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Assessment of Groundwater Quality of Rumuodomaya Community in Rivers State, Nigeria

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Abstract
This study assessed the groundwater quality of Rumuodomaya Community in Rivers State, Nigeria. Six boreholes, denoted as R1 to R6, were randomly selected for the study. Groundwater samples were obtained from the selected boreholes and subjected to physicochemical and bacteriological tests in accordance with established procedures. The results obtained showed that the measured physicochemical and bacteriological parameters were within the Nigerian Standard for Drinking Water Quality (NSDWQ) and the World Health Organization (WHO) permissible limits for drinking water except for pH with values ranging from 4.8 to 5.8. The computed water quality index, using both NSDWQ and WHO standards, ranged from 38.90 – 34.50 to 59.79 – 62.51, indicating good to poor water quality status. The single factor analysis of variance carried out between the mean values of the measured water quality parameters and the standards gave a P-value (0.0734 and 0.0816 for NSDWQ and WHO, respectively) > 0.05, indicating that there is no significant difference between the measured values and standards. The same analysis of variance carried out between the mean values of the measured water quality parameters and sampling points gave a P-value (0.00193) < 0.05, indicating a significant difference in water quality parameters from the different groundwater sampling points. It is therefore concluded that the groundwater in Rumuodomaya community is acidic and hence unfit for drinking without treatment to reduce the acidity.

Keywords: *Groundwater, Rumuodomaya community, Drinking water quality, Water quality index*

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1. Introduction

Water is universally recognized as an essential and vital natural resource for the life of people, plants, animals, and other living things. This is seen in how it is used for residential, agricultural, transportation, recreation, sand mining, industrial, and environmental purposes (Stricklin, 2020). Although the earth is thought to be 70% covered in water, the quality of different water sources, including rain, streams, surface water, and groundwater, is poor because of the presence or concentration of pollutants, especially in developing economies where the majority of people lack access to portable drinking water (WHO, 2010). In fact, according to estimates by Foka *et al*. (2018), only 58% of urban regions and 39% of rural areas in Nigeria have access to clean, portable drinking water, which is attributable to population growth and urbanization. Thus, groundwater is a major source of water consumption in many Nigerian cities, exemplified by borehole water. However, academics and regulatory bodies globally are becoming concerned about the health effects of the quality of water. As a result of its implications for individual well-being, public health, national productivity, and development, it has also attracted growing interest as a topical matter at numerous local, national, and worldwide conferences, seminars, and workshops. The United Nations (2015) acknowledges this reality and includes access to clean water as one of its seventeenth (17th) sustainable development objectives.

The biological, chemical, and physical properties of groundwater as they relate to its suitability for a particular purpose are referred to as groundwater quality. It simply explains the types, levels, and concentrations of pollutants in the groundwater that affect its appropriateness for drinking or other applications. According to research, natural groundwater is generally dangerous since it can be contaminated by human activity, nature/ecosystems, and the geology of the surrounding environment (Lapworth, 2017). This phenomenon, known as spatial variation in groundwater quality, is thought to be caused by the peculiarities of the local geologic system and anthropogenic factors, making it necessary to assess groundwater quality in order to determine whether it is suitable for drinking or other uses (Annapoorna *et al*., 2015).

Groundwater contamination could be caused by a number of factors, namely the use of pesticides and fertilizers, waste from sewers and oil pipelines, improper hazardous waste disposal, natural gas flaring, mining and quarrying, saltwater contamination, landfills, and atmospheric contamination. According to Stricklin (2020), the negative consequences of groundwater pollution include poor drinking quality, water supply interruption, deteriorated water systems, expensive clean-up expenses, high prices for alternative water sources, and potential harm to plants, animals, and human health. Evidence-based studies and numerous reports by national and international organizations have connected drinking contaminated groundwater with cholera, dysentery, typhoid, hepatitis, and death, with some unfavourable outcomes and dangerous health problems (Raimi *et al*., 2022; Stricklin, 2020; Woke *et al*., 2015; WHO/UNICEF, 2010, UNICEF, 2007).

Borehole water is used by many Nigerians for their everyday domestic and industrial purposes, especially in Rumodomaya community, a Port Harcourt suburb. This is due to Rivers State's inability to supply a reliable and sufficient public water system. Even the majority of the borehole water supplies that the locals rely on for their survival are thought to be contaminated with pollutants from several sources, including sewage, oil spills, etc. Meanwhile the quality of the borehole water is not regularly checked. More so, a thorough and coordinated empirical research effort has not been able to clearly demonstrate the extent to which Rumuodomaya's groundwater quality has been impacted by human and organizational activities as well as natural effluents to assess its acceptability for drinking. Thus, the purpose of this study is to evaluate the quality of the groundwater in the Rumodomaya Community.

2. Materials and methods

2.1 Study area

The study was carried out in randomly selected six (6) households in Rumuodomaya community (Fig. 1). The Community is situated close to Rukpoku-Obio and North of Ruodome with coordinates of 4º53′35″ N and 7°0′8″ E. Rumuodomaya serves as the council headquarters of Obio-Akpor Local Government Area. It is a densely populated urban area with natives and non-natives from other parts of Rivers State and Nigeria at large. The Community is one of the major transportation and commercial hubs in Rivers State. Oil pipelines at Agbada Flow stations pass through the community on their way to Bonny Terminal. Hydrocarbon spills from household and automobile power production have a negative effect on the ecosystem by permeating down the soil. As a result of the lack of a public water supply, many households are forced to rely primarily on private groundwater resources (borehole water) for drinking and other necessities.

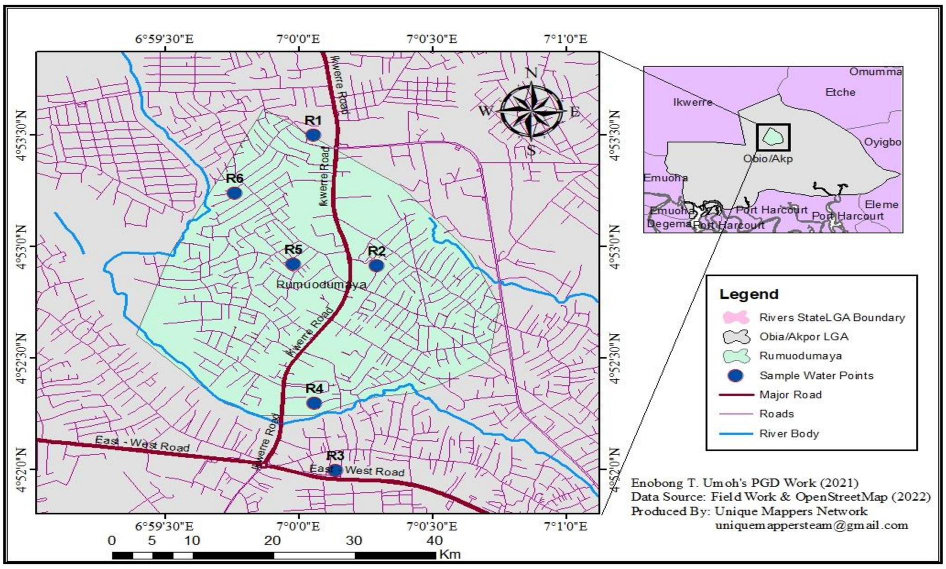

Fig. 1: Map of Rumuodomaya Community showing groundwater sampling points

2.2 Collection of groundwater samples

The water pump was first turned on and left running for at least five (5) minutes before sampling was done. Before taking a representative sample, the sampling vessel was flushed thrice with groundwater, taking care to prevent air bubbles. In-situ measurements were made for some parameters. Each sample container was cleaned twice, labelled properly, and kept in an ice-cooled box. According to established protocols and in accordance with those used by Raimi *et al*. (2022) and Raimi *et al*. (2017), the conserved samples were sent to the laboratory.

2.3 Analysis of groundwater samples

Physicochemical and bacteriological parameters of groundwater were measured as described in the subsequent subsections.

2.3.1In-Situ measurements

Measurements of pH, conductivity, total dissolved solids, dissolved oxygen, and temperature were made in situ using the HACH test kit, CE/890 Advanced Portable laboratory, after instrument calibrations.

2.3.2 Laboratory measurements

Measurements of Chloride (salinity), Total Suspended Solids, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD_5), Total Alkalinity, Sulphate, Nitrate, Phosphate, Hardness, and Metals (Sodium, Calcium, Magnesium, Potassium, Copper, Iron, Chromium, Lead, Zinc, Cadmium, Nickel, Manganese, and Vanadium) were carried out in the laboratory using the following standard methods: ASTM D 512 C; APHA 2540 D; ASTM D 1252; APHA 5210 D; ASTM D1067; ASTM D516; APHA 4500-NO_3^-E; APHA 2340C; ASTM D-1971 & ASTM D-3974; and 9221 A-C, 9221 D & 9221 E, respectively. These variables were measured in order to assess the quality of the water and evaluate whether it is suitable for human use.

2.4 Calculation of water quality index (WQI)

The World Health Organization (WHO) drinking water quality standard and the Nigerian Standard for Drinking Water Quality (NSDWQ) were utilized to determine the WQI using a total of nine (9) physicochemical properties. The calculation of WQI was made using weighed Arithmetic index method (Brown *et al.*, 1970) following the steps below:

Step 1: Collect data of various physicochemical water quality parameters.

Step 2: Calculate the Proportionality constant (k) using Equation (1).

$$k = \left(\frac{1}{\left[\frac{1}{\sum_{t=1}^{n} Si} \right]} \right) \quad (1)$$

where si is the standard permissible for the nth parameter.

Step 3: Calculate quality rating for nth parameter (Qn) where there are n parameters using Equation (2).

$$Qn = 100\{(Vn - Vio)|(Sn - Vio)\} \quad (2)$$

where Vn is the estimated value of the nth parameter of the given sampling station, Vio is the ideal value of nth parameter in pure water, and Sn is the standard permissible value of the nth parameter.

Step 4: Calculate unit weight (Wn) for the nth parameter using Equation (3).

$$Wn = \frac{k}{Sn} \quad (3)$$

Step 5: Calculate WQI using Equation (4).

$$WQI = \left(\sum Wn°Qn\right) / \sum Wn \quad (4)$$

The calculated WQI was compared to the standard WQI table (Table 1) to determine quality status.

Table 1: WQI level and water quality status (Chatterjee, 2001)

Water Quality Index Level	Water Quality Status
0 – 25	Excellent Water
26 – 50	Good Water
51 – 75	Poor Water
76 – 100	Very Poor Water
>100	Unfit for drinking

3. Results and discussion

3.1 Water quality parameters

Table 2 summarises the quality parameters of groundwater from six sampling points in Rumuodomaya Community. The results revealed that the measured values of pH and temperature are not within the standard limits (6.5 – 8.5 for pH and ambient (25ºC) for temperature). On the contrary, water quality parameters such as electrical conductivity, total dissolved solids, turbidity, chloride, alkalinity, total hardness, dissolved oxygen, BOD_5, COD, sulphate, phosphorus, nitrate, sodium, potassium, and zinc are below the standard limits. Still, total suspended solids, iron, lead, manganese, calcium, magnesium, total coliforms and faecal coliforms are below detection limits.

The measured temperature ranged from 28.80 to 30.13ºC with a mean value of 29.70ºC. According to Kostas and Dimitra (2012), the solubility of gases and salts depends significantly on the water's temperature. Also, the dissolution of oxygen in water increases with decreasing temperature (Kostas et al, 2012). In addition, metabolic rate, rates of development, timing, and success of reproduction, as well as the mobility, migration patterns, and susceptibility of organisms to poisons, parasites, and disease, are all impacted by temperature (Kostas et al, 2012). pH values observed ranged between 4.5 and 5.8 with an average value of 5.4, indicating acidity. Acidic water is typically detrimental since it may dissolve iron from pumping stations and mains and result in corrosion issues. Such acidic pH has been reported for Emevor Community in Niger Delta region of Nigeria by Owamah (2020). However, a contrary finding was reported by Olasoji et al. (2019) for groundwater in a peri-urban town in the Southwest region of Nigeria. Temperature and pH as well as other measured water quality parameters were within standards. The observed difference is believed to be due to location difference.

3.2 Statistical analysis

The mean values of all the nine detectable average individual parameters were compared with Sampling Points R1 to R6, NSDWQ and WHO standards. Tables 3, 4 and 5 represent single factor ANOVA outputs. In Table 3, P-value (0.00193) < 0.05 was observed, showing a statistically significant difference in the concentrations of water quality parameters among the groundwater sampling points. Table 4 represents mean of detectable parameters compared with NSDWQ. P-value (0.0734) > 0.05 was observed, indicating that there was no statistically significant difference between the mean concentrations of water quality parameters and NSDWQ standard. Table 5 represents mean of detectable parameters compared with WHO. P-value (0.08157) > 0.05 was observed, implying that there was no statistically significant difference between the mean concentrations of water quality parameters compared with WHO standard.

Table 3: ANOVA output of concentrations of water quality parameters from various groundwater sampling points

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	31023.96	8	3877.995	3.753089	**0.00193**	2.152133
Within Groups	46497.64	45	1033.281			
Total	77521.6	53				

Table 4: ANOVA output of measured concentrations of water quality parameters and NSDWQ standard

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	199444.3	1	199444.3	3.67137	**0.0734**	4.493998
Within Groups	869187.7	16	54324.23			
Total	1068632	17				

Table 5: ANOVA output of measured concentrations of water quality parameters and WHO standard

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	191112.2	1	191112.2	3.45449	**0.08157**	4.493998
Within Groups	885165.5	16	55322.84			
Total	1076278	17				

Table 2: Water quality parameter of groundwater in Rumuodomaya Community

S/No.	Parameter	R1 Av. Value	R2 Av. Value	R3 Av. Value	R4 Av. Value	R5 Av. Value	R6 Av. Value	NSDWQ Max. Level	WHO Max. Level
1	pH	5.8	5.5	4.8	5.2	5.6	5.5	**6.5 -8.5**	**6.5-8.5**
2	Temp. (^{0}C)	28.8	29.9	29.5	30.13	29.9	30.1	**AMBIENT**	**Na**
3	Electrical Conductivity (μS/cm)	81	15	239	57	41	37	**1000**	**Na**
4	Total Dissolved Solid (mg/l)	40	7.0	117	28	20	18	**500**	**1000**
5	Turbidity (NTU)	0.351	0.35	0.35	0.351	0.351	0.351	**5**	**5**
6	Chloride (mg/l)	38.0	4.0	85	12.2	10	8.0	**250**	**250**
7	Alkalinity (mg/l as $Caco_3$)	4.0	4.0	2.0	2.2	2.20	2.4	**Na**	**Na**
8	Total Hardness (mg/l as $CaCO_3$)	14.01	2.0	12.01	6.01	10.21	10.41	**150**	**150**
9	Dissolved Oxygen (mg/l)	8.2	8.4	5.8	5.60	7.2	8.0	**Na**	**Na**
10	BOD_5 (mg/l)	2.88	3.2	3.2	3.20	1.28	1.76	**Na**	**Na**
11	COD (mg/l)	4.0	4.0	4.0	4.0	4.0	4.0	**Na**	**Na**
12	Sulphate (mg/l)	2.04	0.96	11.64	2.64	1.68	1.98	**100**	**250**
13	Phosphorus (mg/l)	Nil	Nil	0.119	Nil	Nil	Nil	**Na**	**Na**
14	Nitrate (mg/l)	0.80	0.40	6.031	1.296	1.468	1.55	**50**	**10**
15	Sodium (mg/l)	15	Nil	17.72	NIL	Nil	NIL	**200**	**200**
16	Potassium (mg/l)	Nil	Nil	15.54	9.997	Nil	NIL	**Na**	**Na**
17	Total Suspended Solids (mg/l)	Nil	Nil	NIL	NIL	Nil	NIL	**Na**	**Na**
18	Iron (mg/l)	Nil	Nil	NIL	NIL	Nil	NIL	**0.3**	**0.3**
19	Lead (mg/l)	Nil	Nil	NIL	NIL	Nil	NIL	**0.01**	**0.01**
20	Manganese (mg/l)	Nil	Nil	NIL	NIL	Nil	NIL	**0.2**	**0.1**
21	Zinc (mg/l)	Nil	0.44	0.003	0.104	0.061	0.602	**3**	**3**
22	Calcium (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	**0.003**	**Na**
23	Magnessium (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	**20**	**Na**
24	Total Coliforms (cfu/ml)	Nil	Nil	Nil	Nil	Nil	Nil	**10**	**Na**
25	Faecal Coliforms (cfu/1ml)	Nil	Nil	Nil	Nil	Nil	Nil	**0**	**0**

4. Conclusion

Assessment of groundwater quality in Rumuodomaya community was carried out. The results obtained showed that the measured water quality parameters were within the Nigerian Standard for Drinking Water Quality (NSDWQ) and the World Health Organization (WHO) permissible limits for drinking water except for pH with values ranging from 4.8 to 5.8. The computed water quality index, using both NSDWQ and WHO standards, ranged from 38.90 – 34.50 to 59.79 – 62.51, indicating good to poor water quality status. The single factor analysis of variance carried out between the mean values of the measured water quality parameters and the standards gave P-value (0.0734 and 0.0816 for NSDWQ and WHO, respectively) > 0.05, indicating that there is no significant difference between the measured values and standards. The same analysis of variance carried out between the mean values of the measured water quality parameters and sampling points gave P-value (0.00193) < 0.05, indicating significant difference in water quality parameters from the different groundwater sampling points. It is therefore concluded that the groundwater in Rumuodomaya community is acidic.

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