampled locations were significantly below the allowable value by the WHO (2003) of 1000 mg/L.

Total hardness:

Water hardness measures the ability of water to cause precipitation of insoluble calcium and magnesium salts of higher fatty acids from soap solution. The average values of 13.27 mg/L (dry season) and 18.55 mg/L (wet season) are below the WHO permissible limit. Sawyer and Mc Carty's (1967) classification of water hardness showed that the boreholes water is soft (0 -75 mg/L) and also fit for drinking and other domestic uses.

Table 3. Classification of water hardness

Hardness as $CaCO_3$ (mg /L)	Water Quality
0 - 75	Soft
75 - 150	Moderately hard
150 - 300	Hard
Above 300	Very hard

Chlorides:

The average chloride content was 22.05 mg/L (dry season) and 20.29 mg/L (wet season) which is found within the permissible limit of 250 mg/L of WHO (2003). These water samples would be regarded as potable and suitable for domestic use.

Sulphate:

The mean value of sulfate shows 3.47 mg/L and 1.82 mg/L for dry and wet season respectively. This shows that the concentration was within safe limits of 250 mg/L (WHO, 2003).

Phosphate:

The level of phosphate detected was considerably low, and within the WHO standard and which suggests that the water from these boreholes was safe for drinking.

Nitrate:

The presence of nitrate in borehole water inmost times, is an indication of contamination of groundwater. Since nitrate is the final product of biochemical oxidation of ammonia, it is important to study its content in water. It has adverse effects on the health of human and animals generally. Nitrate values obtained in the study, ranged between 0.65 mg/L and 0.31 mg/L in dry and wet seasons respectively which was below the permissible limit of 50 mg/L (WHO, 2003). The water is therefore safe for drinking.

Fluoride:

The Fluoride test is often used to assess the quality of boreholes water because its intake presents both benefits and disadvantages. Fluoride intake is essential for dental care in human but exceeding intake could cause tooth enamel and skeletal fluorosis (WHO, 2003). The fluoride levels in the water were recorded to be 0.07 mg/L (dry season) and 0.10 mg/mL (wet season) which was below the allowable concentration level of 1.5 mg/L (WHO, 2003). This shows that the water was safe for drinking.

Calcium, Sodium, Potassium, and Magnesium concentrations

The concentration of Calcium, Sodium, Potassium, and Magnesium in the water samples were within allowable concentration which means the water is potable and suitable for domestic use.

Iron:

The iron concentration ranged between 0.19 mg/L (dry season) and 0.40 mg/L (wet season). These values were within the WHO standard of 0.3 mg/L except that high value (2.4 mg/L) obtained at Igbuku site

Table 4. Rating of Water Quality Index

Values	Result
0 – 25	Excellent water quality
26 – 50	Good water quality
51 – 75	Poor water quality
76 – 100	Very Poor water quality
Above 100	Unsuitable for drinking purposes

Source: Balamurugan *et al.*, (2020)

Table 5. Water quality index for different locations in Isoko-North

Location	Dry	Result	Wet	Result
Ozoro1	34.97	Good	35.3	Good
Ozoro2	31.21	Good	43.94	Good
Otibio	33.91	Good	57.97	Poor
Erawah	43.88	Good	62.56	Poor
Ovrode	22.09	Excellent	52.97	Poor
Otor	9.63	Excellent	57.45	Poor
Igbuku	84.63	Very Poor	49.78	Good
Ofagbe	29.17	Good	49.11	Good
Owhe	7.92	Excellent	27.1	Good
Emevor	44.46	Good	18.08	Excellent
Ellu	21.12	Excellent	27.47	Good

Table 4: Analysis Result on Significant Difference between Average Result on Water Quality Parameters

Source of Variation	*F*	*P-value*	*F crit*
Between Groups	0.22	0.64127	4.130018

The water quality index is a sure data to convey information on the quality of both surfaces and groundwater. The water quality index provides information on a rating scale from zero to hundred. The lower value of WQI indicates better quality of water and the higher the value of WQI the poor water quality could be. The overall assessment of water quality using the afore-mentioned indexes revealed that the water quality at Ozoro (1 and 2) and Ofagbe was good and remains unchanged for both seasons. However, water quality at Otibio, Erawah, Ovrode, and Otor decreased from good to poor and varied with the seasons. As for other assessed locations (Ellu, Owhe) water quality depreciated was also observed due to contamination of the water reservoirs by both natural and human activities. Whereas, improved water quality was observed for Emevor which may be due to borehole water treatment. This result is supported by a report from a study by Teame and Zebib (2016) in which the electrical conductivity of water was lower in the dry season (233 - 367µS/cm) compared to the wet season (390 - 452µS/cm) indicating the influence of season, possible connection to electrical conductivity and decrease in water quality. Ekwuonu *et al.*, (2019) stated a similar situation with electrical conductivity not exceeding 68.2µS/cm during dry season. The result was similar to the 28.93mg/L concentration of chloride ions recorded in Delta Central by (Olobaniyi *et al.*, 2007). A study by Owamah *et al.*, (2013) on drinking water collected from the Isoko North local government area of the Delta State recorded a slightly lower but similar concentration level of chloride (18mg/L and 14mg/L) for wet and dry seasons, and their effect on water quality.

CONCLUSION

This study has revealed that, the water quality of boreholes water varied according to seasons. Borehole water quality at Ozoro (1 and 2) and Ofagbe was good and remained unchanged for both seasons. However, water quality at Otibio, Erawah, Ovrode, and Otor decreased in quality (Good to poor) according to seasons which may be due to natural and/or anthropogenic activities. The seasons played a major role in the quality of boreholes water.

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