CHALLENGES AND OPPORTUNITIES OF GROUNDWATER USE
(CASE STUDY OF BOSSO LOCAL GOVERNMENT AREA)

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DECEMBER, 2010.

DECLARATION

I hereby declare that this project work is a record of a research work that was undertaken and written by me. It has not been presented before for degree or diploma or certificate at any university or institution. Information derived from personal communication, published and unpublished work were duly referenced in the text.

22nd Dec 2010

Oguche, Felix Michael

Date

CERTIFICATION

his is to certify that the project entitled "Challenges and Opportunities of Groundwater Use Case Study of Bosso Area Council)" by Oguche, Felix Michael meets the regulations overning the award of the degree of Bachelor of Engineering (B. ENG.) of the Federal niversity of Technology, Minna, and it is approved for its contribution to scientific knowledge nd literary presentation.

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DEDICATION

This project work is dedicated to Almighty God, my wonderful and ever steadfast Parents, my Brothers and Sisters.

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My most profound gratitude goes to God the most powerful for his unending flow of mercy and favour towards me, seeing me through the hurdles of life and most especially for loving me beyond measure.

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ABSTRACT

The present study was undertaken to identify the Challenges and Opportunities of Groundwater use and to assess the chemical, physical and bacteriological property of groundwater in Bosso to determine their usability, water samples were collected from 3 different water sources, the collected water samples were analyzed, The parameters examined include conductivity, temperature, turbidity, pH, Iron, Calcium, Nitrate, Sulphate, Chloride, total hardness, Nitrite. The results obtained were compared with WHO standard and Nigerian Industrial Standard for drinking water to ascertain whether the samples are safe for consumption. All the parameters tested and listed were above the minimum permissible limit for drinking by WHO and Nigerian Industrial Standard. The distance of water sources from contaminants were also checked and found to be less than the least permitted distance of 100m by NRETAS (2004) , From the results obtained the water from the sample are not fit for drinking purpose. The water from the three samples should be boiled to eliminate bacterial risks and should be properly covered to disallow any insect or foreign material getting in contact.

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CHAPTER ONE

1. INTRODUCTION

1.1 Background of the Study

Life on earth requires water, and society's need for this precious resource is growing. More than half of the world's population depends on ground water for drinking purposes (Roger, 2000). Surprisingly, although the resources is widely used and is very important to the health and economy of the world, it's physical and chemical characteristics are poorly understood and are subject to many misconceptions. This has been a challenging concern to the ground water management in the last few years.

The quality of groundwater is of vital importance for industrial, irrigation and domestic purposes. Drinking water standards are based on two main criteria:

i. The presence of objectionable taste, odours and colours.

ii. The presence of substances with adverse effects on the quality of available water resources Ako et. al (1990).

Because food security is so closely linked to water availability and irrigation in many regions, conflicts over water are evident. Increasing water scarcity will increase the potential for within and between Nations. Water scarcity is further jeopardized by pollution from human and industrial activities. The fact that less than 1percent of the earth's aquatic endowment is fresh water that is reliably for human consumption calls for greater management and conservation (Carruther and Morrison 1994., FAO 1993).

1.1.1 Groundwater

Water that is held as soil moisture will percolate downward until it reaches zone where all of the open spaces in sediment and rock are completely filled with water, this is the zone of saturation. water within is called groundwater the upper limit of this zone is known as the water table the area above the water table where the soil, sediment, and rock are not saturated is called the zone of aeration, (Fig 1.1) below, you can see how the ground below the water table (the blue area) is saturated with water. The unsaturated zone above the water table (the greenish area) still contains water (after all, plants' roots live in this area), but it is not totally saturated with water. You can see this in the two drawings at the bottom of the diagram, which show a close-up of how water is stored in between underground rock particles (Roger, 2000).

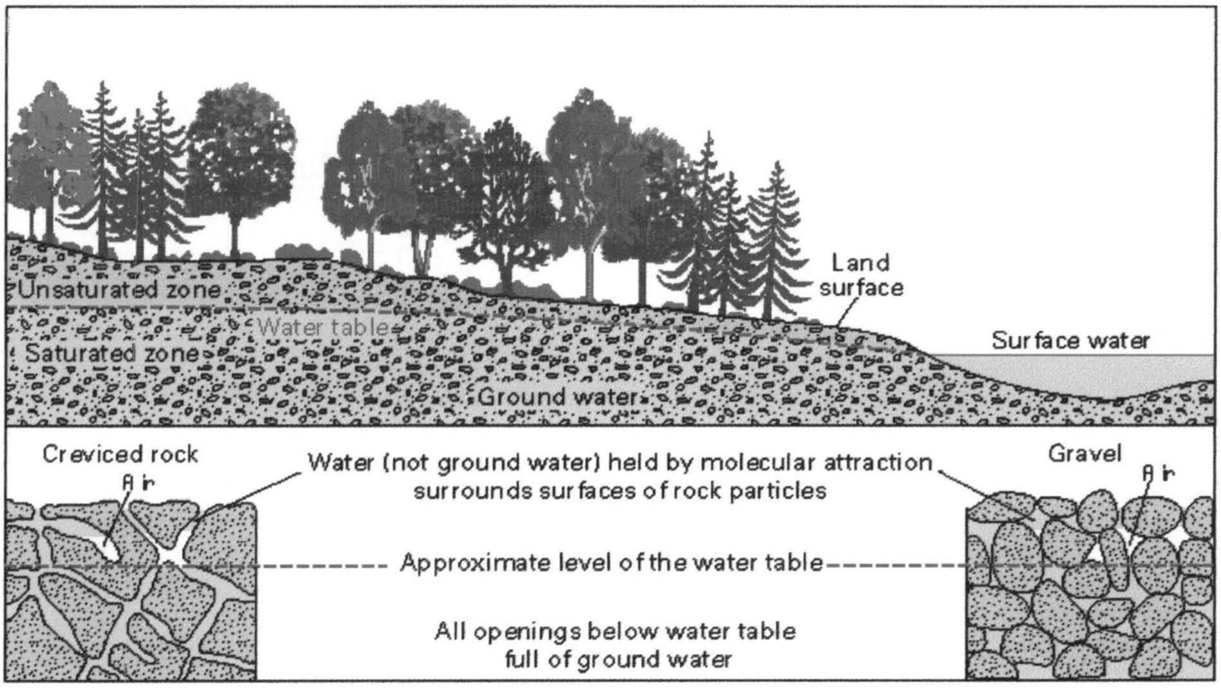

Fig 1.1 Different zones of groundwater and water table (Roger, 2000)

Irrespective of water source, the chemistry is basically the same. Water is such an excellent solvent that it can contain lots of dissolved chemicals. And since groundwater moves through rocks and subsurface soil, it has a lot of opportunity to dissolve substances as it moves. For that reason, groundwater will often have more dissolved substances than surface water will (Waller and Roger 2000).

1.1.2 Hydrological Cycle

Most water on our planet occurs as saline water in the oceans and deep underground or is contained in polar ice caps and the permanent ice cover of the high mountain ranges. So, only 30 million km^3 of fresh water, that is only 2 percent of all water, plays an active part in the hydrological cycle and in the maintenance of all life on the continents. The hydrological cycle (Fig 1.2) depicts how part of the ocean water evaporates, the water vapour turns into fresh water precipitation (rain, hail, snow) on the earth's surface (seas, land), then flows over the land surface (glaciers, runoff, streams) and partly infiltrates into the soil (soil water) to be used by the vegetation (evapotranspiration), or to recharge the groundwater bodies. Subsequently, most groundwater returns either by being pumped or by natural outflow, to surface water bodies which subsequently discharge back into the sea (Ken and Gideon 2004).

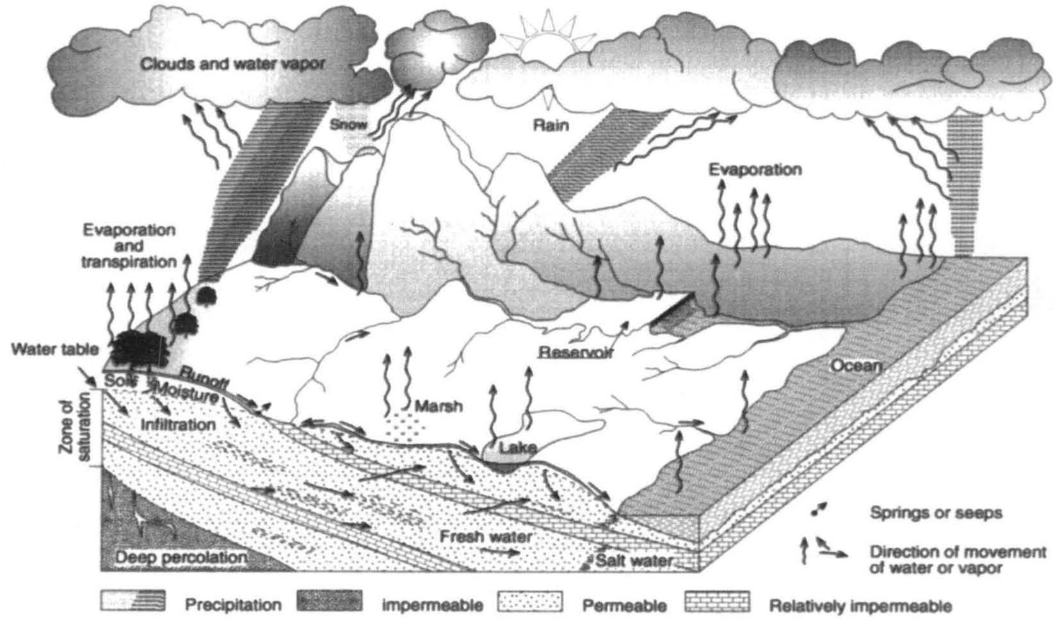

Fig 1.2 The Hydrological cycle (After De Wiest,2005)

Water on land masses is always in motion, either moving quickly (vapour transport, precipitation, surface flow) or slowly (groundwater flow, glaciers). The slowness of groundwater flow means that most fresh water is in the form of groundwater. Consequently, groundwater is the main storage reservoir of fresh water, while surface water can be considered as the surplus precipitation that could not infiltrate, or that has been rejected as overflow from the groundwater reservoir (springs and other outflows). When water enters the soil (infiltration) it becomes soil water; soil water may not completely fill the pores between the soil particles. Thus the zone through which the water moves is unsaturated (unsaturated zone). The flow through the unsaturated zone is essentially vertical. At the top of the unsaturated zone the vertical flow may be downward under the influence of gravity, or it may be upward (capillary flow) resulting from the evapotranspiration processes. To a depth of 5 m below the ground all unsaturated flow is downward (deep-rooting trees and shrubs, e.g. salt cedar, may still abstract water from the downward flow). When vertical flow is impeded by

an impervious layer, the pores above this layer fill completely and become saturated. The voids filled by the groundwater may have different origins and may occupy a smaller or larger part of the gross volume. The porosity is the percentage of a gross volume of soil or rock that is filled by air or water; the soil or rock containing such pores is called a porous medium. When the pores have their origin in the genesis of the rock, the rock is said to have primary porosity (sedimentary deposits, weathered hard rocks). When their origin is from events that occurred during a later stage (jointing, faulting, dissolution) the porosity is said to be secondary. Most sedimentary rocks with primary porosity also contain some joints and fracture that add secondary porosity to the total porosity of the porous medium. Similarly dense rocks (quartzites and granites) may have some primary porosity which is subordinate to the secondary porosity. Occasionally the effects of both forms of porosity can be recognised in the behaviour of a single groundwater body; this phenomenon is called dual porosity
(Ken and Gideon 2004).

The large proportion of water on the earth's surface, (over 96 percent), is saline water in the oceans. But it is the freshwater resources such as the water in streams, rivers, lakes and ground water that provide (and all life) with most of the water they need every day to live. Water sitting on the surface of the earth is easy to visualize, and your view of the water cycle might be that rainfall fill up the rivers and lake. But, the unseen water below our feet is critically important to life. There is much more freshwater stored in the ground than there is in liquid form on the surface. In fact, some of the water you see flowing in rivers comes from seepage of groundwater into river beds. Water from precipitation continually seeps into the ground to recharge the aquifers, while at the same time, underground water aquifers continually recharges rivers through seepage (Waller and Roger 2000).

High-quality water is defined as water that contains no pathogenic organisms and is free from biological forms that may be aesthetically objectionable. It is clear and colorless, and has no objectionable taste or odor. It does not contain concentrations of chemicals that may be physiologically harmful, aesthetically objectionable, or economically damaging. It also is not corrosive, nor does it leave excessive or undesirable deposits on water-conveying structures, including pipes, tanks, and plumbing fixtures. Criteria used to evaluate the safety of drinking water are continually reassessed as new constituents are identified and health effects research advances. Regulatory agencies are developing standards and recommendations for contaminant levels in drinking water. Concurrently, the water supply industry is developing new and improved operation and treatment techniques to respond to the changing criteria. Drinking water quality criteria must consider all factors that affect the quality of water, the public health significance of the constituents, and the available technology to treat water (Carruther and Morrison 1994., FAO 1993)

1.2 Statement of the Problem

Throughout Bosso, Communities that have sustainable groundwater balance are shrinking by the day. Three problems dominate groundwater use: depletion due to overdraft, waterlogging and salinization due mostly to inadequate drainage and insufficient conjunctive use, and pollution due to agricultural, industrial and other human activities.

1.3 Objectives of the Study

i. to determine remedia measures to depletion of groundwater level due to overdraft, waterlogging and pollution due to agricultural and other human activities

ii. to determine the groundwater quality of the study area.

iii. to identify the opportunities of groundwater use.

1.4 Justification of the Study

The use of groundwater is a function of their physiochemical and properties. Groundwater contains different concentration of minerals (Dissolved major inorganic, dissolved minor inorganic constituents, dissolved trace constituents) offers multiple uses and these uses are dependent on a specific physical and chemical property exhibited by the mineral. Thus, there is the need for a timely and intensive research acquisition of detailed physiochemical data on groundwater in Bosso Communities, Minna, Nigeria in order to determine the use to which they can be put. General analysis had been carried out on mostly all regions with little attention to North central Nigeria and the results well documented, but there is need to prioritize the research work on the groundwater in this area. Hence, a detailed physical chemical and bacteriological analysis of groundwater was particularly carried out and selected for this singular reason. It is hoped that this research project will in a way add to the existing records on groundwater analysis of Niger State of and North Central Nigeria at large.

1.5 Scope of the Study

This study covers some of the challenges and opportunities of groundwater use of Communities in Bosso Local Government Area and also the physical, chemical and bacteriological analyses of groundwater within the study area for groundwater restoration.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Groundwater importance

Water is of major importance to all living things; up to 60 percent of the human body is water, the brain is composed of 70 percent water, and the lungs are nearly 90 percent water. About 83 percent of our blood is water, which helps digest our food, transport waste and control body temperature. Each day, humans must replace 2.4 litres (0.0024 m^3) of water, some through drinking and the rest taken by the body from the foods eaten (Gleick, 1996).

Groundwater is one of our most important and widely available resources yet people's perception of the subsurface environment from which it comes are often unclear and incorrect. The reason is that the groundwater environment is largely hidden from view except in caves and mines, and the impressions people gain from these subsurface opening are misleading without question, groundwater represent the largest reservoir of fresh water that is readily available to humans its value in terms of economics, groundwater is important as an Erosion agent. The dissolving action of groundwater slowly rework rock allowing surface depressions known as sinkholes as well as creating subterranean cavens. Groundwater is an equalizer of stream flow much of water that flows in river is not direct runoff from rain and snowmelt. Until recently, groundwater quality has been for granted. Although some well and springs were known to contain natural high level of salt or sulphur and other were known to be contaminated by sewage bacteria, groundwater and was generally thoughts to be immune from contamination by many chemical we use for industrial agriculture and house hold purpose. Only within the past decade have we made the link between what we do to the land surface and what we find in our groundwater supplies.

The importance of water, (universal solvent) in the life of man cannot be overemphasized. According to Franceshir (1972), life would not be possible without water, also stated by Michael Dye (2001) that no life could ever exist on earth without this precious liquid. There is no point questioning the validity of this claim because scientific investigations carried out have shown that water actually ranked second next to air in the classification of basic essentials requirements for the survival of man on the surface of the earth, the other essentials are food, heat and light respectively. Water is therefore a life necessity and not a luxury. It is in view of his relevance amongst others that the International Hydrogeological Decade, I.H.D (1965 – 1974) was launched at the 13th session of the conference of UNESCO

2.2 Water Movement in Aquifers

Water movement in aquifers is highly dependent of the pearmeablility of the aquifer material. Permeable material contains interconnected cracks or spaces that are both numerous enough and large enough to allow water to move freely. In some permeable materials groundwater may move several metres in a day; in other places, it moves only a few centimetres in a century. Groundwater moves very slowly through relatively impermeable materials such as clay and shale

2.3 Groundwater Composition

2.3.1 Physical and Chemical Properties

A water molecule consists of two atoms of hydrogen (H) and one atom of oxygen (O), so it has the chemical formula H_2O. At sea level its freezing point is 0°C and its boiling point is 100 °C. Water is a good solvent and natural water always contains some chemicals in solution. The total amount of dissolved solids in a water sample (TDS) is expressed in mg/l and water is classified according to the TDS as fresh, brackish, saline or brine. The limits in this classification vary from country to country and even from study to study. The major cations in groundwater are usually sodium (Na^+), potassium (K^+), calcium (Ca^{++}), magnesium (Mg^{++}) and the major anions are chloride (Cl^-), bicarbonate ($HCO_3{}^{+}$), sulphate (SO_4^{--}) and nitrate (NO_3^-). Of the solutes that occur in minor amounts the following are mentioned because of their influence on the water use: iron (Fe; taste, staining), boron (B; toxicity to plants), fluoride (F; health risk), aluminium (Al; health risk), nitrate (NO_3^-; health risk). Very small amounts of other ions, usually called trace elements, are often present in natural water. Furthermore, small amounts of the isotopes of hydrogen, such as deuterium 2H, tritium 3H and oxygen 180 occur in all natural waters. Groundwater that comes from deep aquifers (> 2000 m) or from aquifers in contact with subterranean (volcanic) heat sources may have high temperatures and may be used as a source of geothermal energy; this topic will not be discussed in this publication. Water with a particular chemical composition may be exploited as 'mineral water' for bottling and for 'medical' use in health resorts; this is another topic not covered in this publication (Anderson and Woessner 1992).

2.4 Risk of Groundwater Pollution

Groundwater pollution from human activities has become a major topic of groundwater research and large amounts of money are currently being invested in the prevention of groundwater pollution and in the rehabilitation of polluted groundwater bodies. The contaminants that may pollute groundwater are grouped according to their physico-chemical characteristics in order to characterise their fate in the groundwater environment:

i. metals
ii. oxy-anions
iii. dissolved organics

iv. non-aqueous phase liquids (NAPLs)

v. bacteria and viruses.

(i) Metals

Dissolved metals usually occur as cations in groundwater, but important exceptions exist such as chromium (Cr) and uranium (U), which may also occur as oxy-anions. The mobility of metal cations often increases with decreasing pH, for a combination of two reasons. Firstly, most minerals that are formed by metals are less soluble at increasing pH: carbonates, oxyhydroxides, sulphides. Secondly, the sorption capacity of solid phases for cations increases with increasing pH.

(ii) Oxy-anions

Oxy-anions have less singular characteristics in groundwater than metals. The sorption capacity

or anions generally increases with decreasing pH. However, the importance of sorption strongly

varies for individual anions and oxy-anions and is still an active topic of research. However, it has become clear that sorption is relevant for oxy-anions that can be considered as weak bases, like phosphate, arsenate and chromate. Sulphate, being a strong base, is weakly adsorbed, and adsorption of nitrate, which is also a strong base, is negligible. Oxy-anions that behave as weak bases are most mobile under weakly acid conditions (pH approximately 5 to 6). At higher pH the mobility is limited by solubility of minerals and at lower pH it is limited by sorption. Several oxy-anions are not stable within the entire range of redox conditions that can be found in groundwater which makes them susceptible to redox processes. With decreasing redox potential , the major anions, nitrate and sulphate may be converted to N_2 and H_2S, respectively. The former is unreactive in groundwater, the latter may form sulphides with Fe or other heavy metals. Arsene occurs in three redox states in groundwater: arsenate, arsenite and arsenic. Their mobility is distinctly different, since arsenic binds to sulphides. This limits as concentrations in groundwater in strongly reduced environments. The redox state for chromium also varies from Cr(VI) as $Cr_2O_7^{2-}$ to Cr(III) as Cr_3^+. The latter is also much more susceptible to sorption and precipitation than the former.

(iii) Dissolved organics

Dissolved organics are relevant in the groundwater environment in two different ways. First, dissolved organic matter may be a reductant of the groundwater system , i.e. its decomposition brings about anaerobic conditions in the groundwater. Second, organic molecules may be undesirable in groundwater because of their toxicity. The first condition is normally indicated by the concentration of Dissolved Organic Carbon (DOC) and refers to organic matter as a major contributor to the overall groundwater composition. The latter refers to individual organic species at low concentrations and these species are referred to as micro-organics. Examples are pesticides, polycyclic aromatic hydrocarbons and chlorinated aliphatic hydrocarbons. The transport of micro-organics is controlled by aqueous solubility, sorption and degradation. As soon as the organic carbon content of the aquifer exceeds 0.1% solid organic matter is the major sorbing compound. Degradation of micro-organics may be controlled biotically or abiotically. Often, biotic degradation is faster than abiotic. The degradation rate strongly depends on the redox type of the groundwater/aquifer system.

(iv) Non-aqueous phase liquids

Following spills on the surface, Non-Aqueous Phase Liquids (NAPLs) may occur as immiscible fluids in the subsurface. The flow of these liquids is hydrodynamically not geochemically controlled. Their behaviour depends on their density; fluids like petrol, diesel, etc. are lighter than water and form floating layers. On the other hand, several solvent fluids like trichloroethene are heavier and form sinking layers. Non-aqueous phase liquids are important as a source of dissolved organic matter in groundwater. The DOC may change the redox status of the aquifer system and the soluble compounds of oil derivatives may cause deterioration in the groundwater quality. Benzene, toluene, ethylbenzene and xylene, for example, are compounds in oil that show relatively high mobility in groundwater.

(v) Bacteria and viruses

Bacteria and viruses may cause diseases if the contaminated water is used for drinking. These bacteria are referred to as pathogenic bacteria. The contamination is often related to sewage or waste water. Short-circuit flow from the surface to well screens is a well-known cause of bacterial contamination, which can often be attributed to poor well construction. Bacteria can be considered as living colloidal particles. Viruses are particles that have a smaller radius than bacteria: in the order of 0.01 μm versus 1 μm, for bacteria. Like colloids, the mobility of bacteria is primarily controlled by filtration. The movement is enhanced by large pores, i.e. coarse matrices having small sorption capacities. Survival of pathogenic bacteria is encouraged by high moisture contents, low temperature and neutral pH. Filtration is less important for viruses due to their small size. The dominant factor affecting their movement is adsorption. Survival of viruses is favoured by high moisture contents and low temperatures. The mobility of bacteria and viruses is largely determined by the same factors. Greatest movements occur in coarse aquifers and infiltration areas with thin unsaturated zones. Fractured and karstified rock have the highest potential risk. Contamination by bacteria or viruses is often local, for similar reasons to colloidal-facilitated radionuclide transport (Anderson and Woessner 1992).

2.5 Potential consequences of changed groundwater conditions

Groundwater exploitation, the construction of irrigation schemes and urban development can all lead to major changes in groundwater conditions. Groundwater development leading to heavy exploitation can cause significant falls in the water table and a reduction in the yields of boreholes due to the extra height over which the water has to be raised; if the aquifer is over-exploited it may become unusable. Another consequence of heavy exploitation and the removal of large volumes of water can be settlement of the ground (Downing, 1994). Rising water tables can occur due to excessive irrigation, losses from canals or return flow from irrigated fields, the result of the rising water table may be water-logging and salinisation. In urban areas, the natural drainage by surface water courses and through the aquifer system may be unable to take away excess water, unless sufficient additional drainage is provided, water tables may rise to the ground surface. Riyadh in Saudi Arabia provides a typical example where it was thought that the aquifer would provide natural drainage but the vertical permeability of underlying strata is too small to take away the recharge which results from losses from the water supply system and the irrigation of gardens; the result is that the water table is close to the ground surface in many areas of the city (Raesner and Walesh, 2000).

Warren (1979) implied that groundwater resources engineer and planners must be conversant with society's view regarding water and water related environment according to the author, if there are not, the technical role in water management will be inefficient at best and over look as worse it was however observe that stresses associated with water quality degrading; particularly those associated with toxic and hazardous materials are mounting.

Much as it would be expected for volumes of records to be available for reference, the development of groundwater in Nigeria as a source of water supply for other uses has received very little attention in the past. By the virtue of claim, little surprise it's then, that only a few publication relating to quality of groundwater in the country can be found. This is observed by author of the project to be a serious oversight by both local and federal water authorities because a large numbers of the Nations rural population depends solely on groundwater (which is indiscriminately consumes) and this reluctance to inform people of the important of good quality is an unnecessary expose to health harzard condition.

2.6 Groundwater quality

Water quality is a term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose. Although scientific measurements are used to define a water's quality, it's not a simple thing to say that "this water is good," or "this water is bad." After all, water that is perfectly good to wash a car with may not be good enough to serve as drinking water at a dinner party for the President! When the average person asks about water quality, they probably want to know if the water is good enough to use at home, to play in, to serve in a restaurant, etc., or if the quality of our natural waters are suitable for aquatic plants and animals. As the diagram (Fig 2.1) below shows, assessment of the occurrence of chemicals that can harm water quality, such as nutrients and pesticides in water resources, requires recognition of complicated interconnections among surface water and ground water, atmospheric contributions, natural landscape features, human activities, and aquatic health. The vulnerability of surface water and ground water to degradation depends on a combination of natural landscape features, such as geology, topography, and soils; climate and atmospheric contributions; and human activities related to different land uses and land-management practices.

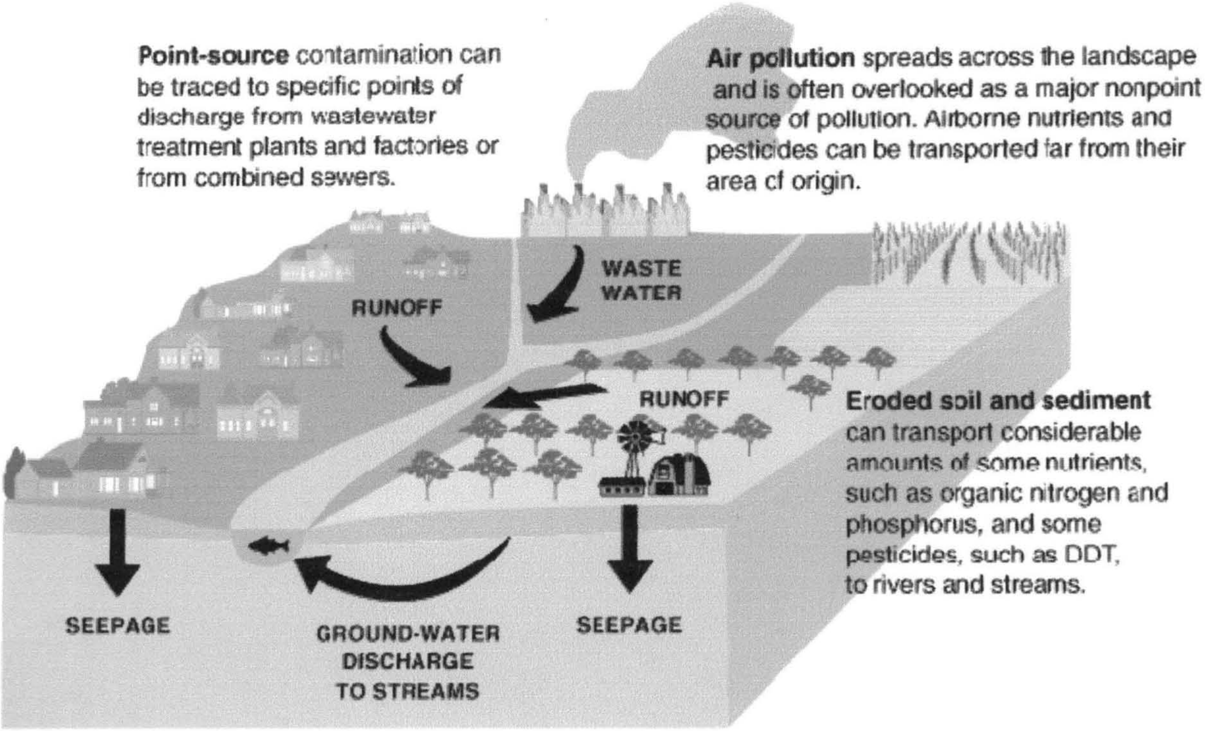

Fig 2.1 Assessment of the occurrence of chemicals (Waller, 2000)

More and more nowadays we are hearing about situations where the quality of our water is not good enough for normal uses. Bacteria and microorganisms have gotten into drinking-water supplies, sometimes causing severe illness in a town; chemical pollutants have been detected in streams, endangering plant and animal life; sewage spills have occurred, forcing people to boil their drinking water; pesticides and other chemicals have seeped into the ground and have harmed the water in aquifers; and, runoff containing pollutants from roads and parking lots have affected the water quality of urban streams. Yes, water quality has become a very big issue today, partly because of the tremendous growth of the Nation's population and urban expansion and development. Rural areas can also contribute to water-quality problems. Medium- to large-scale agricultural operations can generate in animal feed, purchased fertilizer, and manure, more nitrogen and phosphorus than can be used by crops or animals. These excess nutrients have the potential to degrade water quality if incorporated into runoff from farms into streams and lakes All this growth puts great stress on the natural water resources, and, if we are not diligent, the quality of our waters will suffer (Waller and Roger 2000).

2.7 Water Parameters Characterization

2.7.1 Physical parameters

These are properties of water, which determine its attractiveness to human sense. The most significant of the physical characteristic of water are however, determine by the turgidity these parameters are however determined by organic and inorganic constituent of environments in which water occurs. For instant color may be due to pigments of organic matter such as metabolites produced by actinomycetes, algae and other micro-organisms or from metallic iron; contributed mostly by iron and manganese which produce reddish brown stains; odour emanating from groundwater may be due to the decayed remains of micro-organisms or animal within the periphery of the source; turbidity is usually as a result of suspended or dissolved solid particles in water, temperature of water depends on the weather of the area where the slope of water was collected or source of the water

2.7.1.1 Temperature

Water bodies undergo temperature variable along with normal climatic fluctuations these variations occur seasonally and in some water bodies over period of 24hours thus temperature is the degree of hotness and coldness of the body or object. The temperature of surface water is influenced by latitude, longitude, altitude, and season, time of day, and the flow and depth of water body. Temperature affects physical chemical and biological processes in water bodies and therefore the concentration of many variable as the temperature in water increase the rate of chemical generally increase together with the evaporation and vitalization of substances from the water. Increase temperature also decreases the solubility of gases in water such as O_2, CO_2, N_2 and CH_4 and others. Groundwater usually maintain a fairly constant temperature which surfical aquifers is normally close to the mean annual air temperature however deep aquifers have higher temperature due to earth's thermal gradient. Temperature should be istiu, using a thermometer or thermistor and express in degree centigrad ^0C

2.7.1.2 pH

Is a measure of the acid balance of a solution and is defined as the negative of the logarithm to the base 10 of the hydrogen concentration. The pH scale run from 0 to 14 (very acidic to very alkaline) with pH representing neutrals condition. The pH is an important variable in water quality assessment at it influences many biological and chemical processes within a water body and all the processes associated with water supply and treatment. In water polluted area. pH is principally controlled by balanced between the carbon dioxide, carbonate bicarbonate ions as well as other neutral compound such as humic and fluvic acids . Changes in pH can indicate the present of certain effluents particularly when continuously measured and recorded together with the conductivity of water body. The pH of most natural water is between 6.0 and 8.5

2.7.1.3 Conductivity

Conductivity is a measure of the capacity of water to conduct an electric current, and can vary with the concentration and degree of ionization of the constituent in water (EPA 1986) in general, conductivity represents the mineral content of water. Conductivity can be influence by the amount of dissolved solids, which comprises inorganic salt (primarily calcium, magnesium, potassium sodium bicarbonate chloride and sulfates) and small amount of organic matter that are dissolved in water. Conductivity is expressed as microsienmens percentimeter (µs)

2.7.2 Chemical Properties

These are characterized by both dissolved major and minor inorganic substances with trace constituents; these include the common minerals constituents such as calcium, manganese, iron, hardness, chlorides, Nitrates and silica. Salts of these elements determine the suitability of groundwater for a wide range of municipal, industrial and agricultural uses. The chemical parameter also include dissolved solids acidity alkalinity and they are the major quality indicators PH and are useful in making regional comparison Dissolved gases in water include oxygen (O_2), Carbon(IV) Oxide (CO_2)Nitrogen(N_2), Hydrogen(H_2) sulphide (H_2S), Ammonium (NH_3) of these dissolved oxygen is the most important and is used as an index of dissolved gases for the design purpose. The tables below show the minor, major and trace constituents in groundwater.

2.7.2.1 Nitrogen

Concentrations of nitrate and ammonium related to pollution inputs may be high in some shallow

groundwaters, particularly from dug wells and dugouts, if pollution sources exist nearby. (Ako, et al., 1990) reported concentrations of nitrate-N up to 124 mg/l and nitrite-N up to 1.2 mg/l in shallow groundwaters from dug wells in weathered basement rocks of south-west Nigeria.

2.7.2.2 Salinity

Groundwaters in most Nigerian aquifers are likely to be fresh with low concentrations of total dissolved solids. As noted above, exceptions have been reported in some coastal aquifers where the groundwaters are heavily abstracted and have resulted in saline intrusion (Ako et al., 1990).

2.7.2.3 Fluoride

The WHO guideline value for fluoride in drinking water is 1.5 mg/l. Problems with fluoride occurrence in groundwater above this value tend to be found in crystalline rock terrains (metamorphic rocks and granite) and occasionally in sedimentary basins. They are also more likely to be found in arid regions than regions with high rates of groundwater recharge (Fluoride Fact Sheet). Granitic rocks and sedimentary basins in the arid northern parts of the country are therefore potentially most vulnerable to development of high groundwater-fluoride concentrations. As noted above, granitic rocks occur extensively in Nigeria. These typically contain significant concentration of fluoride-bearing minerals such as mica, hornblende and apatite which on weathering may release fluoride to groundwater. The Younger Granites have peralkaline compositions with many similarities to the acid igneous rocks of the East African Rift. This is a well-known high-fluoride province with significant groundwater fluoride problems. Only a few fluoride data are currently available for Nigerian groundwaters. As early as 1954

2.7.2.4 Iron and Manganese

Groundwaters in the confined aquifers of the sedimentary basins are particularly vulnerable to the build-up of dissolved iron and manganese under anaerobic conditions. A number of accounts have noted the occurrence of high iron and manganese concentrations in confined groundwaters.

High concentrations of iron and manganese may also be expected in groundwater from areas of crystalline basement if acidic conditions occur. As groundwater abstracted from the crystalline basement is often derived from dug wells, high iron concentrations in these may also be due to the presence of particulate iron, especially if the groundwaters are highly turbid. Ako et. Al (1990) found some high-iron groundwaters in basement rocks of north central Nigeria, although all were found to be below the WHO guideline value.

2.8 Groundwater Challenges

Certain problems have beset the use of groundwater around the world. Just as river waters have been over-used and polluted in many parts of the world, so too have aquifers. The big difference is that aquifers are out of sight. The other major problem is that water management agencies, when calculating the 'sustainable yield' of aquifer and river water, have often counted the same water twice, once in the aquifer, and once in its connected river. This problem, although understood for centuries, has persisted, partly through inertia within government agencies. In Australia, for example, prior to the statutory reforms initiated by the Council of Australian Governments water reform framework in the 1990s, many Australian States managed groundwater and surface water through separate government agencies, an approach beset by rivalry and poor communication. (n.d., 2010).[1]

The Basement Complex areas are also generally of high relief thus, the runoff is high with low infiltration. The challenges of water occurrence in crystalline rocks is further compounded in areas of adverse climatic conditions of aridity and semi-aridity where weathering as well as recharge are limited. Hence, in the northern arid and semi-arid areas of the country underlain by basement crystalline rocks, groundwater is scarce and problematic. Also, exploration for water becomes more challenging in topographically rugged terrains of high relief. Such areas include Sokoto, Zamfara, Kastina, Kano, Jalingo, Kaduna, Niger, Adamawa, Bauchi, Bornu South, Taraba and Gombe states. (Oteze, 1983)

In the Basement Complex fluvio-volcanic areas, aquifers are developed mostly in weathered zones, fractured zones of basalts and metasedimentary rocks. Depth to water level rarely exceeds 24 m. Most aquifers occur within 40 m of the surface under unconfined conditions (Oteze, 1983), and very few tap water to below 60 m. Mean dry season groundwater level is 12.2 m. Average regional yields from this study area vary from 0.41–15 l/ s. However, water yield may increase where the aquifer is in hydraulic continuity with surface water systems. The time lags inherent in the dynamic response of groundwater to development have generally been ignored by water management agencies, decades after scientific understanding of the issue was consolidated. In brief, the effects of groundwater overdraft (although undeniably real) may take decades or centuries to manifest themselves. (Sophocleous, 2002) . In a classic study in 1982 Sophocleous Modelled a situation where groundwater extraction in an intermontane basin withdrew the entire annual recharge, leaving 'nothing' for the natural groundwater-dependent vegetation community. Even when the borefield was situated close to the vegetation, 30 percent of the original vegetation demand could still be met by the lag inherent in the system after 100 years. By year 500 this had reduced to 0 percent, signalling complete death of the groundwater-dependent vegetation. The science has been available to make these calculations for decades; however water management agencies have generally ignored effects which will appear outside the rough timeframe of political elections (3 to 5 years). Sophocleous argued strongly that management agencies must define and use appropriate timeframes in groundwater planning. This will mean calculating groundwater withdrawal permits based on predicted effects decades, sometimes centuries in the future (Sophocleous 2002).

As water moves through the landscape it collects soluble salts, mainly sodium chloride. Where such water enters the atmosphere through evapotranspiration, these salts are left behind. In irrigation districts, poor drainage of soils and surface aquifers can result in water tables coming to the surface in low-lying areas. Major land degradation problems of soil salinity and waterlogging result. (n.d., 2010).[2] combined with increasing levels of salt in surface waters. As a consequence, major damage has occurred to local economies and environments. (Ludwig, et. al., 1993)

Four important effects are worthy of brief mention. First, flood mitigation schemes, intended to protect infrastructure built on floodplains, have had the unintended consequence of reducing aquifer recharge associated with natural flooding. Second, prolonged depletion of groundwater in extensive aquifers can result in land subsidence, with associated infrastructure damage – as well as (thirdly) saline intrusion, (Zektser, et.al., 2005) Fourth, draining acid sulphate soils, often found in low-lying coastal plains, can result in acidification and pollution of formerly freshwater and estuarine streams. (Sommer and Horwitz, 2001). Another cause for concern is that groundwater drawdown from over-allocated aquifers has the potential to cause severe damage to both terrestrial and aquatic ecosystems – in some cases very conspicuously but in others quite imperceptibly because of the extended period over which the damage occurs.(Zektser, et.al., 2005) Groundwater is a highly useful and often abundant resource. However, over-use, or overdraft, can cause major problems to human users and to the environment. The most evident problem (as far as human groundwater use is concerned) is a lowering of the water table beyond the reach of existing wells. Wells must consequently be deepened to reach the groundwater, the water table has dropped hundreds of feet because of excessive well pumping. (n.d, 2010)[3.] A lowered water table may, in turn, cause other problems such as groundwater-related subsidence and saltwater intrusion.

2.8.1 Groundwater-Related Subsidence

Subsidence occurs when too much water is sucked out from underground, deflating the space below the above-surface, and thus causing the ground to actually collapse. The result can look like craters on plots of land. This occurs because in its natural equilibrium state, the hydraulic pressure of groundwater in the pore spaces of the aquifer and the aquitard supports some of the weight of the overlying sediments. When groundwater is removed from aquifers by excessive pumping, pore pressures in the aquifer drop and compression of the aquifer may occur. This compression may be partially recoverable if pressures rebound, but much of it is not. When the aquifer gets compressed it may cause land subsidence, a drop in the ground surface. The city of New Orleans, Louisiana, is actually below sea level today, and its subsidence is partly caused by removal of groundwater from the various aquifer/aquitard systems beneath it. In the first half of the 20th century, the city of San Jose, California, dropped 13 feet from land subsidence caused by overpumping; this subsidence has been halted with improved groundwater management.

2.8.2 Seawater Intrusion

Generally, in very humid or undeveloped regions, the shape of the water table mimics the slope of the surface. The recharge zone of an aquifer near the seacoast is likely to be inland, often at considerable distance. In these coastal areas, a lowered water table may induce sea water to reverse the flow toward the sea. Sea water moving inland is called a saltwater intrusion. Alternatively, salt from mineral beds may leach into the groundwater of its own accord.

2.8.3 Mining

Sometimes the water movement from the recharge zone to the place where it is withdrawn may take centuries. When the usage of water is greater than the recharge, it is referred to as mining water. (n.d 2010)[4].

2.9 Groundwater Contamination

The pollution of groundwater is a serious matter, particular in areas where aquifers provide a large part of water supply one common source of groundwater pollution is sewage, it source include an even increasing number of septic tanks, as well as inadequate or broken sewer system and farms waste. Regardless of the source (surface or underground) water polluted by either excessive chemical constitute or faecal materials become potential agent of typhoid and paratyphoid fevers, dysentery, cholera and vital disease e.g. Hepatitis. The United Kingdom Department of health and social security (1971) has its in record a relationship between water hardness and cardiovascular diseases.

According to Saxena (1977), there exist a relationship between groundwater pollution of an area and open refuse dumps. Holler (1989) also mentioned that street refuse depositions amongst other factors like land erosion, wet and dry atmosphere deposition is a source of storm water run–off pollution which invariably ends in the ground. In another literature, Raesner and walesh (1988) claim that a urban run – off contributes tones of nutrients and pollutants to receiving water in year (groundwater inclusive).

The presence of dissolved nutrients in groundwater is attributed to the accumulation of these solutes in minute interstices and indices in the porous zones of rocks and soil. As a result of hydrolytic and enzyme characteristic of neighboring bacteria the mentioned substances concentrate within the micro-environment and consequently seep into neighboring groundwater.

It was in recent years that salt-water intrusion is a possible phenomenon in ground water quality related analysis but actually been substantiated the outcome of practical analysis. In far away Switzerland the results of study carried – put by Von – Bunten and Kull (1986) on the Glatt River indicated that rivers exert strong influence on the quality of groundwater within their influence. These can channels to adjacent aquifer. From these reviews, it is apparent that there is a variation in concentration level of groundwater constituents with season and a definite between groundwater quality and that of surface water.

Slividher (1986), observed heavy metal concentration in solid waste leach out chemical compound from dumped waste, which eventually percolated into the soil to mix groundwater. This often result to ground water of adulterated quality. Another great factor which affect groundwater quality in the soil and rock formation (limnology) for which the water is source.

In a report of the research carried out by Gillies and Brands (1980) it was discovered about 37,000 people spread over the united states suffered from outbreak of water borne disease numbering about 200 varieties between 1971 – 1977 also reported on july 29, 1999 and and june 2, 2001 from the statistic issue of U.S.A news and world report one in six American (40 million people) continue to drink water containing excessive levels of lead, a heavy metal that can impair the IQ, attention span of the children. One is six children under the age of six has elevated levels of lead in their blood. More also, "more the 1 in 5 Americans unknowingly drink underground polluted with faces, radiation or other contaminants nearly 1, 000 deaths each year and at least 400,000 cases of waterborne illness may be attributed to contaminated water or due to the use of untreated of partially treated groundwater.

A typical case study affected on ground water quality cannot be restricted to its relation with health alone; it also plays a very significant economic role. Rapid consumption of soap and increase in the role of deterioration of household cooking utensils and clothing's has been attributed to the use of underground water associated with hardness characteristics. The formation of scales inside kettles and pot due to the use of calcium carbonate ($CaCO_3$) dissolved groundwater is not uncommon. It is to be expected that naturally occurring groundwater should be the purest form of water, while this is true in some cases, it is not entirely so in others. This is due to a number of reasons, which can be classified as natural and man-made. In rain water to about 35,000 mg/L in sea-water .in order to gain true picture of the nature of particular sample of water, it is often necessary to measure several deferent properties by carrying out a standard analysis in the laboratory. For standard qualitative requirement recommended by the world health organization (1971), These requirements are classified into three broad headings of physical, chemical and bacteriological characteristics. It is to be expected that naturally occurring groundwater should be the purest form of water, while this is true in some cases, it is not entirely so in others. This is due to a number of reasons, which can be classified as natural and man-made. However, its not sufficient for man to seek water but also ensures that it is suitable in nature to his needs. This is of where the question of quality comes in it's necessary that the quality of water is utilized for various course such as Agricultural, Residential, Industrial, and Natural functions must be monitored because water of good quality is of prime importance in order to ensure good health. It is in view of his relevance amongst others that the International Hydro-geological Decade, I.H.D (1965 – 1974) was launched at the 13th session of the general conference of UNESCO with the purpose of enlightening all countries to make a better assessment of their water resources and a more rational use of them. The management of water in relation to human health is a vital aspect. Various research works previously carried out on water revealed the quality aspect of water is an integral one. Atherton "et al" (1946) established that water should be clear, colorless and relatively soft. In addition, it was asserted that water should be free from disease producing bacteria (pathogens) in order to become useful.

According to Hammer (1977) polluted water is that which is found to be unacceptable for its interacted usage. The degree of its unacceptability learns on a number of physical, chemical and Biological characteristics. An attempt to classify the quality of groundwater without a consideration of its interlink with surface water will be inadequate. It is an entirely wrong notion to believe the groundwater and surface water are each antonymous and independent. This is because one of the sources of groundwater is surface water, which seeps through cracks, fissures and joints within stratified layers of soil to form it's own body (aquifer) after sufficient accumulation. It is therefore not a futile attempt to study the effect of groundwater as related to the quality of groundwater.

2.9.1 Sources of Water Contamination in Groundwater

All water is susceptible to contamination it may accumulate contaminants from the air, ground or from rocks. Groundwater contamination when man made substance, or in some naturally occurring substance are dissolved in water recharging the groundwater zone source of contamination include storage tanks, hazardous waste sites uncontrolled landfills septic system and both legal and discharges to the environment. These contaminations include the chemicals found in gasoline oil and road salt and can cause groundwater to become unsafe for human consumption. Contamination of groundwater also occurs through natural means arsenic and lead in rock formation can migrate into groundwater. Hammer (1977)

Groundwater becomes contamination as contaminants move from a source, through the soil and into groundwater. Contamination varies their ability to move through soil. Low pH (acidic) groundwater can cause metal to leach, but the effect of high pH (alkaline) water on movement of metals is not completely understood. Also for example gasoline components such as benzene, will tend to stay in the air packet in the soil but of contamination (Charles, 2002).

Sources of groundwater contamination come in a great variety of sizes and shapes. It may be a leaking underground pipeline or tank, a waste water lagoon, a septic system leaching field, a spill into a drain at a factory, or leaking barrels of waste chemicals. These examples are all relatively small and would be classified as point sources. On the other hand, nonpoint sources are larger, broadly distributed sources. Examples of nonpoint sources include polluted precipitation, pesticides applied to a cropland, and runoff from roadways and parking lots. Sometimes contamination is introduced to the subsurface as an aqueous solution such as septic system effluent or landfill leachate. This is not always the case, though. The source of contamination can be a spilled separate liquid phase like gasoline or dry cleaning solvent. These liquids, usually organic, are known by the acronym NAPL, for nonaqueous-phase liquid. NAPLs can persist in the subsurface and slowly dissolve into the water, acting as a continuous point source for years. Organic contamination and NAPLs are such a large portion of groundwater contamination. (Charles, 2002).

2.9.1.1 Leaking Storage Tanks

Tanks are widely used to store fuels and chemicals, and many of these have leaked over the years. Underground tanks have caused the most contamination, because they can leak slowly for a long time without being discovered. The U.S. Environmental Protection Agency estimated that by 1996 there had been 318,000 releases from underground storage tanks reported at the federal, state, and local levels in the U.S. (EPA, 1996). The most common tank sources are gas tanks at filling stations, and fuel and solvent storage tanks at industrial facilities. What leaks out of these are organic NAPLs. Most tanks installed before the 1970s were bare steel tanks that tended to corrode. Many of these tanks and their associated piping eventually sprang leaks when corrosion went too far. Most of us have seen gas stations, temporarily closed, with gaping excavations made for removal of the old tanks and installation of the new. Newer tank systems are most commonly made of fiberglass-reinforced plastic, coated and cathodically protected steel, or composites of these two materials. Cathodic protection greatly slows the rate of galvanic corrosion of buried steel tanks and piping. Hundreds of thousands of these new types of tanks have been in service in the U.S. for up to 30 years, with very few failures reported (EPA, 1988). New tanks sometimes have double wall layers with leak-detection devices between the walls. As of 1998, underground storage tanks in the U.S. have to meet certain requirements regarding leak detection, spill and overfill protection, and corrosion protection.

2.9.1.2 Septic Systems

Septic systems for subsurface disposal of human wastewater are the rule in more rural areas not served by sewers and sewage treatment systems. Most septic systems serve a single household, but some larger systems serve a cluster of homes and/or offices. A typical septic system starts in the series of drainpipes in a home's plumbing system. These all connect and drain to one pipe that runs outside to a buried septic tank, where solids settle and are trapped. The tank needs to be pumped out periodically to remove accumulated solids. From the tank, wastewater flows to a leaching field, usually a network of porous distribution pipes set in a porous material in the unsaturated zone (Fig 2.2).

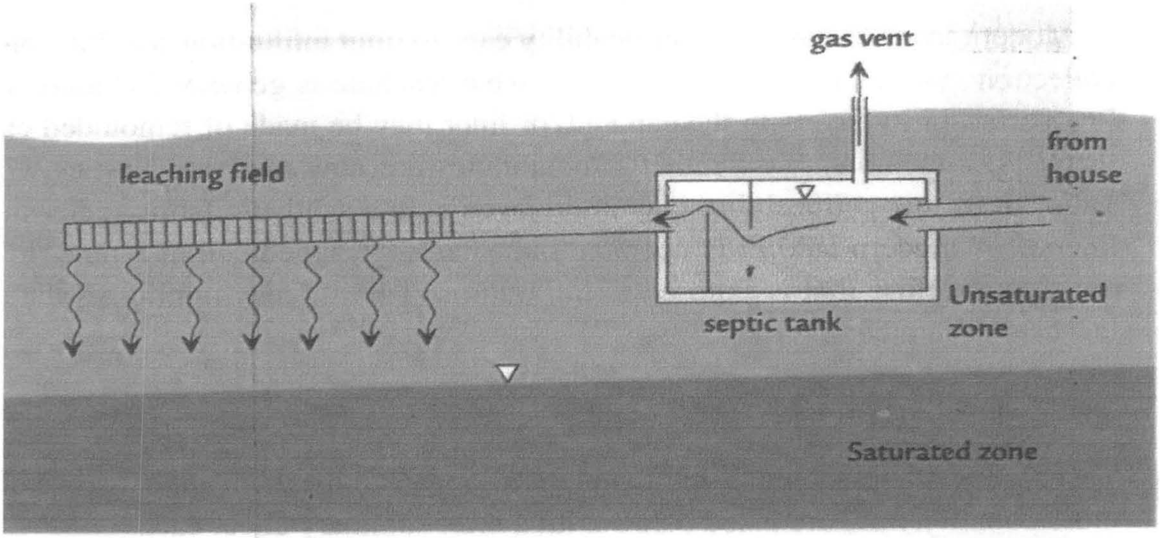

Fig 2.2 Typical household septic system (Charles, 2002).

Wastewater contains dissolved organic compounds that fuel redox reactions in microbes that live in the system. Redox reactions in the tank are usually anaerobic, including fermentation, methane generation, and sulfate reduction (Wilhelm et al., 1994). The water leaving the tank has high concentrations of organic compounds, CO_2, and ammonium (NH^+_4). The concentrations of organic compounds and NH^+_4 decrease, CO_2 is evolved, and the nitrate (NO^-_3) concentration increases. It is typical for effluent leaving the unsaturated zone of a properly functioning leaching field to have nitrate concentrations in the range of 20 to 70 mg/L (NO^-_3 ¯N: mass of nitrogen in nitrate per volume), which exceeds the U.S. drinking water MCL of 10 mg/L (NO^-_3 ¯N). In most septic systems, nitrate is the only groundwater contaminant of concern. Some septic system designs include another anaerobic zone beyond the aerobic zone in the leaching field, where denitrification reduces nitrate concentrations in the effluent (Robertson and Cherry, 1995., Robertson *et al.,* 2000). Septic systems fail when the leaching field doesn't have enough access to oxygen to fully degrade the organic carbon with aerobic respiration. This can happen when the system is placed too close to the water table, in soils that are too fine grained, or in old systems that become clogged with a biological mat that remains saturated.

2.9.2 Organic Contaminants

A large portion of all groundwater contamination problems involve organic contaminants. We use vast quantities of hydrocarbon fuels, solvents, and other organic liquids and it should come as no surprise that they are frequently spilled into the subsurface. Some releases were intentional, many of them perfectly legal because there used to be little or no regulation of waste disposal. Between the 1950s and the 1980s, environmental awareness and regulation increased dramatically, so now most releases are accidental or illegal. Until the last several decades, few people were aware that spilled organic liquids could move deep into the subsurface, dissolve into groundwater, and then migrate great distances. Organic contamination can migrate as a separate liquid phase, in the aqueous phase, and in the gas phase. Typical patterns of migration are discussed in the following section.

2.10 Drinking Water Quality

In preparing the following table of parameters and maximum permitted limits, care has been taken to ensure that flexibility is carefully managed and balanced taking into consideration water system economic viability without unduly compromising the health of the consumers. The substances in Nigerian Industrial Standard for Drinking Water Quality are simply divided into physical, chemical organic and inorganic constituents, disinfectants and disinfectants by-products, radionuclides and microbiological parameters. All drinking water shall at any time meet the minimum requirements set out in Table 2.1. All water sources intended for human consumption shall comply with Nigerian Standards for Drinking Water

Quality and shall receive authorization from Ministry of Health before being supplied to the population, Nigerian Industrial Standard (2007).

Table 2.1 Water Quality Standard

Parameters	Unit	Maximum permitted level	Health impact
Physical			
Colour	TCU	15	None
Turbidity	NTU	5	None
Temperature	^0C	Ambient	None
Ph		6.5-8.5	None
Conductivity	µS/cm	1000	None
Chemical			
Hardness (as $CaCO_3$)	Mg/l	150	None
Nitrate (NO_3)	Mg/l	50	Cyanosis, and asphyxia („blue-baby syndrome") in infants under 3 months syndrome") in infants under 3 months

Parameters	Unit	Maximum permitted level	Health impact
Sulphate (SO4)	mg/L	100	None
Nitrite (NO2)	mg/L	0.2	Cyanosis, and asphyxia („blue-baby syndrome") in infants under 3 months
Iron (Fe+2)	mg/L	0.3	None
Copper (Cu+2)	mg/L	1	Gastrointestinal disorder,
Chloride (Cl)	mg/L	250	None
Lead (Pb)	mg/L	0. 01	Cancer, interference with Vitamin D metabolism, affect mental development in infants, toxic to the central and peripheral nervous systems

Parameters	Unit	Maximum permitted level	Health impact
Chromium (Cr6+)	mg/L	0.05	Cancer
Microbiologicals			
Total Coliform count	cfu/mL	10	Indication of faecal contamination
E.coli	cfu/100mL	0	Urinary track infections, bacteraemia, meningitis, diarrhea, (one of the main cause of morbidity and mortality among children), acute renal failure and haemolytic anaemia

Nigeria Industrial Standard (2007)

2.11 Minimum Separation Distances

When drilling or constructing a bore within a Water Control District, Bore Construction Permit holders must uphold the following condition from the Terms and Conditions of the Permit, that is Separation distance from any obvious pollution sources such as; the closest part of any septic tank effluent trench, fertilizer storage, chemical storage, packing sheds, plant workshops, and animal enclosures must be a minimum of 100m NRETAS (2004).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

3.1.1 Location extent accessibility

The study area Bosso, is within Minna Capital of Niger state, Nigeria. Maikunkele which is the Headquarters of the council about 12 kilometers from the central of Minna Metropolis, The area is accessible through a major road linking Zungeru – Minna – Suleja. The area mapped lies between longitude 6°13E and 6°40E and latitude 9°23N and 9°50N covering a total area of about 900km^2. The 2006 National Housing Census put the Human population of the local Government at 147,361,000

3.1.2 Climate vegetation and land use

Bosso has a special savannah climate with distinct rainy, dry and harmattan seasons respectively. The dry season occurs between October/November and ends at about march/April while the rainy season starts at about April/May through September/October and harmattan period starts around November through February.

Temperatures prevailing in the area are generally high with values ranging from 24°C to 35°C with an annual mean of about 30°C. The average rainfall is about 250mm.

Bosso has the largest number of inhabitant in Niger State, villages and hamlets are scattered around the state, peasant farmers who cultivate yam, rice, guinea corn, maize, millet, pepper, vegetables and Tomatoes which thrives abundantly due to the availability of sandy soil from weathered rocks of the Minna batholiths.

3.1.3 Drainage and Relief

The relief of the area is flat lying of the landscape occurring in only a few parts of the area. The topography of the area is controlled by its geology. The areas close to the main road have a good drainage network that generally keeps the area partially dry and free from flooding during the rainy season. However some parts are water logged in the study area.

3.1.4 Sample

Three water samples were collected from boreholes in the study area.

3.1.5 Apparatus

Spectrophotometer, Cuvette cork, conductimeter, Lovibond, colour comparator, Incubator, Autoclave, Mc cathy bottles, Bunsen burner, Sterile needle and syringe (5ml and 10ml), Measuring Cylinder (50ml, 100ml and 200ml), Durham tubes (5ml, 10ml, 15ml), Aluminium container, Clay pot, Plastic container, Brilliant green lactose bile broth (21%) Lactose broth, Mc Cathy bottles, Bunsen burner, beaker (10ml, 250ml and 500ml), Conical flask (10ml, 50ml and 250ml), disinfectant, autoclave, distilled water, masking tape, weighing balance, and Durham Tube.

Table 3.1 Show's the Locations of where the samples were collected

S/N	SAMPLE LOCATION	DESCRIPTION	SAMPLE SOURCE
A	Maikunkele (Church Borehole)	The Borehole is situated near rice farming and refuse dump site	Borehole
B	Bosso district	The Borehole is situated in the centre of houses. The location of the septic tank is slope towards the borehole of about 50m.	Borehole
C	Duste Kura Hausa	The borehole is located close to the residential buildings.	Borehole

Field survey (2010)

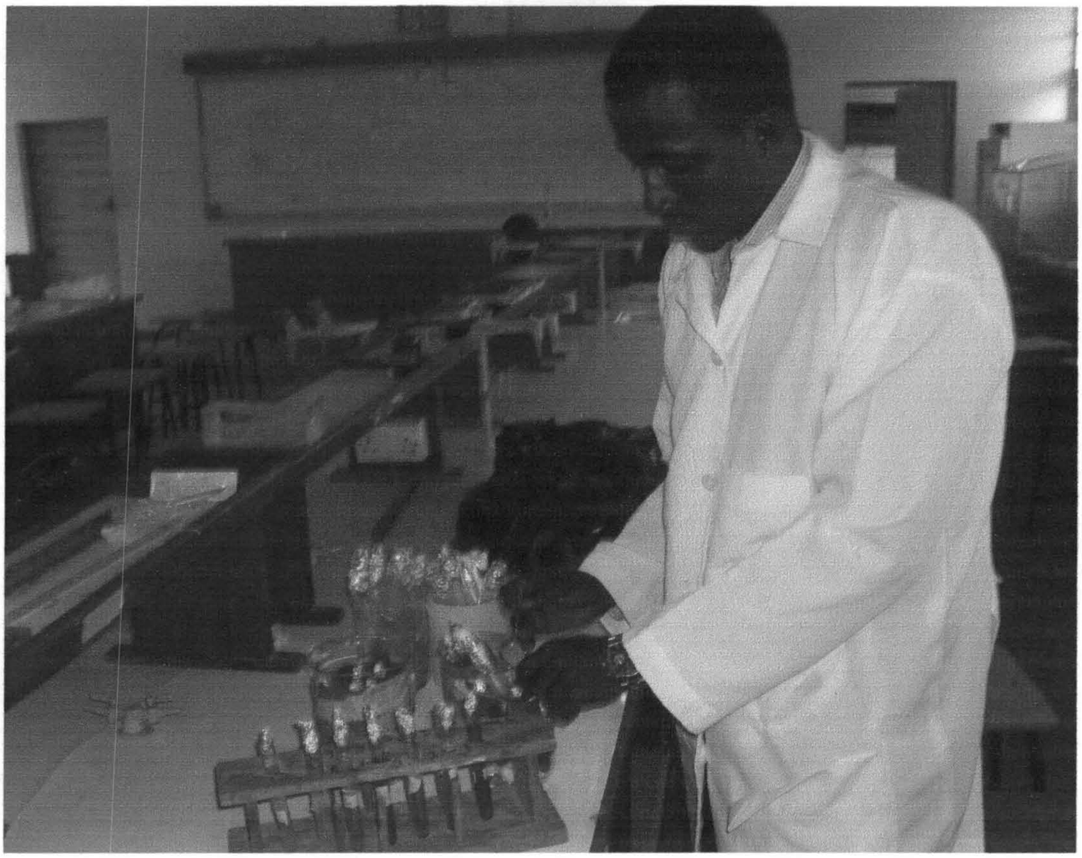

Plate 3.1 Laboratory analysis (2010)

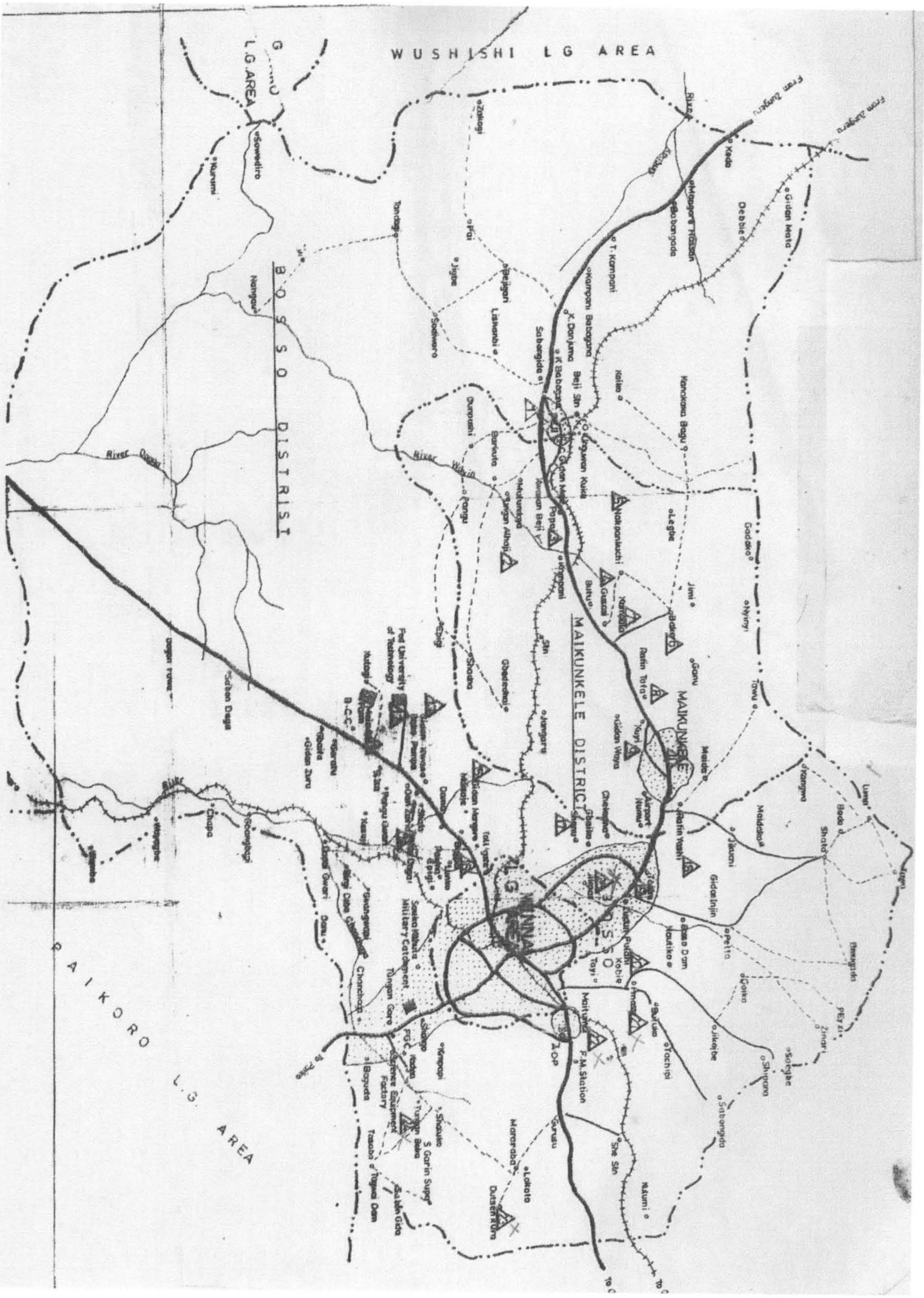

Fig 3.1 Map of the Study Area Bosso Local Government (2010)

3.2 Methods

3.2.1 Field investigation

I went to the field observing the sites, collected water samples and carried out water investigation.

Three water samples were collected from wells and boreholes located within the study area. Water sample were collected between June and July 2010 to ensure that the effects of surface run-off and infiltration would be minima. The analysis was carried at Niger State Water Board western By- pass, Minna and Microbiology laboratory, FUT Minna

3.2.2 Measurement of physical parameters

i. Conductivity

ii. Temperature

iii. P^H

3.2.3 Laboratory analyses

Samples of water from borehole water were collected in different of plastic containers and were labeled A, B, and C respectively.

3.2.4 The Method of Determination of Physical, Chemical and bacteriological parameters are in the Appendices B_1 to B_{16}

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 Presentation of Results

This chapter presents the result obtained from the analysis of the collected three water samples, which are shown in Table 4.1 below. These results include the chemical, physical and bacteriological analyses of water samples from the study Area.

The original result of physico-chemical analysis from Niger State Water Board, is presented in Appentice A_1

Table 4.1 presentation of Physical, Chemical and Bacteriological Results

S/N	PARAMETERS		SAMPLES		
			A	B	C
1	Electrical Conductivity	µs/cm	206	208	206
2	Total dissolved solid	mg/l	103	104	106
3	Suspended solid	mg/l	06	03	04
4	Turbidity	ftu	02	04	02
5	Colour	ptco	06	12	04
6	PH		8.2	8.2	8.4
7	Total hardness as CaCo3	mg/l	172	173	172
8	Hardness (Ca) as CaCo3	mg/l	68.8	69.2	68.8
9	Hardness (mg) as CaCo3	mg/l	103.2	103.8	103.2
10	Alkalinity mg/l		0	0	0
11	Total Alkanity mg/l		142	146	150
12	Sulphate mg/l		162	171	163
13	Phosphate mg/l		0.01	0.01	0.01

S/N	PARAMETERS	SAMPLES		
		A	B	C
14	Nitrate mg/l	31.68	35.20	36.08
15	Nitrite mg/l as nitrogen mg/l	7.3	8.0	8.2
16	Nitrite mg/l	0.02	0.02	0.02
17	Iron content mg/l	0.29	0.31	0.3
18	Chloride mg/l	62	63	62
19	Chromium µg/l	0	0	0
20	Temperature oC	27.0	27.0	27.0
21	Lead µg/l	0	0	0
22	Copper mg/l	1.01	1.2	1.03
23	Coliform Cfu/100ml	460/100	15/100	7/100
24	E-coli Cfu/100ml	15/100	0/100	3/100

Field analysis NSWB, (2010)

The Separating distance from obvious pollution sources such as the closest part of any septic tank effluent trench, fertilizer storage, waste dump and animal enclosures are shown in table 4.2.

Table 4.2 Distances between waste dumps and the water sources

Samples	Septic tank (m)	Dump site (m)	Water log (m)
A	70	4.2	3.2
B	25	30	40
C	28.9	7	6

Field investigation (2010)

4.2 Discussion of Results

The results of the analyses which were given in Table 4.1. Shows that the level of some constituents are dangerously higher than the permitted level by Nigerian Industrial Standard 2007 and WHO'S drinking water standard.

4.2.1 Cations

4.2.1.1 Calcium: In the sulphate form ($CaSO_4\ 2H_2O$) is relatively less soluble in water. In calcium chloride and calcium nitrate form, the minerals are very readily soluble in water. However high concentration of calcium in water tends to precipitate soap, and is object able in laundry and other domestic and industrial purposes. Low calcium intake can be related to hypertension and cardiovascular disorders, with low level of calcium in the diet drinking water may provide a significant portion of the daily calcium. The mean concentration for samples A, B and C are 172mg/l, 173mg/l, 172 mg/l, which are higher than Nigerian Industrial Standard and WHO for Drinking Water Quality permissible limit of 150mg/l

4.2.1.2 Iron: The ranges of their concentrations are high in all the samples examine, higher than the Nigerian industrial Standard and WHO Permissible limit of 0.3. Iron can appear as dark flecks that stain clothing and plumbing, and can promote the growth of iron and manganese bacteria that can form slimy black colonies that clog pipes.

4.2.1.3 Copper : The concentration of copper in the sampled boreholes are higher than Nigerian Industrial Standard and WHO permissible limit of 1mg/l , It can be inferred that the underground rocks in that environments constitute high copper concentration. hence it is not good for drinking.

4.2.1.4 Lead: the boreholes are free from lead with a concentration of 0 mg/l.

4.2.2 Anions:

4.2.2.1 Chloride – chlorides are salt compounds resulting from the combination of the gas chloride and metal some common chloride includes sodium chloride (NaCl) and magnesium Chloride ($MgCl_2$). High Chloride level can be can cause human illness. Chloride can get into groundwater through rocks containing level Chlorides Agricultural runoff and effluent waste water the evaluated level of chloride in water can be attributed to geological factors such as weathered rocks materials. The samples of the borehole water have low concentration of chloride which is very acceptable.

4.2.2.2 Nitrate is regarded as an indicator of pollution in groundwater. The increase application of fertilizer also from human waste. The concentration of Nitrate found in the samples are close to to the permissible limit which is not also acceptable. The state of anion NO_3 is not absorb by the soil and moves with infiltrating water some Nitrate in groundwater are due to natural occurring sources, typically indicate that the pollution is seeping in from septic tanks, animal waste, sewage sluge, fertilizers opens dumps the drinking standards for nitrate level in the groundwater far exceed the WHO and Nigerian Industrial Standard recommended standard of 50mg/l evaluated nitrate level in the water can be attributed to the poor sanitary condition of the Area , since most homes are equipped with simple unlined part latrines with a direct contacts with groundwater.

4.2.2.3 Bicarbonate: when carbon dioxide dissolved in water their presence has been found to be highly dependent on the PH of the water because when a pH of 8.2 and above occurs in solution HCO_3 loses its hydrogen to become carbonate. Water from the boreholes all have P^H of 8.2, 8.2 and 8.4 respectively which makes them undesirable

4.2.2.4 Carbonates – the concentration range falls with this might be due to dissolution of carbonate rocks.

4.2.2.5 Electrical conductivity is use to estimate the total amount of dissolved salts or solid in water measured in ohms / cm at the water temperature the range of conductivity falls between 206µs/cm Maikunkele(A) 208µs/cm Bosso District(B) and 206µs/cm Dause Hausa (C) It can be inferred that a soluble rock must have underlined the well and can also be inferred that the material that made up the concrete ring might contributed to the high value while that the borehole shows that the mineral present are weak soluble.

4.2.2.6 Temperature of water is important in times of its intended use it treatment to remove impurities and its transport. The temperature is a function of the source of water. The range of water collected all are 27 °c. Higher for boreholes where human activities are prominent this indicates that the borehole gets its temperature source not only from the radioactive minerals present underground only also through other human activities.

4.2.2.7 pH: the water are basic in nature, their pH range falls from 8.2 – 8.4, thus good for drinking when compared by Nigerian Industrial Standard and WHO Standards. Ground water quality can be affected by different form of pollution, which includes liquid and solid waste.

The pollution factor can influence natural and human cause whether directly or indirectly by certain factors that limit water location for specific purposes.

4.2.3 Water pollution in Bosso

Water pollution of groundwater, from pollutants released to the ground which work their way down into groundwater, create a contaminant plume within an aquifer. Movement of water and dispersion within the aquifer spreads the pollutant over a wider area, its advancing boundary often called a plume edge, which can then intersect with groundwater wells or daylight into surface water such as seeps and springs, making the water supplies unsafe for humans and wildlife.

Water contaminants are natural or Anthropogenic (man made). The manmade contaminants are the major causes of groundwater pollution in Bosso from the research carried out on the samples shows that most communities in Bosso suffer from chronic shortages of freshwater or the readily accessible water resources are heavily polluted. Accelerated population growth coupled with impoverished socioeconomic development with limited water resources and poor sanitation, leads to an increase in diseases associated with poor living conditions among which water-related and water-borne diseases play a major role. They get their drinking water supply from groundwater sources. People from these communities often complain that the water tastes brackish which is normally an indication of poor quality,

From the research it was observe that the contaminants are mainly NO_3, CL^- and faecal pellet (Coliform and E-coli)

4.2.4 Water logging in Bosso

Excessive irrigation on poorly drained soils is water logging. This occurs (as is common for salinization) in poorly drained soils where water can't penetrate deeply. For example in Bosso, there is an impermeable clay layer below the soil. It also occurs on areas that are poorly drained topographically. What happens is that the irrigation water (and/or seepage from canals) eventually raises the water table in the ground, the upper level of the groundwater, from beneath. Growers don't generally realize that water logging is happening until it is too late, tests for water in soil are apparently very expensive. The raised water table results in the soils becoming waterlogged. When soils are water logged, air spaces in the soil are filled with water, and plant roots essentially suffocate, lack oxygen. Water logging also damages soil structure. Worldwide, about 10 percent of all irrigated land suffers from water logging. As a result, productivity has fallen about 20 percent in this area of cropland

4.2.5 Overdrafting in Bosso

Groundwater is a highly useful and often abundant resource in Bosso. However, over-use, or overdraft, causes major problems to human users and to the environment. The most evident problem (as far as human groundwater use is concerned) is a lowering of the water table beyond the reach of existing wells. Wells must consequently be deepened to reach the groundwater; in some places (e.g, Elwaziri) the water table has dropped hundreds of feet because of excessive well pumping, and the rate of depletion is accelerating. A lowered water table may, in turn, cause other problems such as groundwater-related subsidence and saltwater intrusion in some places.

4.2.6 Opportunities of Groundwater Use

Ironically, at the heart of all these problems that Bosso faces are the unique advantages that groundwater has and the opportunity this offers for human development. Groundwater is accessible to a large number of users; it can provide cheap, convenient, individual supplies, it is generally less capital-intensive to develop, and does not depend upon mega-water projects. Groundwater development is also largely self financing, its largely private development and use ensure automatic cost recovery. When it is not degraded by human intervention, the major advantage of groundwater is its high microbiological quality, arising from its situation below ground and the natural protection this affords. Compared to surface water, which is flashy in nature, groundwater offers better insurance against drought because of the long lag between changes in recharge and responses in groundwater levels and well yields. Irrigation with groundwater is also generally more productive compared to much surface water irrigation, groundwater is produced at the point of use, needing little transport, it offers individual farmer irrigation "on demand" that few surface systems can offer, and because its use entails significant incremental cost of lift, farmers tend to economize on its use and maximise application efficiency.

4.2.7 Responses to Groundwater Depletion

By far the most serious groundwater challenge facing the world, then, is not in developing the resource but in its sustainable management. As problems of groundwater depletion and its deleterious consequences have surfaced in different parts of the world, a variety of responses have been forged to mitigate or even reverse these. The standard reasoning is that even after 800,000 big and small dams around the world, the reservoirs can capture and store no more than a fifth of the rainwater, the bulk of the remainder still running off to the seas. Minna has more than its share of the Nigeria's dams but a greater portion of its rainwater precipitation still run off to the seas annually in the form of "rejected recharge". If a fraction of this could be stored underground by reducing the velocity of the runoff and providing time for recharge, groundwater supplies could be enhanced significantly. Below are approaches for responding to groundwater depletion.

4.2.7 .1 Recharge with Rainwater

Long-distance transport of large quantities of water is however often problematic besides being expensive. In many parts of the Niger State, especially in Bosso, increasing stress is being placed on in situ rainwater harvesting and recharge. This approach seems particularly important because, in Bosso, the bulk of the year's rainfall is received in between two months August and September in heavy downpour, providing little time for recharging the groundwater. Moreover, the relationship between the recharge area, recharge rate and the extent of sustainable groundwater irrigation is now becoming increasingly important.

4.2.7.2 Vegetative Treatment of the Catchment

Vegetative cover on the free catchment of a basin has proven to be a problem as well as an aid to groundwater recharge. In contrast, there is a growing worldwide movement to promote the cultivation of vetiver grass hedgerows as a powerful way of reducing the velocity of rainwater runoff and recharging groundwater. The Vetiver Network, supported by the World Bank, the Government of Denmark and several global NGOs claims that rainwater runoff is reduced by 70 percent when vetiver hedgerows are planted across the slope by slowing down and spreading out runoff over a larger area because the strong roots of this grass can penetrate hard pans and improve infiltration.

4.2.8 Responses to Groundwater waterlogging and salinization

Both waterlogging and salinization could be reduced if the efficiency of irrigation systems could be improved, and more appropriate crops (less water hungry) could be grown during the dry season.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Groundwater is the source of water for wells and stream it is found underground within crack in bedrock or filling the space between particle of soil and rock. The groundwater studies in this basement terrain tend to produce consistent results which are similar from region to region. It is quite possible to make some conclusive statements based on this research work. The results of the physical, chemical and bacteriological analyses indicates that the ground water in study area is not portable and suitable for drinking purposes due to high concentration of Nitrate, chloride, iron, copper, sulphate, E-coli and Coliform. Also all the groundwater samples collected have more than 0.28mg/l of iron in solution, precipitations after exposure to air causes stain to laundry and cooking utensils, also impart objectionable tastes and colours to food and drink , stain plumbing fixture. Defective well construction and failure to seal abandoned wells cracked casing, leakage of pipe, the minimum distance between water source and (toilet, septic tank and waste deposit site) which is 100 m, as well as poor groundwater production management are responsible for pollution or contamination of groundwater in Bosso Communities.

5.2 Recommendation

i. We also recommend that a fracture of "rejected recharge" be stored underground by reducing the velocity of the runoff and providing time for recharge, groundwater supplies could be enhanced significantly.

ii. I recommend that the Protection of groundwater quality and quantity such as Nitrates and chloride can best be accomplished by controlling potential contaminant sources and by managing land use in the recharge area.

iii. I recommend that groundwater sources should be at least 100 meters from sewer, septic tanks, waste dump etc.

iv. I recommend that Vetiver hedgerows be planted across the slope to slowing down and spreading out runoff over a larger area because the strong roots of this grass can penetrate hard pans and improve infiltration.

v. I recommend that the efficiency of irrigation systems should be improved to reduce waterlogging and salinization, and more appropriate crops (less water hungry) should be grown during the dry season.

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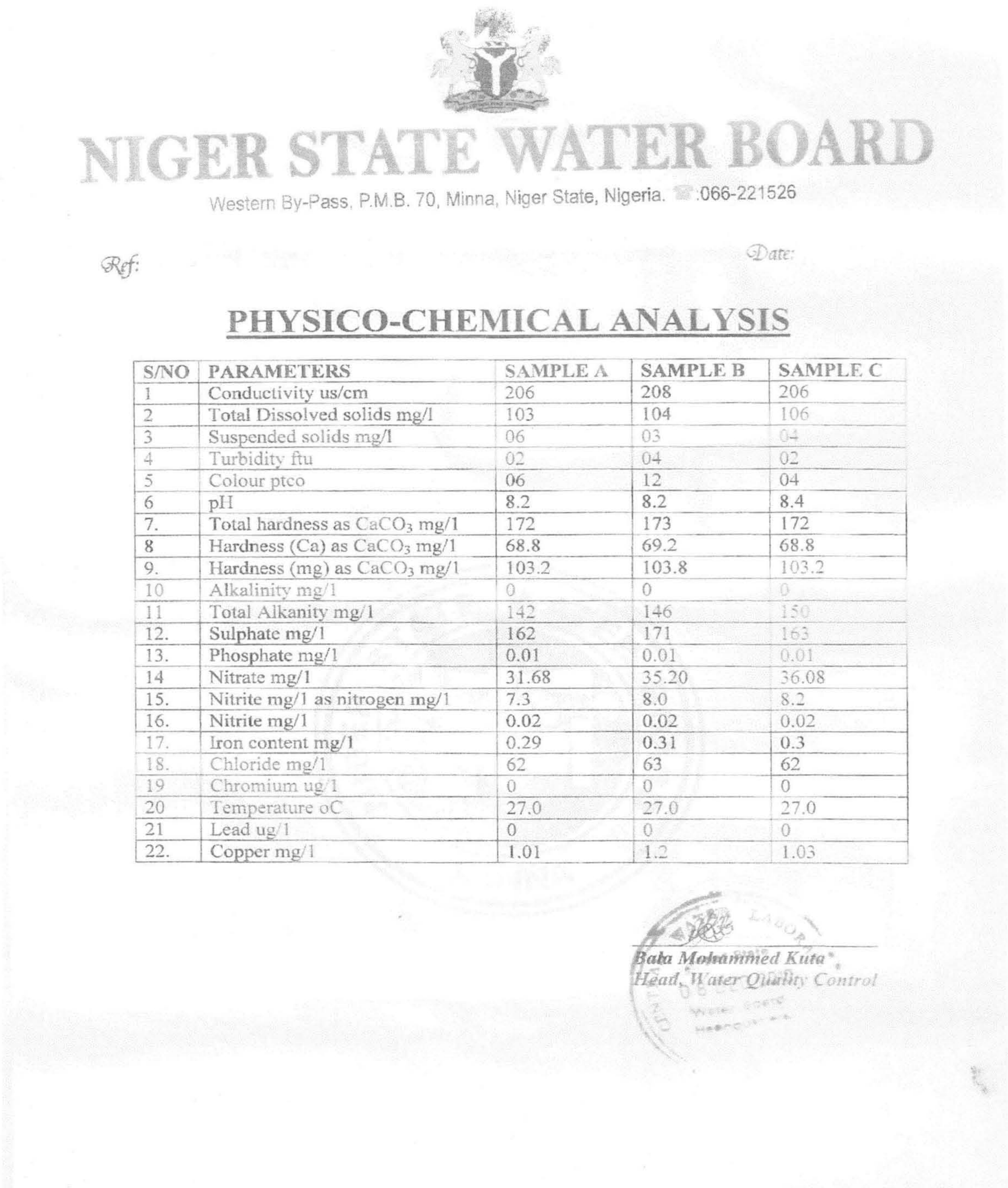
APPENDICES

A$_1$ RESULT OF PHYSIO-CHEMICAL ANALYSIS



NIGER STATE WATER BOARD

Western By-Pass, P.M.B. 70, Minna, Niger State, Nigeria. ☎:066-221526

Ref:

Date:

PHYSICO-CHEMICAL ANALYSIS

S/NO	PARAMETERS	SAMPLE A	SAMPLE B	SAMPLE C
1	Conductivity us/cm	206	208	206
2	Total Dissolved solids mg/l	103	104	106
3	Suspended solids mg/l	06	03	04
4	Turbidity ftu	02	04	02
5	Colour ptco	06	12	04
6	pH	8.2	8.2	8.4
7.	Total hardness as $CaCO_3$ mg/1	172	173	172
8	Hardness (Ca) as $CaCO_3$ mg/1	68.8	69.2	68.8
9.	Hardness (mg) as $CaCO_3$ mg/1	103.2	103.8	103.2
10	Alkalinity mg/1	0	0	0
11	Total Alkanity mg/1	142	146	150
12.	Sulphate mg/1	162	171	163
13.	Phosphate mg/1	0.01	0.01	0.01
14	Nitrate mg/1	31.68	35.20	36.08
15.	Nitrite mg/1 as nitrogen mg/1	7.3	8.0	8.2
16.	Nitrite mg/1	0.02	0.02	0.02
17.	Iron content mg/1	0.29	0.31	0.3
18.	Chloride mg/1	62	63	62
19	Chromium ug/1	0	0	0
20	Temperature oC	27.0	27.0	27.0
21	Lead ug/1	0	0	0
22.	Copper mg/1	1.01	1.2	1.03

Bala Mohammed Kuta

Head, Water Quality Control

B_1 Color Determination

Using spectrophotometer, the stored program number (120) for true colour was entered. "Read/Enter" was then pressed and Dial nm455. The nub of the wave length dialed was rotated until the small display showed 455nm then "Read/Enter" was pressed. The display showed platinum cobalt (P_tC_o). A sample cell (the blank) was filled with 25ml of deionized water. The blank was placed into the cell holder. The light shield was closed. "Zero" was pressed. The display showed "Wait" and then O. units P_tC_o colour was shown. The water sample (A) from clay pot, which was measured into a cell, was placed into the holder. The light shield was closed, "Read/Enter" was pressed, and the display showed "Wait" and then the result platinum cobalt units was displayed. When the display stabilized, the result was recorded.

B_2 Determination of Turbidity

The store program number for turbidity was entered into the spectrophotometer. 750 "Read/Enter" was pressed. The display showed; "Dial" nm to 450. The wavelength dialed was rotated until the small display showed; 450nm "Read/Enter" was pressed. The display showed; FTU Turbidity. 25ml of deionized water (the blank) was poured into a sample cell. The blank was placed into the cell holder. The light shield was closed, zero was pressed; on the spectrophotometer. Then, O formazin turbidity unit (FTU) was shown; 25ml of sample A was poured into another cell. Immediately, the sample cell was placed into the cell holder. The light shield was closed. "Read/Enter" was pressed. The display showed "Wait". Then the results in formazin Turbidity units (FTU) were displayed. When the display stabilized, the results were recorded. Same was done for sample B and C.

B_3 Determination of Total Solid Dissolved

A conductometer was used in determining TDS (Total Dissolved Solid). The electrode was placed in deionized water and swilled to stabilize the electrode. This electrode was then placed into sample A in a beaker and the reading was displayed on the conductometer screen. Same was done to sample B and C.

B_4 Determination of Potential Hydrogen (pH)

The pH was determined using universal pH strips and lovibond colour comparator with phenol red as an indicator. 2 clean 10ml cuvettes were used. Distilled water was filled in one of the 10ml curette and 1 to 2 drops of phenol red was added. The phenol red disc was placed in the lovibond comparator. It was then rotated for colour matching. The reading was then recorded.

B_5 Suspended Solid Determination

The stored program number was entered for suspended solids. 630R "Read/Enter" was pressed. The display showed: "Dial" nm to 810. The wavelength dialed was rotated until the small display shows: 810nm. "Read/Enter" was pressed. The display showed: Mg/L suspended solids. The sample was filled cell with 25ml of deionized water (the blank). The blank was placed into the cell holder. The light was closed, "Zero" was pressed, the display showed "Wait". Then 0.mg/L suspended solid was shown the prepared sample cells were covered to remove any gas bubbles and uniformly suspended residue. The prepared sample was placed into the cell holder. The light shield was closed. "Read/Enter" was pressed, the display showed: "Wait". Then the result in mg/L suspended solids was displayed and recorded. Same procedure was done for sample B and C.

B_6 Determination of Temperature

Temperature/conductivity/T.D.S meter was switched on by pressing the appropriate button. The probe was immersed in the beaker containing the sample A and moved up and down and taped on the beaker to free any bubbles from the electrode area. The probe was immersed beyond the vent holes. The reading was recorded in degree Celsius (oC). Same procedure was done for sample B and C.

B_7 Determination of Sulphate

The stored program for sulphate (SO_4^{2-}) was entered. 680 "Read/Enter" was pressed. The display showed "Dial" nm to 450". The wavelength dialed was rotated until the small display showed 450nm. "Read/Enter" was pressed. The display showed mg/l SO_4^{2-}. A clean sample cell was filled with 25ml of sample. The content of one sulf over 4-reagent powder pillow was added to the sample (the prepared sample). It was swirled to dissolve. A while turbidity developed unifying the presence of sulphate. "Shift timer" was pressed. A 5 minutes reaction period began. The cell was allowed to stand undisturbed. When the timer beeps, the display showed: mg/l SO42-. A second sample cell was filled with 25ml of sample (the blank). The blank was placed into the cell holder. The light shield was closed. "Read/Enter" was pressed. The display showed "Wait". Then the result in mg/l SO_4^{2-} was displayed. Same procedure was done for sample B and C.

B_8 Determination of Chloride

100ml of the sample and Mecuric Nitrate ($Hg(NO_3)_2$) titration catridge corresponding to the volume of sample was selected. A clean delivery tube was inserted into the titration cartridge. Digital titrator with the catridge tip pointed up. Delivery knob was turned to eject air and a few drops of the titrant. The counter was reset to zero and the tip was wiped. A clean graduated measuring cylinder was used to measure 100 ml of the sample A. the sample was transferred in to 250ml of conical flask. One Diphenyl carbazone powder pillow was added and swirled to mix. The delivery tube tip was placed into the solution and swirled while titrating with the mercuric nitrate from a pale yellow to light pink colour. The number of digits was recorded. Same was done for samples B and C.

Calculation:

Digit × Digit multiplier = mg/l Chloride.

B_9 Determination of Total Hardness, Magnesium and Calcium

100ml water sample was poured into a 100ml graduated mixing cylinder. 1.0ml of calcium and Magnesium indicator solution using a 1.0ml measuring dropper was added. It was inverted several times to mix. 25ml of solution was poured into each of three sample cells. One drop of 1M EDTA solutions was added to one cell (the blank). It was swirled to mix. One drop of EDTA solution was added to another cell (the prepared sample) and swirled to mix. A stored programme number for magnesium was entered. 225 “Read/Enter” was pressed. For units of mg/l mg as CaCO3. The display showed “Dial” nm to 522. The wave length dial was rotated until the small display shows: 522nm. “Read/Enter” was pressed. The display showed mg/l CaCO3 mg. the blank was placed into the cell holder. The light shield was close, Zero was pressed. The display showed “Wait” the 0.00mg/L CaCO3 mg. The light shield was closed. “Read/Enter” was pressed, the display showed: “Wait”. CONTTG/METD was pressed two times. A store programme number for calcium was entered. 220 “Read/Enter” for units of mg/l Ca as CaCO3 was pressed. The display showed: “Dial” nm to 522. “Read/Enter” was pressed. The display showed mg/l CaCO3 Ca. Zero was pressed. The display showed: “Wait”. Then the result in mg/L Ca as CaCO3 was displayed. Samples B and C were equally determined.

NOTE:- mg/l hardness equals Mg/l Ca as CaCO3 plus mg/l as CaCO3.

B $_{10}$ Determination of Iron Content

The stored program number for iron (Fe), ferrover powder pillows was entered. The wavelength dialed was rotated until the display showed. 510nm. “Read/Enter” was pressed. The display showed mg/l Fe Fr. A cell with 25ml of samples was filled. The contents of one ferrover iron reagent powder pillow was added to the sample cell (the prepared sample) and swirled to mix. An orange colour indicates the presence of iron. SHIFT timer was pressed. A 3-minute reaction period began. When the timer beeps, the display showed: mg/l Fe Fr.

Another sample cell (the blank) was filled with 25ml of sample. The blank was placed into the cell holder. The light shield was closed. Zero was pressed. The display showed “Wait”. Then: 0.00mg/l Fe Fr. Within thirty minutes after the timer beeped, the prepared sample was placed into the cell holder. The light shield was closed. “Read/Enter” was pressed. The display showed “Wait”. Then the result in mg/l iron was displayed. Same procedure was done for samples B and C.

B$_{11}$ Determination of Phosphorus as Phosphate

The value of phosphate was determined with wavelength 890nm. A clean sample cell was filled with 25ml of sample and the content of one phosver 3 phosphate powder pillows was added to the sample cell (the prepared sample) and was swirled to dissolve. After 2 minutes reaction, the second sample cell was filled with 25ml of the blank. The blank was placed into cell holder and light shield was closed, the equipment was set to 0.00mg/l PO_4^{2-} was displayed and the values were recorded. Same procedure was done for sample B and C.

B_{12} Determination of Conductivity

The conductivity/TDS meter was switched on by pressing the appropriate button. The probe was immersed in a beaker containing the deionized water to rinse the probe. The probe was immersed in the beaker containing the sample A. The probe was immersed beyond the vent holes. The reading was recorded in micro-Siemens/cm (µs/cm) or milli- Siemens/om (ms/cm). Same procedure was followed for sample B and C.

B_{13} Determination of Copper

The stored programme number for copper (cu), cuver/copper powder pillows was entered. 135 "Read/Enter" was pressed. The display showed "Dial" nm to 560. The wavelength dialed was rotated until the small display showed 560nm. "Read/Enter" was pressed. The display showed mg/l cu. A sample cell was filled with 25ml of sample and the content of cuver/copper reagent powder pillow was added to the sample cell (the prepared sample) and swirled to mix. "Shift/Timer" was pressed and a 2 minutes reaction period began. The timer beeped and display showed mg/l cu. The second sample cell (the blank) was filled with 25ml of sample cell placed in cell holder. Zero was pressed then 0.00mg/l cu was displayed. Within 30 minutes after timer beeped, a prepared sample was placed in the cell holder. "Read/Enter" was pressed then result in mg/l copper was displayed.

B_{14} Determination of Nitrate

The stored programme number for low range nitrite nitrogen (NO_2-N) powder pillow was entered. 371 "Read/Enter" was pressed, the display showed "Dial" nm to 507. The wavelength was rotated until small display showed 507nm. "Read/Enter was pressed and the display showed mg/ln No2-L. A sample cell was filled with 25ml of sample. The content of one nitriver 3 Nitrite reagent powder pillow was added (the prepared sample) a stopper was used to cover the lid and shaked to dissolve. "Shift/Timer" was pressed. A 15 minutes reaction began. When the timer beeped, the display showed mg/ln NO_2-L. A second sample cell was filled with 25ml of sample (the blank) and was placed into the cell holder. "Zero" was pressed. Display showed "Wait" then 0.00mg/ln NO2-L. The stopper was removed from the prepared sample then placed into the cell holder. "Read/Enter" was pressed and display showed WAIT then result in mg/l nitrite was expressed as Nitrogen (NO_2-N).

B_{15} Procedures of Bacteriological Analysis

Most portable method was used

i. To detect the presence of coliform in the water samples

ii. To detect the present of feacal coliform

Procedure

i Set of three separate series of three of group was set up, with the total number of nine test tube per sample.

The test tubes were labeled according to water sample and volume of sample inoculated. The tubes were incubated at 37°C for 48 hours.

Table B_{16} Separate series of tubes

Sample A	3 tubes of Double strength + 10ml Sample

	3 tube of single strength + 1.0ml of sample
	3 tube of single strength + 0.1ml of sample
Sample B	3 tubes of Double strength + 10ml Sample
	3 tubes of single strength + 1.0ml of sample
	3 tubes of single strength + 0.1ml of sample
Sample C	3 tubes of Double strength + 10ml Sample
	3 tubes of single strength + 1.0ml of sample
	3 tubes of single strength + 0.1ml of sample

ii The water sample (A) was mixed by shaking thoroughly. Flame bottle, and using a 10ml aliquots to the three tubes labeled A, B and C 10ml. Flame bottle and using a 0.1ml a 1ml of water to the three tube 1ml. Flame bottle and using a 0.1 ml pipette transfer 0.1ml of water to the three tubes. Repeat steps 2 through 5 for B and C. Incubate all tube for 48 hour at degree Celsius.