Evaluating The Quality of Groundwater in Rural Nigerian Communities. A Case Study of Borehole Water in Amaokpala, Focusing on Salinity, Ph Level, Turbidity, and Heavy Metal Contamination

OKOYE, OBIORA EMEKA[1], JOHN, GODSON NNAMDI[2], KPADUWA, SAMUEL[3], OBIESIE FLORENCE N.[4], SAM, EDIKAN MICHAEL[5]

[1]*Department of Physics with Electronics Technology, School of Science Laboratory Technology, University of Port Harcourt.*

[2, 3]*Department of Biochemistry/Chemistry Technology, School of Science Laboratory Technology, University of Port Harcourt.*

[4]*Department of Physics Electronics, Federal Polytechnic Oko, Anambra State.*

[5]*Department of Geology/Mining Technology, School of Science Laboratory Technology, University of Port Harcourt.*

Abstract- ***Groundwater accessed through boreholes serves as a critical source of drinking water in rural Nigerian communities, including Amaokpala, Anambra State. However, concerns over water quality due to natural geological processes and human activities, such as agricultural runoff and improper waste disposal, necessitate comprehensive assessments. This study evaluates the salinity, pH, turbidity, and heavy metal levels in five strategically selected boreholes (BH-01 to BH-05) within the community to determine their suitability for domestic and agricultural use. Water samples were analyzed using standard analytical methods, with results compared against World Health Organization (WHO) standards for drinking water quality.The findings reveal salinity levels ranging from 150 to 200 ppm, pH levels between 6.8 and 7.2, and turbidity values from 2.8 to 5.0 NTU. Heavy metal concentrations remained within WHO guidelines, ranging from 0.02 to 0.06 mg/L. However, elevated salinity in BH-02 and turbidity in BH-05 indicate localized contamination that warrants immediate intervention. These issues underscore the need for regular water quality monitoring, the implementation of appropriate water treatment systems, and public education on sustainable water management practices.This study highlights the importance of addressing emerging water quality challenges to safeguard public health and support agricultural productivity. The insights provided aim to inform policymakers, community leaders, and researchers in developing effective, evidence-based strategies for ensuring access to safe and reliable water in Amaokpala and similar communities.***

Indexed Terms- ***Groundwater, Borehole Water, Salinity, Ph Level, Turbidity and Heavy Metal***

I. INTRODUCTION

In many rural communities across Nigeria, including Amaokpala, groundwater accessed through boreholes serves as the primary source of drinking water. However, concerns regarding water quality have become increasingly urgent due to the potential contamination arising from both natural and human-induced factors. The geology of the Amaokpala region, characterized by sedimentary rock formations, contributes to groundwater quality variability. This variability can be further influenced by agricultural runoff, industrial waste, and improper disposal of household waste. In particular, salinity and heavy metal contamination have emerged as critical issues, with far-reaching implications for public health and agricultural productivity. Access to safe drinking water remains a challenge in rural communities like Amaokpala, Nigeria, where boreholes are the primary water source. Groundwater quality is influenced by natural geology and human activities, leading to contamination risks such as elevated salinity. High

salinity levels can reduce water palatability, harm agricultural productivity, and pose health risks like hypertension and kidney problems (Djaouda et al., 2018; Obioma, 2020). Despite the reliance on boreholes in Amaokpala, comprehensive studies assessing their water quality remain scarce, leaving a significant gap in understanding and addressing potential risks. The consumption of water with elevated salinity levels poses a risk of hypertension and kidney disease, while its use in agriculture may lead to soil degradation and reduced crop yields. These challenges are compounded by a lack of regular water quality monitoring and limited public awareness of safe water practices. Evaluating the salinity and other water quality parameters in boreholes within Amaokpala is essential to determine their suitability for drinking and irrigation, identify factors influencing water quality, and propose sustainable management strategies. This study investigates the salinity, pH, turbidity, and heavy metal levels in borehole water within Amaokpala. By benchmarking these parameters against WHO standards, this research aims to identify contamination sources, evaluate the implications for public health and agriculture, and propose evidence-based recommendations for sustainable water resource management. Addressing this issue can guide community leaders and policymakers in implementing practices that ensure access to safe and reliable water. In doing so, the study seeks to provide actionable insights for policymakers, researchers, and community stakeholders, ensuring that access to safe and reliable water is prioritized in Amaokpala and similar communities. The quality of groundwater, a critical resource for many communities, is determined by a combination of geological, chemical, and anthropogenic factors. The presence of salinity in groundwater, often a result of mineral dissolution and seawater intrusion, has been extensively studied due to its significant impact on water usability. George et al. (2015) highlight that groundwater salinity is exacerbated by agricultural runoff and industrial discharges, particularly in regions with poor regulatory frameworks. Elevated salinity levels can reduce the suitability of water for drinking and irrigation, leading to health issues such as hypertension and adverse impacts on soil fertility and crop yields. Turbidity, another key parameter, is a critical indicator of water contamination. Studies by Nahian et al. (2018) in coastal Bangladesh demonstrate the correlation between high turbidity levels and the presence of pathogenic microorganisms, underscoring the importance of maintaining turbidity levels below WHO-recommended limits for effective disinfection. Similar findings have been reported in the Niger Delta, where turbidity and salinity are attributed to oil exploration activities and poor waste management practices (Yusuf et al., 2021). Furthermore, the presence of heavy metals in groundwater poses long-term health risks. Research in Nigerian coastal regions reveals elevated levels of lead and arsenic in borehole water, often linked to industrial and agricultural activities (Omorogieva et al., 2024). These findings emphasize the need for stringent monitoring and mitigation strategies to prevent contamination and ensure compliance with global water quality standards. Examples of successful groundwater studies provide valuable insights into effective management strategies. In Rajasthan, India, community-led initiatives to monitor and recharge groundwater levels have demonstrated significant improvements in water quality and availability. Programs like the "Pani Bachao Abhiyan" focus on rainwater harvesting and reducing agricultural runoff to combat salinity intrusion. Similarly, in Bangladesh, integrated water resource management projects have successfully reduced arsenic levels in drinking water by promoting the use of deep tubewells and alternative water sources. These initiatives have not only improved water safety but also enhanced public awareness about sustainable water use practices. The challenges associated with maintaining groundwater quality are not unique to Nigeria. Global studies, such as those conducted in India and Bangladesh, provide valuable insights into the effectiveness of community-based water management programs. These programs prioritize regular water quality testing, public education, and the adoption of sustainable agricultural practices to mitigate contamination. The integration of such approaches into local contexts, like Amaokpala, could offer practical solutions for safeguarding water resources and ensuring their sustainability. The quality of groundwater, a critical resource for many communities, is determined by a combination of geological, chemical, and anthropogenic factors. The presence of salinity in groundwater, often a result of mineral dissolution and seawater intrusion, has been extensively studied due to its significant impact on water usability. George et al. (2015) highlight that

groundwater salinity is exacerbated by agricultural runoff and industrial discharges, particularly in regions with poor regulatory frameworks. Elevated salinity levels can reduce the suitability of water for drinking and irrigation, leading to health issues such as hypertension and adverse impacts on soil fertility and crop yields. Turbidity, another key parameter, is a critical indicator of water contamination. Studies by Nahian et al. (2018) in coastal Bangladesh demonstrate the correlation between high turbidity levels and the presence of pathogenic microorganisms, underscoring the importance of maintaining turbidity levels below WHO-recommended limits for effective disinfection. Similar findings have been reported in the Niger Delta, where turbidity and salinity are attributed to oil exploration activities and poor waste management practices (Yusuf et al., 2021). Furthermore, the presence of heavy metals in groundwater poses long-term health risks. Research in Nigerian coastal regions reveals elevated levels of lead and arsenic in borehole water, often linked to industrial and agricultural activities (Omorogieva et al., 2024). These findings emphasize the need for stringent monitoring and mitigation strategies to prevent contamination and ensure compliance with global water quality standards. The challenges associated with maintaining groundwater quality are not unique to Nigeria. Global studies, such as those conducted in India and Bangladesh, provide valuable insights into the effectiveness of community-based water management programs. These programs prioritize regular water quality testing, public education, and the adoption of sustainable agricultural practices to mitigate contamination. The integration of such approaches into local contexts, like Amaokpala, could offer practical solutions for safeguarding water resources and ensuring their sustainability. Groundwater quality is shaped by a combination of natural geological processes and human activities. The presence of contaminants such as salinity is often linked to mineral dissolution, seawater intrusion in coastal areas, or agricultural runoff. Studies have established the impact of salinity on human health, including risks of hypertension and kidney problems, and its detrimental effects on soil fertility and crop yields (George et al., 2015). Regular monitoring of groundwater has been highlighted as crucial to identifying contamination sources and mitigating their effects (Nahian et al., 2018). In Nigeria, particularly in the Niger Delta and sedimentary regions, similar studies have shown elevated salinity levels caused by industrial discharges and natural geological features (Yusuf et al., 2021). Furthermore, research in coastal regions such as Bangladesh emphasizes the challenges posed by saline intrusion due to over-extraction of groundwater and rising sea levels. These findings underscore the importance of tailored, region-specific solutions to safeguard groundwater resources (Omorogieva et al., 2024).

II. MATERIALS AND METHODS

This study was conducted in Amaokpala, a community in Anambra State, Nigeria, characterized by tropical rainforest conditions and sedimentary rock formations that favor groundwater storage. The research aimed to assess groundwater quality and its implications for public health and agriculture. To achieve a representative coverage of the community's geographical and residential layout, five boreholes (BH-01 to BH-05) were strategically selected. The selection criteria included proximity to residential and agricultural areas, ensuring the results reflect areas of high water demand and potential contamination. Boreholes with high usage rates were prioritized to capture water quality in areas that serve the majority of the population. Additionally, boreholes with varying levels of maintenance and accessibility were included to evaluate how these factors influence water quality.

Water samples were collected from each borehole using clean, sterile containers to avoid any contamination during the sampling process. The samples were then preserved following standard protocols to maintain their integrity until analysis. The analysis focused on several key water quality parameters, including salinity, pH, turbidity, and heavy metals, which are critical indicators of water safety and suitability for consumption and agricultural use.

Salinity levels were determined using Total Dissolved Solids (TDS) meters, while pH was measured with a calibrated pH meter to ensure accuracy. Turbidity, an indicator of water clarity and potential contamination by suspended particles, was assessed using a turbidity meter. Heavy metal concentrations, including lead,

cadmium, and arsenic, were analyzed in the laboratory using advanced spectrophotometric techniques (Callistus et al., 2024). These metals were chosen due to their significant health risks and prevalence in contaminated water sources.

The results were compared against the World Health Organization (WHO) standards for drinking water quality (WHO, 2020) to determine the safety and suitability of the groundwater. This comprehensive approach allowed for a thorough understanding of water quality variations and their implications for public health and agriculture. The data obtained from this study will be invaluable for local authorities and policymakers in developing strategies to improve water quality and ensure the health and well-being of the community.

III. RESULTS AND DISCUSSION

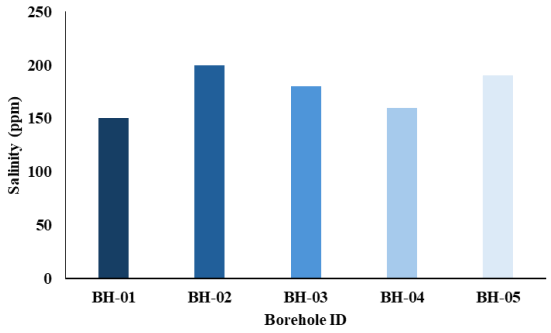

Figure 1: Salinity Levels in Boreholes

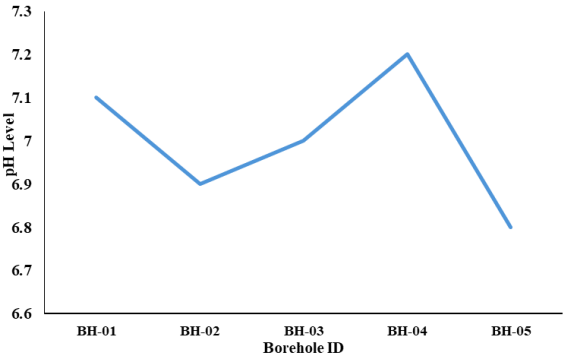

Figure 2: pH Levels in Boreholes

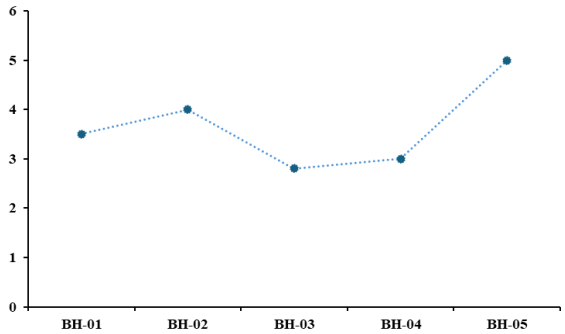

Figure 3: Turbidity Levels in Boreholes

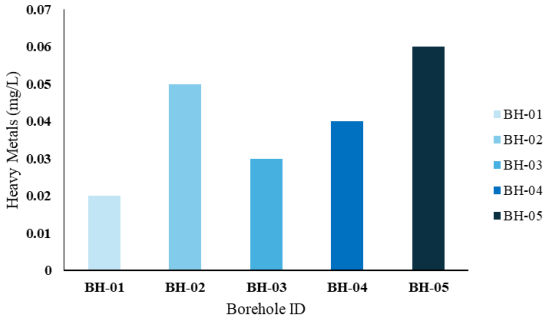

Figure 4: Heavy Metal Concentrations in Boreholes

IV. DISCUSSION

The study findings reveal significant spatial variability in the water quality of boreholes within Amaokpala. Elevated salinity levels in BH-02 and BH-05 suggest the influence of geological formations or anthropogenic activities such as improper waste disposal and agricultural practices. While pH levels were within acceptable limits, the higher turbidity and heavy metal concentrations in BH-05 highlight the need for regular monitoring and immediate intervention to prevent potential health risks. Comparatively, the observed water quality issues align with studies in similar regions, indicating a broader pattern influenced by local geology and human activities. The high turbidity in BH-05 could also indicate an increased risk of microbial contamination, necessitating further microbiological testing. The relationship between salinity and heavy metal concentrations suggests a common source, likely mineral dissolution, underscoring the need for comprehensive water resource management strategies. Addressing the findings of this study requires targeted policy interventions. Policymakers must prioritize the establishment of a systematic monitoring framework

to track changes in water quality over time. Regulatory standards for borehole construction and maintenance should be enforced to minimize contamination risks. Investment in community-level water treatment technologies, such as reverse osmosis systems, can mitigate the effects of high salinity and heavy metals. Furthermore, education campaigns should inform residents about the dangers of improper waste disposal and the benefits of sustainable agricultural practices. Collaborations between local governments, environmental agencies, and international organizations can foster the development of long-term strategies to protect groundwater resources. These measures are critical to ensuring access to safe and reliable water for both domestic and agricultural purposes, promoting public health and socio-economic development.

CONCLUSION

In conclusion, the proactive management of borehole water quality, coupled with community involvement and stringent regulatory frameworks, is essential to ensuring the provision of safe drinking water in Amaokpala. The insights gained from this study should inform policy decisions and water management practices not only in Anambra State but also in similar regions facing groundwater quality challenges. This study highlights significant variability in the water quality of boreholes in Amaokpala, Anambra State, Nigeria. Notably, boreholes BH-02 and BH-05 exhibited elevated levels of salinity, turbidity, and heavy metals, which necessitate immediate attention. The findings underscore the importance of regular monitoring and intervention to ensure safe drinking water for the community. The water quality in Amaokpala's boreholes varies considerably, with certain boreholes presenting levels of salinity and turbidity that exceed recommended thresholds. The presence of heavy metals, albeit within acceptable limits, further underscores the need for vigilance. This study provides a comprehensive assessment that can guide both immediate and long-term water management strategies to safeguard public health and support sustainable agricultural practices. To address these challenges, the following recommendations are very essential, to implement a systematic and regular monitoring program for all boreholes to promptly identify and address any deviations in water quality parameters. Developing and installing appropriate water treatment systems, especially for boreholes with higher salinity and turbidity levels, will ensure the delivery of safe drinking water. Additionally, educating the community on the importance of sustainable water use practices, proper maintenance of boreholes, and the potential health risks associated with water contamination is crucial. Policymakers should prioritize the creation and enforcement of region-specific guidelines for groundwater management, setting stringent standards for water quality and establishing protocols for regular inspections and maintenance of water sources. Encouraging further research into advanced and cost-effective water purification technologies that can be implemented in rural communities will also enhance water safety and accessibility.

REFERENCES

[1] Callistus, O., et al. (2024). An Assessment of Saltwater Intrusion in Coastal Regions of Lagos, Nigeria. *Journal of Geoscience and Environment Protection,* 12(01), 93-119. https://doi.org/10.4236/gep.2024.121007

[2] Djaouda, M., et al. (2018). Assessment of Bacteriological Quality of Groundwater in Maroua, Cameroon. *African Journals Online*, 12(2), 958-958. https://doi.org/10.4314/ijbcs.v12i2.26

[3] George, N. J., Ibanga, J. I., &Ubom, A. I. (2015). Evidence of Saline Water Intrusion in Coastal Aquifers. *Journal of African Earth Sciences*, 109, 37–46. https://doi.org/10.1016/j.jafrearsci.2015.05.001

[4] Muo, I. (2023). Social Entrepreneurship and Medical Entrepreneurship: Lessons from Nigeria. *Springer*. https://doi.org/10.1007/978-981-19-6696-5_11

[5] Nahian, M. A., et al. (2018). Drinking Water Salinity and Health in Coastal Bangladesh. *BioOne,* 6, 143. https://doi.org/10.1525/elementa.143

[6] Obioma, A. (2020). Bacteriological Risk Assessment of Borehole Water in Niger Delta, Nigeria. *Biomedical Research Network*, 24(4), 4093. https://doi.org/10.26717/bjstr.2020.24.004093

[7] Oloruntola, M. O., et al. (2019). Freshwater–Saltwater Interface in Coastal Aquifers. *Applied Water Science*, 9(4). https://doi.org/10.1007/s13201-019-0957-1

[8] Omorogieva, O. M., et al. (2024). Hydrogeochemical Evaluation of Groundwater Suitability for Drinking in Gbaramatu Kingdom, Nigeria. *Journal of Applied Science and Environmental Management*, 28(2), 565-575. https://doi.org/10.4314/jasem.v28i2.29

[9] WHO. (2020). Guidelines for Drinking-Water Quality. *World Health Organization.*

[10] Yahaya, T., et al. (2020). Concentration and Health Risk Assessment of Groundwater Contaminants. *Journal of African Environmental Health*, 8(3), 234-242. https://doi.org/10.22102/jaehr.2020.245629.1183