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Physiochemical Parameters and Groundwater Resource in the Eastern Dahomey Basin, Southwestern Nigeria

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Abstract. Groundwater which accounts for 30% of the estimated earth's freshwater is an essential natural resource stored in the subsurface geological formations in the critical region of the earth's crust for sustaining ecosystems and human well-being. One of the challenges in water resources management in semi-arid and tropical regions like Eastern Dahomey basin, Lagos state, Nigeria is how to sustainably manage groundwater resources in relation to water pollution. Despite its importance, groundwater management in the region has been hampered by lack of comprehensive policies, leading to overexploitation and contamination issues. Therefore, a better understanding of the quality processes to a changing future is necessary. This study delves into assessing the groundwater quality in Eastern Dahomey basin, aiming to provide insights for effective management in the face of growing water pollution, scarcity and in relation to the world Health Organisation (2022) and Standard of Nigeria (2015) standard for drinkable water. Fourteen parameters were investigated on forty samples selected from a transient mapping of 6km square transient and the dug wells samples were selected randomly. The samples were taken to the laboratory for in depth analysis for both dry and wet season to denote seasonal variation and climate change impacts. Findings showed significant variations in physiochemical groundwater quality across seasons and parameters. pH levels fluctuated, likely due to rainfall and evaporation, but remained within standard ranges. Odors varied, with most samples not meeting odorless standards. Appearance showed particle concentrations mixed, with clarity below standard. Temperature also varied between seasons but conformed to standard guidelines. The study recommends the development of integrated water resource management plans, adoption of sustainable land use practices, and robust monitoring systems to ensure the long-term viability of groundwater resources. Moreover, there is a pressing need for stringent regulations, comprehensive awareness campaigns, and collaborative research efforts to address groundwater quality issues and promote sustainable groundwater use. By implementing these recommendations, stakeholders can mitigate the adverse impacts of climate change, safeguard groundwater resources, and ensure the well-being of present and future generations in the Eastern Dahomey Basin and similar regions globally.

Keywords: Physiochemical, Groundwater, Resource, Dahomey, Basin

1. Introduction

The most abundant natural resource on earth and a major substance that ensures continuity of ecosystems and biodiversity is water. All organisms, including humans, require water for their survival. Oki and Kanae (2006) opined that ensuring adequate supplies of water available is essential for human well-being. Our planet is often called the "Blue Planet," warnings of increasing water scarcity in the world are common. Adeboye (2015) In specific terms said that over the last 50 years the world has changed from a situation of an abundance of water to a situation of water scarcity. Mancosu et al. (2015); Usha et al. (2021) and Vrbka et al. (2008). Agreed that water having both surface and groundwater sources for human domestic activities, Agricultural, Industrial, flora and fauna uses cannot be over-emphasised; the management of either surface and groundwater resources are highly an interactive study that is very vital to the socio-economic sustainability of a society.

Groundwater is an essential natural resource stored in the subsurface geological formations in the critical region of the earth's crust that accounts for 30% of the estimated earth's freshwater Senanayake et al. (2016) and Arulbalaji et al.. (2019) argues that despite the importance of groundwater, no major public policy has been promulgated to promote sustainable use which poses a significant threat to the future water accessibility of inhabitants of these cities in Sub-Sahara Africa. The West-African coast has some of the largest and densely populated cities (Almar et al., 2022). The increasing population without commiserate development of public waterworks results in the overexploitation of groundwater resources from a fragile coastal aquifer. This leads to among others the saltwater intrusion into the freshwater aquifer (Alfarrah & Walraevens, 2018).

Previous works on groundwater quality were limited by the availability of resources, precision level required, spatio-temporal components, range of research, time and cost constraints. The direct/insitu approach to quality assessment is usually expensive and not feasible for estimation at a large scale that involves a whole catchment area or a system of catchments similar to the southwestern region of Nigeria. The indirect approach, especially the use of tracers is very popular because of its accuracy and reliability and can be used for studies over a relatively large sample area. The approach is however not suitable for areas with rich mineral basement formations like the Southwestern Nigeria as well as densely populated and industrialized southern part of Lagos and Ogun states which can cause anthropogenic mineral leaching into the aquifer and thus obstruct the result of the approach. The use of remote sensing technique is however scarce.

For instance, Healy et al. (2020) indicated that around 70% of Lagosian in Nigeria rely on groundwater for their domestic, industrial and commercial activities since the municipal water agency could currently only serve between 10% and 30% of the state's population. This has resulted in the emergence of individualized water supply infrastructure through borehole and well development across the state. The increasing population in this region without commiserates development of public waterworks results in the overexploitation of groundwater resources from the fragile coastal aquifer leading to imbalance in the hydraulic gradient and eventually resulting in saltwater intrusion into the freshwater aquifer. Therefore, this study aims to investigate the physiochemical parameters of groundwater in the Eastern Dahomey Basin, focusing on southwestern Nigeria. This research aims to address gaps in understanding groundwater quality, especially in densely populated areas like Lagos and Ogun states. By leveraging remote sensing techniques and assessing groundwater quality indicators, the study seeks to inform sustainable water resource management policies and mitigate the risks of overexploitation and saltwater intrusion in coastal aquifers.

2. Literature Review

The physical and chemical characteristics of groundwater can be altered by anthropogenic factors like wastewater, industry, agriculture, and natural phenomena. This poses a major risk to the environment as well as the social and economic advancement of many areas (Soceanu et al., 2021). Adebayo et al., (2021) conducted a study on the physicochemical properties of groundwater in parts of Irun Akoko, Ondo State, Nigeria. Their research aimed to assess the suitability of this groundwater for drinking and irrigation. Ten groundwater samples were collected from hand dug wells within the local basement complex. Analysis included pH, Total Dissolved Solids (TDS), turbidity, and the presence of various ions (Na, Ca, Mg, K, Cl, SO4, PO4, NO3). The findings revealed that the groundwater tended towards neutral to slightly alkaline pH (7.0 – 7.9) and was characterized as fresh based on TDS levels (12.26 – 19.35 mg/l). Cation concentrations ranked in the order of K>Ca>Na>Mg, while anions followed Cl>SO4>NO3>PO4. Notably, potassium and chloride levels exceeded WHO drinking water standards in approximately 90% and 40% of samples, respectively. Other parameters such as Ca, Mg, Na, SO4, PO4, and NO3 fell within WHO guidelines.

Longe et al., (1987) and Edwards et al; (2015) delineated three major regional aquifers, which form part of the Dahomey Basin in south-west Nigeria. The uppermost Coastal Plain Sands Aquifer is characterized by interbedded sand and clay horizons. Below this is the confined Ilaro Formation Aquifer, described as a sequence of predominantly coarse sandy estuarine deltaic and continental beds (i.e., alternating sequences of sand and clay). The Deep Confined Aquifer, which is the most productive, also consists of alternating sequences of sand and clay. In the study area the Coastal Plains Sands Aquifer is the most significant in terms of water supply. This aquifer is divided into three distinct units: a shallow unconfined unit, an intermediate semi-confined unit, and a deeper confined unit. The unconfined unit, accessed by hand-dug wells and shallow boreholes, is vulnerable to pollution from surface activities. Along the coast, the semi-confined and confined units are

found at depths of 30-120m and 120-270m, respectively. In inland areas, the deeper confined aquifer occurs at depths of 30-150m. These aquifer units are utilized through boreholes and serve as the basis for water supply systems in parts of Lagos State. Saline intrusion has been noted in the semi-confined units, particularly along a zone extending from Apapa to Lekki, beneath a freshwater lens up to 5km inland in certain locations. Additionally, further east, freshwater layers are situated between saltwater-bearing sands within the Coastal Plain Sands Aquifer (Oteri and Atolagbe, 2003)
Increasing interest in seawater intrusion as a consequence of over-exploration of groundwater and sea-level rise has been generated in recent years. Alfarrah and Walraevens (2018) contented that groundwater overexploitation and seawater intrusion concludes that arid and semi-arid regions of the world suffer extreme water stress, and the saline water intrusion is more prominent because of the overreliance on groundwater as the main freshwater source. The complex geological formulations in these areas further complicate the issue, such that the aquifer formations are becoming more sensitive and fragile.

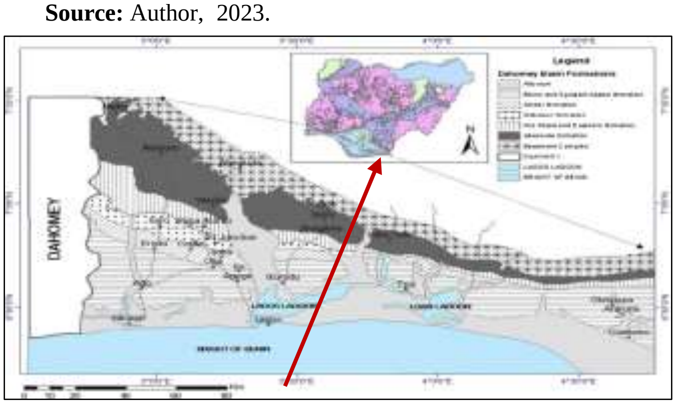
Direct and indirect risks to groundwater quality are posed by a wide variety of human activities and processes (such as agriculture, urbanization, industry, population increase, and climate change). Fertilizers, plant and animal protection goods (such as herbicides, fungicides, and other pesticides), and other agricultural operations are a major cause for alarm and have received a lot of attention across the world (Ascott et al. 2017). The production, processing and treatment processes of the industrial sector are also major contributors to anthropogenic pollutants. Lapworth, et al (2012) showed numerous organic pollutants, bacteria, viruses, and macronutrients all originate in domestic wastewater systems. In areas where shallow groundwater is utilized for drinking and irrigation and wastewater systems like pit latrines and septic tanks are in use, this may pose a serious danger to groundwater quality. Graham and Polizzotto (2013) advocated in respect of agricultural uses that groundwater from the different basins is of low salinity and low alkalinity hazard. This indicates the usability of these waters for irrigation in most soil and crops with little danger of development of exchangeable sodium and salinity. Considering sodium percentage (%Na), the groundwater of the different basins suggests good to excellent quality and can be used for irrigation purposes.

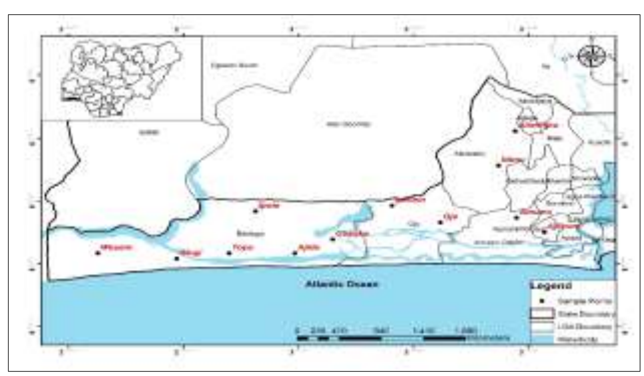
3. Materials and Methodology

3.1 Study Area

Eastern Dahomey Basin is administratively located in the South-Western part of Nigeria. It is bordered to the west, east and north by the Republic of Benin, Okitipupa Ridge, and the Precambrian Basement Rocks, respectively, while tretching into south into the Atlantic Ocean. Geographically, the EDB is located between Latitudes 2°41’10” and 4°59’59” N and Longitudes 6°21’13” and 7°52’42” E along the coast of the Gulf of Guinea. The Nigerian part of th6s basin is known as the Eastern Dahomey Basin which the three states of Lagos, Ogun, and Ondo. The study area is low lying, with several points virtually at or below sea level, which is always saturated with water, and prone to flooding. The highest elevation, 265 m above sea level, is at Abeokuta town, where the basin thins out into the Precambrian basement rocks. The climate of the basin is characterised by wet and dry seasons, within the tropical rain forest belt. Precipitation in this area occurs as rainfall and ranges between 750 and 1000 mm mostly between April and October (wet season) and 250 mm and 500 mm between November and March (dry season).

Fig.1: Groundwater recharge sampling points communities
Source: Author, 2023.





3.2 Methods

Groundwater samples of the forty selected wells were collected and taken to the chemical laboratory for the physiochemical. They were analyzed to establish the baseline groundwater conditions of the study area. At each sampling location of the forty wells, Groundwater sample were collected into a 2-litre polyethylene bottles each and immediately transferred into a rinsed 50cl bottles each with a well labelled samples tag and same taken to the laboratory for general physio-chemical analysis and microbial analysis. The wells were selected within a transient plot of 6km by 6km and the selected wells were randomly selected within the communities/sites within each transient plots. The fieldwork was carried out during the dry season (24th– 28th February, 2023 and also during the wet season (26th–30th June, 2023). The samples were collected and delivered for laboratory analyses within 24 hours for the accuracy of results. The forty well samples were tested with twelve water quality parameters: Colour level, Odour Appearance, pH of water, Temperature T(^{0}C,), Turbidity, Conductivity (mS/cm), Salinity (ppm), Dissolved Oxygen(mg/L), Oxygen (%,), TDS (ppm), TSS(mg/L), Total Hardness (mg/L) and Alkalinity level (mg/L) for the dry and wet seasons. The researchers aim to investigate whether there were seasonal fluctuations in the groundwater quality within the study area. The range and the mean for the samples were also calculated to give adequate information on the study area groundwater quality. The results were compared with the Federal Environment Protection maximum permissible levels), in order to determine their suitability and the significance of each parameter tested despite the season variation to denote the significant level of the water quality of the study area with Standard Organisation of Nigeria (2015) standard limits and the World Health Organization (2022) standard.

4. Result and Discussion

Assessing the Physiochemical quality of groundwater resource in the study area

This section presents findings from the assessment of physiochemical groundwater quality in the study area. Forty wells were sampled during dry and wet seasons, analyzing twelve parameters to explore seasonal variations and compliance with water quality standards.

pH

The pH of the water shows range of 5.0 – 7.4 in the dry season, with mean as 6.2; while the range during the wet season shows 4.2 – 6.8 with mean as 5.5. The Ph of water fluctuate between the two major seasons. During the wet season, increased rainfall can cause runoff, carrying organic matter and minerals from the soil into water bodies, which can alter the water's pH. In contrast, during the dry season, water bodies may have experience more evaporation, which led to the slightly elevated pH levels. Therefore, the pH is in conformity with standard of 6.5 – 8.5. One of the ecology factors that provides an important piece of information in many types of geochemical equilibrium is pH. It was based on this importance the findings revealed that the maximum pH value recorded was at 7.1 and the minimum was at 5.0 during dry season while the maximum pH recorded was at 6.8 and minimum was at 4.4 during wet season. In comparison of the findings to the standard values Standard Organization of Nigeria (2015) and World Health Organisation (2022), the results revealed no significance value. The result was similar in most cases in other studies conducted by various researchers as reported in the literature. Yadav et al., (2012) reported from their study that the pH value of 7.7 was recorded as maximum while 7.2 was recorded as minimum of the groundwater samples collected for the study. In the study of Ayodele et al., (2017), the pH value of 6.77 was recorded as maximum while 5.61 was recorded as minimum from the water samples of hand-dug well collected for the study. Jyothilekshmi, et. al. (2019) from their study reported 7.14 of pH value was recorded as maximum and 6.00 was recorded as minimum value of pH from the water samples collected for the study. In another study of Iyasele & Idiata (2011), 6.54 of pH value was recorded as maximum and 5.30 was recorded as minimum value of pH of the borehole water samples. Isa, Allamin et al., (2013) from their study reported 6.60 of pH value was recorded as maximum and 5.72 was recorded as minimum value of pH. Also, in the study of Nagamani, et al., (2015), the pH value of 7.2 was recorded as maximum while 6.9 was recorded as minimum without considering the seasons.

Odour

The results reveal on the forty samples that some samples are with slight indifferent smell in both dry and wet season; some with slight and major smell of decaying organism matter in dry and wet season respectively; some samples with no characteristic smell in both the dry and wet season; some samples with a slight and major sewage smell in the dry and wet season; some samples with slight smell of rotten egg in both dry and wet season and some samples with slight foul smell in the dry and wet season and samples with no significant Odour in both dry and wet season.

Therefore, the odour range could be said to be from no significant odour to sewage smell in both dry and wet season which indicate that most of the samples are not in conformity with the required standard on Odour for groundwater which is to be odourlessless. This result indicates that most of the samples are not in conformity with the required standard of the Standard Organization of Nigeria (2015) and World Health Organisation (2022) standard on odour for groundwater. This result was supported by Shukla et al., (2013); Iyasele & Idiata (2011) as they obtained odourless for the water samples collected for their studies. Similar results were also obtained by Nagamani et al., (2015) from their respective findings as zero value was recorded for Odour.

Appearance

The result shows appearances of small reddish tiny particle, Low concentration of visible particles, High concentration of visible particles and very Clear Appearance. Therefore, the appearance range could be said to be from low concentration of visible particles to very clear appearance in both dry and wet season which indicate that most of the samples are not in conformity with the required standard of Clear Appearance on Appearance for groundwater and drinkable water. The findings of the study revealed that either in the dry or wet seasons, the appearance was recorded as low particles which is significant over the standard values of Standard Organization of Nigeria (2015) and World Health Organisation (2022) as no particle. The results is supported by the study of Iyasele & Idiata (2011) that reported the appearance of their samples as clear appearances and two with tiny particles and Okonko et al., (2008) from their study reported that the samples are appearances of small reddish tiny particle, Low concentration of visible particles, High concentration of visible particles and very Clear Appearance.

Temperature (^{0}C)

On Temperature (^{o} C), the result shows the range from 26.9 – 30.5 in the dry season with the mean as 28.7, while the range during the wet season shows 20.0 – 30.2 with the mean as 25.1. Temperature in the study area during the dry season tends to be hotter than the wet season. As a result, Warmer water can influence the solubility of certain substances and affect the rates of chemical reactions occurring in water bodies. Therefore, the temperature is in conformity with Federal Environmental Protection Agency, Standard Organization of Nigeria and World Health Organisation (2014) standard of <40^{o}C. On temperature of water samples, the findings revealed that the maximum temperature value recorded was at 30.5^{0}C and the minimum was at 30.1^{0}C during dry season while the maximum temperature recorded was at 30.2^{0}C and minimum was at 28.1^{0}C during wet season. This result was similar to various researchers in the literature. Nagamani et al., (2015) from their study reported 30^{0}C of temperature value was recorded as maximum and 29^{0}C was recorded as minimum value of temperature. In the study of Isa, et. al. (2013), 30^{0}C of temperature value was recorded as maximum and 26.6^{0}C was recorded as minimum value of temperature. Jyothilekshmi, et. al. (2019) from their study reported 27.5^{0}C of temperature value was recorded as maximum and 27.4^{0}C was recorded as minimum value of temperature. Also, in the study of Okonko, et. al., (2008), 29.2^{0}C of temperature value was recorded as maximum and 28.0^{0}C was recorded as minimum value of temperature. Ayodele, et. al., (2017) from their study reported 28.1^{0}C of temperature value was recorded as maximum and 26.0^{0}C was recorded as minimum value of temperature. Thus, in comparison of the findings to the standard values of World Health Oeganisayion (2022) and Standard Orrganisatiom of Nigeria (2015) the results revealed no significance value as <40^{0}C.

Colour

The laboratory results on Colour shows that the samples range between 4.0 - 305 in the dry season, while the range during the wet season is 3.0-315, of which some colour are seen as out of range for both dry and wet season. Federal Environmental Protection Agency, Standard Organization of Nigeria and World Health Organisation (2014) standard on colour for groundwater and drinking water is to be colourless, It is therefore obvious that some samples fell below required standard On the part of colour, the findings revealed that the maximum colour value recorded was at 48.0 and the minimum was at 33.0 during dry season while the maximum colour recorded was at 53.0 and minimum was at 31.0 during wet season which are average value of colourless. The findings correlate the standard values of Standard Organization of Nigeria (2015) and World Health Organisation (2022) that establish the water sample colour to be colourless. This result was supported by Iyasele & Idiata, (2011) study that colourless was recorded for all the water samples of the study but similar with Okonko, et. al., (2008) who recorded colourless for most of the water samples with exemption to one which was recorded as bluish colour. This was also similar with Jyothilekshmi, et. al., (2019) who reported that seven samples out of ten samples as colourless but difference with two samples as yellow colour and one sample as brown colour. Isa, et. al., (2013) from their study reported not determined for both maximum and minimum values of the colour of water samples.

Turbidity

On Turbidity the results of the analyses showed that the samples range from 1.0 - 37 in the dry season with the mean as 19, while the range during the wet season is 3.0 – 40 with the mean as 21.5. Turbidity refers to the cloudiness or haziness of a fluid caused by large numbers of prticles suspended in it. During the wet season, increased sediment runoff led to higher turbidity levels in water samples than the dry season with clearer and lower turbidity. Therefore, the turbidity is not in conformity with Standard Organization of Nigeria (2015) and World Health Organisation (2022) standard of (NTU)5.

Turbidity is an important parameter that affects quality of water due to colloidal and extremely fine dispersions in most waters. The findings of the study revealed that the maximum turbidity value recorded was at 4.0 and the minimum was at 1.0 during dry season while the maximum turbidity recorded was at 6.0 and minimum was at 3.0 during wet season. In comparison of the findings to the standard values of WHO, SON and SON, the results revealed significance value as over 50% of samples shows greater value than prescribed value. Similar results were reported by Yadav, et. al., (2012) with turbidity value of 31.4 NTU which was recorded as maximum higher than the findings and 1.1 NTU was recorded as minimum value of turbidity closely to the findings. Nagamani et al., (2015) from their study reported that an increase value occurs for the value of turbidity. On the contrary, Ayodele, et. al., (2017) reported turbidity value of 0.6 NTU recorded as maximum which is below the findings and 0.1 NTU was recorded as minimum value of turbidity from their study which is also below the findings. Isa, et. al., (2013) from their study reported 0.98 of turbidity value was recorded as maximum which is below the findings and 0.77 was recorded as minimum value of turbidity also below the findings. Also, below the findings, Iyasele & Idiata (2011) reported 0.0 NTU of turbidity value was recorded for all the borehole water samples and Okonko, et. al. (2008) reported 0.56 of turbidity value was recorded as maximum and 0.08 was recorded as minimum value of turbidity.

Conductivity

On Conductivity, the results showed yhe range of 0.1 - 3.54 in the dry season with the mean as 1.82; while the range during the wet season as 0.03 – 2.86 with mean as 1.45. Therefore, the conductivity is in conformity with Federal Environmental Protection Agency, Standard Organization of Nigeria and World Health Organisation (2014) standard of (ns/cm)1000. The usefulness of conductivity in estimating the cleanliness of water cannot be overestimated as this study sees it as an essential tool. The findings revealed that the maximum conductivity value recorded was at 1.52 µS/cm and the minimum was at 0.08 µS/cm during dry season while the maximum conductivity recorded was at 1.12 µS/cm and minimum was at 0.03 µS/cm during wet season. This result was supported by Nagamani et al., (2015) who reported that conductivity value of 290 µS/cm was recorded as maximum and 180 µS/cm was recorded as minimum value of conductivity; Ayodele, et. al., (2017) reported 586.00 µS/cm of conductivity value was recorded as maximum and 129.00 µS/cm was recorded as minimum value of conductivity; Jyothilekshmi, et. al., (2019) reported 625 µS/cm of conductivity value was recorded as maximum and 1.04 mS/cm was recorded as minimum value of conductivity; Iyasele & Idiata, (2011) reported 33 µS/cm of conductivity value was recorded as maximum and 0.02 µS/cm was recorded as minimum value of conductivity; Isa, et. al., (2013) reported 1092 µS/cm of conductivity value was recorded as maximum and 189 µS/cm was recorded as minimum value of conductivity and Yadav, et. al., (2012) from their study reported that the electrical conductivity ranges from 1580 micromhos/cm to 5200 micromhos/cm which they are all higher than the findings. However, in comparison of the findings to the standard values of Standard Organization of Nigeria (2015) and World Health Organisation (2022) the results revealed no significance value which is lesser than prescribed value.

Salinity

On Salinity, the analyses show range as 64 - 1579 in the dry season, with the mean as 821.5; while the range during the wet season shows range as 53 - 8020 with the mean as 4036.5. Therefore, the salinity is not in conformity with Federal Environmental Protection Agency, Standard Organization of Nigeria and World Health Organisation (2014) standard of ppt N5. The findings revealed that the maximum salinity value recorded was at 1579 and the minimum was at 64 during dry season while the maximum conductivity recorded was at 8020 and minimum was at 53 during wet season. However, in comparison of the findings to the standard values of WHO and SON, the results revealed significance value which is greater than the prescribed value. Jyothilekshmi, et. al., (2019) from their study reported 0.0 psu for all ten water samples of their study.

Dissolved Oxygen

The result showed range of 1.5 – 4.7 in the dry season with the mean as 3.1; while the range during the wet season showed the range of 1.1 – 4.1 with the mean of the sample as 2.6. The concentration of dissolved oxygen in water can vary between the two seasons. In the wet season, increased water flow from rainfall can lead to higher oxygen levels due to aeration and mixing. In contrast, during the dry season, water bodies may experience reduced oxygen levels due to decreased flow and increased biological activity, such as respiration by aquatic organisms. Therefore, the Dissolved Oxygen is in conformity with Standard Organization of Nigeria (2015) and World Health Organisation (2022) standard of Ny02 L = 7.5. The findings revealed that the maximum dissolved oxygen value recorded was at 2.5 mg/L and the minimum was at 1.5 mg/L during dry season while the maximum dissolved oxygen recorded was at 2.1 and minimum was at 1.1 during wet season. Ayodele, et. al., (2017) from their study reported 50.00 mg/L of dissolved oxygen value was recorded as maximum and 29.17 mg/L was recorded as minimum value of dissolved oxygen. However, in comparison of the findings to the standard values of WHO and SON, the results revealed no significance value which is lesser than the prescribed value.

Oxygen

On Oxygen (0_2) the analyses result shows range of 4.1 – 10.0 in the dry season with the mean as 7.0; while the range during the raining season as 3.8 – 9.0 with the mean as 6.4. Therefore, the Oxygen (^{02}) is in conformity with Federal Environmental Protection Agency, Standard Organization of Nigeria and World Health Organisation (2014) of no particular standard. The findings revealed that the maximum oxygen value recorded was at 8.9 and the minimum was at 4.1 during dry season while the maximum oxygen recorded was at 6.5 and minimum was at 3.8 during wet season. However, in comparison of the findings to the standard values of Standard Organization of Nigeria (2015) and World Health Organisation (2022), the results revealed no significance value which is lesser than the prescribed value.

Total dissolved solids

On Total Dissolved Solids, the results of the analyses show the range of 1.0 – 199 in the dry season with the mean as 100; while the range during the wet season shows the range as 0.5 – 197 with the average range as 98.75. Total Dissolved Solids (TDS) refers to the total concentration of dissolved substances in water. In dry season, due to decreased water flow and increased evaporation, the concentration of dissolved solids may increase, leading to higher levels of total dissolve solids compared to the wet season. Therefore, the Total Dissolved Solid is in conformity with Standard Organization of Nigeria (2015) and World Health Organisation (2022) standard of Mg/L500. Total dissolved solids are typically related to conductivity while water containing more than 500 mg/L of total dissolved solids is not considered desirable for drinking water supplies. The findings revealed that the maximum total dissolved solids value recorded was at 186 and the minimum was at 11 during dry season while the maximum total dissolved solids recorded was at 155 and minimum was at 6 during wet season. This result was in contrary to Yadav, et.al., (2012) with total dissolved solids value of 4950mg/l was recorded as maximum and was1020 mg/L was recorded as minimum value of total dissolved solids. On the other hand, Nagamani et al., (2015) supported the findings with total dissolved solids value of 75 was recorded as maximum and 58 was recorded as minimum value of total dissolved solids. Jyothilekshmi, et. al., (2019) from their study reported 297.5 mg/L of total dissolved solids value was recorded as maximum and 34.29 mg/L was recorded as minimum value of total dissolved solids. Iyasele & Idiata, (2011) from their study reported 14 mg/L of total dissolved solids value was recorded as maximum and 0.1 mg/L was recorded as minimum value of total dissolved solids. Isa, et. al., (2013) from their study reported 547 mg/L of total dissolved solids value was recorded as maximum and 94 mg/L was recorded as minimum value of total dissolved solids. Ayodele, et. al., (2017) from their study reported 1.08 mg/L of total dissolved solids value was recorded as maximum and 0.16 mg/L was recorded as minimum value of total dissolved solids. However, in the comparison of the findings to the standard values of , the results revealed no significance value which is lesser than the prescribed value.

Total Suspended Solid

On Total Suspended Solid, the result showed range of 0.01 – 0.1 in the dry season with the mean of 0.05; while the range during the wet season reflects the range of 0.04 – 4.0 with the mean as 2.02. Therefore, the Total Suspended Solid is in conformity with Standard Organization of Nigeria (2015) and World Health Organisation (2022) standard of Mg/L500. The findings revealed that the maximum total suspended solid value recorded was at 0.01 maximum and the minimum was at 0.10 during dry season while the maximum total suspended solid recorded was at 0.04 and minimum was at 40 during wet season. Ayodele, et. al., (2017) from their study reported 0.07 mg/L of total suspended solid value was recorded as maximum and 0.02 mg/L was recorded as minimum value of total suspended solid. However, in the comparison of the findings to the standard values of Standard Organization of Nigeria (2015) and World Health Organisation (2022), the results revealed no significance value which is lesser than the prescribed value.

Table 1. Summary of the Physiochemical Analysis

Characteristics	range		MEAN	MEAN	W.H.O
	Dry Season	Wet season	AVERAGE DRY	AVERAGE WET	& S.O.N
Ph	5.0 – 7.1	4.4 – 6.8	6. 5	5.4	6.5 – 8.5
Odour	Little Odour	Little Odour	Little Odour	Little Odourless	Odourless
Appearance	Low Particles	Low particles	Low particles	Low particles	No particles
Temperature (T ^{0}c)	30.1 – 30. 5	28.1 – 30.2	30.3	29.4	< 40^{0}c
Colour	33 – 48	31 – 53	Colour code	Colour code	Colourless
Turbidity	4.0	3.0 – 6.0	2.3	4.8	(NTU)5
Conductivity	0.08 – 1. 52	0.03 –1.12	0.95	0. 60	1000(ns/cm)
Salinity	64 – 1108	53 – 8020	571.1	1844. 5	^{ppt} N5
Dissolved Oxygen	1.5 – 2. 5	1.1 – 2.1	2.1	1. 68	Ny02 L=7.5
Oxygen	4.1 – 8.9	3.8 – 6.5	5.9	1. 68	No specification
Total dissolved solids	11 – 186	6 – 155	109.5	91.3	Mg/l=500
Total Suspended Solids	0.01 – 0.04	0.07 – 0.1	0.03	0.08	mg/l ns
Total Hardness	510 – 820	495– 790	625	599	(mg $caco_3$=250l)
Alkalinity	62. 5 – 1012.5	60 – 1010	562. 5	56	No Specification

Source: Author, 2024
Note: OOR was valued as 500 for the plotting of the graph

Total Hardness

On Total Hardness, the result of the analysis shows range of 93 – 980 in the dry season with the mean of 536.5; while the range during the raining season is 82 - 900 with the mean as 491. Therefore, the Total Hardness is not in conformity with Standard Organization of Nigeria (2015) and World Health Organisation (2022) standard of (mg $caco_3$ = 250L).The property of water which increases its boiling points and averts the lather formation with soap is refers as hardness. The findings revealed that the maximum total suspended solid value recorded was at 980 and the minimum was at 93 during dry season while the maximum total suspended solid recorded was at 900 and minimum was at 82 during wet season. Ayodele, et. al. (2017) reported total hardness value of 208.74mg/L was recorded as maximum and 36.20mg/L was recorded as minimum value. Yadav, et. al., (2012) from their study reported total hardness value of 1425 mg/L was recorded as maximum and 240 mg/L was recorded as minimum value of total hardness. However, in the comparison of the findings to the standard values of Standard Organization of Nigeria (2015) and World Health Organisation (2022) the results revealed no significance value which is lesser than the prescribed value.

Alkalinity

The result showed range of 25 – 1012.5 in the dry season with the mean as 518.75; while the range during the wet season is 60 - 1010 with the mean as 535. Therefore, the Alkalinity is in conformity with Federal Environmental Protection Agency, Standard Organization of Nigeria and World Health Organisation (2014) of no particular standard. Alkalinity value in water provides an idea of natural salts present in water and it causes the minerals to dissolve in water from soil. The findings revealed that the maximum alkalinity value recorded was at 1012.5 and the minimum was at 25 during dry season while the maximum conductivity recorded was at 1010 and minimum was at 60 during wet season. This result was supported by Yadav, et. al., (2012) with alkalinity value of 525 mg/L was recorded as mum and 330 mg/L was recorded as minimum value. Isa, et. al., (2013) from their study reported 100 mg/L of total alkalinity value was recorded as maximum and 60 mg/L was recorded as minimum value of total alkalinity. Ayodele, et. al., (2017) reported alkalinity value of 382.20 mg/L was recorded as maximum and 43.26 mg/L was recorded as minimum value. Similarly, Nagamani, SaraswathiDevi and Shalini (2015) from their study reported that an increase value occurs for the value of Alkalinity. However, in comparison of the findings to the standard values of Standard Organization of Nigeria (2015) and World Health Organisation (2022), the results revealed significance value which is greater than the prescribed value.

Dry Season Physiochemical Analysis

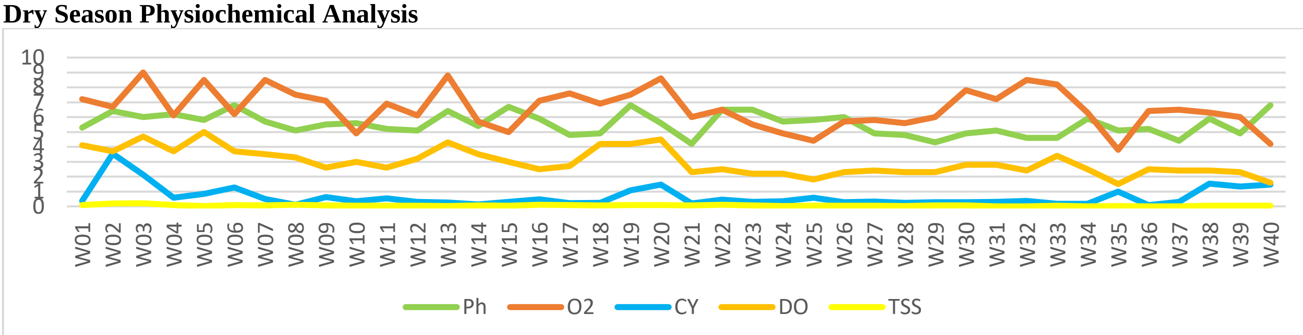


Figure 1.1: Physiochemical parameters of water samples in Dry season

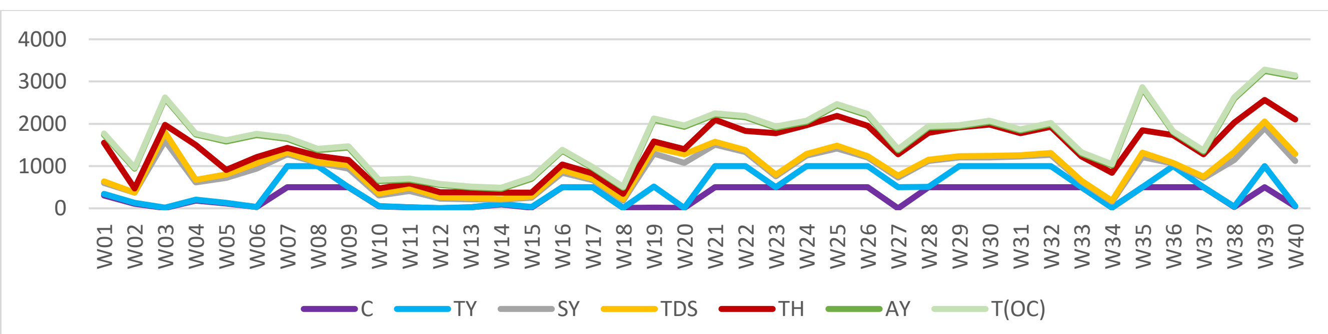


Figure 1.2: Physiochemical parameters of water samples in Dry season

Wet Season Physiochemical Analysis

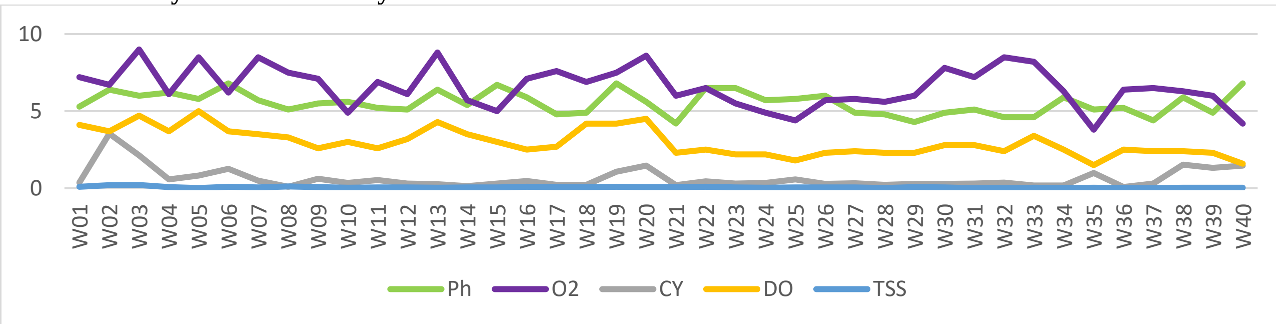


Figure 1.3: Physiochemical parameters of water samples in dry season

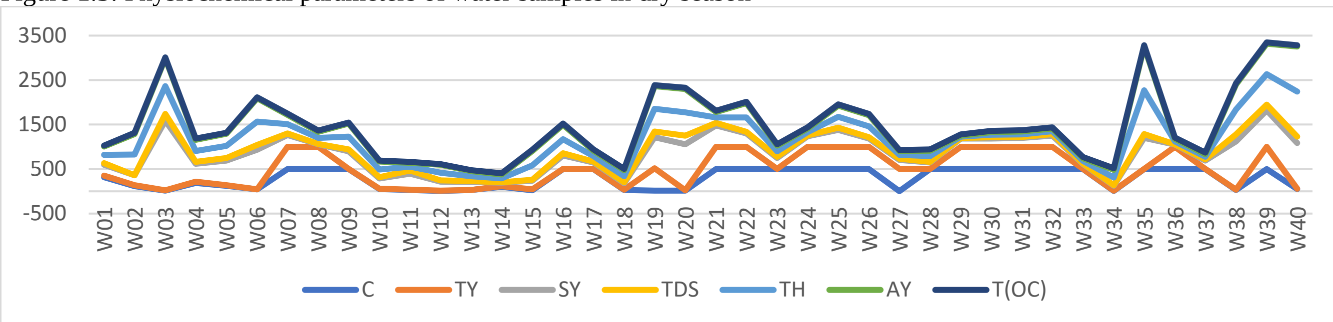


Figure 1.4: Physiochemical parameters of water samples in Wet season

5. Conclusion

The assessment of physiochemical groundwater quality in the study area revealed notable variations across seasons and parameters. pH levels showed seasonal fluctuation, likely influenced by rainfall and evaporation. Despite these fluctuations, the pH values remained within the standard range. Odour assessment indicated a range of smells, from slight to significant, with most samples not meeting the required standard of being odorless. Appearance assessments showed a mix of particle concentrations, with clarity falling below the standard. Temperature variations were observed between seasons, with values conforming to standard guidelines. Similarly, findings related to color, turbidity, conductivity, salinity, dissolved oxygen, and total dissolved solids were reported, showing some discrepancies with standard values. The study advocates for integrated water resource management, sustainable land use practices, and robust monitoring to preserve groundwater. There is need for stringent regulations, awareness campaigns, and collaborative research for sustainable groundwater management to ensure groundwater quality aligns with regulatory standards.

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