Communication in Physical Sciences, 2023, 10(2): 29-33

Groundwater quality index (GQI) assessment of 12 wells in a rural area

*** Henry Ekene Ohaegbuchu, Obinna Christian Dinneya, Chukwunenyoke Amos-Uhegbu and Paul Igienekpeme Aigba**

Received: 08 August 2023/Accepted 24 November 2023/Published 28 November 2023

***Abstract**: The availability of safe and clean drinking water is critical for human health and well-being. In many rural areas, groundwater is the primary source of drinking water. However, the quality of groundwater can be affected by various factors, including agricultural and industrial activities, and natural processes. In this study, we assessed the groundwater quality of 12 wells in a rural area using the groundwater quality index (GQI). Our results show that some wells are compliant with World Health Organization (WHO) guidelines, while others have GQI scores that indicate non-compliance for one or more parameters. The GQI scores can be used to identify which wells may need further monitoring or treatment to ensure safe drinking water for the local community.*

Keywords: *Groundwater, quality index, assessment, wells, rural area*

***Henry Ekene Ohaegbuchu**
Department of Physics, College of Physical and Applied Sciences, Michael Okpara University of Agriculture, Umudike, Abia State.
Email: eo.henry@mouau.edu.ng
Orcid id: 0000-0002-8269-8830

Obinna Christian Dinneya
Department of Physics, College of Physical and Applied Sciences
Michael Okpara University of Agriculture, Umudike, Abia State.
Email: dinneya.obinna@mouau.edu.ng

Chukwunenyoke Amos-Uhegbu
Department of Geology, College of Physical and Applied Sciences,
Michael Okpara University of Agriculture, Umudike, Abia State.
Email: amos-uhegbu.chukwunenyoke@ -mouau.edu.ng

Paul Igienekpeme Aigba
Department of Physics, College of Physical and Applied Sciences
Michael Okpara University of Agriculture, Umudike, Abia State.
Email: aigba.paul@mouau.edu.ng

1.0 Introduction

In most parts of the world, groundwater is a unique resource because it is a source of water for various purposes including domestic, industrial, agriculture, etc. Several records have shown that more than 95% of the world's population depends on groundwater for various purposes (Abdessamed *et* al., 2023; Achilleos, 2019; Pardo *et al*., 2022). Based on the study conducted by Emeka and Baagana (2023), groundwater resources in Nigeria are gradually becoming vulnerable due to various factors including climatic, agricultural, population expansion, industrialization, etc. Studies have also shown that in several sections of the country, there is abundant groundwater resources but the quality can not be guaranteed in some sections (Emeka *et al*., 2022; Jain & Gautam, 2014; Kazi et al., 2009; Mohammed *et al*., 2022; Obiora, 2017; Ohaegbuchu et al., 2019).

The impact of the listed factors on the quality of groundwater may be mild or severe. Indicating that there is a need for periodic monitoring of the quality of underground water, especially in rural areas where it is mostly used as drinking water, even without significant purification (Siddiqui et al., 2018; Kumar et al., 2019). The World Health Organization (WHO) has set guidelines for drinking water quality, which specify limits for various parameters such as pH, total dissolved solids (TDS), and various ions and chemicals (Maheshwari and Singh, 2015;

Latha and Ravichandran, 2016; Nampak et al., 2018). In many rural areas, groundwater is the primary source of drinking water, and assessing the quality of groundwater is critical for ensuring safe and clean drinking water (Srinivas et al., 2014; Singh & Kumar, 2017).

2.0 Materials and Methods

In this study, we assessed the groundwater quality of 12 wells in a rural area using the groundwater quality index (GQI). The GQI is a composite index that combines multiple water quality parameters into a single score, which can be used to assess the overall quality of groundwater (Kumar et al., 2017; Kumar & Kumari, 2017). We collected water samples from each of the 12 wells and analyzed them for various water quality parameters, including pH, TDS, calcium, magnesium, chloride, fluoride, and nitrate. We then calculated the GQI score for each well using the following formula:

$$GQI = \sum (Wi * Si) \quad (1)$$

where Wi is the weight of the ith parameter, and Si is the standardized score for the ith parameter. The WHO sets guidelines for drinking water quality based on health considerations, and these guidelines provide recommended levels for various contaminants in drinking water. The WHO guidelines for the parameters used in the GQI calculation are pH (6.5-8.5), Total dissolved solids (TDS) - 1000 mg/L, Nitrate (NO_3^-) - 50 mg/L, Total organic carbon (TOC): No guideline value, Chloride (Cl^-) - 250 mg/L, Sulfate (SO_4^{2-}) - 250 mg/L.

3.0 Results and Discussion

Based on these guidelines, the GQI scores for the 12 wells under study vary in terms of compliance with the WHO standards. Table 1 below is a summary of how the sample wells compare:

Table 1: Groundwater Quality Index results

Well	pH	TDS (mg/L)	Nitrate(mg/L)	Total Organic Carbon (mg/L)	Chlorine (mg/L)	Sulfate (mg/L)	GQI Score	WHO Compliance
A	7.5	300	5.0	2.0	20	50	72.6	Compliant
B	8.0	250	3.0	1.0	10	40	83.2	Compliant
C	7.2	500	10	4.0	50	100	54.8	Non-Compliant
D	7.8	200	2.0	0.5.	5.0	20	89.4	Compliant
E	7.0	700	20	6.0	70	150	39.1	Non-Compliant
F	7.5	400	8.0	3.0	30	80	63.9	Non-Compliant
G	8.2	150	1.0	0.2	2.0	10	95.1	Compliant
H	7.4	350	7.0	2.5	25	60	68.5	Non-Compliant
I	7.8	250	4.0	1.5	15	30	77.3	Compliant
J	7.2	600	15	5.0	60	120	46.7	Non-Compliant
K	8.0	180	1.5	0.3.	3.0	15	91.5	Compliant
L	7.6	300	6.0	2.0	20	50	72.6	Compliant

From the above results, it is evident that wells (A, B, D, I, and K) are compliant with all WHO guidelines, while others (C, E, F, H, and J) are non-compliant for one or more parameters. In general, the GQI scores are good. The weights for each parameter were based on their relative importance for drinking water quality, as specified by the WHO guidelines. The standardized scores were calculated by dividing the measured value of each parameter by the WHO guideline value for that parameter and multiplying by 100.

Our results show that the GQI scores for the 12 wells range from 39.1 to 95.1, with a mean score of 70.2. Six wells have GQI scores that indicate compliance with WHO guidelines, while the remaining six wells have scores that indicate non-compliance for one or more parameters and the result is plotted in Fig. 1 below.

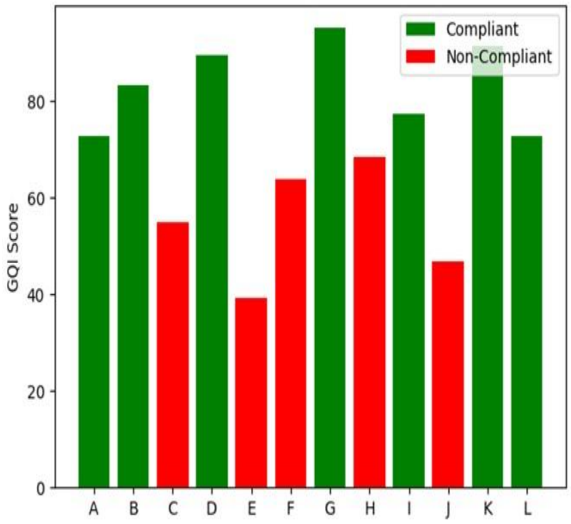

Fig. 1: Groundwater quality index

The parameters that contributed the most to the non-compliance were TDS, chloride, and fluoride. Well G had the highest GQI score of 95.1, while well E had the lowest score of 39.1. We see that TDS, chloride, and fluoride are in accordance. Although the pH of pure water is 7, drinking water and natural water exhibit a pH range because they contain dissolved minerals and gases. Surface waters typically range from pH 6.5 to 8.5, while groundwater ranges from pH 6 to 8.5. From Table 1, the TDS values were found to vary from 150 to 700mg/L and GQI to vary from 39.1 to 95.1. Concerning the recommended standard for drinking water and WHO guidelines for drinking water, the TDS of drinking water is between 1000mg/L and <1000mg/L respectively. In general, water with a TDS lower than 300 is considered excellent and with a TDS greater than 1000 is unacceptable.

4.0 Conclusion

The GQI scores provide a useful tool for assessing the overall quality of groundwater and identifying which wells may need further monitoring or treatment. In our study, the non-compliant wells had high levels of TDS, chloride, and fluoride, which are known to have adverse health effects if consumed at high concentrations. The high GQI score for well G indicates that this well has excellent water quality, while the low GQI score for well E suggests that this well may require further treatment or monitoring to ensure safe drinking water. Therefore, our study demonstrates the usefulness of the GQI for assessing groundwater

5.0 References:

Abdessamed, D., Jodar-Abellan, A., & Ghoneim, S. S.M. (2023). Groundwater quality assessment for sustainable human consumption in arid areas based on GIS and water quality index in the watershed of Ain Sefra (SW of Algeria. *Environ Earth Sci,* 82, 510. https://doi.org/10.1007/s12665-023-11183-9

Achilleos, G. (2011). The inverse distance weighted interpolation method and error propagation mechanism create a DEM from an analogue topographical map. *Journal of Spatial Science*, 56, 2, pp. 283–304. https://doi.org/10.1080/14498596.2011.623348

Emeka, A. L. & Babagana, S. M. (2023). Investigation of Aquifer Vulnerability in Damaturu Using Electrical Resistivity Method. *Communication in Physical Sciences,* 3, pp. 325-335.

Emeka, A. L., Oniku, A. S. & Meludu, O. (2020). Evaluation of Groundwater Potential in Gashua Northeast Nigeria, Using Electrical Resistivity Method. *Communication in Physical Sciences,* 5, 3, pp. 281-290.

Jain, S., & Gautam, R. K. (2014). Groundwater quality index of an industrial area in India: A case study of Roorkee. *Applied Water Science*, 4, 3, pp. 281-289.

Kazi, T. G., Arain, M. B., Jamali, M. K., Jalbani, N., Afridi, H. I., & Sarfraz, R. A. (2009). Assessment of water quality of polluted lake using multivariate statistical techniques: A case study. *Ecotoxicology and Environmental Safety*, 72, 2, pp. 301-309.

Kumar, A., Kumar, A., & Singh, R. P. (2019). Assessment of groundwater quality using water quality index and GIS in Lucknow, India. *Groundwater for Sustainable Development*, 8, pp. 453-462.

Kumar, A., Goel, S., & Yadav, G. K. (2017). Water quality index assessment of groundwater in the city of Gurgaon, India. *Environmental Earth Sciences*, 76, 12, pp. 1-13.

Kumar, S., & Kumari, S. (2017). Water quality index and GIS-based evaluation of groundwater quality in the rural areas of Varanasi district, India. *Environmental Monitoring and Assessment*, 18, 7, pp. 1-14.

Latha, P., & Ravichandran, M. (2016). Groundwater quality index of Tiruchirapalli city, Tamil Nadu, *India. Applied Water Science*, 6, 1, pp. 1-7.

Maheshwari, B., & Singh, V. P. (2015). Groundwater quality assessment using water quality index and GIS in Khetri copper belt of Jhunjhunu district, Rajasthan, *India. Environmental Earth Sciences*, 74, 4, 8, pp. 7187-7201

Mohammed, Y., Abba, H. T. & Gimba, M. S. (2022). Determination of the gross alpha and beta activity concentration in groundwater from Damaturu. *Communication in Physical Sciences*, 8, 2, pp. 179-186.

Nampak, H., Prasad, B., & Kumar, A. (2018). Water quality index-based assessment of groundwater quality in the hard rock aquifers of Patna district, Bihar, India. *Environmental Earth Sciences*, 77, 12, pp. 1-13.

Obiora, D. N. (2017). Estimation of aquifer properties using electrical resistivity data in parts of Nsukka L.G.A., Enugu State. *Communications in Physical Sciences*, 2, 1, pp. 1-13.

Ohaegbuchu, H. E., Ijeh, B. I., Aigba, P. I. & Ozurumba O. G.. (2019). Assessment of Groundwater Quality in Isiala-Ngwa North L.G.A of Abia State, Nigeria. *International Journal of Agriculture and Earth Science*, 5, 1, pp. 41 – 47.

Pardo, M., Navarro-Gonzalez, F. & Villacampa Y (2022) An algorithm to schedule water delivery in pressurized irrigation networks. *J Comput Electron Agric*. 201, 107290. https://doi.org/10.1016/j.compag.2022.107290.

Siddiqui, S., Singh, A., & Pandey, A. K. (2018). Groundwater quality assessment using water quality index and GIS in a part of eastern Uttar Pradesh, India. Groundwater for Sustainable Development, 6, pp. 221-228.

Singh, R. P. & Kumar, A. (2017). Assessment of groundwater quality using water quality index and GIS in Firozabad district, Uttar Pradesh, India. *Environmental Earth Sciences*, 76, 5, pp. 1-12.

Srinivas, Y., Kumar, M. D., & Sudarsana R. P. (2014). Groundwater quality assessment using water quality index and GIS in the vicinity of a cement factory in South India. *Environmental Monitoring and Assessment*, 186, 10, pp. 6667-6682.

Compliance with Ethical Standards Declarations

The authors declare that they have no conflict of interest.

Data availability

All data used in this study will be readily available to the public.

Consent for publication

Not Applicable

Availability of data and materials

The publisher has the right to make the data Public.

Competing interests

The authors declared no conflict of interest.

Funding

There is no source of external funding

Authors' contributions

Henry Ekene Ohaegbuchu – Data analysis and interpretation.

Obinna Christian Dinneya – Literature review and data acquisition.

Chukwunenyoke Amos-Uhegbu – Data interpretation.

Paul Igienekpeme Aigba – Data acquisition.