

**GEOSPATIAL DISTRIBUTION OF POTENTIALLY GROUNDWATER POLLUTANTS
IN SHALLOW AQUIFEROUS ZONES IN EBIRA CAMP, AKOKO EDO LOCAL
GOVERNMENT EDO STATE, NIGERIA.**

BY

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UNIVERSITY OF BENIN,

BENIN CITY

MAY, 2023

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**A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF SCIENCE
LABORATORY TECHNOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF
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MAY,2023

CERTIFICATION

This is to certify that this project work described in this work was carried out by **EZEH Evangeline Amarachi** with Matriculation number **LSC1807219** in the Department of Science Laboratory Technology, Faculty of Life Sciences, University of Benin, Benin-City, Edo State, Nigeria.

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EXTERNAL EXAMINER

DATE

DEDICATION

This project work is dedicated to God Almighty for his faithfulness, mercies and support towards the completion of this research.

ACKNOWLEDGEMENTS

First of all, I want to express my sincere thankfulness to God Almighty for using his might and discernment to make this job successful. I genuinely appreciate my boss, Mr Ken OJEAGA who painstakingly reviewed and corrected each level of my work. His kindness and advice helped me avoid several mistakes and improved the way my work was presented. My regards to my HOD, Prof. E.O. Oshomoh. My lecturers; Mr P. Bassey, Mrs Janet A. and Mr James O. for their moral support in making this work a success.

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ABSTRACT

Heavy metal content was determined by analyzing water samples taken from Ebira camp, Akoko Edo Local Government, Edo state. In all, ten samples were taken at ten distinct Ebira camp sampling sites. With the aid of the Atomic Absorption Spectrometer (AAS), the samples were examined and tested for five distinct heavy metals: iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), and nickel (Ni). The average concentrations of these heavy metals are 1.0384, 0.5362, 0.2975, 0.0376, and 0.0244 mg/l for Fe, Zn, Cu, Mn, and Ni, respectively. The acquired results were compared to the 2011 WHO standard, which corresponds to Fe, Zn, Cu, Mn, and Ni values of 0.3, 1.0, 2.0, 0.1, and 0.1, respectively. With the exception of iron, which has a mean iron content higher than the WHO guideline, the results indicated that the concentration of heavy metals in the area was generally lower than levels permitted by the WHO. The possibility exists that an excessive amount of iron in the groundwater could promote the growth of bacteria responsible for the foul smell. Geospatial analysis of the gathered data was done using geographic information system (GIS) software. Maps showing pollution concentrations and patterns of spatial distribution were produced using spatial interpolation techniques (kriging or inverse distance weighting). According to the heavy metals' spatial distribution map, manganese (Mn) levels varied greatly throughout the region, with the eastern and northeastern regions exhibiting the highest values. According to the nickel concentration map, the region's southwest is where the concentration of nickel increases most unevenly. The zinc content of the water rose non-uniformly from the community center to the boundary, according to the spatial distribution map of zinc. The spatial distribution map of copper reveals that the amount of copper in groundwater rose unevenly from the region's center to its borders, with the community's center having the lowest level of copper and the region's northeastern regions having the highest copper value. The spatial distribution map of iron indicates that there was also a non-uniform increase in the iron content of the water. Anthropogenic factors, such as factories or industries, agricultural practices, or geogenic processes, such as variations in the composition of the underlying rock or soil, are to blame for the irregularities in the geographical distribution maps. It may also be connected to the metallic ion concentration and volume at each site. The groundwater in the study area, is generally less contaminated by heavy metal pollution, with little to no contamination index.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Nigeria's economic and social development depends on groundwater, a crucial water resource. Since 60% of Nigeria's population depends on groundwater for drinking water, groundwater resources are crucial strategic resources for promoting sustainable development. In fact, groundwater supplies make up approximately 80% of the nation's overall water supply. In order to sustain metabolic processes and serve residential and agricultural needs, groundwater is essential to human existence.

Inappropriate development and use of land can lead to the discharge of pollutants via geochemical processes, thereby impairing the quality of groundwater. Both natural and man-made (anthropogenic) sources may be the source of these pollutants (Jehan et al., 2019). Anthropogenic sources, such as groundwater withdrawal, fertilizer leaching, industrial wastewater, and unintentional spills, all have an impact on groundwater quality. Natural sources include recharge and discharge positions, precipitation or dissolution of aquifer materials, oxidation, reduction, residence and mixing time, water source, and type of rock and mineral.

According to Adrian *et al.* (2020), geochemical transformation in the urban environment includes changing the distribution of pollutants, changing the volume of surface storm water runoff, changing the physicochemical characteristics of groundwater, and changing the mineral and elemental composition. Anthropogenic activities related to mining, agricultural, and industrial operations have resulted in a rise in heavy metal contamination in the environment in recent times (Aminiya *et al.*, 2022). One major anthropogenic activity that endangers groundwater is rock

quarrying. This is because of the intricate relationships between hydrologic systems, changes in flora, land use, and effluents released by mining wastes. The weathering of geogenic pollutants during mining operations can lead to the leaching of contaminants into groundwater. Furthermore, organic and inorganic pollutants in the soil may be transported to the intruding recharge water during the hydrologic cycle when water passes through the soil (Eyankware, 2019).

1.2 THE AIM AND OBJECTIVE

The aim of this study is to assess the extent of heavy metals contamination in groundwater in mining area, Auchi, Benin city, Edo State.

The specific objectives are to;

- 1) determine the concentration of potentially toxic metals in groundwater samples
- 2) determine the spatial distribution of potentially toxic metals in groundwater obtained from the study area.

1.3 STATEMENT OF PROBLEM

Unregulated mining and quarrying activities are common in modern-day Nigeria; this is partly due to the regulatory bodies' lax oversight and their burden of enforcing strict adherence to established norms.

Many security concerns have been raised by the unapproved mining extraction that has occurred in several regions of the nation. This is because a number of people, including foreign nationals, have either died or been abducted from mining sites. Due to the lack of oversight or regulation, these illicit activities have resulted in a number of environmental risks, such as soil contamination, groundwater pollution, and subsidence.

Acid mine drainage may result from the potential interaction of mine wastes with recharge water that seeps through under the right circumstances. Acid mine drainage, an acidic solution with high metal concentrations, can deteriorate the quality of the water in quarry sites, depriving locals of portable drinking water.

1.4 JUSTIFICATION OF STUDY

The research area's abundant mineral resources have drawn investors over the years. Nwachukwu *et al.* (2019) have documented that mining operations have resulted in elevated traffic conditions, amplified surface runoff, and substantial accumulations of quarry wastes within the studied area. The impact of mining on groundwater has been the subject of numerous research (Ikpeshi Nwachukwu *et al.*, 2019, Idris *et al.*, 2014). Numerous researches have focused heavily on determining the pollution levels in groundwater in mining sites and contrasting them with acceptable limits.

Therefore, determining and projecting the hazards associated with consuming groundwater rich with heavy metals in the research area will be made easier by looking at the spatial distribution of heavy metals in groundwater.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 WATER

Water, represented by the chemical formula H_2O is made up of molecules with one oxygen atom and two hydrogen atoms bound together by covalent bonds. This inorganic compound exhibits polarity and is a liquid at normal temperature. Both flavor and odor are absent from water. It is almost colorless, yet it may have a slight blue tint (Saeid et al., 2018). Life as we know it requires water. Only 0.3% of the world's water resources are thought to be suitable for human use, according to Kiliç (2020).

It is the most abundant molecule on Earth, constituting approximately 70 % of the Earth's surface. It is unique in that it can exist in its natural state as a solid, liquid, or gas. This distinguishes it from other materials that exist on Earth (Pennington, 2021). The oceans contain about 97.25% of all the water on Earth's surface. About 2.05% of the world's water is found in the polar ice caps and glaciers, with the remainder being found in freshwater lakes, rivers, and groundwater sources. Zumdahl (2019).

It is unique in that it can exist in its natural state as a solid, liquid, or gas. This distinguishes it from other materials that exist on Earth (Pennington, 2021). The oceans contain about 97.25% of all the water on Earth's surface. About 2.05% of the world's water is found in the polar ice caps and glaciers, with the remainder being found in freshwater lakes, rivers, and groundwater sources. Zumdahl (2019). On Earth's surface, water is liquid under typical circumstances. Because it allows water to be used for enjoyment, transportation, and as an essential habitat for a variety of plants and animals, this feature is extremely significant.

Water is also able to be moved through the atmosphere due to its ease of evaporation and gas transformation. Water from the oceans is more easily transported inland thanks to this mechanism, where it condenses and falls as rain, giving vital support to the many plant and animal habitats (Cammarata *et al.*, 2001). Having access to clean, safe drinking water is essential for both preserving health and advancing socioeconomic progress.

The primary source of drinking water for the local Nigerian populace is borehole water. Only a small percentage of people may depend on bottled water that has been treated and purified for their consumption needs due to limited access and affordability (Getso *et al.*, 2018). Agbaire and Obi (2010) state that the use of borehole water is a workable way to alleviate water scarcity in many dry and semi-arid parts of Africa. This strategy is especially important in regions with seasonal or sporadic rainfall patterns and significant restrictions on surface water availability.

Water body contamination, especially in the case of underground waterways like boreholes, has become a serious environmental concern. Boreholes can get contaminated for a number of reasons, such as materials that may end up in the well during construction, drilling fluids, chemical casings, and other causes. Given that these pollutants have the potential to contaminate water, it is crucial to use appropriate building and maintenance techniques to protect water quality (Getso *et al.*, 2018).

Naturally occurring concentrations of metals and other chemicals have the potential to be hazardous to human health even in the absence of sources of anthropogenic pollution. It is essential to analyze the physical and chemical characteristics of natural water sources, including the presence of trace elements, while undertaking research on public health. This approach facilitates the evaluation of possible health risks related to natural water sources and allows for well-informed choices about water use and treatment methods (Egwari and Aboaba, 2002). The physical,

chemical, and biological characteristics of a given location or source are evaluated in order to determine the water quality assessment. The health of people may be at risk if these parameters' values rise above established thresholds.

To make sure that water stays within reasonable bounds and is safe for consumption and other applications, it is imperative to monitor and control these parameters (Cotruvo, 2017). Thus, the use of water has demonstrated that certain water sources are suitable for human consumption.

2.2. Sources of Ground Water Contamination

There are many different ways that human activity or natural sources can contaminate ground water. Ground water quality can be impacted by commercial, industrial, residential, and municipal activity. Ground water can be contaminated by activities that occur on the surface of the land, like spills or releases from industrial waste that has been stored; by sources below the surface but above the water table, like leaking underground petroleum storage systems or septic systems; by structures below the water table, like wells; or by contaminated recharge water (Chukwu, 2008).

2.2.1. Natural Sources

Ground water may dissolve some naturally occurring materials present in rocks or soils, such as iron, manganese, arsenic, chlorides, fluorides, sulfates, or radionuclides (Ahmad *et al.*, 2020). Particles of other naturally existing materials, such as decomposing organic debris, can travel through ground water. Depending on the circumstances in the area, none of these compounds may be found in ground water. When ingested in excess, certain compounds might be harmful to your health; other substances can give off an unwanted taste, odor, or color. If the concentrations of these compounds in ground water are too high, it should be treated before using it for drinking or other household purposes.

2.2.2. Septic Systems

The effluent (outflow) from rivers and septic tanks is one of the primary sources of ground water contamination in the United States. To get rid of their human waste, over 25% of American homes have septic systems installed. Despite the fact that each system alone only releases a little amount of trash into the earth, these systems are a significant source of contamination due to their widespread use and enormous number. Inadequate septic system placement, design, construction, or upkeep can introduce bacteria, viruses, nitrates, detergents, oils, and chemicals into ground water. Commercially available septic system cleaners that contain synthetic organic compounds (such 1,1,1-trichloroethane or methylene chloride) are also contaminated with these substances. These cleansers have the potential to damage septic systems' natural decomposition processes and contaminate water supply wells. The majority of state and local laws, if not all of them, stipulate the precise distance that must exist between drinking water wells and septic systems. Furthermore, computer models for determining appropriate densities and distances have been created.

2.2.3. Improper Disposal of Hazardous Waste

It is imperative that hazardous waste is disposed of appropriately, either by a certified hazardous waste handler or during designated municipal hazardous waste collection days. Numerous chemicals, including as oils (from cooking and motor vehicles), paints and paint thinners, paints, disinfectants, medications, chemicals used in photography, and chemicals used in swimming pools, should not be disposed of in residential septic systems. Similar to this, a lot of materials used in industrial processes shouldn't be disposed of in workplace drains since they may contaminate a supply of drinking water. Employers must provide workers with training on how to safely handle and dispose of any chemicals used on the job. The proper disposal of wastes is

especially crucial for ground water preservation because of the wide variety and significant volumes of chemicals utilized at industrial locations (Adeyomo).

(Adeyomo *et al.*, 2002).

2.2.4. Releases and Spills from Stored

Petroleum Products and Chemicals Petroleum products and other chemicals are frequently kept in aboveground and subterranean storage tanks. For instance, subterranean oil tanks are used for heating in many houses. In addition, a lot of companies and local transportation agencies keep chemicals, fuel oil, diesel fuel, and gasoline in tanks on their premises. Storage tanks are used by industries to keep chemicals for use in their operations or to hold hazardous waste until a licensed hauler can pick it up.

There are around 4 million underground storage tanks in the US, and many of them have leaked and spilled their contents into the environment throughout time. An underground storage tank's contents may seep through the ground and into ground water if it leaks, which happens frequently as the tank ages and corrodes (Hansen *et al.*, 2017). Although they are less prone to malfunction, tanks that satisfy state and federal requirements for new and improved systems are not infallible. Another issue with abandoned subterranean tanks is that it's frequently difficult to find where they are. In addition, if sufficient barriers are not in place and a spill or leak happens, above-ground storage tanks may endanger groundwater.

Ground water can be seriously threatened by careless material handling, inadequate chemical storage, and subpar containers. Another risk associated with chemical storage are tanker trucks and train wagons. Approximately 16,000 chemical leaks happen annually from storage tanks, railroads, and trucks, frequently during the transfer of commodities. Ground water contamination

is more likely to occur at the scene of an unintentional spill because the chemicals are frequently diluted with water and then washed into the soil.

2.2.4. Landfills

Thousands of municipal and industrial landfills across the nation are used to dispose of solid waste. Municipal landfills occasionally contain chemicals that have to be disposed of at hazardous waste landfills. Furthermore, many domestic trash are not controlled when it comes to disposal. Chemicals may get into the ground water through surface runoff and precipitation once they are in the landfill. To preserve ground water, leachate (liquid from a landfill containing toxins) collecting systems and clay or synthetic liners are necessary for new landfills (Adeyomo *et al.*, 2002). However, the majority of older landfills lack these protections.

The likelihood of leachate contaminating ground water was increased by the fact that older landfills were frequently located near surface waters, over aquifers, and in permeable soils with shallow water tables. If closed landfills are not covered with an impermeable substance (like clay) before closure to stop pollutants from leaking through precipitation, they may still be a risk for ground water contamination.

2.3. GROUNDWATER QUALITY

The term "groundwater quality" describes the total physical, chemical, and biological aspects of groundwater. Water quality is influenced by various physical characteristics, such as temperature, turbidity, color, taste, and odor. Although groundwater is frequently tasteless, odorless, and colorless, its chemical and biological properties are more important to assess because of their possible influence on the safety of the water and its suitability for different uses (Harter, 2003).

Water body contamination has grown to be a serious environmental issue. After decades of waste and pollution, clean water is a rare and precious resource that humanity has only recently begun to recognize (Slberberg and Amateis, 2021). The main cause of pollution in rivers, streams, and subsurface water sources is anthropogenic activity. The main causes of these activities are people's inadequate and unclean lifestyles as well as the unsustainable business methods of factories, companies, and corporations.

As a result, these sources discharge wastewater and untreated waste, making the issue of water contamination worse (Akpoveta *et al.*, 2010). Over 25% of the world's population, according to Hill (2004), depends on groundwater for other basic necessities like drinking water. Groundwater is typically extracted using pipes to drill boreholes or well water, which requires open surface drilling. Since it is thought to be among the purest forms of water found in nature, it is a dependable source for semi-rural and rural areas' water needs.

2.4. PHYSIOCHEMICAL PARAMETERS OF WATER

2.4.1. POTASSIUM

Although potassium is an essential component for human health, it is typically not found in drinking water in quantities that pose a risk to public health. It naturally exists in the environment, particularly in untreated natural water sources. Potassium permanganate, an oxidant used in water treatment procedures, occasionally results in potassium being present in drinking water. However, for healthy people, drinking water potassium levels are usually not a reason for concern (Meride and Ayenew, 2016).

2.4.2. SALINITY

Salinity is defined by Li et al. (2020) as the total dissolved solids (TDS) content of groundwater expressed as milligrams per liter (mg/L). Salinization of freshwater resources poses a major risk to the quality of the water and may have detrimental effects on ecosystem services, food security, biodiversity, and water use. Although salinity monitoring is more common than other water quality indicators, no worldwide databases for surface water and groundwater have been thoroughly compiled and harmonized as of yet (Thorslund and van Vliet, 2020).

High concentrations of several elements, including salt, sulfate, boron, fluoride, selenium, arsenic, and increased radioactivity, are frequently linked to elevated groundwater salinity. Although salinity is a problem everywhere, it gets worse in dry and semi-arid areas with little water supplies, where groundwater is the main supply of water. Depletion of water tables and subsequent rise in salt levels are caused by the growing demand for groundwater (Krishan, 2019).

Three types of salinity can be found in groundwater: dry land or secondary salinity, which is brought to the surface by rising water levels or vegetation clearing that causes salt to accumulate in soil and groundwater; natural or primary salinity, which is caused by the dissolution of minerals from bedrock or salts accumulated over a long period of time.

2.4.3. CALCIUM

The human body has a lot of calcium, which is essential for healthy growth and general wellbeing. A sufficient calcium intake is necessary for overall health. The recommended daily allowance of calcium is two to three grams, with dairy products being the main source. It's interesting to note that some research indicates a decreased incidence of heart disease in regions with high drinking water hardness, primarily from the presence of calcium.

As a result, calcium in the water supply may be advantageous to human health (Suleiman et al. 2020). Prostate and colorectal cancer, kidney, miscarriage, birth defects, menstrual and premenstrual complications, bone and joint disorders, periodontal disorders, muscle spasms and cramps, sleep disorders, and psychological health are just a few of the health issues that can be linked to severe calcium deficiency.

2.4.4. pH

The pH scale, which measures the acidity or alkalinity of water, is an essential component of water quality. A pH reading of less than 7.0 denotes acidity, and a pH reading of more than 7.0 denotes alkalinity. Alkaline water helps disinfect water, while acidic water can corrode plumbing fixtures and metal pipelines. When evaluating the quality of water and making sure that water infrastructure is operating properly, pH is an important factor to consider (Rahmanian *et al.*, 2015). The pH scale is logarithmic, not linear, and usually extends from 0 to 14. Accordingly, an increase or decrease in acidity or alkalinity of ten times is represented by every unit change in pH.

A solution with a pH of 6 is ten times more acidic than one with a pH of 7, for example. The pH of pure water is 7, which is regarded as neutral. When determining the relative acidity or alkalinity of various solutions, it is essential to comprehend the logarithmic character of the pH scale (Gorde and Jadhav, 2013). In addition to having a big impact on how water tastes, pH levels can reveal possible corrosion problems brought on by metals like copper, zinc, and cadmium dissolving in the water. Low pH (acidic) water can taste sour or metallic and leach metals out of plumbing systems, which can cause corrosion issues.

Both the integrity of the water distribution system and the taste quality of the water must be guaranteed by keeping an acceptable pH level in the water under regular observation (Duru *et al.*, 2019).

2.4.5. Temperature

The geothermal gradient of the surrounding area and the surface temperature both have an impact on the temperature of groundwater, which varies with depth. The average temperature of groundwater in the upper reaches of aquifers is usually between 10 and 11°C. Groundwater's natural or baseline quality, which is its intrinsic quality, varies a great deal. According to Bloomfield *et al.* (2013), this variance is explained by the chemical makeup of the recharge water as well as the geochemical properties of the rocks and soils that the groundwater passes through and is stored in.

Significant alterations in water quality and ecological patterns occur in highly contaminated aquifers located in urban and intensively used areas, especially when temperatures rise beyond 30 degrees Celsius. Anaerobic redox reactions, oxygen depletion, and heat-induced mobilization of organic matter and pollutants (like arsenic) result in the formation of greenhouse gases (like methane and carbon dioxide) and hazardous byproducts (like hydrogen sulfide). Aquifer microbial biodiversity is significantly decreased by temperature changes, which also encourage atypical thermophilic communities (Griebler *et al.*, 2016).

Warm temperatures have the potential to accelerate the deterioration of organic contaminants in groundwater. Ni *et al.* (2015) discovered that reductive dichlorination proceeded more quickly when in-situ temperatures were raised from 10 to 25°C. In addition to influencing aquifer temperatures, global warming will also have an effect on the biogeochemical cycles in the soils

above them. Any temperature-related changes in the chemistry of soil water are anticipated to eventually show up in the composition of groundwater since recharge links soil water with groundwater (Riedel, 2019).

2.4.6. Turbidity

A liquid's degree of transparency or clarity is referred to as its turbidity. According to Riedel (2019), it is frequently employed as a surrogate indicator of the existence of suspended silt. Additionally, it is linked to the existence of pathogens in water, which can enter through soil runoff (Rahmanian *et al.*, 2015). Five nephelometric turbidity units (NTU) is the standard recommended maximum turbidity limit for drinking water, as determined by WHO and NDWOS (Ministry of Health Malaysia, 2004; WHO, 2011). The probability of microbiological contamination in water can rise with higher turbidity values (Agrawal, 2010).

Numerous elements, such as the presence of suspended and dissolved solids, the size, shape, and composition of the particles, can affect the turbidity of water. Water quality metrics include total suspended solids, volatile suspended solids, total dissolved solids, suspended sediment concentration, and particle size analysis can be useful in characterizing turbidity (Peterson and Gunderson, 2008).

Retaining low turbidity levels in drinking water is a proven sign of successful pathogen elimination, which in turn guarantees the water's safety. Many disease outbreaks have been connected to cases of increased turbidity (Mann *et al.*, 207). In addition to being unsightly, drinking water with high turbidity or cloudiness can be harmful to your health. Pathogens benefit from the favorable conditions created by elevated turbidity, which give them food and shelter.

Turbidity can encourage the regeneration of germs in the water distribution system if it is not properly eliminated, which can result in gastroenteritis and other waterborne illnesses.

While turbidity itself is not a direct sign of health hazards, multiple studies have demonstrated a substantial association between the removal of turbidity and the elimination of protozoa. The presence of turbidity particles affords protection to germs, limiting their vulnerability to disinfectants.

2.4.7. Iron (Fe):

Natural water sources frequently contain iron, which is a common element that is released when iron-containing minerals in rocks and soil dissolve. The World Health Organization has set a tolerable level of 0.3 mg/L (milligrams per liter) or 0.3 parts per million (ppm) for iron in drinking water. Elevated levels of iron in drinking water can result in taste disturbances, discoloration of clothing and plumbing materials, and in extreme situations, health complications such digestive disorders (Kantor, 2006).

2.4.8. Copper (Cu)

Although humans need copper, taking too much of it can be harmful, especially for those with Wilson's disease or other disorders that affect the body's ability to metabolize copper. Copper can find its way into water sources through natural deposits in specific geological formations or corrosion of copper plumbing components. The WHO recommends 2 mg/L of copper in drinking water. Consuming too much copper can irritate the stomach and intestines, and prolonged exposure to elevated levels might harm the kidneys or liver.

2.4.9. Lead (Pb):

Lead exposure is still a major public health risk, particularly in older cities with lead plumbing fixtures and pipes (Chukwu, 2008). Old lead pipes, solder, or plumbing fixtures are typically the source of lead pollution in water, especially in older buildings. According to WHO recommendations, the maximum amount of lead in drinking water is 10 µg/L (micrograms per liter), or 0.01 mg/L. Even modest levels of lead exposure can affect a child's brain development and produce problems for an adult's kidneys and cardiovascular system.

2.4.10. Chromium (Cr):

Hexavalent chromium (Cr(VI)), which is poisonous and carcinogenic, and trivalent chromium (Cr(III)), which is necessary for human health, are the two primary forms of chromium. For drinking water, the WHO recommends a total chromium level of 50 µg/L, which includes both Cr(III) and Cr(VI). According to Bloomfield *et al.* (2013), drinking water containing high amounts of hexavalent chromium has been associated with an elevated risk of cancer and other illnesses.

2.4.11. Magnesium (Mg):

The element magnesium is necessary for human health and is frequently found in natural water sources. Magnesium in drinking water is not regulated by any specific WHO guidelines because it is generally regarded as healthy. Though this is uncommon in most drinking water sources, too high magnesium concentrations in water may have a laxative effect on some people (Ogwuegbu and Ijioma, 2003).

2.4.12. Cadmium (Cd):

Mining operations, the usage of fertilizers containing cadmium, and industrial discharge can all lead to cadmium poisoning of water supplies. According to WHO recommendations, drinking water should not contain more than 3 µg/L of cadmium. Even at low concentrations, long-term cadmium exposure can cause kidney damage, bone disorders, and possibly even cancer (Getso *et al.*, 2018). The implementation of industrial emissions restrictions, the promotion of sustainable farming techniques to decrease cadmium in food crops, and the encouragement of smoking cessation programs are some of the strategies being used to reduce cadmium exposure.

2.4.13. Zinc (Zn)

Mining operations, the usage of fertilizers containing cadmium, and industrial discharge can all lead to cadmium poisoning of water supplies. According to WHO recommendations, drinking water should not contain more than 3 µg/L of cadmium. Even at low concentrations, long-term cadmium exposure can cause kidney damage, bone disorders, and possibly even cancer (Getso *et al.*, 2018). The implementation of industrial emissions restrictions, the promotion of sustainable farming techniques to decrease cadmium in food crops, and the encouragement of smoking cessation programs are some of the strategies being used to reduce cadmium exposure.

2.4.14. Mercury

Mercury is recognized to be harmful, but it is unknown how it affects human biochemistry and physiology. Inorganic forms of mercury cause spontaneous miscarriage, gastrointestinal disorders (e.g., corrosive esophagitis and hematochezia), and congenital abnormalities. Erethism, or abnormal irritation or sensitivity of an organ or body part to stimulation, acrodynia (Pink disease,

characterized by rash and desquamation of the hands and feet), gingivitis, stomatitis, neurological disorders, complete damage to the brain and central nervous system, and congenital malformation are all symptoms of organic mercury poisoning (Ferner, 2001; Lennetech, 2004).

2.5. SUMMARY OF PREVIOUS WORK DONE

Using pollution and contamination models, Duru *et al.* (2019) evaluated the quality of borehole water at Orji Mechanical Village, Owerri. The results showed that the pH of the water samples was acidic (6.5–8.5), falling below the standard set by the Standard Organization of Nigeria (SON). Other physio-chemical parameters analyzed included color, pH, electrical conductivity, total dissolved solids (TDS), alkalinity, nitrate, nitrite, phosphate, sulfate, chlorine, and concentrations of heavy metals like nickel, lead, cadmium, chromium, silver, manganese, zinc, copper, and iron.

At the majority of the sampling sites, nitrates, nitrites, and phosphates exhibit contamination factors ranging from significant to extremely high levels. Additional research showed that some parameters had a positive link with one another. pH/PO, pH/Fe, NO₃ /Cd, NO₃ /Co, PO₄ /Fe, Cl /Mn, Cl /Co, Cr/Fe, and Ag/Fe all showed positive associations.

Nonetheless, none of the sampling sites show any contamination, according to the pollutant load indices (PLI). The area's borehole water has an overall Water Quality Index (WQI) of 153.53, which indicates the presence of water pollutants. It highlights the necessity of better cleanliness habits and ongoing community hygiene education.

The effects of temperature and the need of keeping an eye on important water quality metrics were examined by Kale (2016). The influence of several physicochemical factors on water quality, including temperature, turbidity, pH, and dissolved oxygen, are covered. In order to ensure that

water is safe to drink and suitable for all living things, the report emphasizes that regular monitoring is necessary.

Standards set by agencies like the World Health Organization (WHO) are used as a guide when assessing drinking water quality. The author emphasizes how important it is to evaluate factors like color, hardness, sulfate, chloride, and heavy metals like Pb, Cr, Fe, and Hg because they can be extremely dangerous for both human health and aquatic life. Temperature, turbidity, pH, and dissolved oxygen are the four main water quality metrics that are the subject of this study.

The author describes how temperature affects biological activity, how it affects chemical reactions, and how minerals dissolve. Additionally, the effects of turbidity on light penetration, microorganism proliferation, and water clarity are covered. The significance of pH in water is also discussed in the study, with particular attention paid to how it affects consumer taste preferences, corrosion rates, and coagulation.

The final section examines how dissolved oxygen varies with temperature and how it supports aquatic life. Water quality can be efficiently controlled to protect people and the environment by following set rules and being aware of the repercussions of going outside of these bounds. In summary, the study provides a thorough analysis of the significance of water quality metrics and their implications, offering insightful knowledge to scholars, decision-makers, and interested parties in the fields of public health and water resource management.

In Wudil Local Government Area, Kano, three wards' worth of borehole water quality was evaluated by Getso *et al.* (2018). The study's goal was to evaluate and analyze the water quality for residential use from three boreholes in Wudil Local Government. The three areas in Wudil metropolis where the researchers gathered water samples were KUST Wudil, Unguwar Danya,

and Unguwar Fulani. For five weeks, samples were taken once a week, and in the lab, numerous water quality-related factors were examined.

The study's test parameters included temperature, conductivity, hardness, total dissolved solids (TDS), turbidity, pH, dissolved oxygen (DO), five-day biochemical oxygen demand (BOD5), nitrate ion (NO₃), and hardness. The findings revealed notable variations in the water quality throughout the various wards. The results of a one-way analysis of variance (ANOVA) showed that there were notable variations in the physicochemical characteristics between the various sites. The study's conclusions showed that, albeit not significantly, there were differences in the water quality indices during the several sampling periods.

The ranges for the temperature, pH, DO, and BOD5 were 27°C to 30.3°C, 6.0 to 6.3 mg/L, 3.0 to 3.6 mg/L, and 1.1 to 1.9 mg/L, respectively. The TDS ranged from 586.4 to 589 mg/L, and the electrical conductivity varied from 1176 to 1178.3 µs/cm. There was a range of 9.6 to 11.4 NTU for turbidity, 601 to 601.5 mg/L for hardness, and 68.3 to 71.3 mg/L for nitrate. The KUST borehole had the highest temperature and the Unguwar Fulani borehole had the highest DO concentration when the water quality characteristics from the various test sites were compared.

CHAPTER THREE

MATERIALS AND METHODS

3.1 DESCRIPTION OF THE STUDY AREA

Latitude 07° 08' 22''N to 07° 10' 00''E and Longitude 06° 14' 18''E to 06° 161' 00'' E define the study region. It is a polycyclic component of Nigeria's Southwestern Precambrian Basement Complex. It is located at Ebira Camp Akoko Edo Local Government Edo State Nigeria. The Area has both basement and sedimentary rocks. The Lokoja-Basange Formation's Cretaceous sandstone is linked to the sedimentary rocks (Rahaman, 1989). The African crystalline shield that makes up Nigeria's Basement Complex rocks is a portion of the Pan-African mobile belt, which is situated south of the Tuareg shield—affected by the Pan-African Orogeny—between the Congo and West African crusts.

Granite in the area represents the youngest group of rocks of Precambrian age in the southwestern Nigeria Basement complex. The majority of the activity in the Syn-to-late tectonic granites occurred during the last stages of the Pan-African orogeny. Massive ridges and broken boulders are the features of Iyuku granite (Olaorun and Akintola, 2018).

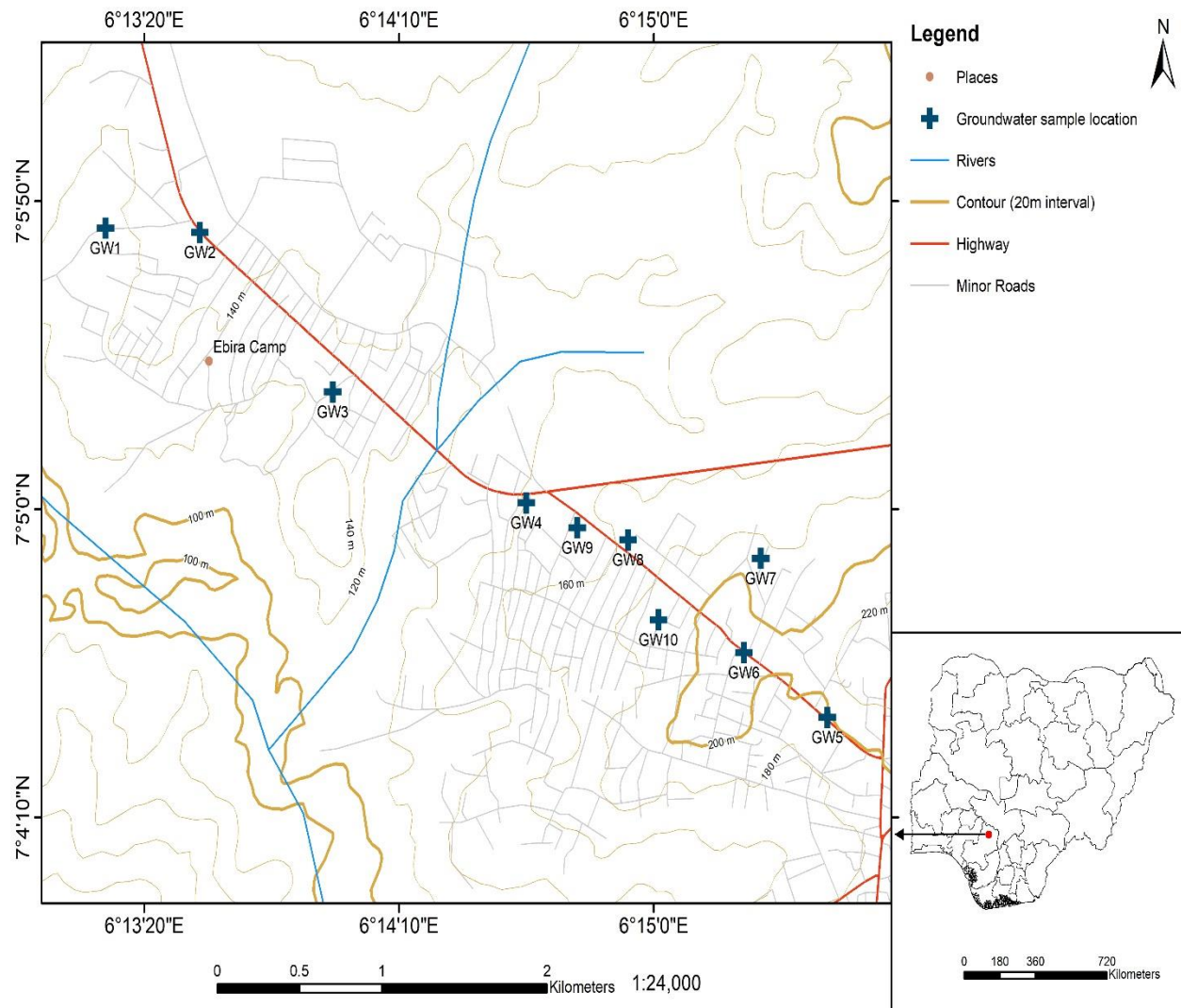


Figure 3.1: Sample map showing the different sampling locations; G1-G10

3.2. Materials and Software Used

A. The following instruments and tools were utilized in the research:

- Water samplers and sample containers
- Laboratory equipment for chemical analysis
- GIS software for geospatial analysis and mapping

B. Hardware Laptop for GIS operations Global Positioning System (portable GPS) for field verification of features on the imageries.

- Software

These softwares would be used for underground water potential zones in the study area:

- i. ArcGIS 10.1 for digitizing and Groundwater analysis.
- ii. iii. PCI Geomatica v10.0 for lineament extraction.
- iii. iv. Microsoft Excel graphical representation of charts.

3.3. Reconnaissance Survey

A preliminary survey was conducted to acquaint the researcher with the study region. During this process, authorization to enter the study area was secured from the head of the wards inside the study area.

3.4. Sampling Design

The study area's sampling sites were chosen using a stratified random sampling technique. Land use patterns, possible sources of pollution, and hydrogeological factors were used to determine the strata. Sampling locations were randomly chosen within each stratum to guarantee representative coverage of the research region.

3.5. Data Collection

Measurements of groundwater parameters and the gathering of water samples for laboratory analysis were part of the field data collection process. Using portable multiparameter probes,

groundwater parameters including pH, temperature, electrical conductivity, and dissolved oxygen were assessed on-site. Using accepted sampling methods, ten groundwater samples were taken and stored in accordance with guidelines.

3.6. Laboratory Analysis

To ascertain the amounts of possible groundwater pollutants, ten (10) groundwater samples were examined in a laboratory. The quantity of hazardous metals (Fe, Cu, Zn, Mn, and Ni) in ten (10) groundwater samples was measured in a lab setting using atomic absorption spectrophotometry (AOAC, 1990).

3.7. Geospatial Analysis

Geospatial analysis of the gathered data was carried out using Geographic Information System (GIS) software. Maps of pollution concentrations and patterns of spatial distribution were produced using spatial interpolation techniques like kriging and inverse distance weighting. The link between pollutant sources, hydrogeological parameters, and groundwater quality was evaluated using modeling tools based on geographic information systems.

CHAPTER FOUR

4.0 PRESENTATION OF RESULTS

4.1 PHYSICOCHEMICAL PARAMETERS

The results of heavy metals analyzed in groundwater samples obtained from the study area is presented in Table 4.1. From Table 4.1 it was observed that Fe ranged from 0.293 mg/l to 2.344 mg/l across sampling points and a mean of 1.038mg/l. Zn ranged from 0.182 to 0.952 mg/l with a mean of 0.5362. Cu ranged 0.122 mg/l to 0.587mg/l. Mn ranged from 0.013 to 0.82 mg/l. Ni ranged from 0.01 to 0.045mg/l with a mean value of 0.024mg/l.

Table 4.1: Heavy metals concentration in groundwater samples obtained from the area of study

SID	Easting	Northing	Fe mg/l	Zn mg/l	Cu mg/l	Mn mg/l	Ni mg/l
GW1	6.220111111	7.096	1.217	0.735	0.338	0.044	0.023
GW2	6.22525	7.095805556	0.293	0.189	0.129	0.013	0.015
GW3	6.2325	7.088611111	0.746	0.473	0.364	0.021	0.018
GW4	6.243055556	7.083611111	0.628	0.435	0.296	0.029	0.017
GW5	6.259472222	7.073944444	0.318	0.182	0.127	0.013	0.017
GW6	6.254916667	7.076861111	0.321	0.175	0.122	0.015	0.01
GW7	6.255833333	7.081111111	1.853	0.952	0.587	0.082	0.045

GW8	6.248611111	7.081944444	1.275	0.673	0.274	0.053	0.038
GW9	6.245833333	7.0825	1.389	0.655	0.386	0.043	0.026
GW10	6.250258	7.078347	2.344	0.893	0.352	0.063	0.035
Mean			1.0384	0.5362	0.2975	0.0376	0.0244
Standard deviation			0.700963	0.291214	0.145102	0.023557	0.011413
Minimum			0.293	0.182	0.122	0.0130	0.01
Maximum			2.344	0.952	0.587	0.082	0.045
WHO, 2011			0.3	1.0	2.0	0.1	0.1

Table 4.2: Summary of univariate statistical analysis of heavy metals in groundwater samples.

Parameters	Minimum	Maximum	Mean mg/l	WHO,2011
Fe	0.293	2.344	1.0384	0.3
Zn	0.182	0.952	0.5362	1.0
Cu	0.122	0.587	0.2975	2.0
Mn	0.0130	0.082	0.0376	0.1
Ni	0.01	0.045	0.0244	0.1

Spatial Distribution maps of heavy metals in the groundwater samples

The spatial distribution maps of heavy metals in the groundwater from the study location is presented in figures 4.1, 4.2, 4.3, 4.4 and 4.5 respectively.

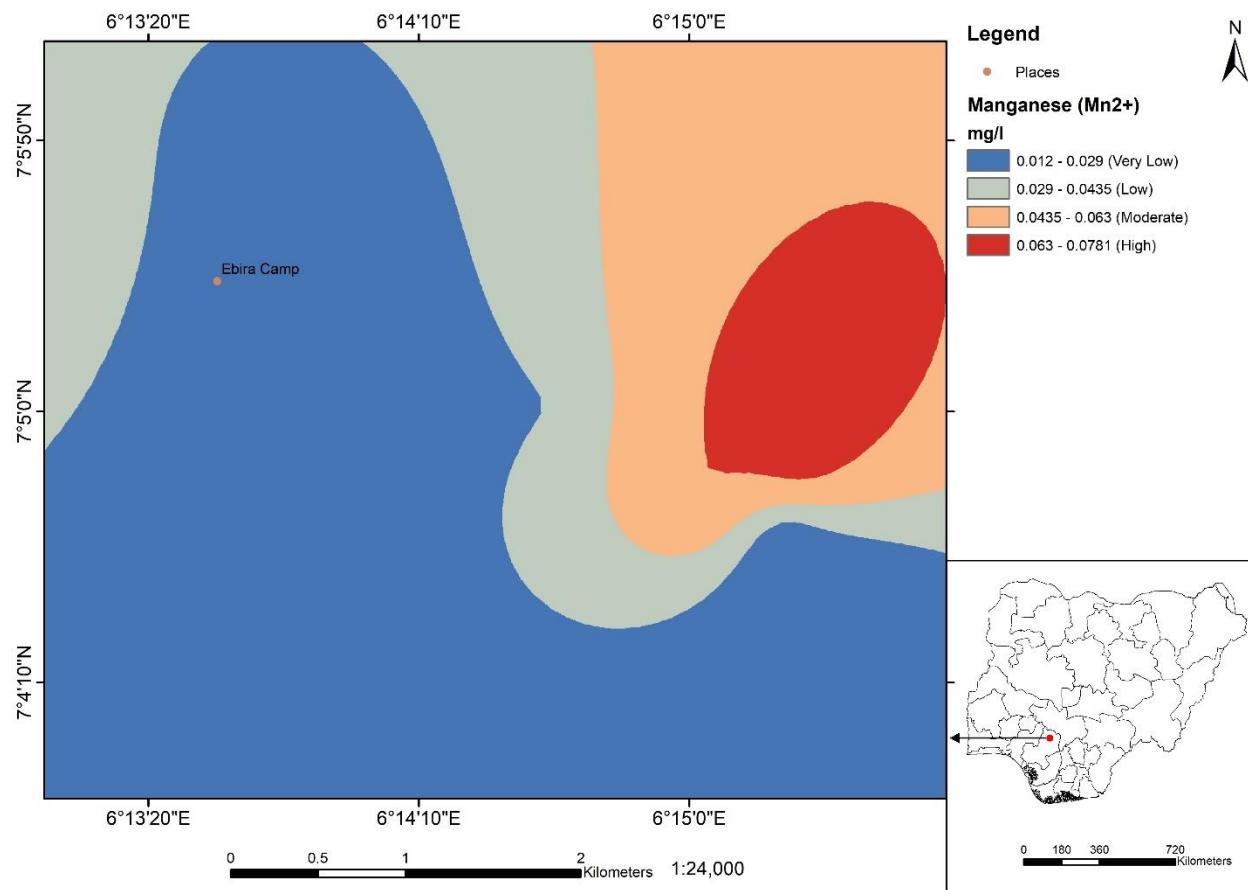


Figure 4.1: Spatial distribution of Mn in groundwater samples in the area of study

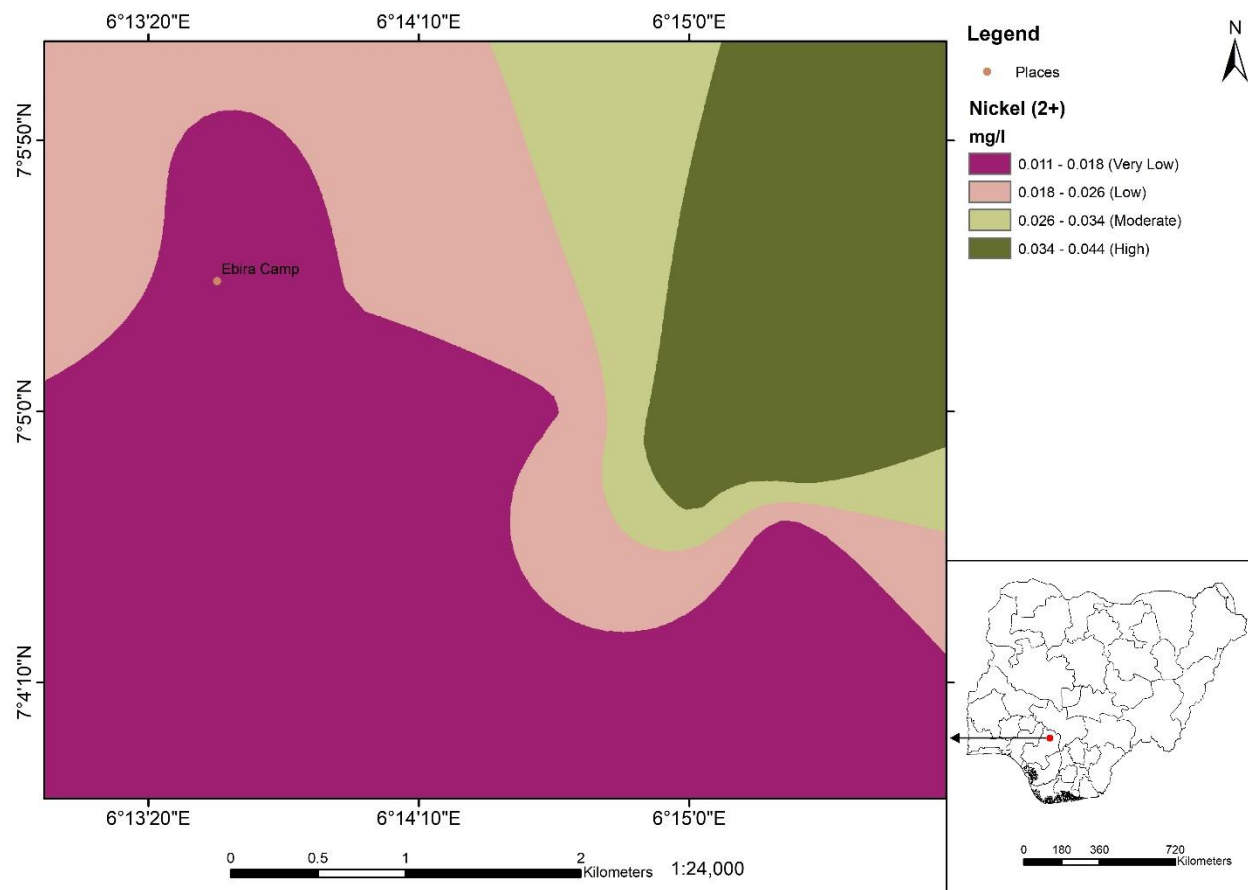


Figure 4.2: Spatial distribution map of Ni in groundwater samples in the area of study

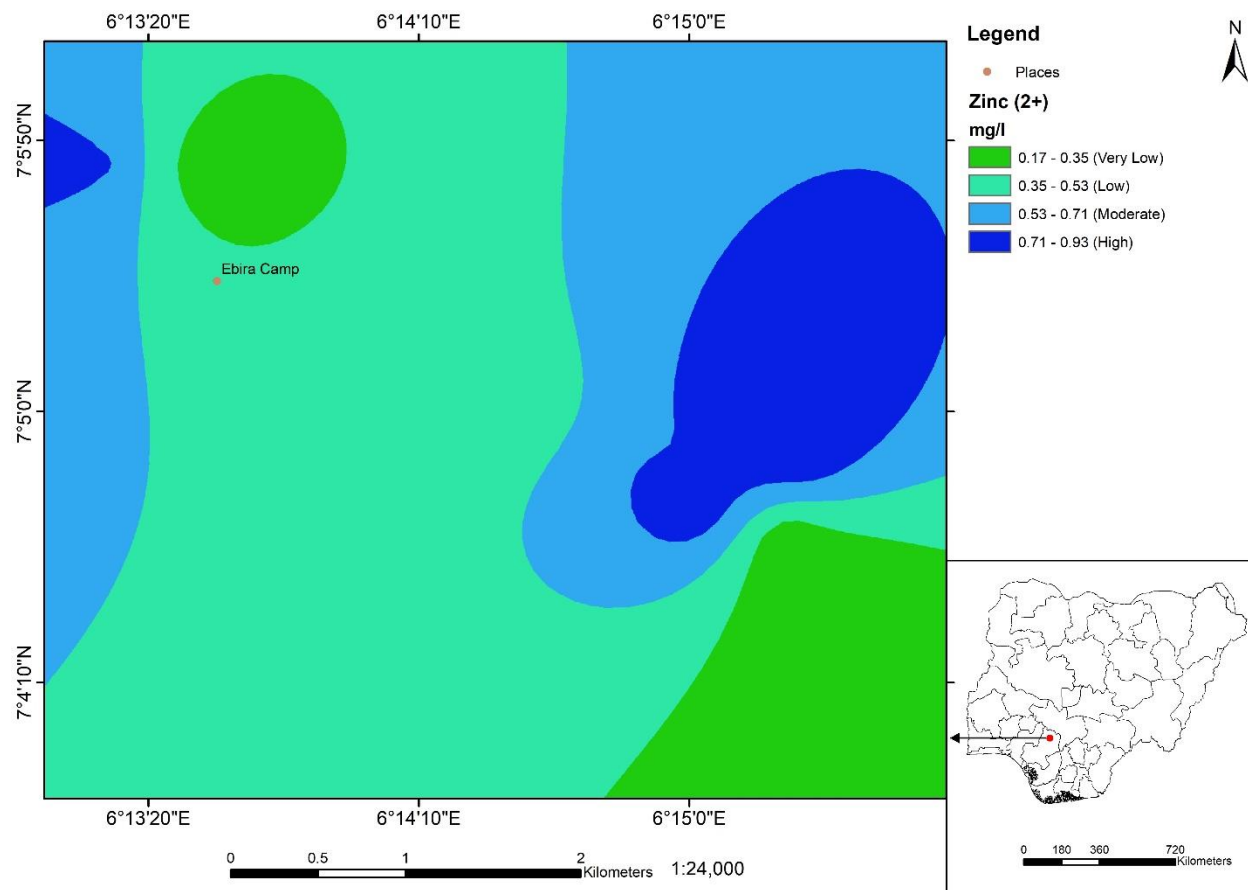


Figure 4.3: Spatial distribution map of Zn in groundwater samples in the area of study

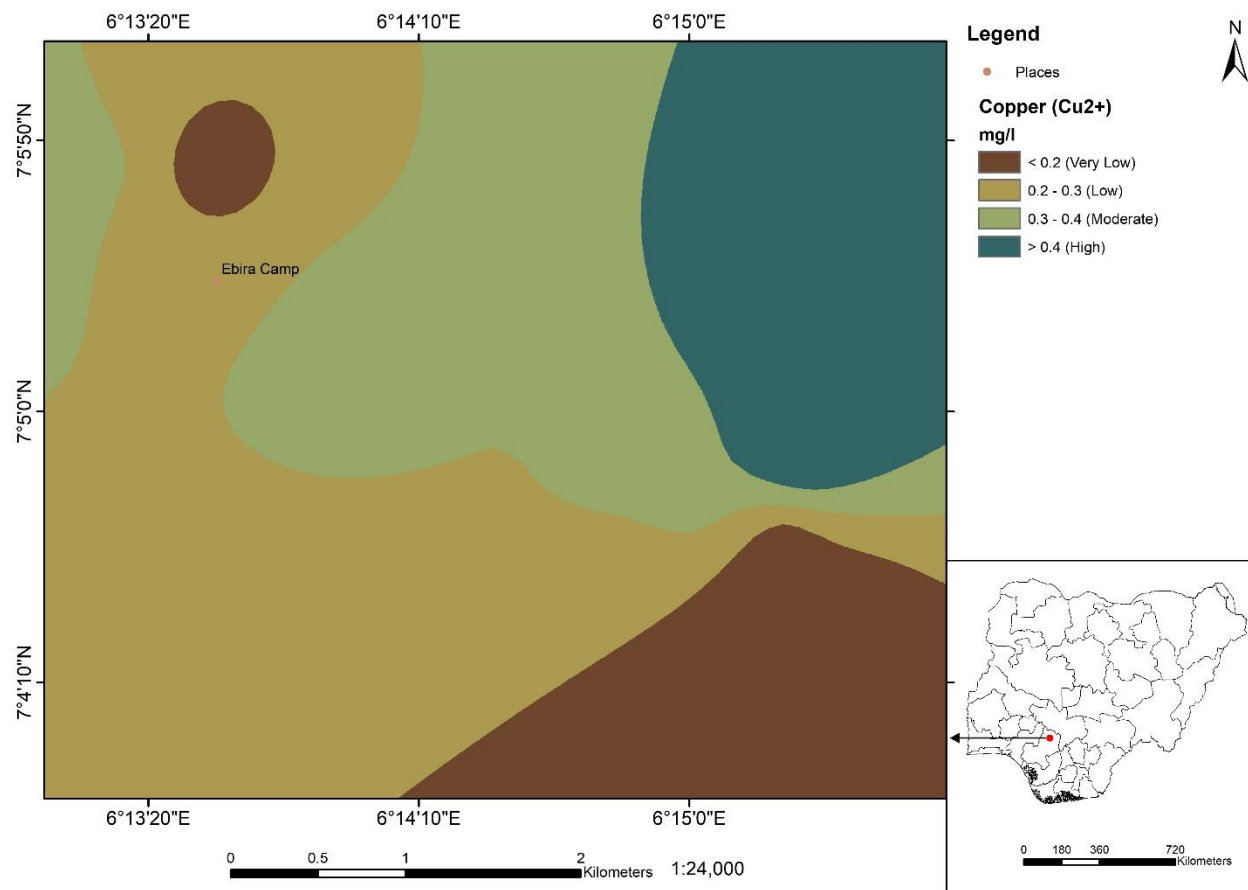


Figure 4.4: Spatial distribution of map of Cu in groundwater samples in the area of study

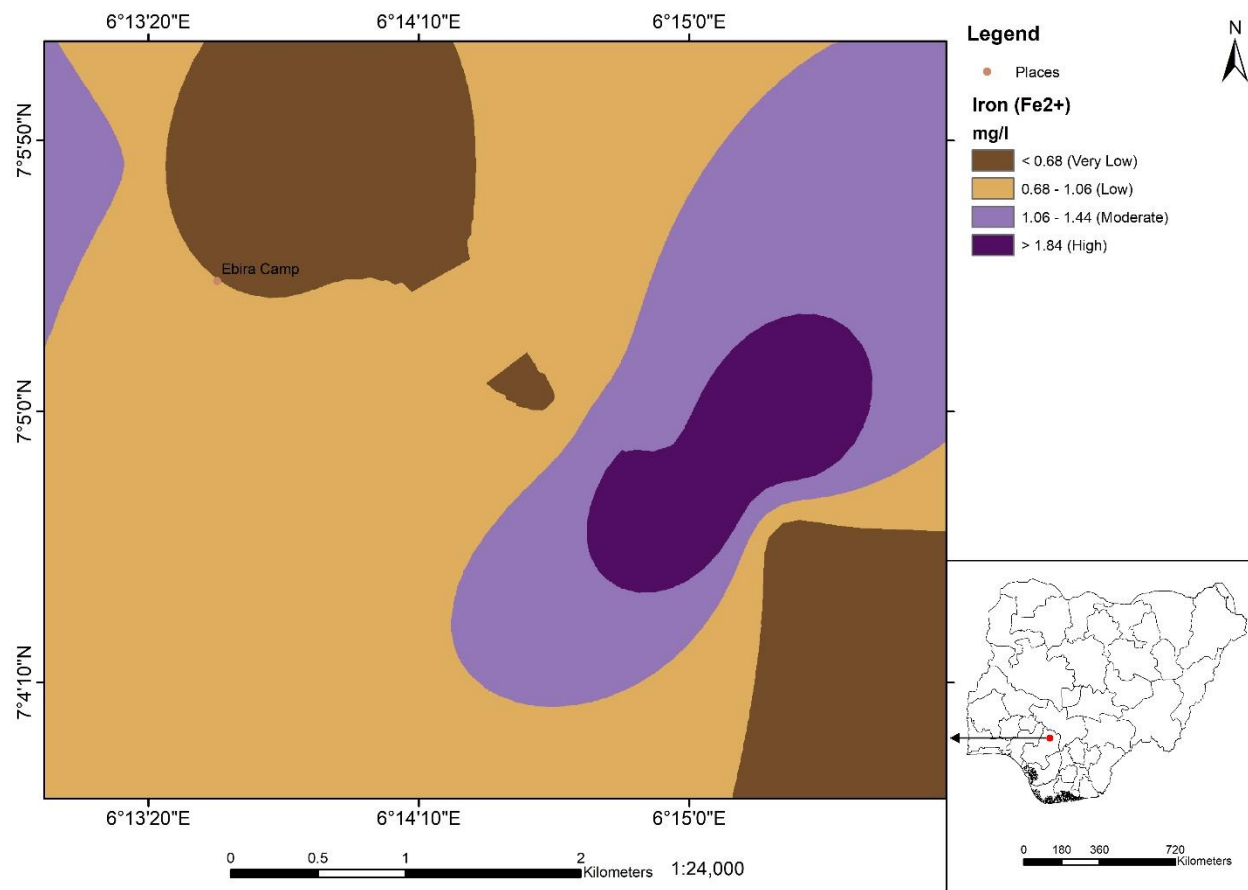


Figure 4.5: Spatial distribution map of Fe in groundwater samples in the area of study

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1. Physicochemical parameters in groundwater samples

The order of heavy metal concentration in groundwater samples was found to be Fe>Zn>Cu>Mn>Ni, according to the results of physicochemical parameters, which are displayed in Tables 4.1 and 4.2. It can be inferred that of the heavy metals, iron had the highest concentration in groundwater (average value: 1.0384 mg/l) while nickel had the lowest concentration (average value: 0.0244 mg/l) in groundwater in the research region.

Iron (Fe)

Fe concentration was found to vary between 0.293 and 2.344 mg/l, with a mean level of 1.0384 mg/l exceeding the 0.3 mg/l WHO acceptable limit. Elevated iron levels in groundwater have been linked to leachates from metals found in car waste (Talabi *et al.*, 2019). An offensive unpleasant odor may result from bacteria growing in water due to excess iron (Fe) in groundwater (Nwachukwu and Garba 2004; Rusin *et al.*, 1997).

Zinc (Zn)

The use of zinc in detergent production, lubricant use, and oil spills are all possible causes of zinc contamination in groundwater. The mean Zn level in this investigation was found to be 0.5362 mg/l, which is less than the 3 mg/l WHO permissible limit.

5.2. Spatial Distribution of the heavy metal concentration

The heavy metal concentration's spatial distribution maps are shown in figures 4.1, 4.2, 4.3, 4.4, and 4.5, in that order. Manganese levels varied greatly throughout the region, as seen in Figure 4.1, with the highest values found in the Eastern and North Eastern regions. In a similar vein, the nickel concentration map shown in figure 4.2 shows that the groundwater's nickel concentration content rose non-linearly—that is, without following any regular or expected pattern—from the community's southwest region. This might be the result of nearby mining or industrial activity that are leaking nickel into the groundwater.

An additional factor might be the existence of nearby natural mineral deposits or geological formations, which may have higher nickel concentrations (Uguru *et al.*, 2020). The spatial distribution of zinc throughout the study area is also displayed in figure 4.3. The concentration of zinc in the water rose unevenly from the community's center to its outside. There could be a number of reasons for the uneven or non-uniform increase in zinc content. Agriculture (Anthropogenic sources) or natural geologic fluctuations in the area, such as variations in the underlying rock or soil composition (Geogenic sources) could all have an impact (Uguru *et al.*, 2020). It could also be influenced by the closeness to industrial districts or factories placed closer to the boundary.

This suggests that the community's end had a higher concentration of zinc, while the community's center had the lowest level of zinc in the water. The spatial distribution of copper is depicted in figure 4.4. It increases non-uniformly from the area's/region's center to the community's boundaries, with the area's northeastern regions showing the highest copper values. The community's core has the lowest water copper level in this copper concentration map. Additionally,

the spatial distribution of iron level throughout the research region is depicted in figure 4.5. The iron concentration in the water rose unevenly from the community's center to its limits, as seen in fig. 4.5.

Despite the fact that the North-West and South-East typically have low concentrations of iron, the community's center had the lowest water iron level, while the community's end recorded a greater level of iron concentration. The concentration and volume of metallic ions at each place may be related to the non-uniformity or inconsistency in the heavy metal distribution that is commonly observed throughout the area. Akpomrere and Uguru (2020) claim that the vegetation in these areas, which would have provided preliminary remediation to the toxic leachates, and the type of soil, which prevents these metallic ions from moving through the soil, are responsible for the volume and concentration of groundwater metals at the end of the community.

CONCLUSION

The purpose of the study was to determine the level of heavy metal contamination in the groundwater mining area in Ebira Camp, Nigeria's Edo State, specifically in the Akoko Edo Local Government. Ten groundwater samples in all were taken from ten distinct sampling locations. Heavy metals were examined in the samples. An atomic spectrometer (AAS) was used to evaluate five heavy metals: Fe, Zn, Cu, Mn, and Ni. Geospatial analysis of the gathered data was done using geographic information system (GIS) software. Maps showing pollution concentrations and patterns of spatial distribution were produced by using spatial interpolation techniques like kriging or inverse distance weighting. With the exception of iron, which had a mean iron content of 1.0384 mg/l, the results indicated that the concentrations of heavy metals were generally lower than the WHO-approved values.

Iron has the highest concentration while nickel has the lowest values among the five heavy metals under investigation. The possibility exists that the ground's high iron content encourages the growth of bacteria that cause an unpleasant foul odor. In general, there is little to no groundwater contamination in the mining area of Ebira Camp, Akoko Edo Local Government, Edo state, Nigeria, due to the presence of heavy metals.

RECOMMENDATION

The administration of Ebira Camp Akoko Edo Local Government Edo State, Nigeria, should receive advice from the Nigerian Mining and Geoscience Society regarding the necessity of maintaining controlled mining activity.

The area's groundwater needs to be continuously treated with affordable, efficient methods like ion-exchange adsorption in order to get high levels of heavy metals, particularly iron, down to levels that are safe. In order to solve the issues related to heavy metal contamination in groundwater, the literature currently in publication that has been thoroughly examined for this analysis makes it abundantly evident that more investigation, observation, and preventative action are required.

In order to improve knowledge of the origins, routes, and distribution of heavy metal pollution in groundwater, the government should also promote and fund additional research projects.

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