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Original Research Article

Investigation of Groundwater Pollution: A Case Study of Potiskum, Yobe State

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ABSTRACT
In recent years, the increasing trend in health risks associated with water pollution in Yobe State has encourage researchers to investigate the source of the groundwater contamination. This research examined groundwater pollution in Yobe State, focusing on Potiskum as a case study. The study utilized Electrical Resistivity and Hydrochemical methods. The electrical resistivity survey identified two aquifers in the research area, which comprises a semi-confined aquifer and a confined aquifer. The semi-confined aquifer is the first aquifer in the research area, and its closeness to the surface facilitated the contamination of groundwater within the study area. The Hydrochemical assessment of groundwater samples in the area, using Atomic Absorption Spectrometer, indicated that the groundwater possesses trace metals at high concentrations. The spatial distribution of these trace metals in the groundwater indicated that their levels are greater in the southeastern quadrant of the research area due to heightened human activities and metal works in the region. The inconsistent amounts of trace metals like Chromium, Cadmium, Nickel, Lead, and Arsenic in the groundwater were thought to be contributing factors to the rising water-related risks within the area and Yobe State overall. To mitigate the escalating problem of drinking water contamination in the study area, effective waste management practices must be implemented to safeguard water resources from pollution caused by leachate from dumpsites. Affected boreholes and wells in the region should be sealed, while new ones should be drilled into second aquifer that is confined in the area. Most of the second aquifers in the research area are artesian and suitable for drinking water supply. Based on the outcomes of this study, it is advised that routine groundwater monitoring be promoted in the study area.

INTRODUCTION

Groundwater is an essential mineral resource crucial for healthy living and economic prosperity. All human activities, spanning domestic usage to agriculture and industry, hinge on the availability of quality or drinkable water. The availability of clean drinking water is vital for addressing water-related health challenges impacting both rural and urban areas of Nigeria. Numerous researchers have classified the provision and access to safe drinking water as significantly lacking throughout many developing countries in Africa, including Nigeria.

Human activities such as excessive application of herbicides, pesticides, and fertilizers in agriculture and poor management of domestic and industrial waste significantly comprise the quality of groundwater resources. While natural processes like mineral precipitation, volcanic eruptions, floods, and droughts also affect the quality of groundwater resources, their influence is considerably less than that of human activities, which result into extensive groundwater pollution. Industrial discharges bearing various forms of industrial waste and chemical contaminants penetrate the subsurface, tainting groundwater due to inadequate management and oversight.

Groundwater contamination can be divided into point source or disperse source. Point source contamination of groundwater emerges from a single location, such as a septic tank, sewage pipe, or effluent pipe, where waste is released into the aquifer. Managing this type of contamination is relatively straight forward. Conversely, dispersed source contamination is more challenging to control due to its extensive area. An example of dispersed source contamination is runoff in both urban and rural environments, which frequently washes and transports chemical substances into depositional areas, permitting them to infiltrate into the subsurface and pollute the groundwater. Groundwater is especially susceptible to contamination in regions where aquifers are shallow and unconfined (Agada and Yakubu, 2022).

Atmospheric depositions such as sulfur dioxide and nitrogen dioxide, released from both industrial and vehicular sources, interact with water vapor in the atmosphere to produce acidic precipitation, which contributes to runoff that seeps into the subsurface, tainting the groundwater. Atmospheric deposition contains trace elements like lead, arsenic, mercury, cyanide, nickel, and carbon. These trace elements, when present in high concentrations, present significant health hazards upon ingestion via water. Borehole and well water should be analyzed for chemical pollutants prior to being distributed for consumption (Egboka *et al*., 1989).

As per the United States Food and Drug Administration (1977), the most dangerous trace metals detected in groundwater include mercury, lead, cadmium, uranium, arsenic, boron, and nitrogen. Egboka *et al*. (1989) pointed out that shallow groundwater is characterized by high levels of dissolved oxygen, whereas deep groundwater is associated with very low levels of dissolved oxygen.

The diffusion of pollutants in groundwater is significantly influenced by high hydraulic conductivity and porosity. Increased porosity enables greater water retention in the aquifer, while improve hydraulic conductivity allows the swift movement of contaminants through the vadose zone in the subsurface. Grisak (1975) and Custer (1976) discovered in their respective studies that the primary source of nitrate loading in shallow groundwater systems is the application of fertilizers on agricultural lands. Elevated concentrations of trace metals in groundwater, can result in kidney disease, lung damage, liver and bladder issues, cancer, and stomach pain (WHO, 2000).

The conversion of solid waste under moisture and precipitation's influence into leachate, landfill gyas, and various hazardous pollutants containing trace metals poses a threat to groundwater quality once they infiltrate the subsurface (Abdullahi *et al*., 2011; Agada *et al*., 2020). Solid waste is acknowledged as one of the leading environmental challenges related to leachate formation. Considering the many health risks linked to the intake of contaminated water, different researchers have applied electrical resistivity techniques to investigate groundwater pollution across various global regions (Mosuro *et al*., 2016; Olagunju *et al*., 2017; Alabi *et al*., 2019; Onyenwife *et al*., 2020; Agada and Yakubu, 2022, Adamu *et al*., 2024).

Contaminants in groundwater form pollution plumes that can easily extend to broader areas through diffusion, advection and absorption processes. These contaminant plumes in groundwater contain toxic substances that pose a danger to public health. Groundwater contaminants may be organic, inorganic, radioactive or bacteriological in their origin or nature. Inorganic pollutants such as Cadmium, Arsenic, Chromium, Mercury, Fluoride and Iron can lead to serious health issues if consumed at high concentrations. Drinking contaminated water may result in diseases such as kidney infection, cancer, diarrhea, skin diseases, typhoid, hepatitis A, and dysentery (Wakode *et al*., 2018).

Naz *et al*. (2024) stated that assessing groundwater quality via Geographical Information System (GIS) and water quality index will enhance the understanding of the contaminant's spatial distribution. The ability to make informed decisions in tackling water quality problems is very important (Kamyab *et al*., 2023). Research findings indicated a rising trend in water-related health complications in Yobe, Borno and Adamawa States (Salamatu *et al*., 2019; UNICEF, 2019; NCDC, 2021).

Waziri *et al*. (2009) reported that both surface and groundwater in Nguru and Gashua in Yobe state are contaminated by trace metals, but the sources of the contamination were not specified as their study was limited to water sample analysis. The problem of water pollution in Yobe State in recent times has become an issue of serious concern.

Therefore, monitoring groundwater in areas suspected of contamination is crucial to safeguard lives and raise awareness about health risks associated with groundwater pollution. In the light of increasing incidence of water related diseases in the study area and its surroundings, this study aims to monitor groundwater quality through hydro-chemical and geophysical approaches.

MATERIALS AND METHODS

Materials

To achieve the goals of this study, the following materials were utilized: ABEM Terrameter SAS 1000 and its accessories, 12V Car Battery, Personal Computer, Strater 5 software, Surfer 11 Software, WINRESIT version 1.0 Software. Water samples, Nitric Acid, Water Bottles, Beakers, Atomic Absorption Spectrometer, GPS device.

The Study Area

Potiskum is a local government headquarters in Yobe State. It is situated at a latitude 11. 712° N and longitude 11.070° E. The study area is underlain by the Keri-Keri Formation, which consists of a sequence of grits, clays and sandstones from a deltaic environment (Carter *et al.*, 1963). The depth to groundwater in most hand dug wells in the study area ranged from 15 to 20 m. The study area has semi-arid climate, marked by brief rainfall that occurs between June and September, and an extended dry season lasting from October and May (Obaje *et al.*, 2020) Nwajide (2013) noted that the Keri-Keri Formation resulted from erosion of the Basement complex rocks of the Jos Plateau in North Central Nigeria. The Keri-Keri Formation was deposited unconformably on the eroded surface of the Gombe Sandstone during the Pleistocene (Matheis, 1976). The Keri-Keri formation has an Eocene age (Ola-Buraimo and Boboye, 2011). The study area is shown in figure 1.

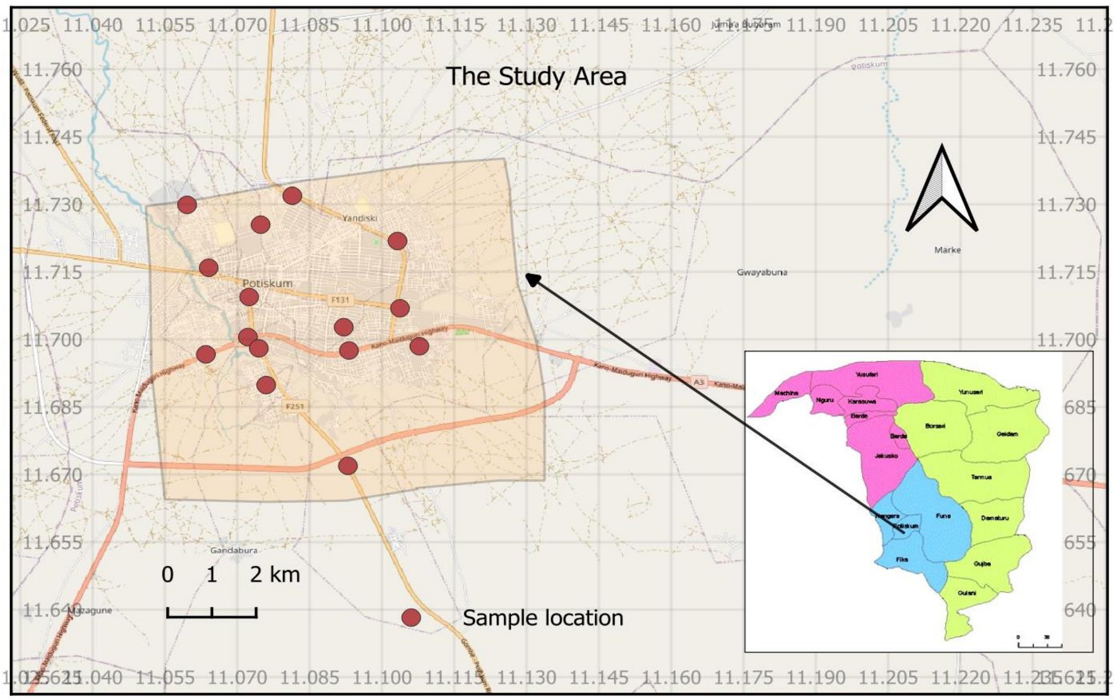

Figure 1: Map of Yobe State showing Potiskum the Study Area

Methods

Geoelectric characterization of the subsurface

The subsurface lithology of the study area was investigated using Vertical Electrical Sounding. A one-dimensional electrical resistivity data was obtained in the study area by passing electric current into the subsurface through two steel current electrodes and the corresponding voltage were measured via two steel voltage electrodes. The apparent resistivity of the subsurface were measured directly by the ABEM SAS 1000 Terrameter. The obtained field data were initially interpreted by partial curve matching and the obtained results were modeled using WINRESIT software to obtain the true resistivity of the subsurface layers. Loke (1999) resistivity table was used to characterize the subsurface layers of the study area (Figure 2).

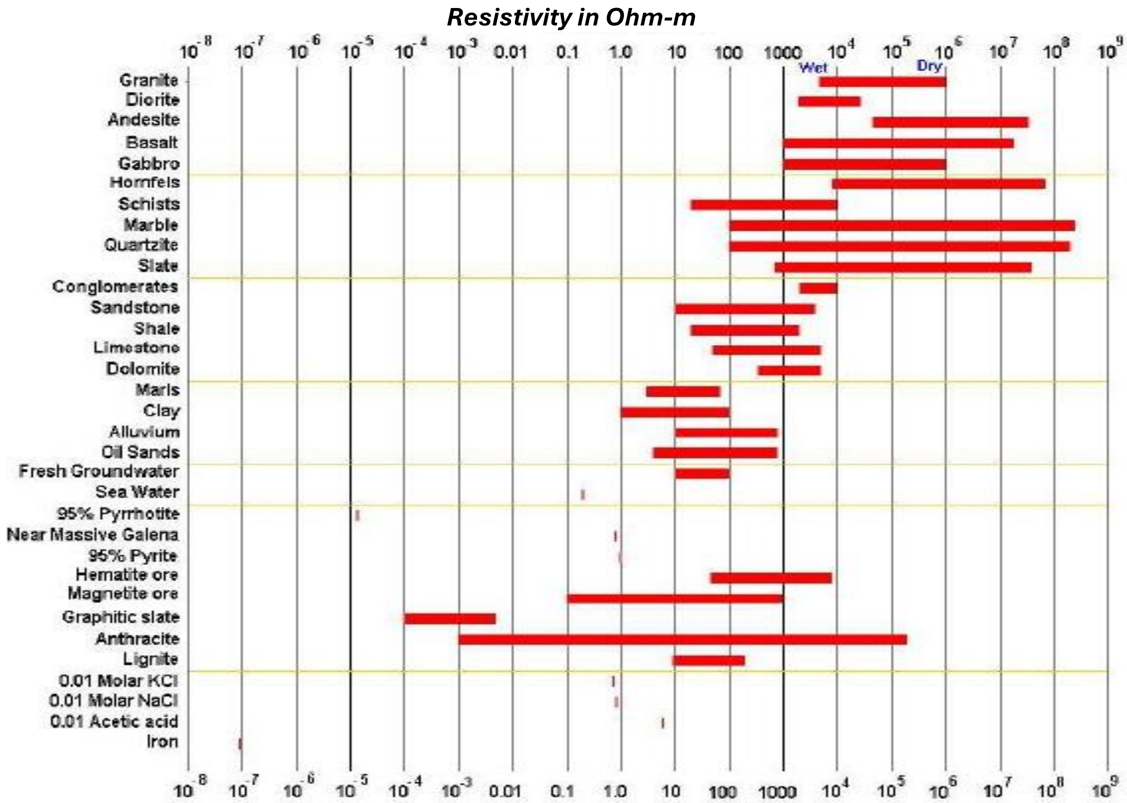

Figure 2: Resistivity of rocks, soils and minerals (Loke, 1999)

The current electrode spacing and the potential electrode spacing were varied accordingly in order to delineate the subsurface layers. The half current electrode offset was 200m. Six vertical electrical sounding data were obtained from the study area to establish the depth to the water table and the aquifer thickness in the study area.

Hydrochemical samples and analysis

In order to determine the groundwater quality status in the study area, fifteen (15) groundwater samples were obtained from different locations in the study area as shown in (Figure 1). The water samples were analyzed for the presence of trace metals such as lead, cadmium, chromium, copper, nickel and arsenic as well as nitrate using the United State Environmental Protection Agency (US EPA) method. The concentration of the Total Dissolved Solids (TDS) in the groundwater was also determined. The collected water samples were digested using 20 ml of concentrated HNO_3 and 6 ml of concentrated HCL to avoid metal precipitation in the water samples. The trace metals in the water samples were analyzed using Atomic Absorption Spectrometer (AAS) at Yobe State University Chemistry Research Laboratory. The obtained results were compared with the World Health Organization (WHO) standards for quality drinking water.

RESULTS AND DISCUSSION

Vertical Electrical Sounding (VES) Results

The resistivity table of Loke (1999) was used to constrain the true subsurface resistivity values obtained from the interpreted VES data. The common geoelectric curves obtained from the study area were HA (Figure 3). The resistivity value of the first layer ranged from 108.5 to 1143.9 Ωm with an average value of 361.6 Ωm (Table 2). The first layer has an average value of 0.9 m. Its thickness ranged from 0.3 to 1.3 m. Its resistivity characteristics indicate that it is a mixture of sand and clay. The resistivity of the second layer varied from 31.2 to 524.6 Ωm. The resistivity of the second layer in exception of VES 3 where there was gravel, showed that the second layer is a clay formation (Table 2). The thickness of the second layer ranged from 3.5 to 11.2 m. The third layer of the subsurface of the study area has resistivity values which ranged from 184.0 to 401.9 Ωm. It has an average resistivity value of 278.8 and thickness which ranged from 25.7 to 70.2 m. Its resistivity values indicate that it is a sandy formation characterized with an average thickness of 46.8 m (Table 2). It is the aquifer in the study area. It is semi-confined in some areas in the study area and confined in the other parts of the study area.

The fourth layer has resistivity values which ranged from 606.6 to 1235.2 Ωm with an average resistivity of 2131.6 Ωm. Its resistivity values indicated that it is a sandstone formation.

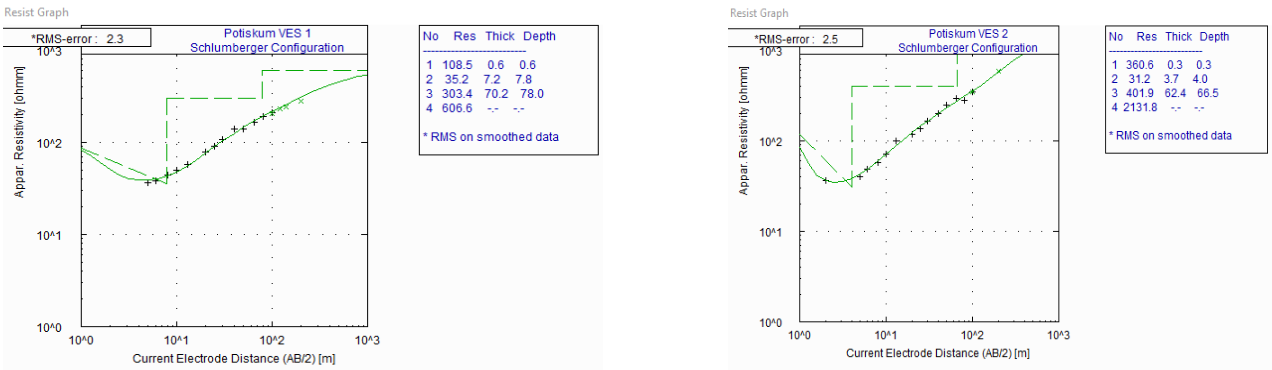

Figure 3: Typical Vertical Electrical Sounding Curves obtained in the study area

Table 2: Vertical Electrical Sounding Results

VES No.	Layer Resistivity (Ωm)				Thickness (m)			Depth (m)		
	ℓ_1	ℓ_2	ℓ_3	ℓ_4	h_1	h_2	h_3	d_1	d_2	d_3
1	108.5	35.2	303.4	606.6	0.6	7.2	70.2	0.6	7.8	78.0
2	360.6	31.2	401.9	2131.6	0.3	3.7	62.4	0.3	4.0	66.4
3	1143.9	524.6	279.9	1963.1	1.2	3.5	25.7	1.2	4.7	30.4
4	189.2	126.0	214.5	769.5	1.0	11.2	40.6	1.0	12.2	52.8
5	135.8	91.8	184.0	889.3	1.3	9.6	45.2	1.3	10.9	56.1
6	231.4	76.2	289.0	1051	0.8	10.4	36.5	0.8	11.2	47.7
Ave.	361.6	147.5	278.8	1235.2	0.9	7.6	46.8	0.9	8.5	55.2
Max.	1143.9	524.6	401.9	2131.6	1.3	11.2	70.2	1.3	12.2	78.0
Min.	108.5	31.2	184.0	606.6	0.3	3.5	25.7	0.3	4.0	30.4

The geoelectric section (Figure 4) showed that the layer overlaying the aquifer in the vicinity of VES 2 and VES 3 is not thick enough to protect the groundwater in that area from possible contamination. The aquifer is thicker in the vicinity of VES 1 and thinner around VES 3 zone (Figure 4).

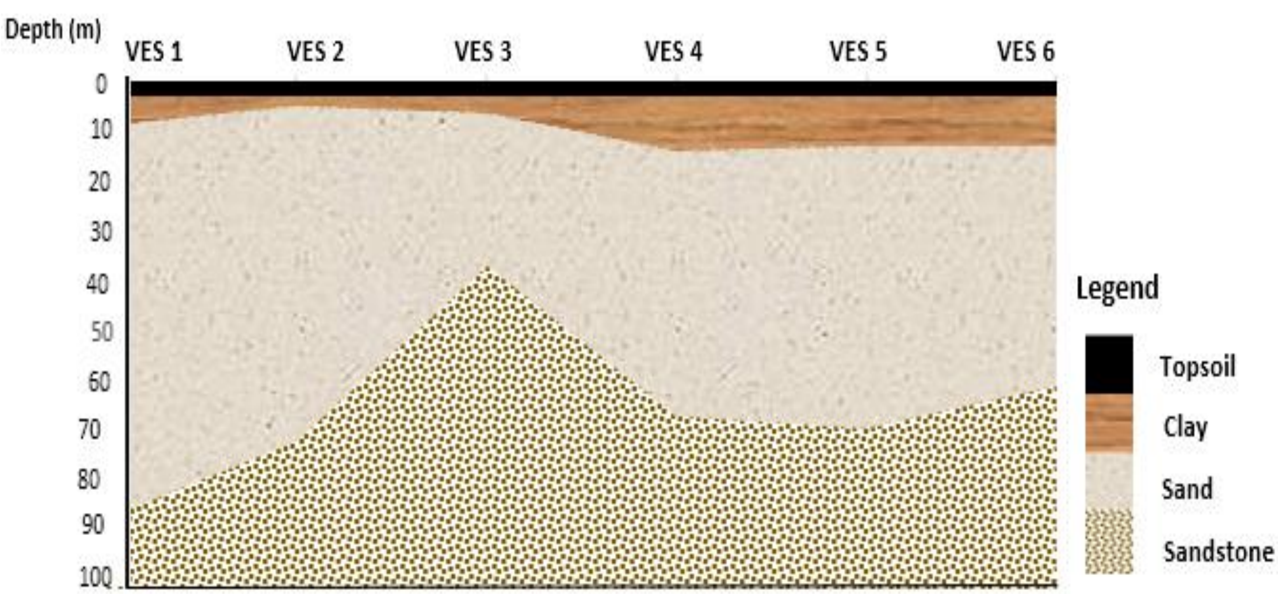

Figure 4: Geoelectrical section of the study area

Results of the Hydrochemical Analysis of the Water Samples

The analyzed groundwater samples showed variations in chemical composition across the study area. These variations in groundwater chemical composition showed that the groundwater quality varies from one location to another within the study area (Table 3). The groundwater chemical parameters were compared with the National and the International set standards (NAFDAC, WHO and NSDWQ).

The PH values of groundwater in the study area ranged from 6.6 to 9.4 with an average value of 7.9 (Table 3). The groundwater PH values were within the permissible limits of the World Health Organization (WHO). Electrical conductivity is the ability of any medium, water in this case, to conduct electric current. The presence of dissolved solids such as calcium, chloride and trace metals in groundwater enhances its electrical conductivities. The groundwater in the study area has electrical resistivity which ranged from 0.01 to 2.46 *mS/cm* with a mean value of 0.4 *mS/cm* (Table 3). The electrical conductivity of groundwater samples in three areas of the study area exceed the regulatory limits of WHO, NAFDAC and NSDWQ which is 1*mS/cm*. The presence of high conductivity medium in the groundwater is an indication that the groundwater is contaminated by leachate in some parts of the study area. The electrical conductivities of groundwater in majority of the study area are within the permissible range of 1 *mS/cm* (Table 3).

Table 3: Results of Hydrochemical Analysis of the Water Samples in the Study Area

S/N	PH	EC (mS/cm)	Nitrate (mg/L)	Phosphate (µg/L)	TDS (mg/L)	Arsenic (µg/L)	Cadmium (mg/L)	Nickel (mg/L)	Lead (µg/L)	Chromium (mg/L)	Copper (mg/L)
1	9.4	1.34	8.56	83.90	326.56	23.48	0.10	0.08	32.96	0.28	0.48
2	8.0	2.46	18.58	156.30	607.48	43.72	0.18	0.14	61.29	0.52	0.87
3	8.1	1.05	7.63	66.00	256.94	18.46	0.08	0.06	25.92	0.22	0.38
4	8.6	0.04	0.45	5.40	15.67	1.46	0.00	0.00	1.80	0.02	0.09
5	8.2	0.05	0.54	5.70	17.19	1.54	0.00	0.00	1.94	0.01	0.02
6	8.4	0.06	0.56	6.20	19.17	1.67	0.00	0.00	2.13	0.02	0.02
7	6.9	0.10	0.96	8.00	26.98	2.20	0.02	0.01	2.89	0.02	0.05
8	7.9	0.07	0.64	6.80	21.70	1.85	0.14	0.01	2.33	0.02	0.04
9	7.9	0.04	0.50	5.20	15.33	1.38	0.02	0.00	1.74	0.01	0.02
10	7.5	0.20	1.63	14.70	52.54	4.05	0.02	0.01	5.48	0.05	0.09
11	7.6	0.17	1.43	12.60	44.34	3.46	0.21	0.01	4.65	0.04	0.07
12	8.2	0.04	0.64	5.40	15.87	1.46	0.00	0.00	1.77	0.01	0.12
13	7.9	0.07	0.69	6.80	21.70	1.85	0.00	0.00	2.39	0.02	0.02
14	7.6	0.01	0.31	3.50	8.75	0.92	0.00	0.00	1.08	0.01	0.01
15	6.6	0.32	3.00	21.30	78.93	5.90	0.03	0.01	8.11	0.07	0.09
Ave.	7.9	0.40	3.07	27.19	101.94	7.56	0.05	0.02	10.43	0.09	0.17

Ave = Average; TDS = Total Dissolved Solids; EC= Electrical Conductivity

Total Dissolved Solids (TDS) have significant impact on the groundwater quality. TDS present in groundwater may originate from natural sources like metal precipitation, urban and agricultural run-off, along with industrial waste. The TDS levels in groundwater within the study area ranged from 8.75 to 607.48 mg/L with a mean of 101.94 mg/L (Table 3). The TDS in the groundwater falls within the permissible limits and does not indicate groundwater pollution in the study area.

Phosphate are chemical compounds that contain phosphorus. This non-metallic element which is vital for life can be found in geological formations. The concentration of phosphate in groundwater in the study area ranged from 5.2 to 156.3 µg/L with an average of 27.19 µg/L. According to the US Environmental Protection Agency, acceptable ranges for phosphorus in drinking water are between 0.01 to 0.5 mg/L. Therefore, the phosphorus levels in the groundwater in the study area are within acceptable standards.

Agricultural methods such as fertilizer application and animal waste significantly contribute nitrate accumulation in the subsurface, impacting groundwater quality. The nitrate concentration in the groundwater across the study area varied between 0.31-18.58 mg/L, with an average value of 3.07 mg/L (Table 3). The highest nitrate concentration in the groundwater was observed at sample location 2, with a value of 18.58 mg/L (Table 3). This high level of nitrate might be caused by run-off or leakage from fertilized soil, waste water, landfills, animal feedlots and septic systems. The nitrate level at sample location 2 exceeds the 10 mg/L regulatory limit set by the US EPA and WHO. Elevated nitrate levels in drinking water can result into methemoglobinemia, a condition affects the blood's ability to transport oxygen. This issue is particularly common in infants. In comparison, the nitrate concentrations in the groundwater at all other sample locations in the study area remain within the regulatory limits.

Arsenic is odorless and tasteless, it can be present in paints, dyes, metals, drugs, soaps and semiconductors. The levels of Arsenic in groundwater in the study area varied from 0.92 to 43.72 µg/L with an average of 7.56 µg/L (Table 3). The levels of Arsenic in groundwater in sample locations 1, 2 and 3, surpassed the WHO's regulatory limit for drinking water, which is 10 µg/L. The observed levels of Arsenic in groundwater at sample locations 1, 2, and 3 are 23.48 µg/L, 43.73 µg/L, and 18.46 µg/L respectively. Groundwater at these sample locations is contaminated with Arsenic (Table 3). However, the levels of Arsenic in groundwater in the other areas of the study remain within the World Health Organization regulatory limits (Figure 5).

Inorganic Arsenic is recognized as a carcinogen and has the potential to cause cancer of the skin, lungs, liver and bladder. Both natural processes and human activities can introduce Arsenic into groundwater. Cadmium on the other hand is an extremely toxic element found in rocks and leachate from landfill sites. Cadmium sulphide and selenite are frequently utilized as pigments in plastics. The consumption of high levels of Cadmium is linked to persistent stomach issues. Extended exposure to Cadmium can result into its accumulation in the Kidneys, leading to potential kidney disorder, lung damage and fragile bones. The concentration of Cadmium in the groundwater in the study area varied from 0.00 to 0.21 mg/L with an average concentration of 0.05 mg/L (Table 3).

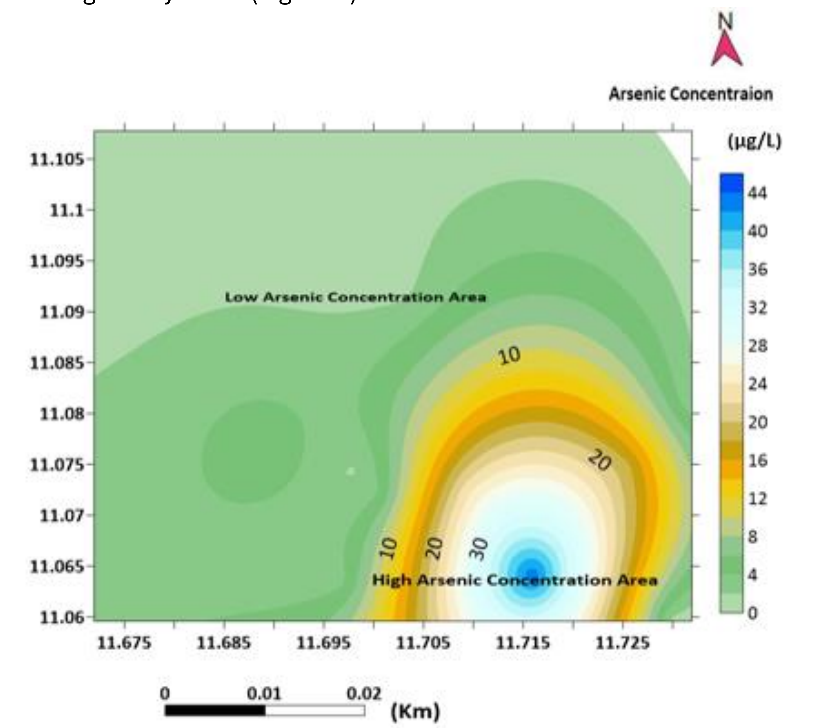

Figure 5: Spatial distribution of Arsenic in groundwater in the study area

The WHO, NAFDAC and NSDWQ regulatory limits for Cadmium in drinking water are 0.010 mg/L, 0.01mg/L and 0.030 mg/L respectively. The levels of Cadmium in groundwater within the study area exceed the regulatory limits, thus indicting that groundwater in the area is contaminated by Cadmium.

Given the increasing instances of kidney infections in the State, this may have been a contributing factor to some degree. The southeastern part of the study area exhibits higher Cadmium concentrations compared to other areas of the study (Figure 6).

The US Environmental Protection Agency (US EPA) advises that the allowable levels of Nickel in drinking water should not exceed 0.1 mg/L. The concentration of Nickel in groundwater of the study area ranged from 0.0 to 0.14 mg/L, with a mean of 0.02 mg/L. The concentration of Nickel in groundwater samples from locations 1, 2 and 3 of the study area exceeded the regulatory limits, thereby constituting groundwater pollution (Table 3). The concentration of Nickel in groundwater, in the southeastern part of the study area is higher, compared to other parts of the study area (Figure 7).

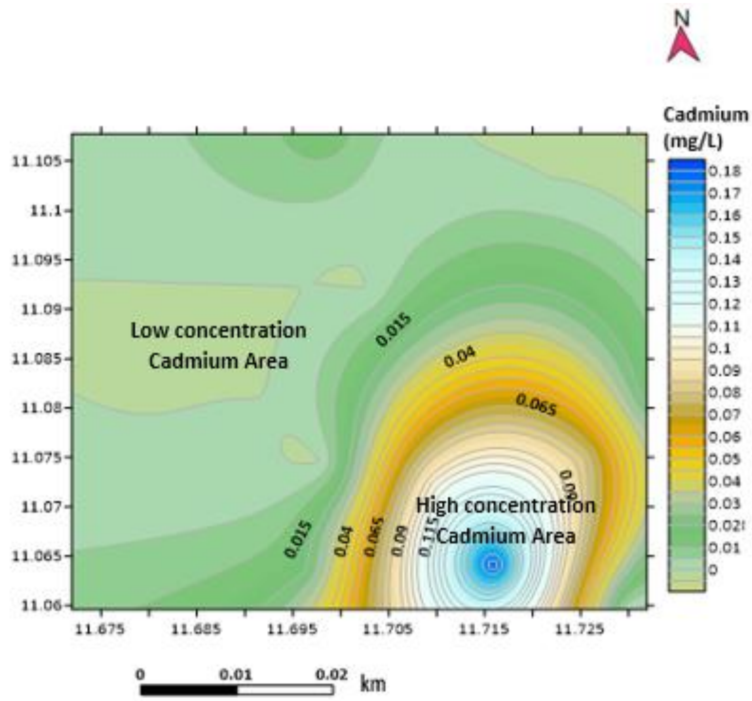

Figure 6: Spatial distribution map of Cadmium in groundwater in the study area

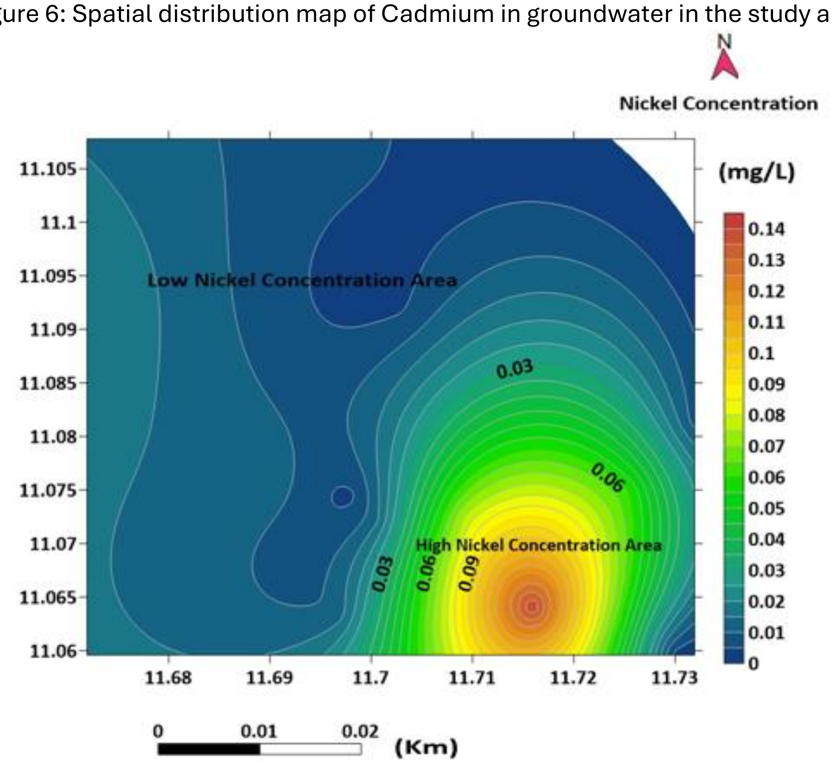

Figure 7: Spatial distribution map of Nickel in groundwater in the study area

At significantly high levels, exposure to Nickel can result in health issues such as irritation of respiratory tract, neurological disorders, and damage to liver and kidneys. The presence of Nickel in groundwater may result from both natural processes and human activities, including inadequate management of industrial and Pharmaceutical waste.

Lead can be present in drinking water due to dissolution from rocks and pollution from leachate entering the groundwater or from household systems containing Lead. The Lead concentration in groundwater within the study area varied from 1.08 to 61.29 µg/L with an average of 10.43 µg/L (Table 3). The concentration of Lead in the study area is higher in the southeastern part of the study area compare to other parts (Figure 8).

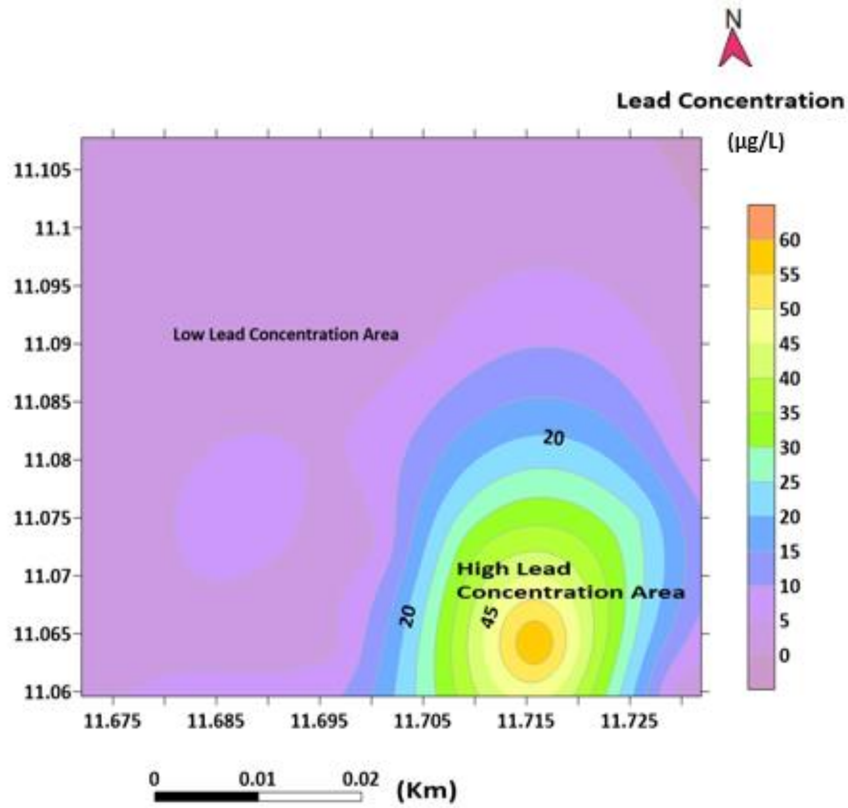

Figure 8: Spatial distribution map of Lead in groundwater in the study area

The allowable limits for Lead in drinking water set by WHO, NSDWQ and NAFDAC are 10 µg/L respectively. Lead levels in the groundwater at sample points 1, 2 and 3, exceeded the permissible limits and these areas are regarded as having groundwater contaminated by Lead. Prolong exposure to Lead can inflict severe harm to the kidneys and other essential organs of the body. The US Environmental Protection Agency (US EPA, 2007) has classified Lead as a carcinogen. Akan *et al*. (2011) reported that Children exposed to elevated levels of Lead may suffer from delay cognitive development and impaired growth.

The concentration of Copper in the groundwater of the study area spanned from 0.01 to 0.87 mg/L with an average of 0.17 mg/L (Table 3). The Copper level in groundwater in the study area is within the regulatory limits of 2 mg/L established by WHO and NAFDAC. The groundwater in the study area is free from Copper contamination. A certain quantity of Copper in drinking water is necessary for human body development, but at elevated levels, it can be toxic to the body. The Copper concentration in groundwater in the study area is elevated in the southeastern part of the study area in comparison to other parts of the study area (Figure 9). Excess Copper levels in the human body can result in anemia, along with liver and kidney damage (Agada *et al*., 2011).

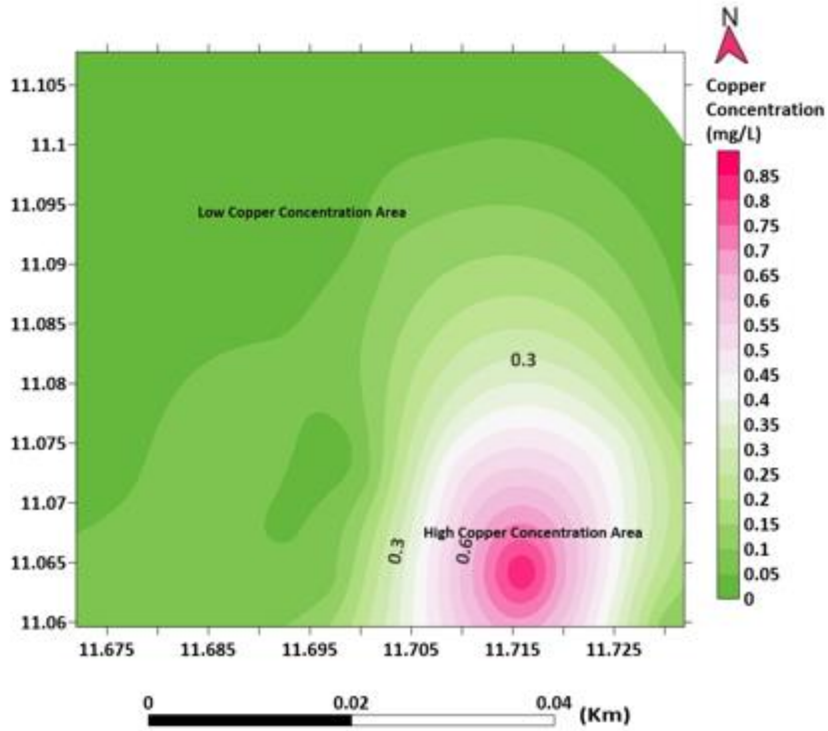

Figure 9: Spatial distribution map of Copper in groundwater in the study area

Chromium and its compounds are recognized as agents that can cause cancer, affecting the lungs, nasal cavity, and stomach (ATSDR, 2000). Although it is a vital nutrient that aids the body in digesting sugar, protein and fat (Hati *et al*., 2005). The concentration of Chromium in groundwater in the study area varied from 0.01 to 0.52 mg/L with an average of 0.09 mg/L (Table 3). The comparison of Chromium concentration in groundwater in the study area, with the regulatory limits of WHO, NSDWQ and NAFDAC which is 0.05 mg/L respectively, showed that the southeastern part of the study area contains more Chromium in groundwater than the remaining parts of the study area (Figure 10). The magnitude of the average value of Chromium in the study area showed that the groundwater in the study area is polluted by Chromium.

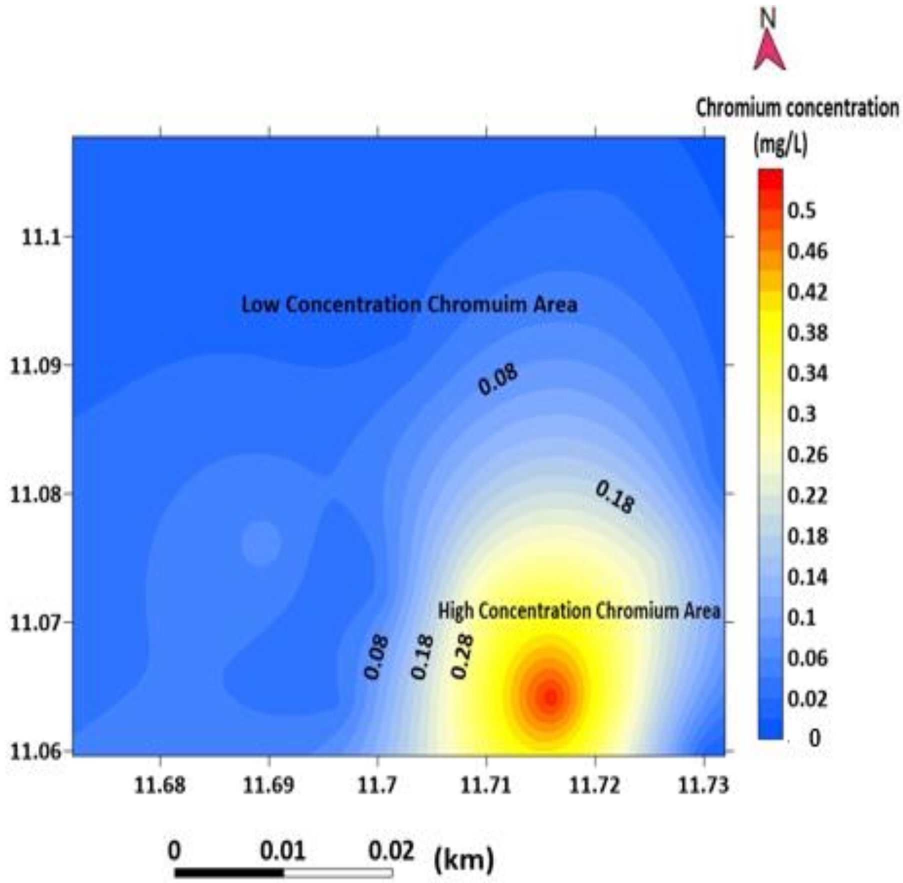

Figure 10: Spatial distribution map of Chromium in groundwater in the study area

The ongoing consumption of this contaminated water may lead to serious health complications for the local inhabitants.

Generally, trace metals are natural occuring substances which are often present in the environment in small quantities, but their presence in large quantities is due to human activities. The contamination of groundwater in the study area were facilited by various human activities which includes agriculture, poor waste management and improper siting of bore holes and wells. The spatial distribution of the contaminants in groundwater in the study area showed that the southeastern part of the study area where there are high volume of anthropogenic activities is characterized by higher degree of groundwater pollution compared to other parts of the study area. The findings of this study are in consonance with the reports of Waziri *et al.* (2009) and Salamatu *et al*. (2019) concenrning the growing trend in water contamination in Yobe State.

The Vertical Electrical Sounding (VES) results showed that the aquifer system in the study area is composed of semi-confined and confined aquifers. The proxiomity of the aquifer to the Earth surface enhanced easy contamination of the groundwater by infiltrating leachate. The groundwater in the southeastern part of the study area is considered unfit for consumption due to its level of pollution.

CONCLUSION

This research assessed groundwater contamination in Yobe State, using Potiskum as a case study. An electrical resistivity survey employing Schlumberger electrode configuration was conducted to define the subsurface stratigraphy in the research area. Four geological layers were identified, including topsoil, clay, sand, and sandstone. The characteristics of the aquifers in the study area are both semi-confined and confined in certain locations. The semi-confined aquifer in the study area is shallow and can be easily penetrated by leachate from dumpsites. The confined aquifer in some areas is artesian and has the ability to impede any infiltrating contaminants. The groundwater in the southeastern zone of the research area is primarily contaminated. The detection of trace metals at elevated levels in the groundwater, particularly in the southeastern section of the area, suggested that groundwater contamination has contributed to the rising trend in water-related health hazards observed in the study area and Yobe State in general. Based on the results of this study, it is advised that effective waste management policies be established by the Environmental Protection Agency to protect groundwater resources within the study area, and subsequent boreholes should be drilled into the second aquifer, while affected ones should be sealed.

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REFERENCES

Abdullahi, N.K., Osazuwa, I.B. & Sule, P.O. (2011). Application of Integrated Geophysical techniques in the investigation of groundwater contamination. A case study of municipal solid waste leachate. *Ocean Journal of Applied Science*. 4(1), 7-25. https://www.scrip.org

Adamu. I. T., Auwalu, Y.L. & Rahama, D.T. (2024). Overview of groundwater occurrence, quality and challenges in Nigeria. DOI:10.5772/intechopen.1006981.

Agada, L.E. and Yakubu, M.S. (2022). Investigation of Groundwater Pollution in Pompomari Area of Damaturu, using Geophysical and Hydrochemical Methods. *FUDMA Journal of Sciences*, 6(5), pp. 82-90. DOI: *https://doi.org/10.33003/fjs-2022-0601-893*

Agada, L.E., Malgwi, D.I., & Abbas, B.K. (2011). Harmattan dust and its effects in semi-arid zone of Nigeria. A case study of Maiduguri metropolis and its environs. *Techno Science Africana, Journal*, 6, 19-25. www.technoscienceafricana.com

Agada, L. E., Oniku, A.S., & Meludu, O.C., (2020). Modeling of Leachate Migration from Solid Waste Dumpsite. *Global Scientific Journals*. 8(2), 3386 – 3406 www.globalscientificjournal.com

Akan, J.C., Abdulrahman, F.I., Mamza, P.T., & Aishatu, N. (2011). Heavy metals in sediments from River Ngada, Maiduguri Metropolis, Borno State. *Journal of Environmental Chemistry and Ecotoxicology. 2(9), pp. 131-140*. http://www.academicjournals.org/jece

Alabi, T.O, Ilugbo, S.O., Akinmoye, O.E, Ibitomi, M.A, Aigbedion, I., Adeleke, K.A., & Ajanaku, B.S. (2019) Application of Resistivity and Hydrochemistry Methods for Mapping Groundwater Contamination around Okun Ilashe Island Area, Lagos State, Southwestern Nigeria. *Journal of Geography, Environment and Earth science International*. 23(4). Pp. 1-15. https://journaljgeesi.com

ATSDR- Agency for Toxic Substances and Disease Registry (2000). *Toxicological profile for chromium*. Atlanta, GA: US department of Health and Human Service, Public Health Service. www.atsdr.cdc.gov

Carter, J.D., Barber, D.F.M. and Tait, E.A. (1963). The Geology of Parts of Adamawa, Bauchi and Borno Provinces in Northeastern Nigeria. *Geological Survey Nigeria, Bulletin* no. 30.

Custer, G.S. (1976). Shallow Groundwater Salinization in Dry Land Areas of Montana. Montana Universities Joint Water Resources Research Centre Rept. No. 79, Bozeman, MT.

Egboka, B.C.E., Nwankor, G.I., Orajaka, I.P., & Ejiofor, A.O. (1989). Principle and problems of environmental pollution of groundwater resources with case example from developing countries. *Environmental Health Perspective, Nigeria*. Pp. 72-79.https://doi.org/10.1289/ehp.898339

Grisk, G. E. (1975). Nitrates in shallow groundwater near Lethbridge. *Tech. Rept. Environ. Protect. Serv.*, Edmonton, Canada.

Hati, K.M., Swarup, A.D., Singh, A.K., & Ghosh, P.K. (2005). Long-term continuous Cropping, fertilization and manuring effects on physical properties and Organic carbon Content of Sandy loam soil. Soil Research 44(5), pp. 487-495. https://doi.org/10.1071/sr/05156

Kamyab, H., Khademi, T., Chelliapan, S., Saberikamarposhti, M. Rezania, S., Yusuf, M., Farajnezahad, M., Abbas, M., Hun, B.J., Ahn, Y. (2023). The latest innovation avenues for the utilization of artificial intelligence and big data analytics in water resources management, Results Eng., 20(101566). https://doi.org/10.1016/J.RINENG.2023.101566.

Loke, M.H. (1999). A Practical Guide to 2D and 3D Surveys. Electrical Imaging Surveys for Environmental and Engineering Studies, pp. 8-10.

Matheis, G. (1976). Short review of the Geology of the Chad Basin in Nigeria. In C.A. Kogbe (Ed.) Geology of Nigeria. Lagos: Elizabeth publishing company.

Mosuro, G.O., Omosanya, K.O., Bayewu, O.O., Oloruntola, M.O., Laniyan, T.A., Atobi, O. M.,Okubena, E., & Popoola F.A. (2016). Assessment of groundwater vulnerability to leachate Infiltration using electrical resistivity method. *Appl Water Sci*. 7, 2195-2207. https://doi.org/10.1007/s1320101603934.

NAFDAC- National Agency for Food, Drug Administration and Control (2001). Guidelines for drinking water quality. NAFDAC Bulletin, Oct-Dec. 1-9.

NSDWQ- Nigerian Standard for Drinking Water Quality (2007). Nigerian Industrial Standard NIS 554, Standard Organization of Nigeria. P.30

Naz, I., Fan, H., Aslam, R.W., Tariq, A., Quddoos, A., Sajjad, A., Sonfan, W., Almutari, K.F., Ali, F. (2024). Integrated geospatial and geostatistical multi-criteria evaluation of Urban Groundwater quality using water quality indices, *Water Basel*, 16(17), p.2549.

Nigerian Centre for Disease Control and Protection (2021). Cholera in Nigeria: Urgent call to Strengthen Water Sanitation and Hygiene (WASH). https://www.ncdc.gov.ng/news/337/nh9i/wbymqs5i.shtml.

Nwajide, C.S. (2013). Geology of Nigeria's Sedimentary Basins. CSS Bookshops Limited, p. 565.

Obaje, N. G., Abdullahi, B. Sunday, D. M., Mohammed, A., Abdulwahid, A., et al. (2020). Updates on the Geology and Potential Petroleum System of the Bida Basin in Central Nigeria. *Petroleum Science and Engineering*, 4 (1), 23-33. https://doi.org/10.11648/j.pse.20200401.13

Ola-Buraimo, A.O., Boboye O. A. (2011). Palynological investigation of the Albian to lower Cenomanian Bima Formation Borno, Nigeria. *World Applied Science Journal*, 12, 17, pp. 1026-1033

Olagunju, E., A., Emmanuel, M., Awoyemi, A., Adebayo, O., Dasho, C., A. (2017). Application of geochemical and geophysical approach to environmental impact assessment: A case study of Emiran active open dumpsite, Ado-Ekiti southwestern Nigeria. *Model Earth Syst. Environ*. https://doi.org/10.1007/S4080801703811

Oyenweife, G.I. & Onyenweife, L.C. (2023). Evaluation of water Contamination and Its Health Implication on the Residents of Ayamelum Local Government Area, Anambra State. *Asian Journal of Geographyical Research*. 6(3), pp.1-8. https://doi.org/10.9734/AJGR/2023/v6i3184.

Salamatu, A.A., Ibrahim, I. & Aliyu, A. (2019). Chronic Kidney disease associated with heavy Metals from irrigation water of Gashua, Yobe Nigeria. *IOSR Journal of Applied Chemistry (IOSR-JAC)*.12(5), pp. 43-48.

United Nations Children's Fund (2024). Baseline Summary Report: Fune LGA, Yobe State, Nigeria. https://knowledge.unicef.org/wash/resource/baseline-summary-report-fune-lga-yobe-state-nigeria .

USEPA (2007). Determination of Metals and Trace Elements in Water and Istes by Inductively Coupled Plasma Atomic Emission Spectrometry. https://www.thermofisher.com/ng/en/home/industrial/environmental/environmental-Learning-center/water-quality-analysis-information/analyzing-water.

Wakode, H.B., Baier, K., Jha, R. Ahmed, S. & Azzam, R. (2014). Assessment of impact of Urbanization on groundwater resources using GIS techniques - Case Study of Hyderabad, Inida. *Int. J. Environ. Res.* 8. 1145-1158.

Waziri, M., Ogugbuaja, V.O. and Dimari, G.A. (2009). Heavy metal concentrations in surface and groundwater samples from Gashua and Nguru Areas of Yobe State, Nigeria. *Integrated Journal of Science and Engineering* 8 (1) 58-63.

WHO, (2000). Hazardous chemicals in Human and Environmental Health: A Resource Book for School, College and University Students. Geneva, Switzerland: World Health Organization.

WHO, (2017). Guidelines for drinking water quality, 4th edition, incorporating the 1st addendum. https://www.who.int/water_sanitation_health/publications/drinkingwater-qualityguidelines-4- including-1st Accessed 15th July, 2021.