Innovative Solutions for Water Quality Assessment: A Comparative Analysis of Electrical Conductivity in Bottled and Sachet Water in Ekwuluobia Community

OBIORA EMEKA OKOYE, NDIDI FLORENCE OBIESIE AND CHINENYENWA JACINTA EZE

DEPARTMENT OF SCIENCE LABORATORY TECHNOLOGY, PHYSICS ELECTRONICS OPTION, FEDERAL POLYTECHNIC OKO.

EMAIL: OBIORA.OKOYE@FEDERALPOLYOKO.EDU.NG

Abstract

The global dilemma of accessing clean and safe drinking water persists, especially in underdeveloped communities. This study evaluated the electrical conductivity (EC) of bottled and sachet water samples collected from various points of sale within the Ekwuluobia community. Using a water quality meter, EC values were measured to assess the concentration of dissolved ions and minerals, which directly impact water quality and safety. Bottled water samples exhibited higher EC values, ranging from 146 µS/cm to 160 µS/cm, while sachet water samples had lower EC values, ranging from 130 µS/cm to 139 µS/cm. The study identified significant differences in EC levels between different brands of bottled water and sachet water producers, with bottled water consistently showing higher mineral content. These elevated levels could pose potential health risks, particularly with prolonged consumption. The findings underscore the need for stricter regulatory oversight of sachet water, which may not meet health standards due to elevated impurities. This study aims to raise community awareness about water quality and offers evidence-based recommendations for local authorities to enhance water safety regulations. By providing consumers with essential data, this research encourages informed decisions regarding drinking water sources and contributes to improved public health outcomes within the community.

Keywords: Water quality, Electrical Conductivity, Sachet water, Public Health, Sachet water

Introduction

Water is essential for life, and its condition directly impacts human health. Clean drinking water, free from contaminants, is a basic human right and a vital element of public health (Agbasi *et al.*, 2023). Water, with its simple chemical composition (H_2O), is crucial for the transport of nutrients, minerals, and other substances within organisms (Taiwo *et al.*, 2023). It makes up approximately 60% of the human body and is necessary for key physiological functions, such as temperature regulation, joint lubrication, nutrient transport, and waste removal (Ogarekpe *et al.*, 2023).

Climate change, poor sanitation, and pollution define the worldwide water shortage. Poor water quality can lead to health issues and waterborne infections. Ekwuluobia, Nigeria residents rely on bottled and sachet water due to pollution concerns. Assessing the safety and quality of these sources is crucial for public health. Monitoring, treatment methods, and ethical management practices are essential for maintaining water quality, as poor water characteristics can make it less appealing for consumption (Oluwasanya *et al.*, 2023; Aralu *et al.*, 2022; Agwu *et al.*, 2023).

Electrical conductivity (EC) is a key metric for assessing water quality by measuring the concentration of total dissolved solids (TDS). Higher EC values indicate a higher level of dissolved salts and minerals (Olaojo and Oladunjoye, 2022). While EC alone does not provide a complete assessment of water quality, it offers a quick way to gauge overall mineral content and potential issues (George *et al.*, 2022). Sachet water, being less expensive than bottled water, often faces more lenient production and distribution regulations, which can result in variations in quality (Amarachi *et al.*, 2023).

Ekwuluobia faces public health concerns regarding clean water access, with bottled and sachet water being widely used. However, quality varies due to differences in filtration, source water, and packaging. High electrical conductivity (EC) in sachet water may indicate impurities, posing health risks like gastrointestinal issues and chronic conditions (George *et al.*, 2022). This study aims to evaluate EC of bottled and sachet water, providing insights into potential health risks, and offering recommendations for local health authorities to improve water safety regulations and quality assurance protocols.

Materials and Methods

Materials

The study involved the collection of water samples from various brands and local suppliers in Ekwuluobia using a range of instruments, such as conductivity, pH, temperature, and turbidity meters. Planning, preparing, and obtaining consent from local authorities were integral components of the data collection procedure, along with ensuring that all equipment was properly calibrated and functional.

Water samples were gathered from five distinct brands of bottled water and five separate producers of sachet water at various places in Ekwuluobia. This was done to prevent contamination. The samples were obtained using sterile containers and consistent processes. Each sample was clearly tagged with information regarding the kind of water and brand. The collected water samples were systematically labeled to ensure clarity and ease of comparison. Bottled water samples were denoted as BWS 1 to BWS 5, representing five distinct brands of bottled water sourced from different points of sale within the Ekwuluobia community. These labels were consistently applied throughout the analysis, allowing for straightforward identification of each brand's corresponding data on electrical conductivity, pH levels, total dissolved solids (TDS), and temperature. Similarly, sachet water samples were labeled as SWS 1 to SWS 5, referring to five different sachet water producers from the same community. This consistent labeling system facilitated a clear comparison between the two water categories, enabling an effective evaluation of the measured parameters. By using numerical identifiers such as BWS 1 and SWS 1, the analysis provided a structured approach to highlighting variations in water quality between bottled and sachet water samples. The samples were stored in a temperature-controlled device and analyzed for electrical conductivity and other metrics.

Methods

The methods of electrical conductivity (EC) analysis and other water quality metrics were carried out using a digital 10-in-1 professional water quality monitor, a versatile tool capable of measuring various parameters crucial for assessing water quality. This device was used to assess the electrical conductivity (EC), pH level, total dissolved solids (TDS), and temperature of the collected water samples. For each water sample, five separate EC measurements were taken to ensure accuracy and reliability. This was done for both the bottled water samples (BWS 1–5) and the sachet water samples (SWS 1–5). The EC values were recorded in microsiemens per centimetre (µS/cm), a standard unit for measuring how easily electricity can pass through water, which correlates with the concentration of dissolved ions and minerals.

In addition to EC, the pH level was measured for each sample, providing insight into the water's acidity or alkalinity. This is important as pH can affect both taste and the potential impact of water on human health. The TDS (mg/L), which indicates the total concentration of dissolved solids in the water, was also measured, providing further insight into the water's purity and mineral content. Lastly, the temperature (°C) was recorded, as temperature can influence the conductivity readings and overall water quality.

Results and Discussion

Table 1 below provides a clear comparison between bottled water samples (BWS 1 to BWS 5) and sachet water samples (SWS 1 to SWS 5) by presenting their average electrical conductivity (EC), pH levels, total dissolved solids (TDS), and temperature. This format simplifies the data and makes it easier to analyze the water quality differences between bottled and sachet water.

Bottled water samples exhibit higher electrical conductivity values, ranging from 146.0 µS/cm to 160.0 µS/cm, with corresponding TDS values between 92 mg/L and 100 mg/L. These higher readings suggest that bottled water generally contains more dissolved ions and minerals, which may be a result of stricter filtration and mineralization processes employed by bottled water manufacturers.

In contrast, the sachet water samples show lower EC values, ranging from 130.0 µS/cm to 139.0 µS/cm, with TDS values between 82 mg/L and 89 mg/L. This suggests that sachet water contains fewer dissolved minerals, possibly due to less rigorous filtration processes or differences in water sources.

Both bottled and sachet water samples exhibited relatively neutral pH levels (ranging from 7.0 to 7.6) and uniform temperature values of 25°C, indicating no significant temperature fluctuations during the analysis. Overall, the table provides a clear overview of the water quality parameters for both types of water and highlights the key differences in mineral content between them.

Table 1: Electrical Conductivity, pH, TDS, and Temperature for Bottled and Sachet Water Samples

Water Sample	EC Average (µS/cm)	pH Level	TDS (mg/L)	Temperature (°C)
BWS 1	150.0	7.5	95	25
BWS 2	146.0	7.4	92	25
BWS 3	160.0	7.6	100	25
BWS 4	156.0	7.5	98	25
BWS 5	159.0	7.5	99	25
SWS 1	139.0	7.2	88	25
SWS 2	135.2	7.1	85	25
SWS 3	139.0	7.3	89	25
SWS 4	130.0	7.0	82	25
SWS 5	133.0	7.2	84	25

Comparison of Electrical Conductivity ECs of bottled and sachet water

The comparison of electrical conductivity (EC) between bottled and sachet water in fig 1 shows notable differences in mineral content and ion concentrations. Bottled water samples had EC values ranging from 146.0 µS/cm to 160.0 µS/cm, indicating a higher presence of dissolved ions and minerals. Specifically, BWS 3 recorded the highest average conductivity at 160.0 µS/cm. In contrast, sachet water samples had lower EC values, ranging from 130.0 µS/cm to 139.0 µS/cm, with SWS 4 showing the lowest at 130.0 µS/cm. This suggests that bottled water, which undergoes advanced filtration and mineralization, offers more consistent quality and mineral enrichment compared to sachet water, which may have less rigorous purification processes and greater variability in ion concentration. Overall, bottled water is more mineral-rich, while sachet water contains fewer dissolved ions.

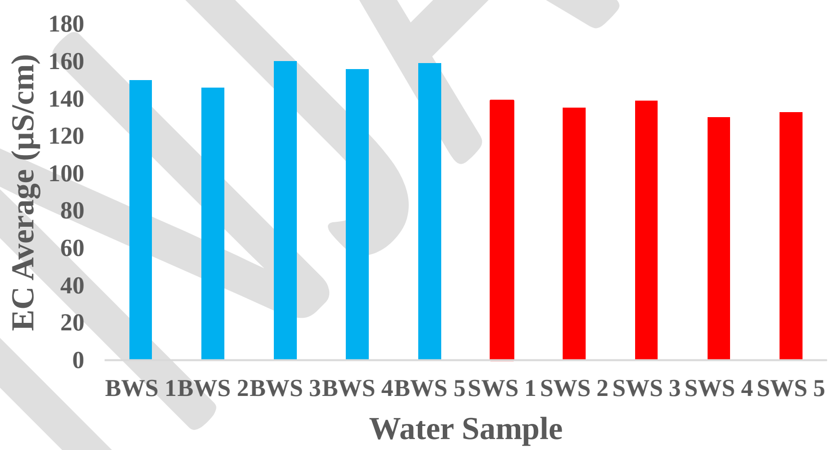

Fig 1: Comparison of Electrical Conductivity Between Bottled and Sachet Water Samples Graph

Comparison of Total Dissolved Solids (TDS) between bottled and sachet water

From fig 2, the comparison of Total Dissolved Solids (TDS) between bottled and sachet water reveals significant differences in their composition and treatment processes. Bottled water samples showed TDS values ranging from 92 mg/L to 100 mg/L, indicating a higher concentration of dissolved substances. Specifically, BWS 3 had the highest TDS value of 100 mg/L, suggesting a mineral-rich source or additional mineralization. In contrast, sachet water samples had lower TDS values, ranging from 82 mg/L to 89 mg/L, with SWS 4 recording the lowest at 82 mg/L, indicating less mineralization likely due to simpler filtration methods. This disparity in TDS reflects the more controlled processing of bottled water, resulting in a richer mineral profile, while sachet water exhibits more variability in dissolved solids, potentially affecting its taste and health benefits.

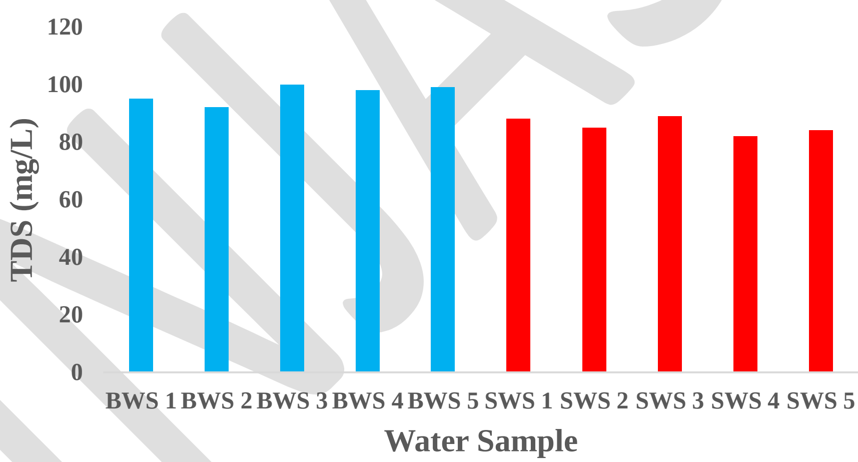

Fig 2: Comparison of TDS Between Bottled and Sachet Water Samples Graph

The study on bottled and sachet water in the Ekwuluobia community reveals significant differences in mineral content and ion concentration, particularly in electrical conductivity (EC) and total dissolved solids (TDS). These findings align with previous research, such as a study in Bangladesh, which indicated that local bottled water manufacturers often do not meet established quality standards. The lower EC and TDS values in sachet water suggest that local producers may not employ rigorous filtration processes, raising concerns about water quality control. The study also highlights the importance of efficient water quality testing technologies, utilizing a digital monitor for real-time assessments, which reflects a global trend towards improved monitoring methods (Thakur and Devi, 2022). Additionally, the research indicates that contamination may occur during the manufacturing process rather than from storage conditions, suggesting a need for stricter protocols among sachet water producers. Furthermore, concerns about microplastic contamination in bottled water (Santana-Mayor et al., 2021; Vitali et al., 2022) emphasize the necessity for comprehensive testing beyond mineral content to ensure overall water safety.

Recommendation

Based on the findings from this survey, the following recommendations were proposed:

1. To improved quality control for sachet water.
2. To enhanced filtration and treatment processes.
3. To adopt real-time water quality monitoring.
4. Regular testing for contaminants, including microplastics.
5. Consumer awareness and education on water quality.

Conclusion

The study reveals that bottled water in Ekwuluobia has a narrow average electrical conductivity range, compared to sachet water, which has a range of 130.0 to 139.0 µS/cm. This suggests that bottled water quality may be more consistent than sachet water, possibly due to stricter quality control processes and standardized methods. Higher conductivity in water may indicate higher concentrations of dissolved salts, potentially affecting health concerns like hypertension or kidney problems. However, some brands, like BWS 3, show elevated conductivity levels, indicating potential health hazards. Sachet water, on the other hand, shows significant variation, indicating potential irregularities in sources and processing techniques. The study underscores the need for rigorous quality control protocols among manufacturers. To improve bottled and sachet water quality in Ekwuluobia, regulatory authorities should implement stricter measures, regularly monitor and test water, raise public awareness, provide financial support for testing, foster transparency, and establish a certification program for water producers.

REFERENCES

Agbasi, J., Chukwu, C., Nweke, N., Uwajingba, H., Khan, M., and Egbueri, J. (2023). Water pollution indexing and health risk assessment due to PTE ingestion and dermal absorption for nine human populations in Southeast Nigeria. *Groundwater for Sustainable Development*, *21*, 100921.

Agwu, E. J., Odanwu, S. E., Ezewudo, B. I., Odo, G. E., Nzei, J. I., Iheanacho, S. C., and Islam, M. S. (2023). Assessment of water quality status using heavy metal pollution indices: A case from Eha-Amufu catchment area of Ebonyi River, Nigeria. *Acta Ecologica Sinica*, *43*(6):989–1000.

Amarachi, N., Austin, T., Michael, O., Bilar, A., and Christopher, A. (2023). Quality assessment and health impact of bottled water in Uratta, Imo state: a retrospective study. *Sustainable Water Resources Management*, *10*(1).

Aralu, C. C., Okoye, P. A. C., Abugu, H. O., and Eze, V. C. (2022). Pollution and water quality index of boreholes within unlined waste dumpsite in Nnewi, Nigeria. *Discover Water*, *2*(1).

George, N. J., Agbasi, O. E., Umoh, J. A., Ekanem, A. M., Ejepu, J. S., Thomas, J. E., and Udoinyang, I. E. (2022). Contribution of electrical prospecting and spatiotemporal variations to groundwater potential in coastal hydro-sand beds: a case study of Akwa Ibom State, Southern Nigeria. Acta Geophysica, 71(5), 2339–2357. https://doi.org/10.1007/s11600-022-00994-2

Ogarekpe, N., Nnaji, C., Oyebode, O., Ekpenyong, M., Ofem, O., Tenebe, I., and Asitok, A. (2023). Groundwater quality index and potential human health risk assessment of heavy metals in water: A case study of Calabar metropolis, Nigeria. *Environmental Nanotechnology, Monitoring & Management*, *19*, 100780.

Olaojo, A. A., and Oladunjoye, M. A. (2022). Field-Scale Apparent Electrical Conductivity Mapping of Soil Properties in Precision Agriculture. *Brazilian Journal of Geophysics*, *40*(3).

Oluwasanya, G., Omoniyi, A., Perera, D., Layi-adigun, B., Thuy, L., and Qadir, M. (2023). Water quality, WASH, and gender: differential impacts on health and well-being in Abeokuta City, Nigeria. *Environmental Monitoring and Assessment*, *195*(10).

Santana-Mayor, L., Rodríguez-Ramos, R., Herrera-Herrera, A. V., Socas-Rodríguez, B., and Rodríguez-Delgado, M. N. (2021). Monitoring of the presence of plasticizers and effect of temperature and storage time in bottled water using a green liquid–liquid microextraction method. *Food Research International*, *164*, 112424.

Taiwo, A. M., Ogunsola, D. O., Babawale, M. K., Isichei, O. T., Olayinka, S. O., Adeoye, I. A., Adekoya, G. A., and Tayo, O. E. (2023). Assessment of Water Quality Index and the Probable Human Health Implications of Consuming Packaged Groundwater from Abeokuta and Sagamu, Southwestern Nigeria. *Sustainability*, *15*(4), 3566.

Thakur, A., and Devi, P. (2022). A Comprehensive Review on Water Quality Monitoring Devices: Materials Advances, Current Status, and Future Perspective. *Critical Reviews in Analytical Chemistry*, *54*(2):193–218.

Uddin, M. R., Khandaker, M. U., Abedin, M. J., Akter, N., Molla Jamal, A. S. I., Sultana, R., Sultana, S., Hasan, M., Osman, H., Elesawy, B. H., Sayyed, M. I., & Sulieman, A. (2021). Quality Assessment of Bottled and Unbottled Drinking Water in Bangladesh. *Water*, *13*(15):2026.

Vitali, C., Peters, R. J., Janssen, H. G., Undas, A. K., Munniks, S., Ruggeri, F. S., & Nielen, M. W. (2024). Quantitative image analysis of microplastics in bottled water using artificial intelligence. *Talanta*, *266*, 124965.