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EVALUATION OF PHYSICOCHEMICAL AND DIVALENT MINERALS QUALITY OF SURFACE AND GROUNDWATER IN OGBELE: A CRUDE OILBEARING COMMUNITY

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ABSTRACT

This study was aimed at evaluating the physicochemical and divalent minerals quality of the surface and groundwater in Ogbele community in Ahoada East Local Government Area, Rivers State, Nigeria, following the upsurge in oil and gas industrial activities in the area. Water samples were collected from five different locations along the Sombreiro River (surface water) as well as five dugout wells and boreholes (groundwater) in selected locations in the community and analyzed for physicochemical properties and divalent minerals using standard APHA methods and AAS respectively. Results for physicochemical parameters of the surface water showed pH (7.20±0.05), Turbidity (5.41±0.03 NTU), Nitrates (0.26±0.01 mg/L), Chlorides (15.80±0.05 mg/L), BOD (2.43±0.03 mg/L), COD (48.00±0.20 mg/L), Magnesium (0.443 ± 0.002 mg/L) and Calcium (39.93 ± 0.03 mg/L). In dugout well water pH was 7.32±0.02, Turbidity 8.79±0.04 NTU, Nitrates 0.22±0.01 mg/L, Chlorides 10.80±0.05 mg/L, BOD 6.49±0.03 mg/L, COD 16.00±0.10 mg/L, Magnesium 0.483 ± 0.002 mg/L and Calcium 6.14 ± 0.04 mg/L. Borehole water pH was 7.58±0.02, Turbidity 1.72±0.02 NTU, Nitrates 0.39±0.01 mg/L, Chlorides 15.80±0.05 mg/L, BOD 3.24±0.04 mg/L, COD 16.00±0.20 mg/L, Magnesium 0.413 ± 0.002 mg/L and Calcium 3.07 ± 0.02 mg/L. This study concludes that while most water quality parameters in Ogbele Community are below the maximum allowable limits (MAL) set by WHO, NESREA and NSDWQ regulatory standards, levels of turbidity (for surface and dugout well samples), BOD (for dugout well sample) and COD (for all the water samples) exceeded the regulatory limits. Therefore, there is need for intervention and continuous monitoring of the water quality to prevent potential health risks associated with increase in non-biodegradable compounds in the various water sources.

KEYWORDS: Physicochemical properties, Divalent minerals, Groundwater, Industrial activities, Ogbele community

INTRODUCTION

Water quality is a fundamental component of environmental health and human well-being, particularly in regions where natural water sources are vital for daily life. Human activities have noticeably changed the characteristics of ground and surface water bodies in Nigeria [1]. Ogbele Community, situated in Ahoada East Local Government Area, Rivers State, Niger Delta, Nigeria, is an area where both groundwater and surface water are integral to the livelihoods of its inhabitants. The Niger Delta, known for its rich natural resources, particularly oil and gas, has experienced significant environmental challenges due to extensive industrial activities. These activities, along with other anthropogenic factors, have posed considerable risks to the water quality in the region [2].

Surface water quality is influenced by several factors, including seasonal variations, natural processes and human activities. Chindah and Braide [3] observed that during the rainy season, increased runoff leads to higher concentrations of pollutants in rivers and during the dry season, lower water levels can concentrate pollutants, exacerbating contamination levels. Rainfall can wash soil, nutrients, and pollutants into rivers, affecting water quality [4]. Effluents from factories and refineries can introduce toxic substances and metals into river systems [5]. Urban runoff can carry oils, metals, and other pollutants from streets and infrastructure into river systems [6].

Groundwater in Ogbele community is primarily sourced from boreholes and dugout wells, offering a cleaner and more stable supply of portable water compared to the river (surface) water. However, its quality is susceptible to infiltration by pollutants from industrial activities and improper waste disposal practices. Groundwater, often accessed through boreholes, is typically considered to be of higher quality than surface water due to natural filtration processes as water percolates through soil and rock layers. However, several studies highlight that groundwater is not immune to contamination. Amadi *et al.*[7] indicated that industrial activities, particularly in oil-rich regions like the Niger Delta, introduce pollutants such as hydrocarbons, metals, and other industrial chemicals into groundwater systems. These contaminants pose significant health risks to local populations who rely on dugout wells and borehole water for drinking and domestic use.

Despite its relative protection from direct pollution, groundwater quality can be affected by various factors, including geological composition. The hydrogeology of the Niger Delta, characterized by alluvial and deltaic deposits, significantly influences groundwater dynamics. The mineral content of aquifers can influence the chemical characteristics of groundwater, sometimes leading to issues like hardness or the presence of trace elements such as arsenic and fluoride [8]. Studies by Tiwari *et al.* [9] indicate that the region's sedimentary formations, while rich in groundwater, are also highly susceptible to pollution from surface activities. The apparent shallow aquifers commonly used for the extraction of borehole water in the region are particularly vulnerable to contamination from waste dumps, agricultural runoff and industrial spills.

With the increasing oil and gas industrial activities in the Ogbele community in recent times, there is need for continuous evaluation of the quality of water available to the population. Hence, this study was designed to provide relevant data on the physicochemical and divalent mineral status of water sources available in the community, to guide public health and environmental management policies and strategies applicable to the area.

MATERIALS AND METHODS

Sample Collection

Water samples were collected from five (5) different locations along the Sombreiro River and 5 selected dugout wells and boreholes. Sample containers were rinsed with the water being sampled before transferring the sample into the containers. The water samples were collected with the aid of a stainless steel water sampler. Samples for BOD_5 and Dissolved Oxygen (DO) analyses were collected in Amber bottles measuring 250 ml and incubated for 5 days at 20^oC. Prior to laboratory analysis, the samples for BOD_5 analysis were fixed with 2 ml of Winkler 1 and II reagents. Samples for physicochemical parameters were collected in 2 L plastic containers while samples for minerals (metal) analyses were collected in plastic vials and fixed with 2% nitric acid to preserve the integrity of the samples before taking them to the laboratory.

Determination of Physicochemical Properties

In-situ analysis was carried out for fast changing parameters using WTW Multi 340i/set Meter. The water samples were added into a 50ml beaker and the WTW Multi 340i/set meter inserted to measure pH, Temperature and Turbidity. Prior to the measurement, the multi-meter probes were calibrated using distilled water.

All laboratory analyses were carried out at the Institute of Pollution Studies, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt. The analyses were conducted in line with American Public Health Association (APHA), American Society for Testing and Material (ASTM), World Health Organization (WHO), United States Environmental Protection Agency (USEPA) as well as Federal Ministry of Environment (FMEnv) standard protocols [10, 11, 12].

Determination of Divalent Mineral Content

Magnesium and calcium content of the water samples were analyzed using Atomic Absorption Spectrophotometer (AAS) (GBC XplorrAA model) in line with standard protocols and manufacturer's recommendations.

Data Analysis

The laboratory test results were analyzed using Microsoft Excel 2021 and values presented as the mean of three separate determinations ± standard deviation.

RESULTS

Results of the physicochemical properties and divalent mineral content of surface and groundwater samples from Ogbele community are contained in Table 1

Table 1: Physicochemical Properties and Divalent Mineral Content of Surface and Groundwater in Ogbele Community.

Parameters	Surface water	Dugout well water	Borehole water	WHO/ NSDWQ Standard
pH	7.20 ± 0.05	7.32 ± 0.02	7.58 ± 0.02	**6.5-8.5**
Temp (^{o} C)	27.30 ± 0.05	27.70 ± 0.02	27.70 ± 0.05	**Ambient**
Turbidity (NTU)	5.41 ± 0.03	8.79 ± 0.04	1.72 ± 0.02	**5.0**
COD (mg/l)	48.00 ± 0.20	16.00 ± 0.10	16.00 ± 0.20	**5.0**
BOD (mg/ml)	2.46± 0.03	6.52± 0.03	3.24± 0.04	**5.0**
Nitrate (mg/l)	0.26 ± 0.01	0.22 ± 0.01	0.39 ± 0.01	**10.0**
Cl^- (mg/l)	15.80 ± 0.05	10.80 ± 0.05	15.80 ± 0.05	**250.0**
Mg (mg/l)	0.443 ± 0.002	0.483 ± 0.002	0.413 ± 0.002	**20.0**
Ca (mg/l)	39.93 ± 0.03	6.14 ± 0.04	3.07 ± 0.02	**75.0**

*Values are mean of triplicate determinations ± Standard Deviation

WHO = World Health Organization; NSDWQ = Nigerian Standard for Drinking Water Quality

DISCUSSION

The physicochemical properties of surface water from the Sombreiro River and groundwater (dugout well and borehole) in Ogbele Community revealed distinct characteristics in terms of their compliance with standard water quality parameters. Comparing these water sources against the established standards set by the World Health Organization (WHO), Nigerian Standard for Drinking Water Quality (NSDWQ), and the United States Environmental Protection Agency (USEPA), helps in identifying areas of concern that needs improvement.

The pH levels across the three water sources were within the WHO standard range of 6.5 to 8.5. This indicates that the water in all sources is neither too acidic nor too alkaline, which is favorable for consumption and most industrial uses. This is consistent with previous studies by Nwaichi et al. [13] who examined the pH of water sources in the Niger Delta and reported values that ranged between 6.8 and 8.4, highlighting similar neutral to slightly alkaline conditions across surface and groundwater sources.

The turbidity value of 5.41 NTU in the Sombreiro River, against 5.0 NTU for regulatory standard, mirrors findings in other parts of the Niger Delta, where surface water bodies tend to accumulate suspended particles due to soil erosion and anthropogenic activities. Ekiye & Luo [14] reported similar turbidity values exceeding 5.0 NTU in surface waters impacted by nearby settlements, industrial activities, and agricultural runoff. The dugout well water in Ogbele, showed a much higher turbidity of 8.79 NTU. This indicates greater vulnerability to contamination, which is consistent with observations by Mmom & Arokoyu [15] in rural communities where shallow wells are prone to surface runoff and inadequate filtration. In contrast, the borehole water with a turbidity of 1.72 NTU suggests that deeper groundwater sources, such as boreholes, are better protected from surface contaminants, an observation supported by Orebiyi *et al*.[16]

The COD values (Table 1) for all samples are relatively higher than the regulatory limits. This attracts attention, as the high levels indicate substantial organic and inorganic pollution. Similar elevated COD levels in Niger Delta water sources have been linked to industrial discharge, agricultural runoff, and municipal waste. Nduka *et al*. [17] observed COD values exceeding 40.0 mg/L in rivers near oil-producing areas, likely due to chemical contamination from industrial activities.

The lower BOD level (2.43 mg/L) in the surface water sample (Sombreiro river) could be attributed to relatively low pollution by biodegradable organic compounds. This is consistent with findings by Ideria *et al* [18], who studied river systems in the Niger Delta and observed BOD values between 2.0 and 4.0 mg/L, indicating a moderate level of organic decomposition. However, the elevated BOD in the dugout well water (6.49 mg/L) highlights the potential for organic contamination from anthropogenic activities. Amadi *et al*.[7] reported similar findings in groundwater sources in other Niger Delta communities. The higher BOD in well water compared to the borehole water (3.24 mg/L) suggests the need for filtration or improved management to reduce organic pollution.

Concentrations of nitrate, chloride, magnesium and calcium in surface and groundwater sources in Ogbele are below the standard Maximum Allowable Limits (MAL) indicating minimal contamination from agricultural fertilizers or inorganic industrial waste. This is consistent with Ideria *et al* [18] and Ogamba *et al*.[19] who found that nitrate, chloride, magnesium and calcium levels in the water sources of the Niger Delta were generally low, particularly in areas less impacted by intensive farming or urban wastewater discharge. These levels are considered safe and pose no health risks.

CONCLUSION

Assessment of the physicochemical parameters and divalent mineral content of surface and groundwater in Ogbele Community revealed acceptable pH, BOD, Nitrate, Chloride, Magnesium and Calcium levels consistent with natural environmental conditions in the Niger Delta. However, turbidity of the dugout well water and COD of all the water sources indicate levels above the Maximum Allowable Limits (MAL) for portable water quality. This calls for intervention and improvement, particularly in providing adequate public water supply, managing surface runoff and proper disposal of industrial and agricultural effluents to avoid further chemical contamination. These measures will help improve water quality in the region and protect the health and general wellbeing of the rural population

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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