Hydrochemical Assessment of Borehole Water Quality in Eku, Delta State, Nigeria

[1*]Abeokuta, O.J, [2]Uriri, S.A, [3]Obruche, E.K, [3]Okurame, O.

[1]Department of Chemistry, Southern Delta University, Ozoro

[2]Department of Physics, Southern Delta University, Ozoro

[3]Department of Chemistry, Delta State College of Education, Mosogar

[*]Correspondence Email: abeokutaoj@dsust.edu.ng

Abstract

The quality of potable water in a society is of great relevance to the health of its inhabitants. Thus, prior to its utilization for drinking, domestic, agricultural, or industrial purposes, water quality must be evaluated. The aim of the research was to investigate the quality of some selected borehole water samples in Eku, Delta State, Nigeria. Twelve borehole water samples were collected in both wet and dry seasons and examined for physicochemical properties using standard analytical techniques. The results obtained showed that physicochemical properties such as pH, S.G, EC, total hardness, TDS, TSS, BOD and heavy metals were within the accepted maximum allowable limits of WHO for drinking water whereas S.G, total hardness and TSS were higher in concentration during raining season as compared to dry season due to increase in water level. Therefore, the results indicate that the groundwater quality in Eku is suitable for both domestic use and drinking, according to its physiochemical characteristics.

Keywords: Water quality; Physiochemical parameters; Heavy metals; Rainy season; Dry season

Introduction

Water is a universal solvent of two major elements; hydrogen and oxygen in the ratio of 2:1. It consists of some soluble salts and mineral elements in different proportions needed as nutrients in respect to its usage. Water is life and all living organisms need water to survive (Kiliç, 2020; Zhang *et al., 2023*). It is essential for health and necessary for numerous body functions such as temperature regulation, cellular function and waste removal. Water is ranked as the second essential component for life apart from oxygen. The average adult body is 55 to 75% (2/3 of human weight) and a new born baby of 0 to 6 months is 75% water (EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA), 2010). It is expected that human body requires between one to seven (1-7) liters of water per day for its efficient functioning to prevent dehydration (Hahn, 2021). Conventionally, drinking water schemes include groundwater (wells and boreholes) and surface water (rivers, streams, lakes, etc.).

However, there is an increased reliance on ground water because it is believed to be purified as water moves down the bedrock (Verlicchi & Grillini, 2020). Moreover, in recent times, majority of Nigerians both in the rural and urban areas depend on borehole water as alternative for well water. Nevertheless, some naturally occurring contaminants, in form of salts or mineral elements, present in rock and sediment dissolve in higher concentrations in the water (Adimalla, 2018; Gevera *et al.*, 2021). Additionally, activities of man such as improper disposal of chemicals, solid waste and microbiological materials on landfill sites can change the water's natural composition and quality (Peters & Meybeck, 2000). Furthermore, proximity of some boreholes to solid waste dumpsites or septic tanks and inadequate construction of boreholes may also cause groundwater contamination (Ugbebor & Ntesat, 2022). In addition, the frequent application of fertilizers on farmland and animal droppings closer to boreholes in the agricultural sector contributes to ground water contamination (Mensah, 2022).

Water contamination may vary from place to place depending on the soil type, nature of underground rocks and climatic changes. According to the World Health Organization,WHO (2016), contaminated water poses significant health risks and is unsuitable for human consumption due to its potential to transmit various diseases, including typhoid fever, diarrhea, bacillary dysentery and cholera. Additionally, the presence of contaminants can lead to elevated pH levels, which may irritate mucous membranes, impart a bitter taste to the water, and contributes to its corrosive properties. Furthermore, increased levels of dissolved oxygen and elevated temperatures can enhance microbial activity, further exacerbating the risk associated with drinking such water (Pat *et al.*, 2018; Calero*et al*., 2021). The pollution of water has emerged as significant environmental challenge. Consequently, prior to its utilization for drinking, domestic, agricultural, or industrial activities, water quality must be evaluated. Such assessments typically involve the examination of various physico-chemical and metallic parameters present in the water and ascertaining its quality. Therefore, this study seeks to evaluate the potability of borehole drinking water in Eku metropolis of Delta State by assessing its physicochemical properties.

Materials and methods

Study area

Eku is a transitional settlement situated within the Ethiope-East Local Government Area of Delta

State, located in the western Niger Delta region. It is bordered by Abraka, Kokori Inland, Okpara-Waterside along Sapele Road, and Okurekpo along Warri Road. The study area comprised six sampling stations, specifically Hospital Road, Ikidioka Street, Urhusi/Erusiafe clan, Iyadjarho Street, Samagidi Road, and Ikreghwa Street. This entire region lies between latitudes 5.72˚N and 5.80˚N, and longitudes 5.94˚E and 6.08˚E, within the tropical zone, featuring a terrain elevation of 63 meters above sea level, and is drained by the River Ethiope, which borders Eku to the west. The climate of the study area is tropical, characterized by distinct rainy and dry seasons. The dry season extends from November to April, while the rainy season typically occurs from May to October each year. The residents of this area are primarily low- and middle-class members of the Urhobo ethnic group, who are involved in small-scale farming, business ownership, artisan work, and middle-class service roles.

Sample collection

Twelve water samples were collected during raining and dry seasons, six samples in July and six in December, 2018 for raining and dry season respectively. Samples were collected in 2.0litres sterilized plastic containers and labeled as S_1 (Hospital road), S_2 (Ikidioka street), S_3 (Urhusi/Erusiafe clan), S_4 (Iyadjarho street), S_5 (Samagidi road), and S_6 (Ikreghwa street). Prior to the collection of water samples, the nozzle of the taps were flamed and sterilized by cleaning with cotton woolsoaked in a methylated spirit to avoid contamination. The tap was allowed to run for 5-10 minutes before sampling. The collected samples were transported to the laboratory in an ice-packed container and preserved in a refrigerator for physicochemical analysis.

Determination of physio-chemical properties of bore-hole water

The physicochemical parameters were determined according to the American Public Health Association (APHA, 2005). The parameters analyzed include temperature and pH which were determined insitu at the sampling site using a calibrated mercury thermometer and pH meter (Hanna microprocessor pH meter, Model: HI991300)) respectively. Electrical conductivity was measured using a conductivity meter (Yantai Stark instrument, Model: DDS-307A). Turbidity was measured using a turbidity meter (Thermo Fisher Scientific, Model: AQ4500). TSS, TDS, and TS were determined using a gravimetric method of analysis (APHA 2005). Total Hardness was analyzed usingComplexometric (EDTA) titration, Total hardness by titrimetry and the metals were determined by AAS (model AA-7000). Dissolve oxygen (DO) and BOD were determined using the Winkler method (APHA, 2005).

Results and Discussion

Physicochemical properties

The results of this study were discussed in term of concentration of the different parameter analyzed in each sample for different seasons in relation to the stipulated WHO standard for portable water in Tables 1 and 2. Water quality parameters, such as pH and TDS, are crucial indicators that act as controlling variables due to their significant impact on the behavior of various other constituent (Iwegbue *et al*., 2023). In both dry and raining seasons, the temperature and the pH had similar value range in $S_1$and S_5 but the S.G., Conductivity, Total hardness, TSS and BOD were little higher in the raining compare to dry season while other parameters were higher in the dry season. Electrical conductivity quantifies the ability of water to conduct electrical current and is closely associated with the levels of ionized substances present in the water. (Soumia *et al*., 2025). In some cases, these electrical conductivity results could serve as the total dissolved solids in water. The values align closely with those recorded for boreholes and hand-dug wells as documented by Agbaire and Oyibo (2009), Ezeribe *et al*. (2012), and Ilechukwu and Okonkwo (2012), yet they remain within the permissible limits set by the WHO. For the heavy metals in Tables 3 and 4, the concentration of iron and lead were higher in dry season but that of Hg was the same in both seasons as also recorded by Ojo *et al*., (2022). Almost all the parameters fell within the desirable standard (WHO) except the BOD mean value which was lower than desirable levels of 6.0. No total hardness in the dry season. In Sample S_2 ,the pH, S.G., TSS, TDS and DO were higher in concentration during raining season while other parameters were lower in dry season. The BOD fell below the desirable level of 6.0 and is higher in raining than in the dry season. The S.G of 56% greater in raining is due to increase in concentration of dissolved salts because the added dissolved salts occupy space between the water molecules (Feng *et al*., 2022).Sample S_3 showed no total hardness in both seasons. All the parameters were almost of the same range value. DO and BOD were higher in dry season while other parameters were higher in rainy season. Comparing the parameters with the WHO recommended standard, all the parameters fell into the desirable level except that of BOD which was lower than the required standard. The S.G of raining > dry season by 61% due to the present of dissolved mineral salts in S_4 while S_5 showed no total hardness in the raining but 1.20mg/l in the dry season. This variation might be as result of dissolved substance in water when it is in abundant supply. Parameters such as S.G., conductivity, TDS, DO and BOD were lower in concentration in the dry while other parameters were higher in the raining season.Apart from the BOD in both seasons which was less than the desirable WHO standard in S_6**,** other parameters fell within the permissible range. The Total Hardness, and TDS and were lower in concentration in dry season except the S.G. which was higher in the rainy season. Meanwhile, the mean concentrations of temperature, pH, TDS, DO_1, DO_5 and BOD showed similar proportions in both seasons in figure 1 while S.G, Tatal hardness TSS are higher in raining season

Table 1: Physicochemical Properties of Borehole Water during Raining Season

Parameters;.	Samples							WHO	NSDWQ
	S_1	S_2	S_3	S_4	S_5	S_6	Mean X		
Temperature (°C)	29.00	28.50	28.50	29.30	30.00	30.00	29.20	25.00	Ambient
S.G (mg/l)	3.06	3.09	3.04	3.09	3.08	3.00	3.06	-	-
pH	7.20	9.00	8.40	8.60	7.80	8.26	8.21	6.50-8.50	6.50-8.50
Conductivity (µS/cm)	68.00	74.00	76.00	80.00	72.00	100.00	78.33	300	1000
Total Hardness (mg/l $CaCO_3$)	1.00	1.30	-	1.80	-	2.00	1.53	5.00	150
TSS (mg/l)	40.00	26.00	22.10	24.30	26.30	24.20	27.15	500	500
TDS (mg/l)	11.40	13.60	14.30	10.20	12.40	13.40	12.55	500	500
DO_1	6.66	11.8	10.68	17.02	16.48	5.85	11.43	5.00	5.00
DO_5	3.01	8.91	7.03	7.62	6.77	4.03	6.23	5.00	5.00
BOD	3.65	2.96	3.65	9.40	9.71	1.85	5.20	5.00	5.00

KEY: - = limit not established; Nigerian Standard Drinking Water Quality NSDWQ (2015)

Table 2**:** Physicochemical Properties of Borehole Water during Dry Season

Parameters	Samples							WHO	NSDWQ
	S_1	S_2	S_3	S_4	S_5	S_6	Mean X		
Temperature (°C)	29.00	28.60	28.00	29.00	28.00	28.90	28.58	Ambient	Ambient
S.G (mg/l)	1.07	1.35	1.19	1.54	1.71	1.63	1.42	-	-
pH	7.30	8.90	8.30	8.40	7.34	8.03	8.05	6.50-8.50	6.50-8.50
Conductivity (µS/cm)	73.00	73.00	78.00	82.00	71.00	98.00	78.17	300	1000
Total Hardness (mg/l $CaCO_3$)	-	1.00	-	-	1.20	0,80	1.00	100	150
TSS (mg/l)	30.00	24.00	21.00	20.00	19.80	19.00	22.30	500	500
TDS (mg/l)	13.00	12.80	13.20	9.02	12.41	13.50	12.16	500	500
DO_1	7.14	9.83	11.44	14.40	13.74	6.82	10.56	5.00	5.00
DO_5	4.08	3.01	6.34	5.64	7.84	4.30	5.70	5.00	5.00
BOD	3.06	3.82	5.10	8.76	5.90	2.52	4.86	5.00	5.00

KEY: - = limit not established; Nigerian Standard Drinking Water Quality NSDWQ (2015)

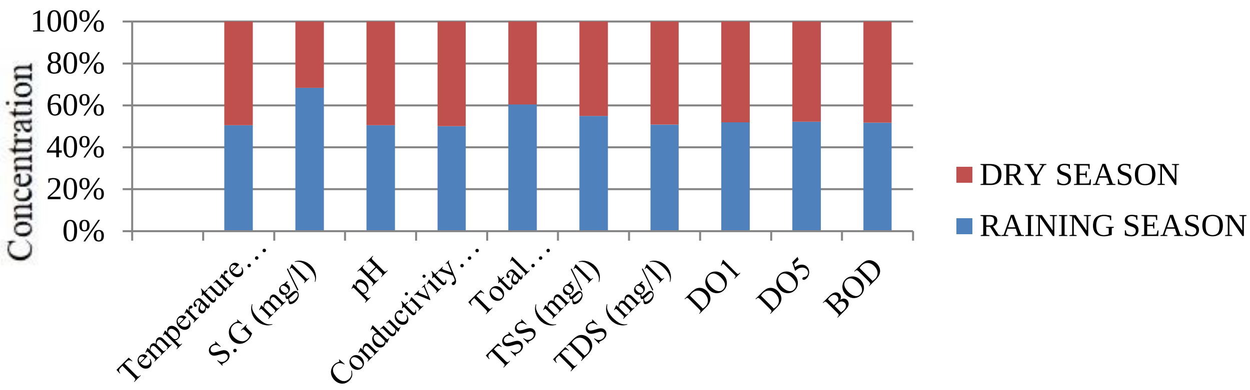

Fig.1: Mean concentration of physicochemical parameters in the seasons

Heavy Metals

The metals analyzed in this study are iron, lead, and mercury as shown in Table 3 and 4. The concentration of heavy metals in the wet season is higher than the dry season, this could be due to increase in ground water volume. The concentration of heavy found in this study is within the concentration of bore-hole water earlier reported by Agbaire and Oyibo (2009), Ezeribe *et al*. (2012), and Ilechukwu and Okonkwo (2012). The concentration of the bore-water is within permissible drinking water of WHO, 2016.

Table 3: HeavyMetals in Borehole Water from Dry Season

Parameters	Results (mg/l)						
	S_1	S_2	S_3	S_4	S_5	S_6	WHO
Iron	0.05	0.05	0.04	0.06	0.01	0.02	0.30
Lead	0.04	0.02	0.03	0.04	0.04	0.03	0.01
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002

Table 4:Heavy Metals in Borehole Water from Raining Season

Parameters	Results(mg/l)						
	S_1	S_2	S_3	S_4	S_5	S_6	WHO
Iron	0.04	0.02	0,03	0.03	<0.01	0.01	0.30
Lead	<0.001	0.001	0.001	0.002	0.001	0.001	0.01
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002

CONCLUSION

This work has presented the levels of some physicochemical properties of borehole water in Eku, Delta State, Southern Nigeria. The result showed that the physicochemical properties such as pH, electrical conductivity, total dissolved solid, total hardness, TSS, BOD and the heavy metals were within the accepted maximum allowable limits of WHO for drinking water. The study reveals that the quality of groundwater is fit for domestic and drinking purposes based on the physiochemical properties. Therefore, it is suggested that further research should be carried out on bacteriological property in Eku metropolis on both wet and dry seasons.

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