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COMMUNIQUE OF THE 33RD ANNUAL CONFERENCE OF THE NIGERIAN ASSOCIATION OF HYDROGEOLOGISTS (NAH) AN AFFILIATE OF INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS (IAH) AND A SPECIALIST GROUP OF THE NIGERIAN MINING AND GEOSCIENCES SOCIETY (NMGS) HELD AT NATIONAL WOMEN DEVELOPMENT CENTRE, ABUJA, NIGERIA

The 33rd Annual Conference and Workshop of the Nigerian Association of Hydrogeologists was held at Abuja, Federal Capital territory, Nigeria from 31st October 2022 to 4th November 2022. There were four hundred (423) participants from both within and outside Nigeria. The Federal and State Ministries of Water Resources, Environment and Agriculture and associated Departments and Agencies, Academia, Captains of water industry, non – Governmental Organisations, the Private Sector and the General Public were in attendance.

The theme of the conference was ‘Prospects and Challenges of Sustainable Management of Water, Sanitation and Hygiene (WASH) in Nigeria’ with the following sub themes:

1. Sustainable Water Resources Management for Water, Sanitation and Hygiene (WASH) Accessibility
2. Policy and Practice for Climate Change Preparedness, Disaster Response, Mitigation and Resilience
3. Mainstreaming Integrated Water Resources Management (IWRM) in a Developing Economy
4. Strengthening Groundwater Governance, Collaboration and Resourcing to Improve Performance
5. Water and Eradication of Open Defecation in Nigeria; Insights into Diversity, Equity, and Inclusion
6. Contributions of Data and Research in Decision Making for Water Resources Development and Management
7. Environmental Protection and Management

The Conference was declared open by the Honourable Minister, Federal Ministry of Water Resources Engr. Suleiman H. Adamu, FNAH, FNSME, FAEng

A total of Forty (40) technical papers were presented at the conference. A panel discussion and brainstorming pre- conference on the theme and sub themes was held and the following observations were made by participants after exhaustive deliberations:

1. Key challenges in the effective realisation of sustainable WASH include growing insecurity, climate change, poor government capacity for coordination and sector leadership, and low financing and investment interest.
2. Climate change has been found to be responsible for environmental challenges that has led to colossal loss of lives and properties and displacement of people globally.
3. There is the urgent need to have detailed and reliable scientific data, good practices, and knowledge diffusion in understanding adaptive strategies in harnessing groundwater.
4. There is the urgent call to promote groundwater management and development opportunities.
5. Integrated data collection, knowledge dissemination, synergy and collaboration with programs and partner agencies with specialized knowledge are required.
6. Understanding of Water Resources in terms of quality and quantity to be able to effectively manage the environment.
7. Groundwater may be close to the surface where it may become prone to contamination and detrimental effects on foundations soils and rocks, water disappearing from fractures below a dam can exert upthrust that can cause failure to the dam.

Consequently, the following recommendations were suggested:

1. Stakeholders should be encouraged to advocate to state governments to prioritise funding of WASH, create enabling environment for Operation and Maintenance for effective sustainability and management.
2. There is the need for governments at sub-national levels to adopt the WASH initiatives of the Federal Government supported by UNICEF and all donor agencies to be able to achieve the Open defecation Free (ODF) status.
3. The conference strongly recommends putting in place effective measures for long term adaptation to climate change and hydrologic variability which will protect or enhance groundwater recharge and manage water demand.
4. The conference recommends identification and integration of opportunities to manage and develop groundwater in future water sector programs to improve the reliability of water supply for multiple uses and protection of ecosystems.
5. Implementation of Institutional and Legal Regulatory Framework with strong political will and holistic management of the country’s water resources.
6. Current International Approaches in Integrated Water Resources Management should be strengthened and encourage States to do same.
7. Effective evaluation and monitoring of water quality at point and distribution sources.
8. Pre-investigations for engineering structures and groundwater protection employing the use of geology, hydrogeology and geophysical methods are considered as key requirements for groundwater protection and forestalling structural failures.
9. Regulations on Geological and Hydrogeological practices in MDAs and promotion of professionalism in the water sector in Nigeria should be fully enforced for effective service delivery.

The Association expresses her immense gratitude and appreciation to the Honourable Minister of Water Resources, Engr. Suleiman H. Adamu FNSE, FNAH, FAEng.; The Hon. Minister of FCT and the good people of FCT for their uncommon African Hospitality and support during the Conference.

Dr Martin O. Eduvie FNAH, FNMGS, FIAH

President National Association of Hydrogeologists



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The Association is a specialized body of the Nigerian Mining and Geosciences Society (NMGS). The Association is subject to those Articles statuses and by laws of the society that apply to the association and to the society. It is an affiliate to the International Association of Hydrogeologists (IAH).

Objectives and functions of the Association:

- 1 To provide a forum for the meeting of professionals in hydrogeology and allied disciplines.
- 2 To prescribe qualifications required for the practice of the profession of hydrogeology.
- 3 To standardize qualifications required for the practice of the profession.
- 4 To encourage the collection of data, research, and dissemination of information on water resources
- 5 To advice the government and their agencies as well as the public on the need to control the investigation and development of our water resources.
- 6 To harmonize funds and support from the government and other bodies in their involvement in programmes to enhance the practice of hydrogeology.
- 7 To cooperate with other allied professional bodies connected with the water resources development.
- 8 To nominate any member or members as arbitrators or investigators on water resources problems when called upon to do so.
- 9 To establish forum and facilities for:
 - a Annual conference and general meetings of the Association
 - b Holding of symposia, seminars, and workshops on water resources problems from time to time.
 - c Publishing proceedings of annual conferences, symposia, seminars, workshops, and hydrogeological papers.
 - d Registering professional Hydrogeologists.
 - e Advertising of curricular development on the training of hydrogeologists in higher institutions in the country.
 - f Any other functions to promote the profession of hydrogeology.

Membership

Membership to the association is open to all practicing Hydrogeologists and allied disciplines. Institutional membership is open to all water resources departments, companies, institutions, research bodies and others.

Information about the Association can be obtained from the Secretary, Dr. Aisha A. Kana, Department of Geology and Mining, Nasarawa State University Keffi, Nigeria

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Assessment of Groundwater Quality Using Water Quality Indices in Lere and Environs, Kaduna State, North Western Nigeria

Michaels, P. S., and Eduvie, M. O.

National Water Resources Institute, Kaduna

Corresponding Author: smykelson@yahoo.com

Abstract

The assessment of groundwater quality using water quality indices was done to determine if the groundwater was suitable for irrigation and for domestic purposes. 30 groundwater samples were taken from various locations and analysed for different parameters which include TDS, DO, pH, EC, SO₄, Cl, HNO₃, NO₃, Mg, Ca and PO₄. For drinking water purposes, the WQI was determined with the aid of various equations the results of which was used to produce the WQI map. The SAR, Na % and PI were used to evaluate the quantity of soluble salts in groundwater that are ionized. With the WQI and WHO guidelines values, about 40% of the sample exhibit good groundwater quality for residential use and for its suitability for irrigation assessment reveals that the groundwater in the study area is appropriate for irrigation.

Keywords: *Water quality indices, Lere, Groundwater suitability*

INTRODUCTION

Although it is a renewable natural resource, water is not always readily available, especially in arid regions and semi-arid regions (Abotalib et al., 2016). Most nations encounter water shortages at specific times of the year (Gleick, 1993). In fact, water resources are crucial for boosting employment across all societal sectors. The concentration and type of minerals transported in solution by groundwater depend on the surface and subsurface environment, the pace of groundwater flow, and the source of the groundwater (Prasad et al., 1999).

Groundwater analysis based on hydrochemical studies is likely to show the amount of ions in the groundwater and indicate if water quality at a particular location is suitable for drinking, agriculture, or other purposes.

The Water Quality Index (WQI) is a score that accounts for the combined impact of various water quality factors. The term "WQI" was first used by Horton (1965), and it was later expanded upon by Brown et al. in 1970. One of the best instruments for disseminating information about the condition of any body of water is the Water Quality Index. It is a mathematical formula used to reduce a sizable amount of data on water quality to a single number. WQI is one of the best instruments for informing interested citizens and policymakers about the quality of the water.

The WQI is a unique digital rating that is based on various indicators for measuring water quality, identifies the general water quality at a certain place and time, such as excellent, good, or bad. To evaluate the state of groundwater and how it is managed in a particular location, the Water Quality Index

is a crucial instrument (Jagadeeswari and Ramesh 2012). WQI is one of the most effective tools to communicate information on the quality of any water body. Usually, water quality analysed using WQI produces excellent result. It is naturally filtered as they go through the earth and is often clear, colourless, and uncontaminated requiring little treatment.

Due to the rapidly rising levels of soluble or dissolved pollutants from urban, industrial, and contemporary agricultural operations, the groundwater is now in risk. The chemistry of the groundwater reflects inputs from the atmosphere, from soil and water-rock processes, as well as from pollution sources such as agricultural operations, mining, terracing, acid rain, household trash, and industrial waste. Groundwater contamination can be remedied by eliminating the contaminant's sources.

Some of the factors that impact the chemical composition of ground water include its interaction with solid phases, its length of residence, seepage of contaminated river water, mixing with pockets of saline water, and anthropogenic activities. Loss of quality results in crop failure, loss of aesthetics, and health risks for humans, cattle, and aquatic life. Umar et al. (2003) and (2006). Groundwater disperses a variety of compounds and pollutants when it passes through the rocks and subterranean soil (Mahmood et al. 2017, 2018). As anthropogenic contaminants, they are dispersed (Rangsviek and Jekel 2005).

Groundwater minerals are linked to industrial, transportation, and construction operations as well as well as agricultural practices, which have adverse environmental

effects (Hegazy *et al.* 2020). Trace metals have been accumulating in soils over time because of application of fertilisers and pesticides on agricultural and industrial wastes (Zwolak et al. 2019). Agriculture's effects on the environment and the leaching of heavy and trace metals are becoming increasingly concerning (Brindha et al., 2020).

Fertilizers are typically not fully purified throughout manufacturing procedures because they contain a variety of contaminants, including heavy metals (Santos et al., 2002). Additionally, the active ingredients of pesticides frequently contain heavy metals. Use of fertilizer also contributes to the high concentration of heavy metals in soils. Insufficient surface water penetration allows soil contaminants like heavy metals to seep into the groundwater (Eugenia et al.1996).

The quality of groundwater affects its suitability as a source of drinking water in a particular place just as much as its quantity does. The intended usage is what essentially determines the quality of water that is required for delivery; for example, the quality of water required for drinking, industrial, and irrigation purposes is not the same. As a result, groundwater quality should be considered in the same way that groundwater quantity is (Todd and Mays, 2005).

Water quality characteristics are measured and used to create acceptable indicators of water quality for comparison of authorised criteria in connection to the planned use of the water are among the methods for evaluating the usability of water quality. The

parameters for the WHO drinking water guideline are frequently utilized in determining the appropriateness of water for human consumption. Indicators of water quality have been acknowledged and successfully used in various parts of the world to assess the suitability of groundwater for drinking and other commercial purposes (Anim-gyampo et al., 2019).

Indices including the ability of water to be utilized for irrigation is assessed using the Magnesium Hazard, The Langelier Saturation Index (LSI), Permeability Index (PI), and Sodium Adsorption Ratio (SAR), Percent Sodium (% Na), and other parameters (e.g., Wanda et al., 2013).

When attempting to categorize irrigation water using just these factors, difficulties and errors could arise. These techniques rely on certain pollutants in the water, and assessing water quality is sometimes fraught with uncertainty, particularly when the quality of the source water fluctuates significantly. Therefore, a thorough a method based on parameters is created to evaluate the feasibility of irrigation using groundwater to solve these drawbacks. The Irrigation Water Quality Index (IWQI), which transforms enormous information into an obvious numerical score that measures the sufficiency it is of irrigation water characterized, aids in evaluating irrigation water quality. The suggested method allows for the classification of irrigation water quality into five groups. They include excellent, good, moderate, poor, and extremely poor, according to Singh et al. (2018) and Horton (1965; 1965; 2018a). In this research the

WHO recommended values and the Water Quality Index are merged.

Location of the Study Area

The research area is in Lere Sheet 147 NW, Kaduna State, North Western Nigeria, and is situated between Latitudes N100151 and N100301 and Longitudes E80301 and E 80451 (Figure 1). It has an approximate 750 km² area. Southwest of the area is where the Jos Plateau's boundaries, in the centre of Nigeria's Jurassic-age anorogenic Younger Granite province, and to the immediate east of the Rishiwa ring complex. (Garba et al., 2012).

Geology and Hydrogeology

The study area is relatively flat topographically and underlain by migmatite occurring as low laying exposures while the granitic rocks stand out conspicuously dotting the area (Garba et al., 2012). The crystalline basement rocks are composed of hard, crystallized, or re-crystallized rocks of igneous and metamorphic origin. It is believed that, in weathered regolith groundwater is found in intergranular spaces between mineral grains, while it is preserved in unweathered basement rocks in networked fracture, joint, and fissure systems linked to regional tectonics. However, inadequate bedrock fracture connectivity and insufficient permeability lead to large local yield fluctuations, which can lead to regional changes in hydraulic conductivity within the same rock mass, over short distances. The study area is underlain by undifferentiated migmatite, fine to medium grained granite and gneisses (Figure. 2).

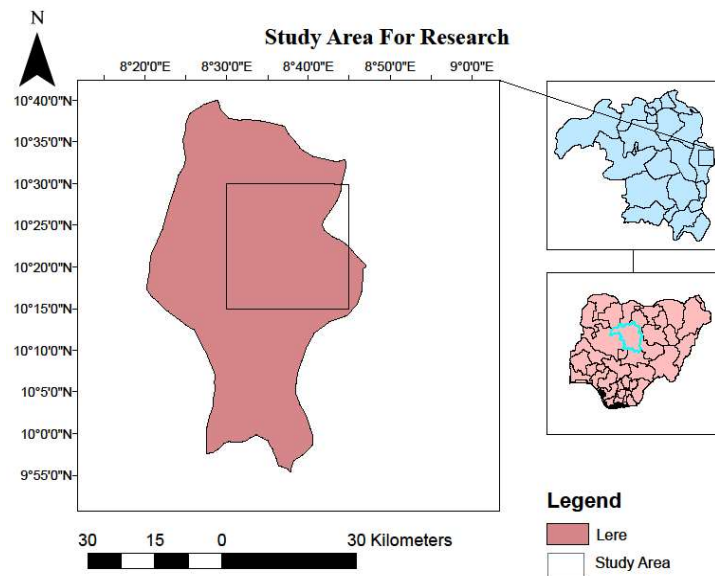


Figure 1: Location of the Study Area

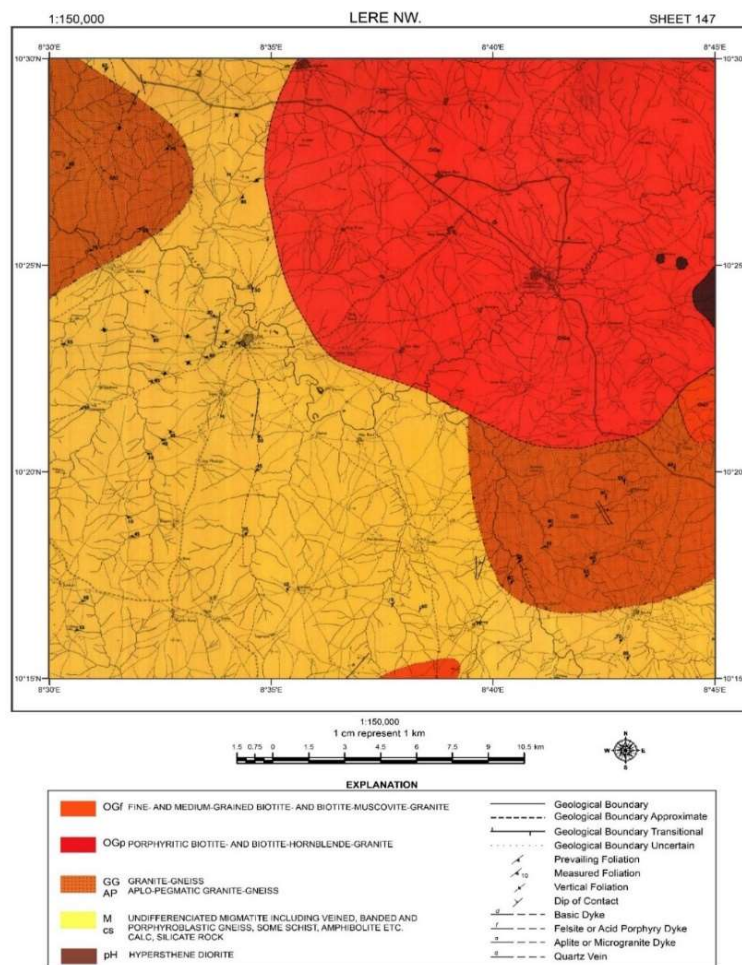


Figure 2: Geologic Map of the Study area

The general flow direction of groundwater in the area of study is from the north and southern parts towards the River Karami and Rahama which are the major groundwater recharged areas and corresponds with the groundwater convergent zone within the study area.

MATERIALS AND METHODS

Data on Groundwater Quality

Physical samples of ground water were physically taken from hand-dug wells. In the year 2020, 30 samples were collected and examined. Figure 3 displays the sites for the groundwater sample. Before being filled with water for sampling, sterilized bottles used to collect water samples were thoroughly cleaned with the water under consideration.

Following sample collection, the samples were stored and sent to Ahmadu Bello University's multi-user laboratory in Zaria for examination. Unstable parameters including pH, turbidity, TDS, and electrical conductivity were measured in-situ using portable, hand-held devices. All of the water quality indicators—aside from pH, electrical conductivity, and turbidity—are stated in milligrams per liter. Each metric was compared to the ideal standard limit set by the WHO in 2008 for drinking and public health. Electrical conductivity, total dissolved solids, dissolved oxygen, nitrate, sodium, potassium, magnesium, chlorine, carbonates, phosphates, sulfates, calcium, and total dissolved solids were all examined in the samples.

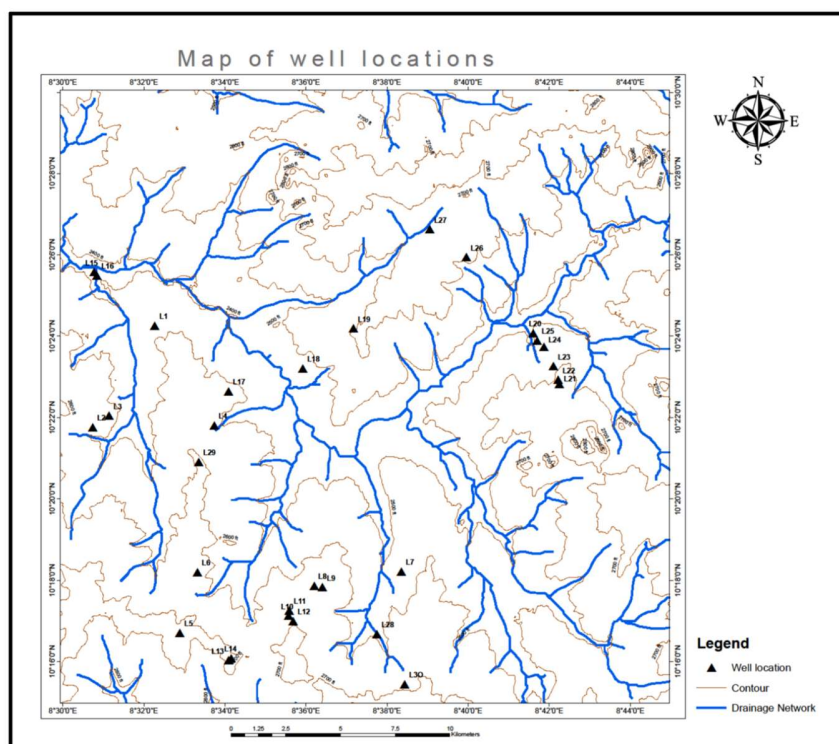


Figure 3: Location of Sample Points

Determination of the Water Quality Index

The Water Quality Index (WQI), which was initially suggested by Horton, was used to measure the groundwater quality in the research region for residential use (1965). To turn complicated transforming water quality data into knowledge that may be utilized to safeguard the public's health, this technique takes into account the physico-chemical factors' respective contributions to the total health risk of groundwater the public can utilize or comprehend. In this work, the WQI was calculated using Horton's (1965) equation, with weights applied to the specific parameters of interest. Based on the available data, a total of eight (8) factors were investigated and employed in this present study Ca, Mg, SO₄, HCO₃, NO₃, Cl, and pH.

Various According to their relative significance on total groundwater quality, each parameter was given a weight, with the most significant ones receiving higher weights. Table 1 shows the allocated weights (wi) and WHO (2008) recommended values. On this premise, nitrate was given a maximum weight of 5 for its significant relevance in water quality pH, Cl, EC, compared to evaluation (Srinivasamoorthy et al., 2008), Due to their little influence on the overall evaluation of water quality for drinking purposes, and SO₄ were given a weight of 4 (Tiwari et al., 2014). The weights of calcium and magnesium separately is 2 because of how little an impact they have on the quality of the water.

Table 1: lists the assigned weights for the variables used to create the WQI.

Parameters	pH	EC	SO ₄	Cl	HCO ₃	NO ₃	Mg	Ca
WHO (2008)	6.5-8.5	500	250	250	200	50	50	75
Weights (wi)	4	4	4	4	1	5	2	2

The relevance of bicarbonate in the water quality evaluation is quite low, hence it is assigned a minimum weight of 1. Equation was then used to get the relative weight (Wi). (1).

$$Wi = \frac{w_i}{\sum_{i=1}^n w_i} \dots \dots \dots (1)$$

Where Wi denotes relative weight, wi denotes the weight of each physicochemical parameter, and n denotes the number of parameters considered. The quality rating (q) for each parameter was determined using

Equation according to WHO (2008) recommendations, (2):

$$qi = \frac{Ci}{Si} \times 100 \dots \dots \dots (2)$$

Where qi stands for the quality index, Ci for the concentration (mg/L) of each chemical parameter, and Si for the WHO (2008) standard for each chemical parameter. After that, each community's groundwater samples WQI was determined using Equation...3 and assessed using Table 2's WQI classification.

$$WQI = \sum_{i=1}^n wiqi \dots \dots \dots (3)$$

where w_i is the parameter's water quality rating and w_i is the parameter's relative weight.

According to Yidana & Yiadana's (2009) classification system, water with a WQI value of less than 50 is excellent, water with

a value of 50 to 100 is good, water with a value of 100 to 200 is poor, water with a value of 200 to 300 is extremely bad, and water with a value of 300 is unfit for human consumption, are typically used to assess the quality of water based on WQI. (Table 2).

Table 2: water types and WQI categorization ranges (Yidana & Yiadana, 2009).

WQI	Water Type
<50	Excellent water
50-100	Good water
100-200	Poor water
200-300	Very poor water
>300	Unsuitable drinking purpose

Groundwater quality

Assessment for irrigation

The SAR, EC value, Sodium percent, and Permeability index were used to evaluate the quantities of soluble salts in groundwater that are ionized.

Sodium Absorption Ratio (SAR)

To support plant development and agricultural output, groundwater's salt absorption properties of soluble sodium percent (Na%) and ratio (SAR) are important. A dirt paste extract made with water was used to compute calcium and magnesium were ionized by sodium ratio using the SAR. It is an important factor to consider when determining whether or not groundwater is appropriate for irrigation. This was calculated using the relationship for all the sampling sites:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \dots\dots\dots (4)$$

Sodium percentage (% Na)

Meq/L units are used to measure ion concentrations. The capacity of a soil to form stable aggregates is decreased, and soil structure is lost, when increased sodium ions in irrigation fluids Mg^{2+} and Ca^{2+} in the same soil are displaced. Additionally, it can result in decreased soil permeability and infiltration, which would lower crop production. It was computed in the study using the relationship: Consequently, it is essential for determining if irrigation water is suitable (Sadashivaiah et al., 2008).

$$Na = \frac{(Na^+ + K^+)}{(Ca^{2+} + Mg^{2+} + Na + K)} \times 100\% \dots\dots (5)$$

Permeability Index (PI)

Similarly, some studies have shown how long-term usage of a certain mineral-rich groundwater impacts soil permeability. This was evaluated using the Permeability Index (PI) of irrigated water (Doneen, 1975; Khalid, 2018). Usage of irrigation water that contains high concentrations of Ca, HCO_3^- , Na, and Mg can affect the permeability of the soil. In this investigation, the PI was calculated using Equation (6) (Doneen, 1975) for determining the appropriateness of groundwater for irrigation.

$$\text{PI} = \frac{\text{Na} + \sqrt{\text{HCO}_3}}{\text{Mg} + \text{Na} + \text{Ca}} \times 100\% \dots \dots (6)$$

where meq/L is the unit of measurement for all ion concentrations

Suitability of Groundwater for drinking

The water quality index (WQI) map was created using ArcGIS 10.1 based on carefully chosen quality parameters to display the many quality classes, including excellent,

good, bad, extremely poor, and unacceptable quality for drinking, as shown in Tables 1 and Fig. 4.

However, based on the WQI computation, no water sample in the study area falls under the excellent class of water. As seen in the WQI Map of the study area, that most of the northwestern area of the study area that houses Dan Alhaji, Maraban Damau and Ungwan Maje communities have good quality (50-100) of groundwater while majority of the southern part of the study area that includes Tudai, Ishema, Gidan dutse and Gasakora communities have poor quality (100-200) drinking water. Mai bindiga and Kafin Tudai communities located at southern part of the study area have very poor (200–300) quality of drinking water. Generally, the quality of groundwater belongs to the good to very poor category in a most portion of the study area and is only suitable for drinking as well as domestic usage after treatment especially in communities that fall under the poor category.

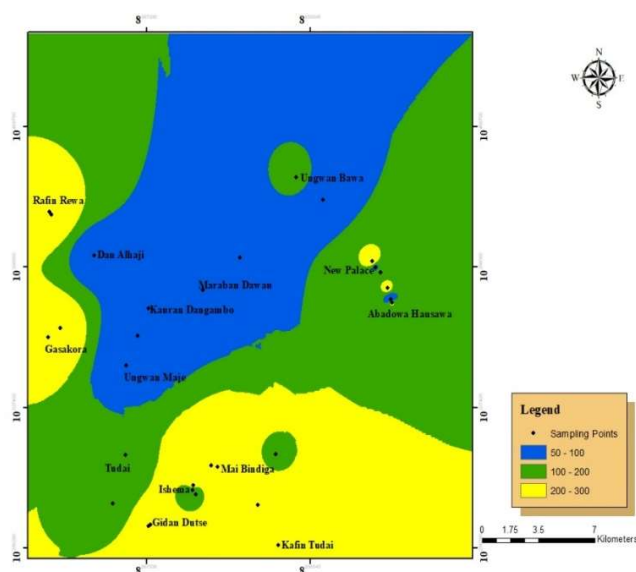


Figure 4: Water quality index map of the study area

Groundwater's suitability for irrigation

According to Wilcox, 1955, the groundwater suitability for irrigation is as follows.

Table 3: Wilcox's (1955) groundwater suitability strategy for use in irrigation

Category	% Sample	Suitability
1	77	Excellent to good
2	10	Good to permissible
3	6	Permissible to doubtful
4	6	Doubtful to unsuitable
5	None	Unsuitable

Table 4: Statistical analysis from the measured parameters

Parameters	Mean	Min	Max	SD	WHO (2008) Guidelines	Outside WHO Guidelines
pH	5.65	4.11	7.19	1.54	6.5-8.5	0
EC(μ S/cm)	267.87	109.89	425.85	157.98	750	3
Cl(mg/l)	44.665	7.75	81.58	36.915	250	0
SO ₄ (mg/l)	4.995	0.8	9.11	0	400	0
HCO ₃ (mg/)	38.05	10.7	65.4	27.35	100	0
NO ₃ (mg/l)	6.96	0	13.92	6.96	45	0
Ca (mg/l)	7.3	0.9	13.7	6.4	200	0
Mg(mg/l)	0.905	0.19	1.62	0.715	150	0

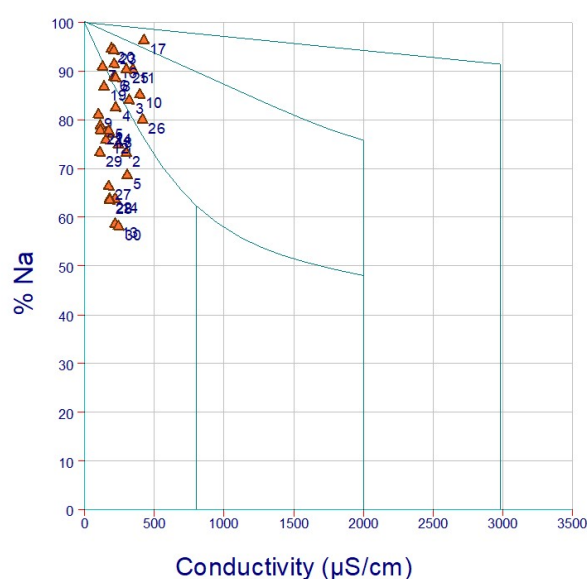


Figure 5: Groundwater irrigation suitability based on Na percent and EC.

The impact of the water's mineral components on the soil and the plants establishes the appropriateness of groundwater for irrigation. High salt in water can harm plant development in two ways: physically, by restricting water absorption capacity both chemically through metabolic processes like those and osmotically brought on by toxic substances. Because of this, the suitability of groundwater for irrigation is determined by its propensity to create soil conditions that are unfavourable to crop development and, consequently, to animal life or people that consume those crops (Rhoades et al., 1992). The region's groundwater research regime was assessed for irrigation purposes using Na percent, SAR, PI, and other classification techniques. To categorize water suitability for irrigation, the Wilcox (1955) approach was utilized,

which separates different waters into four categories (Figure 5) by combining the water's soluble sodium percentage and the corresponding EC value. Hard water has a low amount of soluble sodium, whereas soft water has a higher percentage.

Over 90% of the samples may be appropriate for irrigation, with just 10% being "doubtful to unsuitable" for irrigation, according to the integration of the groundwater's EC and Na percentages' overall effects research region (Table 3). The plot of SAR against Conductivity (Figure 6) illustrates how the groundwater in the research region may be divided into two major groups when considering the categorization of water (Rhodes et al., 1992). It can be shown that the research area's groundwater is typically acceptable for irrigation.

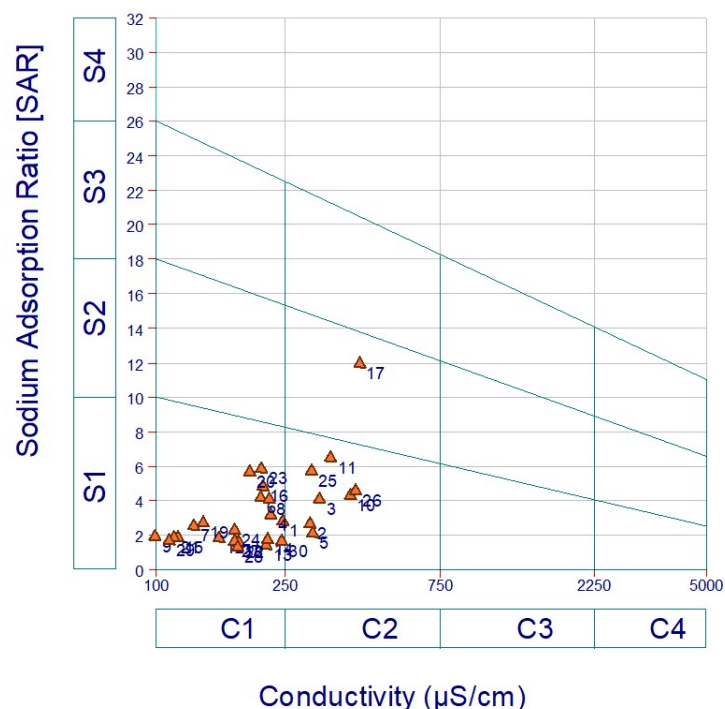


Figure 6: Topsoil SAR threshold values and infiltrating water's EC threshold values

CONCLUSION

The study used a mix of WQI, salinity indices, and WHO Guideline Values to assess groundwater quality in various settlements in the Lere area of Kaduna, Nigeria, for household and irrigation uses. About 40% of the samples exhibit good groundwater quality

for residential use, according to results from a WQI and WHO Guideline Values combined assessments. In addition, SAR, Na percent, PI, and EC-based assessments on the suitability of groundwater for irrigation as opposed to Na percent studies reveal that the groundwater in majority of the research area's studied villages is appropriate for irrigation.

REFERENCE

- Abotalib A. Z., Sultan M, Elkadir R. (2016) Groundwater processes in Saharan Africa: implications for landscape evolution in arid environments. *Earth Sci Rev* 156:108–136
- Anim-gyampo, M., Anornu, G.K., Appiah-adjei, E. Kand Agodzo, S.K., (2019). Groundwater for Sustainable Development Quality and health risk assessment of shallow groundwater aquifers within the Atankwidi basin of Ghana. *Groundw. Sustain. Dev.* 9, 1–10
- Brindha K., Paul R., Walter J and (2020) Trace metals contamination in groundwater and implications on human health: comprehensive assessment using hydrogeochemical and geostatistical methods. *Environ Geochem Health*. <https://doi.org/10.1007/s10653-020-00637-9>
- Eugenia, G., Vicente, S., Rafael, B. (1996) Heavy metals incidence in the application of inorganic fertilizers and pesticides to rice farming soils. *Environ Pollut* 92:19–25. [https://doi.org/10.1016/0269-7491\(95\)00090-9](https://doi.org/10.1016/0269-7491(95)00090-9)
- Garba, M. L., Kurowsky, E., Schoeneich, K., and Abdullahi, I. (2012) Rafin rewa warm spring; A new Geothermal Discovery. *American International Journal of Contemporary Research* Vol2 No.19
- Gleick, P.H. (1993) Water and Conflict: fresh water resources and international security. *Int Secur* 18(1):79–112. <https://doi.org/10.2307/2539033>
- Hegazy, D., Abotalib, Z., El-Bastaweisy, M., Al-Said, M., Melegy. A., and Garamoon, H. (2020) Geo-environmental impacts of hydrogeological setting and anthropogenic activities on water quality in the Quaternary aquifer southeast of the Nile Delta, Egypt. *Afr Earth Sci.* <https://doi.org/10.1016/j.jafrearsci.2020.103947>
- Horton, R. K. (1965). An index number system for rating water quality. *Journal of Water Pollution Control Federation*, 37, 300–305.
- Jagadeeswari, P. B., and Ramesh, K. (2012) Deciphering fresh and saline groundwater interface in south Chennai coastal aquifer, Tamil Nadu, India. *Int J Res Chem Environ* 2:123–132

- Mahmood, Y., Hossein, N. S., Ali, A. M., Amir, H. M., Mansour, G.G., and Hamed, S. (2017) Data on water quality index for the groundwater in rural area Neyshabur County, Razavi Province, Iran. *Data Brief* 15:901–907. <https://doi.org/10.1016/j.dib.2017.10.052>
- Prasad, K. and Shukla, J. P. (2014). Assessment of groundwater vulnerability using GIS-based DRASTIC technology for the basaltic aquifer of Burhner watershed, Mohgaon block, Mandla (India). *Current science*, Vol 107, No. 10, pp.1649-1656.
- Rangsivek, R., and Jekel, R. (2005) Removal of dissolved metals by zero-valent iron (ZVI): kinetics, equilibria, processes, and implications for stormwater runoff treatment. *Water Res* 39:4153–4163. <https://doi.org/10.1016/j.watres.2005.07.040>
- Rhoades, J. D., Kandiah, A., and Mashali, A.M., (1992). The Use of Saline Waters for Crop Production.
- Singh, S., Ghosh, N. C., Gurjar, S., Krishan, G., Kumar, S., and Berwal, P. (2018a) Index-based assessment of suitability of water quality for irrigation purpose under Indian conditions. *Environ Monit Assess* 190:29. <https://doi.org/10.1007/s10661-017-6407-3>
- Srinivasamoorthy, K., Gopinath, M., Chidambaram, S., Vasanthavigar, M. and Sarma, V. S., (2013). Hydrochemical characterization and quality appraisal of groundwater from Pungar sub-basin, Tamilnadu, India. *Journal of King Saud University-Science*, 26(1), 37-52. <http://doi.org/10.1016/j.jksus.2013.08.001>.
- Todd, D. K., and Mays, L.W. (2005). *Groundwater Hydrology*, third ed. ed. John Wiley & Sons, Inc., United States of America
- Wanda, E., Galula, C. L., and Phiri, A., (2013). Hydrochemical Assessment of Groundwater Used for Irrigation in Rumphi and Karonga districts, Northern Malawi. *Phys. Chem. Earth* 66, 55–59. <https://doi.org/10.1016/j.pce.2013.09.001>
- Yidana, S. M., and Yidana, A. (2009). Assessing water quality using water quality index and multivariate analysis. *Environ Earth Sci*, 59, 1461-1473. <http://dx.doi.org/10.1007/s12665-009-0132-3>
- Zwolak, A., Sarzyńska, M., and Szpyrka, E. (2019) Sources of soil pollution by heavy metals and their accumulation in vegetables: a review. *Water Ai*