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6. Assessment of the Domestic Water Supply Situation in Peri-Urban Areas Of Lagos State: A Case Study Of Epe

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Abstract

This study assessed the drinking water quality and associated human health risks in Epe Town, Lagos State, Nigeria as a case study. Available water infrastructures and associated water quality were examined. An assessment of the accessibility of water supply to the inhabitants of Epe Town was also carried out. Three hundred structured questionnaires were administered to gather information about water supply, respondents' daily water usage volume, and the time taken to access water. The research integrates spatial and quantitative analyses of water quality parameters such as pH, EC, turbidity, TDS, DO, Na+, and Cl- with qualitative assessments of residents' experiences and perceptions regarding water scarcity and its daily-life consequences. The results revealed inadequate water infrastructures, leading to limited access to clean water. Residents face challenges in obtaining water, often investing valuable time and resources in securing this essential resource. The study underscores the implications of these constraints for achieving SDG 3. Moreover, the physico-chemical analysis of underground water demonstrates generally good water quality; but cautions against elevated total dissolved solids (TDS) and dissolved oxygen (DO) levels, which can pose health risks. The study emphasizes the necessity for comprehensive water management strategies and proper infrastructure development to mitigate the negative impacts of water supply on public health, in pursuit of achieving the SDGs.

Keywords: Water quality, Sustainable Development Goals, Lagos State, Water supply, Groundwater

Introduction

Water's indispensable role in sustaining life and preserving human well-being is undeniable (Akoteyon, 2019; Popkin, D'Anci, and Rosenberg, 2010; UNDP, 2006). Its involvement spans vital functions like temperature regulation, joint and tissue lubrication, and digestive processes (Healthline, 2023). Despite its paramount significance, a considerable segment of the global populace lacks access to safe drinking water. The World Health Organization (WHO) reports that over 2 billion individuals inhabit countries grappling with water scarcity, and no fewer than 2 billion people rely on contaminated water sources tainted with faecal matter (WHO, 2022). This precarious situation fuels the transmission of diseases such as diarrhoea, cholera, dysentery, typhoid, and polio. The intricate interplay between water and human health is underscored by the profound impacts of water quality and availability on health outcomes, alongside strategies aimed at augmenting access to potable water and fostering healthy hydration practices, aligning with the goals of SDG 3.

Simultaneously, the surge in urban population and heightened commercial activities may induce a pronounced surge in water consumption, potentially generating a conflict between the supply and demand for water resources, particularly in metropolitan zones (Jenerette & Larsen, 2006). This predicament could be exacerbated

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by the deterioration of urban water pollution control measures and a decline in the availability of water resources suitable for human utilisation, further magnifying these challenges (Liang, 2011).

The depletion of the world's available water resources is a mounting concern, aggravated by the rapid escalation of global populations, notably in developing nations like Nigeria. Presently, around 30 countries confront water stress, with 20 of these facing outright water scarcity. Projections indicate that by 2020, the number of water-stressed nations could escalate to 35 (Rosegrant *et al.*, 2002). This predicament stands as a direct contradiction to Sustainable Development Goal 6 (SDG 6), which seeks to ensure the availability and sustainable management of water and sanitation for all. Additionally, based on estimates, a substantial portion of the developing world's populace, amounting to one-third, will grapple with acute water scarcity by 2025 (Seckler *et al.*, 1998), directly impacting progress towards SDG 3 that aims to ensure healthy lives and promote well-being for all. In 2016 alone, inadequate water, sanitation, and hygiene facilities precipitated approximately 1.6 million fatalities on a global scale (Prüss-Ustün *et al.*, 2019). This dire situation starkly contradicts the objectives of SDG 3 and SDG 6, emphasizing the need for clean water and sanitation, as well as good health and well-being.

Study Area

Epe is situated at approximately Latitude 6^0 23' 3" North to 6^0 44' 0" North of the equator and Longitude 3^0 35' 43" E to 4^0 23' 12" E of the Greenwich Meridian. Geographically, Epe town is bounded by Ogun State to the north, the Lekki Lagoon to the west, Eti-Osa Local Government Area (LGA) to the south, and Ikorodu LGA to the east (Ogunbajo *et al.*, 2020). It has an average elevation of around 137 feet above sea level.

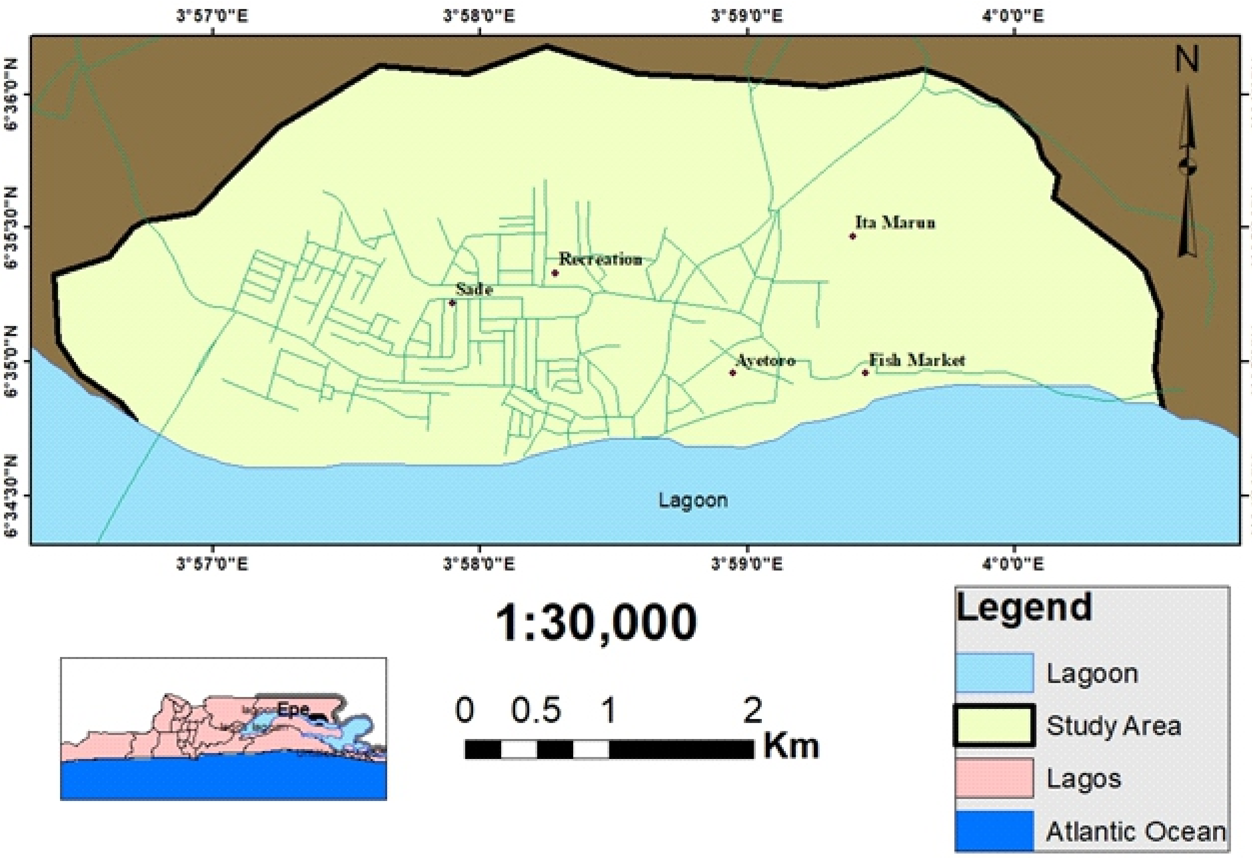

Figure 1: Map of the Study Area
Source: Authors (2023)

DOI: 10.5281/zenodo.14948371

Method of Study

Data Acquisition

To assess the water quality and examine the relationship between human health and water supply, purposive and simple random sampling techniques were adopted, and twenty (20) water infrastructures were purposively selected for the study. The water samples were collected, and the following parameters were measured in situ: total dissolved solids (TDS), dissolved oxygen (DO), pH, and electrical conductivity (EC). While Chloride (Cl^-), Sodium (Na^+) and turbidity were done in the laboratory. The selected parameters were chosen due to the riverine nature of the study area and based on past research on water quality in coastal areas (Sivaranjani et al., 2015). Dissolved oxygen (DO) was selected to measure the oxygen concentration in the water samples, indicating microbial activity. Total dissolved solids (TDS) were chosen to assess the concentration of dissolved minerals. Turbidity was used to evaluate the quantity of suspended particles in the water, while pH was measured to determine the water's acidity or alkalinity. Electrical conductivity was employed as an indicator of the concentration of dissolved ions in the water. Dissolved ions can include salts, minerals, and other chemicals. Chloride (Cl-) and sodium (Na+) were tested in Yen and Rohasliney, (2013); Longe and Balogun (2010); ScienceDaily (2007) and Tasoriero et al., (2004).

Total Dissolve Solid (TDS)/Electrical Conductivity/pH were measured using a portable combined Electrical Conductivity/TDS/Temperature meter (HM Digital Com - 100). The electrical conductivity meter was standardised with 342ppm sodium chloride calibration solution after the different samples were tested in turn.

Dissolved oxygen (DO) The dissolved oxygen of the water sample was determined using a portable Orion 3 DO meter. The DO meter was calibrated with saturated with air after which the different water samples were tested in turn.

Determination of metals Sodium (Na^+) Sample pre-treatment- 100ml of thoroughly mixed water samples was transferred into a beaker and 5ml conc. Nitric acid was added. The beaker was placed on a hot plate and evaporated to dryness. The beaker was then cooled and another 5ml conc. Nitric acid was added. Heating was continued until a light-coloured residue was observed. Then 1ml conc. Nitric acid was added and the beaker was warmed slightly to dissolve the residue. The walls of the beaker were then washed with distilled water. The volume was adjusted to 50ml. Na were determined in the digested samples using an atomic absorption spectrophotometer (Analyst 200 Perkin Elmer AAS).

Chloride (Cl^-) The chloride was determined by the argentometry method. An aliquot portion of water samples was titrated with a standard solution of silver nitrate solution using potassium chromate as an indicator. The colour change at the endpoint was yellow to brick red.

Results and Discussion

The analysis of Total Dissolved Solids (TDS) revealed a significant and wide variation within the dataset, as indicated by a coefficient of variation exceeding 33% (Table 1). The concentrations of TDS ranged from 10mg/L to 278mg/L, with an average concentration of 133.4mg/L (Table 1). It is worth noting that all groundwater samples taken from Point A to Point T exhibited low TDS levels, which were found to be below the drinking water quality standards set by WHO and NSDQW (Fig. 2). The map (Fig. 3) visually displays the spatial patterns

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of TDS concentrations, allowing for identification of areas with higher or lower TDS levels.

TDS primarily consist of inorganic matter and small amounts of organic matter, which dissolve in water. High concentrations of TDS can render water unsuitable for drinking purposes, potentially leading to various health issues such as joint stiffness, arterial hardening, kidney stones, gallstones, and blockages in the body's passages and capillaries through which liquids flow (Rahmanian, 2015). The findings suggest that the water in the study area may contribute to the occurrence of the health problems.

The analysis of groundwater samples reveals a wide range of pH values. The average pH recorded is 1.74, with a standard deviation of 0.65. The minimum pH observed is 0.50, while the maximum is 2.80. The coefficient of variation (CV) for pH is calculated to be 37.41% (Table 1), indicating a moderate level of variability in pH levels. It is important to note that the observed pH levels in the groundwater samples fall significantly below the recommended range of 6.5 to 8.5 pH (Fig. 4) suggested by the World Health Organization (WHO) and the National Secondary Drinking Water Quality (NSDWQ) for drinking water. This indicates that the groundwater samples exhibit an acidic nature. Acidic water can have implications for taste, corrosion, and overall water quality. It may also result in the leaching of metals and other substances from plumbing materials, which can pose potential health risks.

Water with a pH value lower than 6.5 is considered acidic for human consumption and can cause health problems such as acidosis and adverse effects on the digestive and lymphatic systems (Fosu-Mensah, 2016). However, pH has no direct effect on human health, but because it is closely associated with other chemical constituents of water, it is often regarded as having an indirect effect on health (Adesakin et al, 2020). pH changes can also affect aquatic organisms as their metabolic activities are pH-dependent (Kumar et al., 2017).

Table 1: The physico-chemical analyses of the water were carried out following standard analytical methods (APHA, 1992).

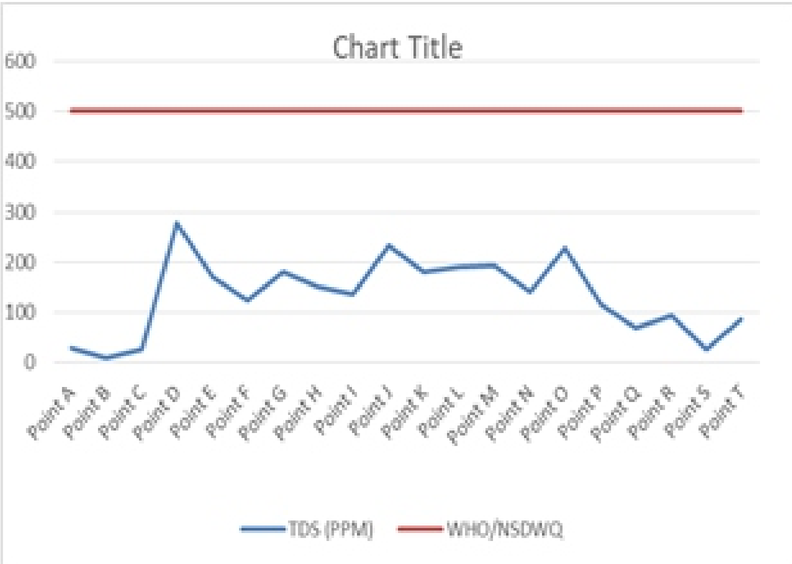
Name	TDS	PH	EC	D0	Cl	Na	Turbidity
Point A	30.5	2.1	0.03	19.7	16	6.291	2.5
Point B	10	1.9	0.01	10.7	8	3.145	2.2
Point C	28	2.6	0.03	10.6	18	7.077	1.8
Point D	278	0.6	0.4	5.9	12	4.718	2
Point E	172	1.4	2.4	7.9	76	29.88	1.5
Point F	123	1.8	0.17	10.7	56	22.017	2
Point G	181	1.2	0.25	4.6	80	31.453	1.9
Point H	152	0.8	0.21	5.7	72	28.308	1.1
Point I	135	1.8	0.18	6.8	76	30.667	1
Point J	232	0.5	0.32	5.4	100	39.316	2.3
Point K	182	1.7	0.25	6.3	75	29.487	1.7
Point L	190	1.4	0.26	9.8	84	33.026	1.6
Point M	193	2	0.26	10	88	34.598	1.4
Point N	140	2.5	0.19	8.1	77	30.274	1.8
Point O	228	1.3	0.32	7.2	103	40.496	1.8
Point P	116.5	1.7	0.16	4.6	60	23.59	2
Point Q	70	1.8	0.09	4.9	32	12.581	1.2
Point R	93	2.3	0.12	5.6	38	14.94	0.7
Point S	28	2.8	0.03	3.4	19	7.47	0.8

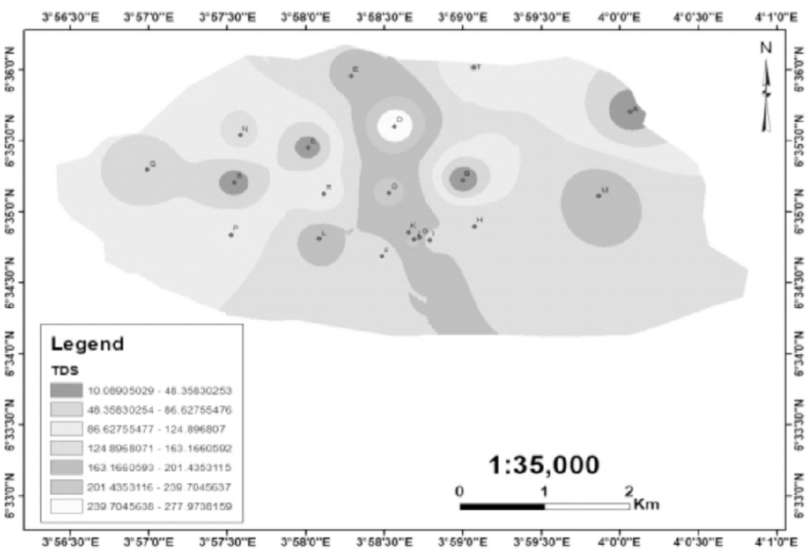
DOI: 10.5281/zenodo.14948371

Point T	86	2.5	0.11	7.9	36	14.154	0.9
Mean	133.40	1.74	0.29	7.79	56.30	22.17	1.61
SD	75.80	0.65	0.51	3.60	31.08	12.25	0.52
Min	10.00	0.50	0.01	3.40	8.00	3.15	0.70
Max	278.00	2.80	2.40	19.70	103.00	40.50	2.50
C V	56.82	37.41	175.66	46.16	55.21	55.23	32.24
WHO/ NSDWQ	500	6.5 - 8.5	NS	NS	200	250	5

Source: Authors' Fieldwork, 2023
NS- Not specify, WHO: World Health Organisation
NSDWQ: Nigerian Standard for Drinking Water Quality

Spatial Variation of Total Dissolved Solid

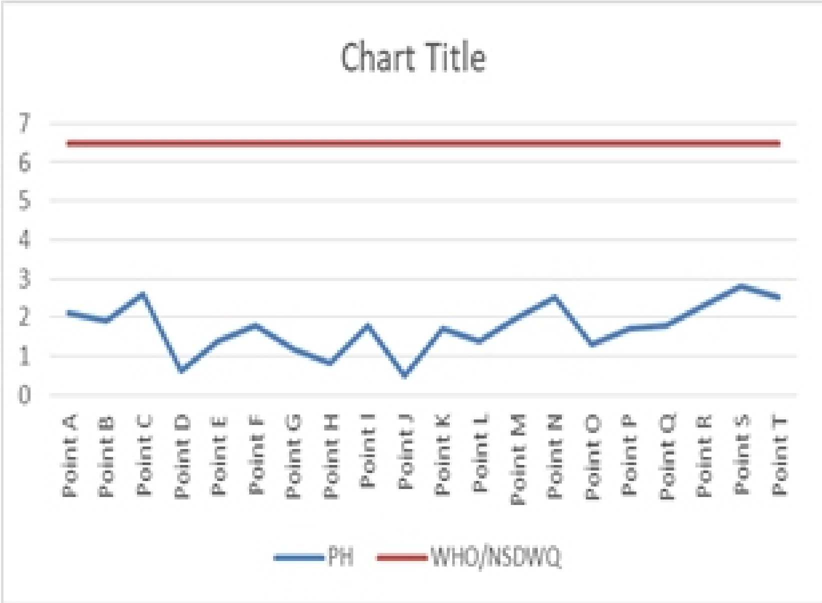


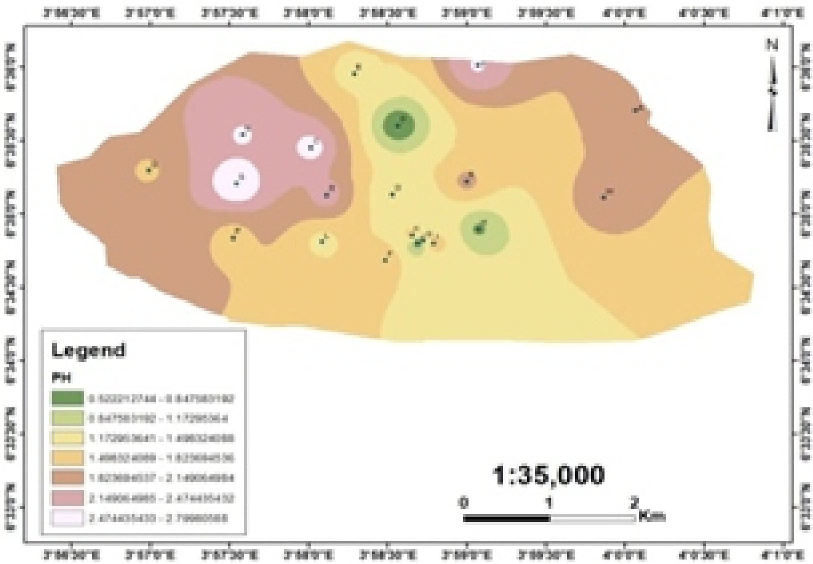


Figures 2 & 3: Chart and map showing TDS distribution in the study

Source: Authors (2023)

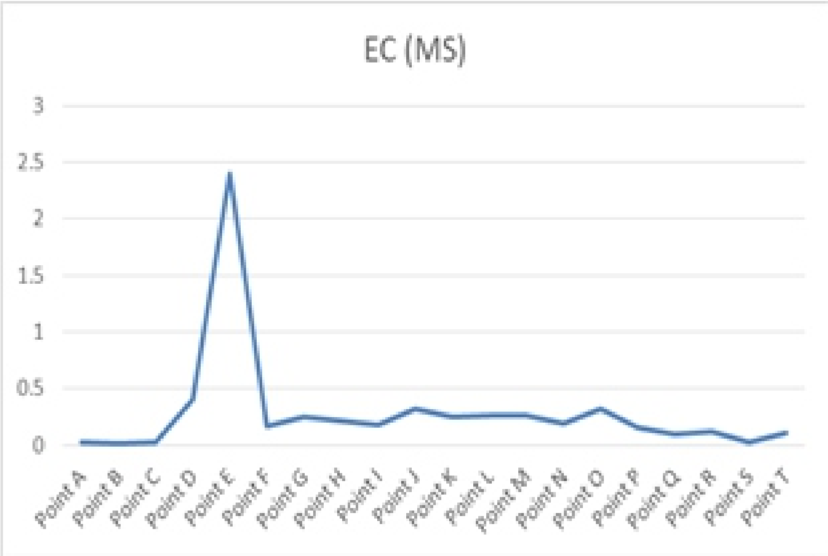
Spatial Variation of pH

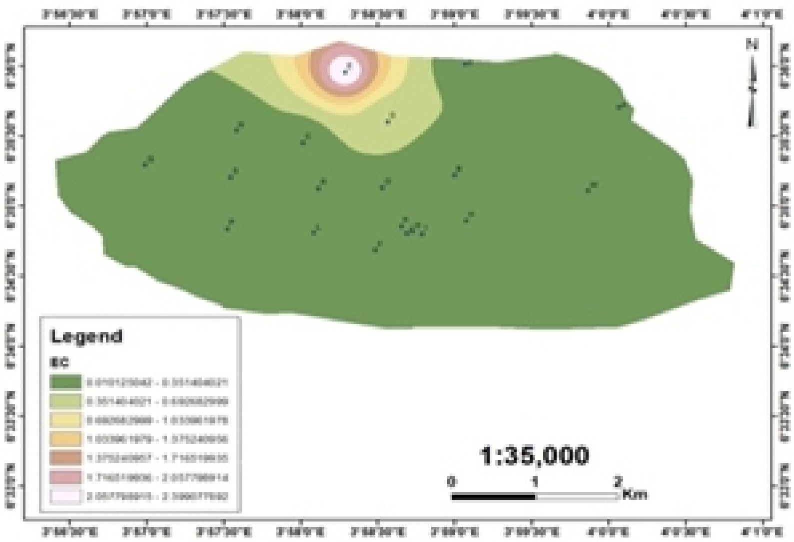




Figures 4 & 5: Chart and map showing pH distribution in the study area
Source: Authors (2023)

Spatial Variation of Electrical Conductivity (EC)





Figures 6 & 7: Chart and map showing E C distribution in the study area

Source: Authors (2023)

The groundwater samples exhibit a wide range of electrical conductivity (EC) values, averaging at 0.29 with a deviation of 0.51. The EC's coefficient of variation (CV) is notably high at 175.66% (Table 1), indicating significant variability. Although no specific WHO or NSDWQ guidelines pertain to EC in drinking water, monitoring it remains vital for water quality assessment and contaminant detection. Elevated EC may suggest dissolved substances or pollutants.

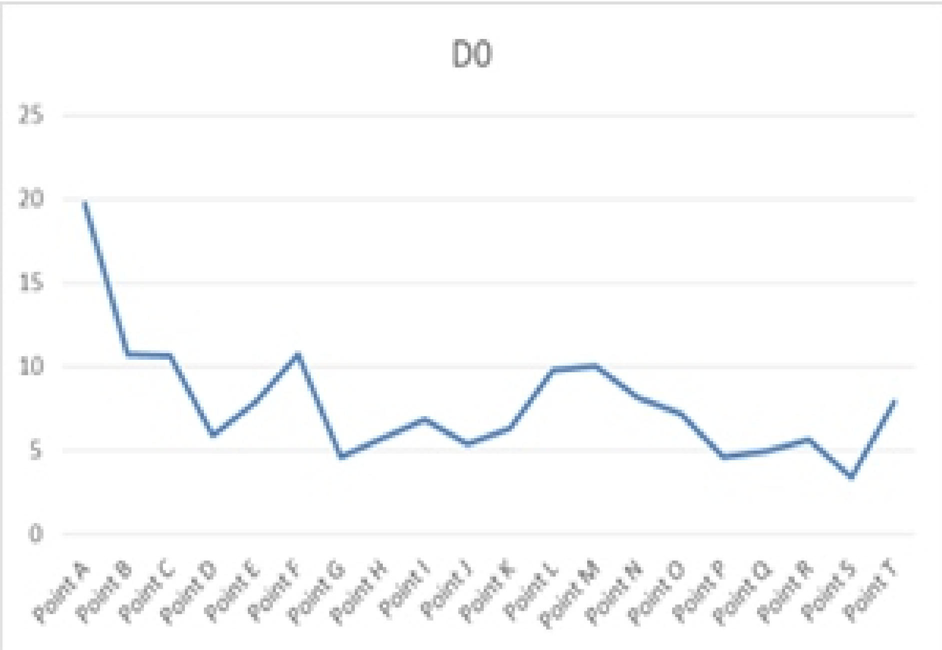
Electrical conductivity (EC) gauges water or soil's electrical current conductivity. Elevated EC in water can signify dissolved salts, heavy metals, or contaminants with potential health implications. For instance, near coalfired power plants, heightened soil EC links to potentially toxic elements (PTEs), posing human health risks (Achterberg et al., 2019). Concerns also extend to the potential health effects of electromagnetic fields (EMF) linked to EC. Though not conclusive, certain studies suggest EMF exposure from sources like power plants might lead to health issues like sleep disturbances (Liu et al., 2014). Furthermore, elevated EC in surface water is associated with heightened heavy metal and contaminant levels, impacting human health (Adesakin et al., 2020). These findings emphasise the relevance of SDGs 3 and 6, urging actions to ensure good health, well-being, and clean water while considering potential risks from environmental factors.

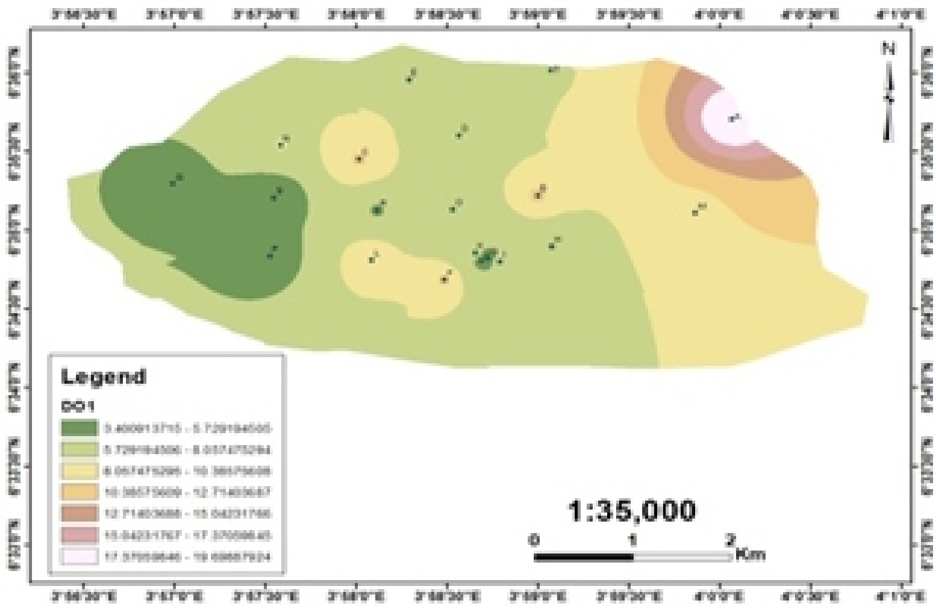
The analysis of dissolved oxygen (DO) concentrations in groundwater samples revealed a significant range, with values ranging from 3.4 mg/L to 19.7 mg/L and a mean concentration of 7.9 mg/L. The coefficient of variation, which exceeds 33%, indicates notable variation in the measured DO levels (Table 1). Specific groundwater samples from Points G, Q, P, and S displayed lower DO levels of 4.6 mg/L, 4.9 mg/L, 4.6 mg/L, and 3.4 mg/L, respectively (Fig. 8). These values suggest relatively low levels of dissolved oxygen in the groundwater samples. While WHO and NSDWQ do not specify permissible levels for dissolved oxygen in drinking water, extremely low DO concentrations below 2 mg/L are described as hypoxic, and the absence of measurable oxygen indicates an anoxic system (Diaz, 2015; Sakizadeh et al., 2019).

However, it is worth noting that high DO levels can accelerate corrosion in water pipes (Jung et al., 2009). Although dissolved oxygen does not directly impact human health, it can contribute to the corrosion of metallic products used for drinking, eating, and cooking. Drinking corrosive water can result in stomach and intestinal distress such as nausea, vomiting, diarrhoea, and stomach cramps. Prolonged exposure to corrosive water may cause severe damage to the brain, kidneys, nervous system, and red blood cells (Chen *et al*., 2022).

Considering the potential health risks and infrastructure damage associated with high dissolved oxygen levels, appropriate measures should be taken to mitigate corrosion and ensure the provision of safe and non-corrosive drinking water.

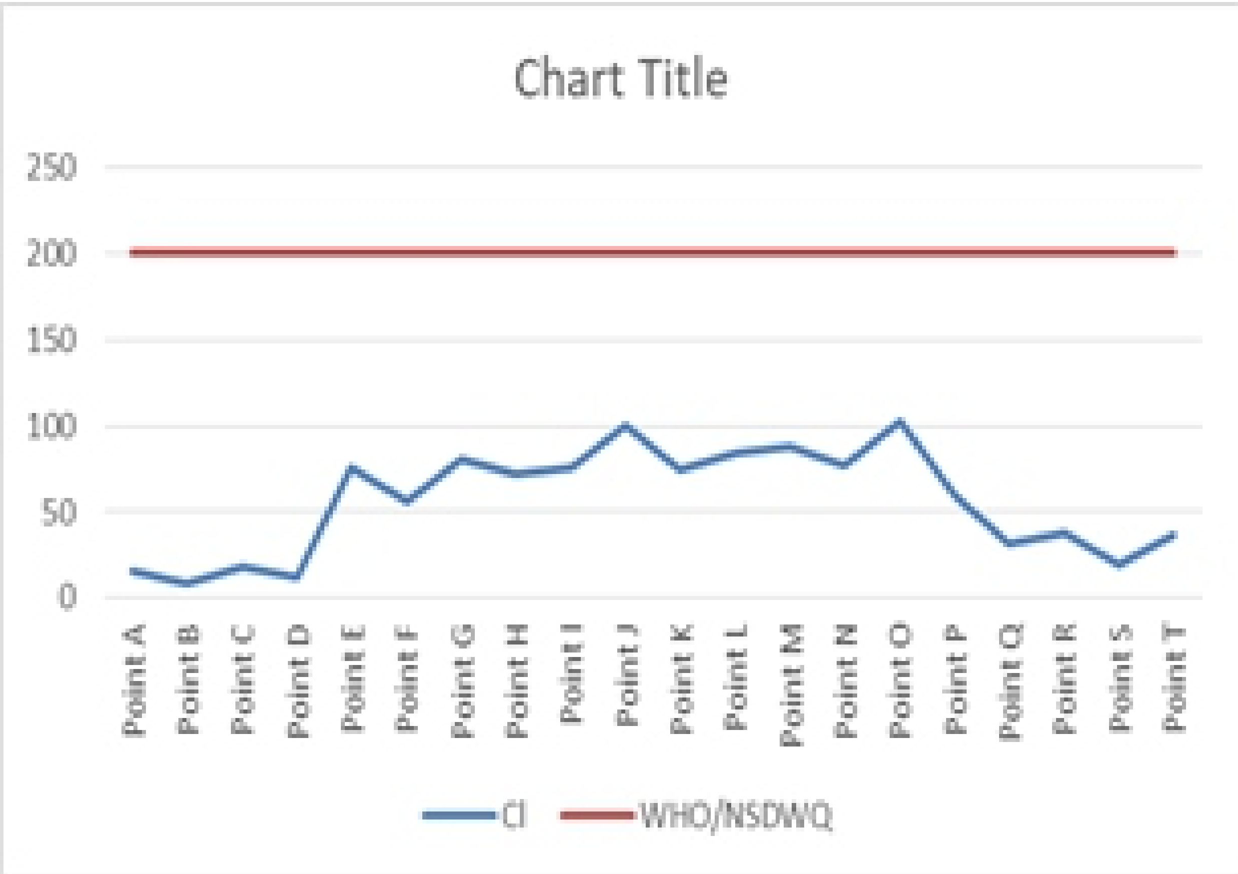
Spatial Variation of Dissolved Oxygen





Figures 8 & 9: Chart and map showing Dissolved Oxygen distribution in the study area
Source: Authors (2023)

Spatial Variation of Chloride



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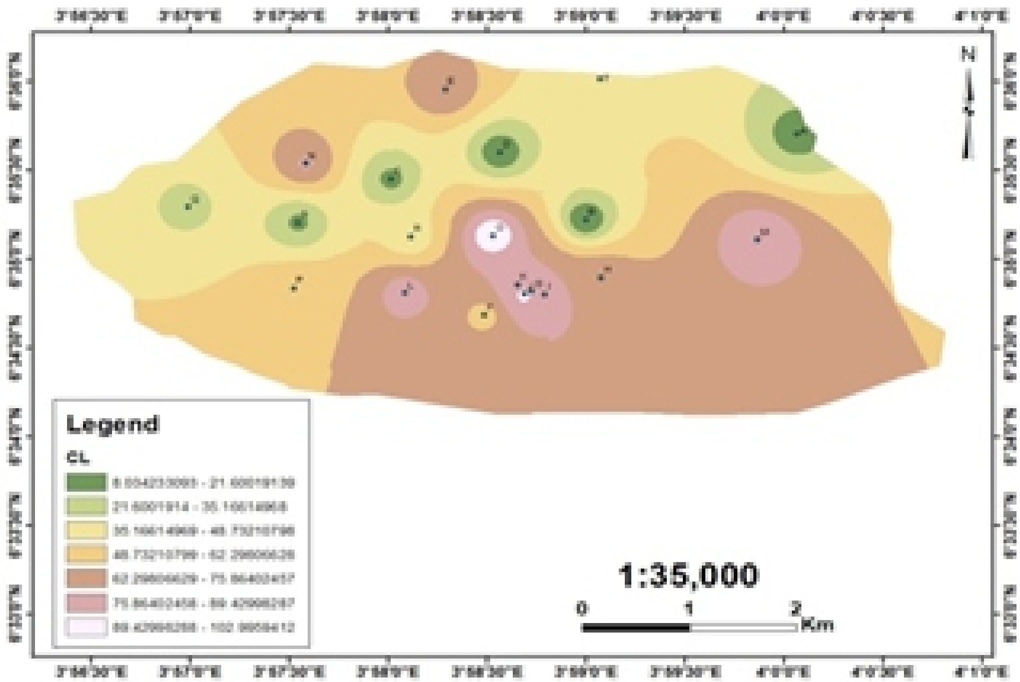

Figures 10 & 11: Chart and map showing Chloride distribution in the study area
Source: Authors (2023)

The concentration of chloride (Cl-) in groundwater serves as an indicator of various sources of pollution, including sewage, saline water intrusion, domestic effluents, septic tanks, and high rainfall. Factors such as soil porosity and permeability also influence the build-up of chloride concentration (Fawell, 1993; Heydari and Bidgoli, 2012). The coefficient of variation for chloride (Cl-) is 55.21, indicating a significant variation in its concentration within the study area. Most of the water samples analyzed had chloride levels below the permissible limit of 250 mg/L set by WHO and NSDWQ (Fig. 10). The recorded chloride concentrations in all sampling sites ranged from 8 mg/L to 103 mg/L (Table 4.3).

It is important to note that chloride contributes to water's corrosivity effect and can affect the taste of water, giving it a salty flavour. In contrast, good-quality water should be tasteless (Fawell, 1993; Heydari and Bidgoli, 2012). Elevated levels of chloride in the bloodstream can lead to hyperchloremia, a condition characterized by an excessive chloride concentration (Duan et al., 2024; Obaido et al., 2024; WHO, 2003). Considering the corrosive nature of high chloride levels and the impact on water taste and human health, it is crucial to monitor and manage chloride concentrations to ensure the provision of safe and palatable drinking water.

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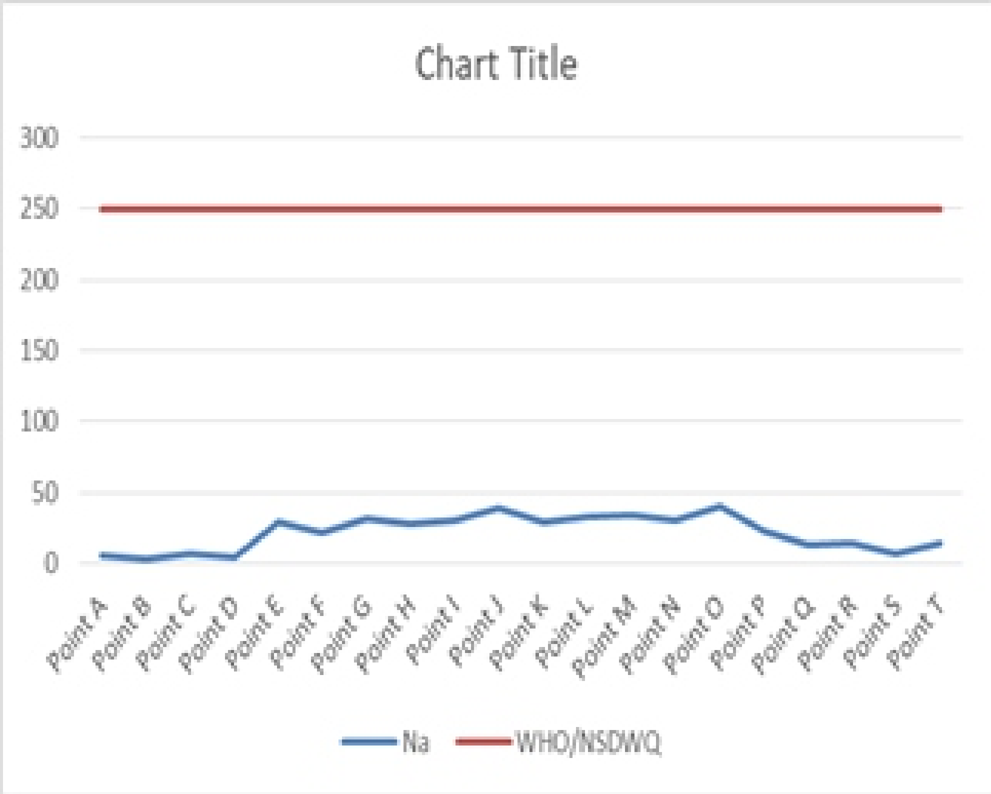
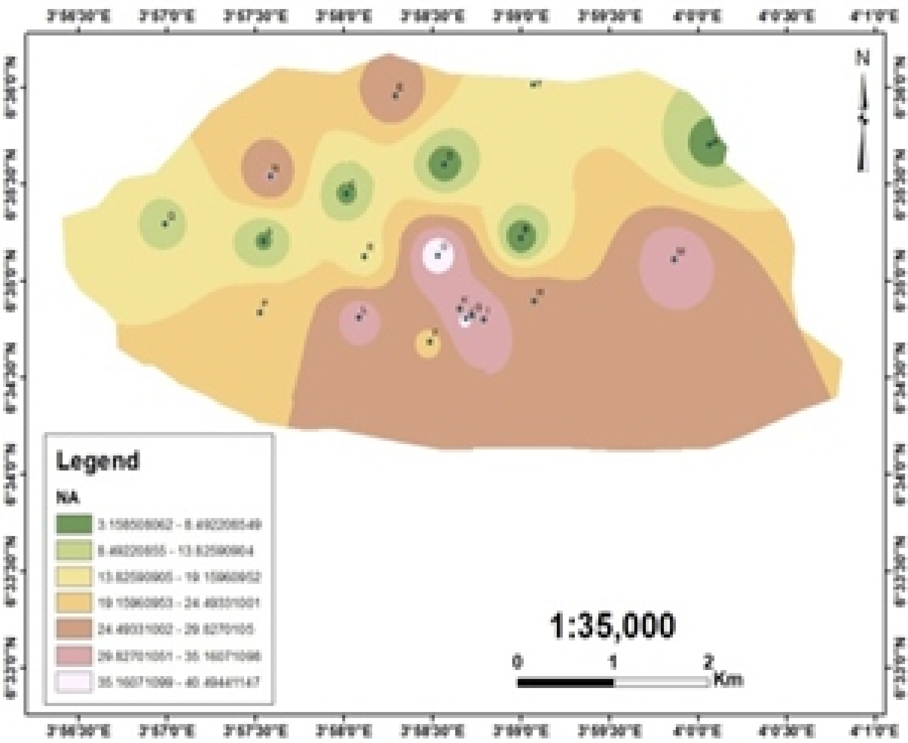
Spatial Variation of Sodium





Figures 12 & 13: Chart and map showing Sodium distribution in the study area
Source: Author (2023)

The coefficient of variation of sodium (Na^+) is 55.23, which is an indication that there is significant variation in the concentration of Na^+ in the study area. Sodium (Na^+) concentration in the groundwater samples ranges from 3.1mg/l to 40.5mg/l with a mean concentration in water of 22.17mg/l. Na^+ concentration in all the samples was found below the specified WHO and NSDQW standards for drinking water quality (Fig. 12).

Consuming high amounts of sodium has been linked to increased blood pressure, which can increase the risk of conditions such as stroke, heart disease, and heart failure. Other health consequences of excess sodium intake include arteriosclerosis, oedema (fluid retention), hyperosmolarity (imbalance of body fluids), convulsions, and an increased risk of infection (Biglari *et al.,* 2016)

On the other hand, sodium shortages can lead to various health issues as well. Insufficient sodium intake may result in dehydration, convulsions, muscle paralysis, decreased growth, and a general sense of numbness. It's important to note that the effects of excess sodium on infants differ from those in adults due to the immaturity of infant kidneys. Infants who experience severe gastrointestinal infections may suffer from fluid loss, leading to dehydration and elevated sodium levels in the bloodstream (hypernatremia) (Heydari and Bidgoli, 2012; USGS, 2013). Considering the potential health risks associated with both excessive and inadequate sodium levels, it is crucial to ensure the appropriate balance of sodium intake in drinking water to promote overall well-being and prevent adverse health outcomes.

The analysis of turbidity in the groundwater samples yielded insightful results. The average turbidity recorded was 1.61, with a standard deviation of 0.52. The range of turbidity values varied from a minimum of 0.70 to a maximum of 2.50. Calculating the coefficient of variation (CV), we obtained a value of 32.24%, indicating a significant degree of variability in turbidity levels within the dataset. Although WHO and NSDWQ do not provide specific guidelines for turbidity in drinking water, it is generally recommended to maintain low turbidity levels to ensure visually clear and particle-free water.

The observed turbidity levels in the groundwater samples indicate that they are relatively low and fall within acceptable limits for drinking water quality. However, continuous monitoring of turbidity is essential to ensure on-going water clarity and prevent potential issues associated with sedimentation and the presence of suspended particles. Turbidity in drinking water can have several health implications. High turbidity levels can hinder the effectiveness of chlorine disinfection by shielding bacteria and other organisms. Certain organisms found in highly turbid water can induce symptoms such as nausea, cramps, and headaches. Additionally, an increased turbidity level in drinking water raises the risk of gastrointestinal diseases. This poses a particular concern for immunocompromised individuals, as contaminants like viruses and bacteria can attach to suspended solids, leading to adverse health effects. While turbidity itself does not directly pose a hazard to human health, it serves as an indicator of poor water quality and can mask the presence of parasites like Cryptosporidium (Stevenson and Bravo, 2019).

Numerous studies have shown that the consumption of highly turbid water can result in acute gastrointestinal illness (AGI). Turbidity can also create a protective barrier for microbacteria during disinfection processes, and high turbidity levels may contribute to the regrowth of pathogens within distribution systems, potentially causing waterborne disease outbreaks. It is important to note that while turbidity is linked to adverse health outcomes, studies often measure exposure at the population level, which can introduce bias due to the ecological

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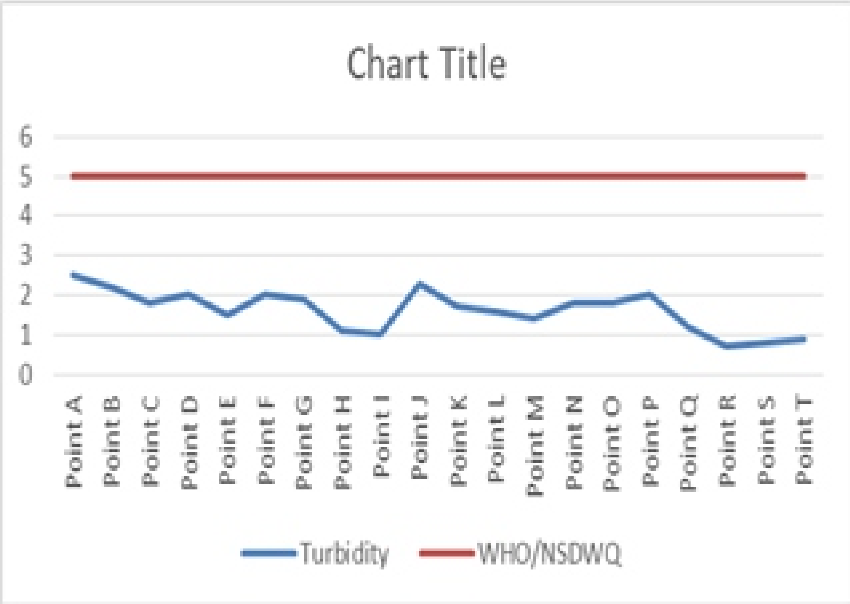
"fallacy" (De Roos *et al.,* 2017; Hsieh, 2015). The analysis of turbidity levels in the groundwater samples underscores the importance of maintaining low turbidity to ensure water quality and prevent potential health risks. Continued monitoring and assessment of turbidity are crucial for ensuring the clarity and safety of drinking water sources.

Spatial Variation of Turbidity



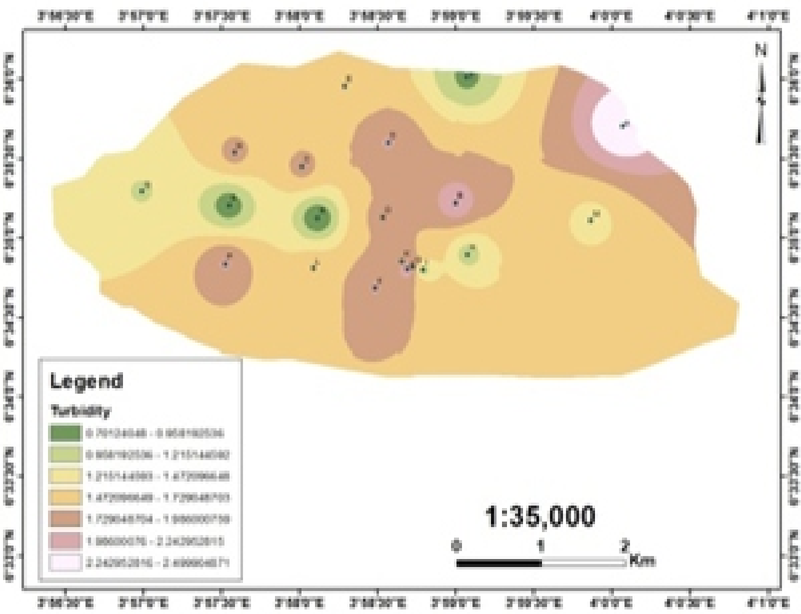


Figure 14 & 15: Chart and map showing Turbidity distribution in the study area
Source: Author (2023)

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Implication and conclusion

The analysis of physicochemical parameters in the study area's underground water provides crucial insights into its quality. This examination revealed both the general freshness of the water and potential risks associated with elevated total dissolved solids (TDS) and dissolved oxygen (DO) levels. It is imperative to emphasize the significance of monitoring these parameters, as demonstrated by studies using IoT technology and low-cost, portable methods by Abdulwahid (2020), Moparthi (2018), and Tuna (2013).

Neglecting water quality monitoring, especially in developing countries and during natural disasters (Jain, 2013), poses significant risks, including the spread of waterborne diseases and adverse effects on agriculture, public health, and the ecosystem (Abbaspour, 2011). Considering these findings, aligning with SDG 6 on clean water and sanitation is crucial, emphasising the importance of accessible and safe water sources. Risks of groundwater contamination from untreated household wastewater necessitate regular septic system inspections, supporting SDG 3 (Good Health and Well-being) through universal access to safe drinking water.

The presence of high sodium levels, particularly for infants, underscores the interconnectedness of water quality with public health. Sustainable water sources demand a comprehensive approach involving monitoring, legislation, and consumer awareness. Challenges persist globally, as evidenced by the need for standardized approaches to managing public drinking water systems in developed countries. This calls for infrastructure investments, educational initiatives, and promoting women's access to formal jobs (Antunes & Martins, 2020).

Ensuring water quality aligns with health standards is crucial, with a focus on ongoing research and technological development to address pollution, especially in groundwater. The World Health Organization's Guidelines for Drinking Water Quality play a pivotal role, but challenges persist, as seen in Beirut, Lebanon (Korfali, 2009; Howard, 2003). In this context, SDG 7 (Affordable and Clean Energy) gains relevance, urging consideration of sustainable energy solutions for water purification (Li *et al*., 2022).

Supporting household water treatment, secure storage initiatives, and advocating for safe rainwater harvesting is imperative for enhancing drinking water quality and reducing waterborne diseases. These measures need implementation in communities, schools, and healthcare facilities to achieve a comprehensive and effective approach to water quality management.

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