GROUNDWATER QUALITY ASSESSMENT OF FUTO AND NEIGHBOURING COMMUNITIES

BY

ANYANWU, CHARLES K.
(20075590009)

A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL
FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS OF TECHNOLOGY DEGREE (M.TECH) IN ENVIRONMENTAL TECHNOLOGY

DECEMBER, 2016

CERTIFICATION

This is to certify that this work "**Groundwater Quality Assessment of FUTO and Neighbouring Communities**" was carried out by ANYANWU, CHARLES K. (Reg. N0. 20075590009) in partial fulfillment of the requirement for the award of Master of Technology (M.Tech) in Environmental Technology, from the Department of Environmental Technology, School of Environmental Sciences, Federal University of Technology, Owerri.

DR. C. O. NWOKO Date
(Supervisor)

DR. C. O. NWOKO Date
(HOD, EVT)

PROF. (MRS.) R. N. NWABUEZE Date
(DEAN, SOES)

PROF. (MRS.) N.N. OTI Date
(DEAN, PGS)

Nzegbule
Prof. E C Nzegbule 25-11-16
(**EXTERNAL EXAMINER**) Date

DEDICATION

This project is dedicated to Almighty for His guidance and protection throughout my academic pursuit in my Master's Degree programme and to my parents Sir and Lady P.E. Anyanwu, my wife Mrs. Emmanuella Anyanwu and my brothers and sisters for their moral and financial support of my programme.

ACKNOWLEDGEMENT

I totally thank and acknowledge the immeasurable encouragement and directives given to me by my able project supervisor Dr. Chris .O. Nwoko, and I also appreciate efforts of my co-ordinator Dr. C.E. Ihejirika, the Dean of school of Environmental sciences, Prof. (Mrs) R.N. Nwabueze, the Dean of post graduate school Engr. Prof. Mrs. K.B. Oyoh, the external examiner and my eminent lecturer Dr. P.C. Njoku, Dr. (Mrs) S.M.O. Akhionbare, Dr. E. E. Nkwocha, Dr. J.D. Njoku and host of the lecturers in the department.

I as well acknowledge the efforts of my wife Mrs. Emmanuela Anyanwu, my parents Sir and Lady P.E. Anyanwu, my brother Mr. Jude Anyanwu, Mr. Anthony Anyanwu and all my friends and well-wishers.

May the good Lord bless all of you as you are remembered in the completion of this my programme.

TABLE OF CONTENTS

CHAPTER ONE

CHAPTER TWO

INVESTIGATION

CHAPTER FOUR

CHAPTER FIVE

LIST OF TABLE

LIST OF FIGURES

ABSTRACT

This study examined the physicochemical and bacteriological analysis of ground water quality in Federal University of Technology, Owerri (FUTO) and its neigbouring Communities. Groundwater samples were collected, two from 4 different locations and were immediately transported to the laboratory for standard analyses. pH ranged between 5.24-4.71; EC (40-11.00 μS/cm); sulphate (5.94-1.58mg/L); Total Hardness (44.30-12.40mg/L); Mg (8.79-1.20mg/L); Cl^- (8.10-5.00mg/L); nitrate (0.0012-0.001mg/L); Fe (1.97-0.51mg/L); Pb (0.030-0.016mg/L); TDS (26-7mg/L); while bacterial count for Total Viable Bacteria was (3000-410 cfu/100ml); Total Coliform count (25-5 cfu/100ml); and *E. coli* count (12-2 cfu/100ml). Most of both physicochemical results and microbial counts showed significant variations from each sample. This showed that the chemical parameters and microbial counts were below World Health Organization potable water standards. The boreholes waters were not fit for human consumption. The water should be adequately treated for human usage.

Keywords: Groundwater, physicochemical, bacteriological, water and boreholes

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of study

Portable water contains nothing but the important chemical elements. Pure water usually carries certain amount of minerals, which it

acquires from its source, treatment, storage, distribution, and household plumbing conditions. These minerals and elements usually occur at very low levels and do not pose a significant risk to health. Water plays several vital roles, which make it such an indispensable factor in the trend of sustainable development. Man uses water mainly for domestic, agricultural and industrial purposes (Camp, 1984). The major issues associated with the use of water by human are quantity and quality.

The importance of drinking water is determined by its quality. For the early people, they could assess water quality only through visual assessment, taste and smell. The evolution of biological, chemical and medical sciences made available several methods to measure water quality and to determine its fitness for human consumption and well being (Nwagbara, 2002). The anthropogenic activities of man have led to pollution of water in the environment with the erratic supply of pipe-born water. These have forced many to resort to exploration and exploitation of ground water in various forms (Bore-holes, open wells) (Ojelabi, 2001).

The hydrologic cycle consists of inflows, out flow, and storage. In flow add water to the different parts of the hydrologic system, while outflows remove water. Storage is the retention of water by parts of the system. Because water movement is cyclical, inflow for one part of the system is an outflow for another. Discharge of ground water from the aquifer to a stream is an outflow (also an inflow for the stream). Overtime, if inflows to the aquifer are greater than its outflows, the amount of water stored in the aquifer will increase. Conversely, if the inflows to the aquifer are less than the outflow, the amount of water stored decreases (Lenntch, 2005).

Ground water originates as a result of infiltration from precipitation, stream flow, lake and reservoirs. It flows horizontally and vertically down ward through water coating commonly referred to as soil moisture and then enters the zone of saturation, which is above the water table held by capillary action. The water below the water table is defined as the ground water (Kayode, 2001). The water below the water table may fluctuate with seasonal supply and demand (Hammer and Kenneth, 1981). The quantity of water obtain at any point is influenced by natural factors such as the strata (aquifer), the area, the thickness of the aquifer, the nature of the fissures and formation porosity, amount of rainfall and types of over burden soil.

1.2 Objectives of Study

1. To determine the level of physicochemical parameter of ground water in the study area.
2. To determine the heavy metal concentration of the underground water.

1.3 Justification of Study

1. The quality of ground water within FUTO and the neighbouring communities (Ihiagwa, Obinze and Eziobodo) needs to be assessed to establish the portability of the water. This to determine its effects on human health.
2. Drinking water must be free from organisms that are capable of causing diseases and from mineral and other organic substances that could produce adverse effect to human health.
3. FUTO and the neighbouring communities are solely dependent on ground water for various purposes. This calls for careful analysis of borehole water within the environment and to determine its conformity with the world health organization standards and suitability for human consumption.

1.4 Scope of Work

This study covers the physical, chemical and bacteriological characteristics of water samples from FUTO hostel, and neighbouring communities – Ihiagwa, Obinze and Eziobodo) from the borehole sites focus is on the newly boreholes and the already existing boreholes.

Some of the parameters assessed include temperature, conductivity, PH, Total Dissolved Solids, Total Suspended Solids, Odour, Taste, Appearance, Turbidity, Sulphate, Iron, Copper, Nitrate, Free Chlorine, Manganese, Total Coliform Bacteria and Total Viable Bacteria.

1.5 Relevance of study

The earth’s water supply remains constant, but man is capable of altering the cycle of that fixed supply. Population increases, rising living standards, and industrial and economic growth have played greater demands on our natural environment. Our activities can create an imbalance in the hydrologic equation and can affect the quantity and quality of natural water resources available to present and future generations.

Water uses by households, industries, and farms have increased. People demand clean water at reasonable costs, yet the amount of fresh water is limited and the easily accessible sources have been developed. As the population increases, so as our need to withdraw more water from rivers, lakes and aquifers threatening local resources and future water supplies. A larger population will not only use more water but will discharge more wastewater. Domestic, agricultural, and industrial wastes, including the intensive use of pesticides, herbicides, and fertilizers, often over load water supplies with hazardous chemicals and bacteria. Also, poor irrigation practices raise soil salinity and evaporation rates.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Concept of ground water

There has been appreciable literature on the issue of water quality. Throughout the world, the conviction is growing that the availability of sufficient quantities of clean, portable water should be considered one of the basic human rights (Balogun, 2000). Many government and international organizations are executing programmes for implementation of water supply system (Gower G.H, 1980). These are often aimed at supplying the urban population with water, since a lack of water and the resulting unhygienic and unsanitary conditions will be felt most strongly in these urban towns, where natural water sources may be less easily available and moreover may be polluted as a result of the concentration of human activities. The different sources of water supply include: pipe-borne, spring well and rain. Among these sources, it is only the pipe-borne water that is treated, in other words, pipe-borne water is portable water (Anyanwu N.O., 2001). Since the spring is not evenly distributed and is not constant, many people are forced to dig wells for their daily water supply. This is common among those who cannot afford pipe-borne water because of the high cost of its installation (Carpenter P.L., 1984).

This first borehole scheme in Nigeria was commissioned in 1665 as was dated by (Oyebande, 1978). By 1969, about twenty-eight water supply schemes were established to supply portable water to different communities in the country. By 1970, after independence, sixty-seven town and villages were served with two hundred and fifty eight million liters of water per day (Ekechukwu K.C, 1998). By 1978, the Nigerian government commissioned Ganf Ingeneire of West Germany to investigate the water supply of the new capital Territory Abuja,

The term, groundwater is defined as the subsurface water that occur beneath the water table in the soil, where the geological formation containing the water is fully saturated and has hydro static pressure that or greater than atmospheric pressure (Charry and Freeze, 1979). Hydro geological data confirmed that no ground water is in the environment surface water by means of impounding water behind (Allian, 1986). Ground water is not confined to only a few or depressions in the same way that surface water is concentrated in streams and lakes. Rather, it exists almost everywhere underground. It is found underground in the space between particles of rock and soil or in crevices and cracks in rock. The water filling these opening is usually within 100 meters of the surface (United States Environmental Agency, 2001). Much of the earth's fresh water is found in these spaces.

At greater depths because of the weight of overlying rock, these openings are much smaller, and therefore hold considerably smaller quantities of water. Groundwater flows to the surface naturally as spring and oases. It may also be tapped artificially by the digging of well. The upper limit of abundant groundwater is called the water table (Unite States Environmental protection Agency ground water, 2003). Ground water can also be referred to as water entering the soil either by rainfall or irrigation gradually percolating down ward to become groundwater if it is not first taken up by plants, evaporated into the atmosphere, or held within soil pores. This percolating water, called recharge, passes downward through the root zone until it reaches the water table. Below the water table is the saturated zone, where the ground water is contained (Virginia, 2003). It is also any water found underground including aquifers, subterranean rivers and streams, permafrost, and soil moisture.

Ground water is naturally replenished from above, as surface water from rain, rivers or lakes sinks into the ground. Some groundwater also comes from below as water from the mantle enters the lithosphere (Willipedia, 2003).

Ground water flows slowly through water-bearing formations (aquifers) at different rates. In some places, where groundwater has dissolved limestone to form cravens and large openings, its rate of flow can be relatively fast but this is exceptional. Many terms are used to describe the nature and extent of the ground water resources.

Ground water should be one of the water that is free from contamination ding on the depth. But due to ignorance of the consequences that suit from wrong sitting, the wells were dug in areas that are unhygienic, for instance near septic tank or even pit privies (Pelczer, 1977).

Hydrologically, groundwater originates as infiltration from horizontally and vertically downwards through zone of aeration by gravity. This percolation on leaves behind thin layers of water coating the soil grains commonly referred to as soil moisture and then enters the zone of saturation, just above the water table through the continuous film of pore water that is held by capillary action. The water below the water table is defined as the ground water (Kenneth A.M., 1981).

Living organisms, including man requires a constant source of water. This water supply is made available as a result of natural recycling of the earth's water in these three locations: land, surface and ground. Most activities of man involve some use of water and the quality desire to satisfy these activities vary widely (Camp and Meserve, Realizing the importance of water, the United Nations Organization declared 1981 to 1996” International Drinking water and sanitary Decade”. Following this, the federal Government collaborated with the water Resources Ministry to establish the National water Rehabilitation project throughout the states of the Federation (Ekechukwu K.C, 1998). Ground water contains substances, which depends on the characteristics of the underground strata. The presence of various gases dissolved helps to determine the microbial flora that can grow in it (Burrows, 1968). Nitrate concentration can build up in ground water where agricultural fertilizers are heavily used such as reported in the central valley of California, where concentration of nitrate have reached the level considered to be a public health hazard and doctors there have recommended the usage of pure bottled water for infant formula preparation (Elemba C.O, 1998). The quality of any water is dynamic and is a function of chemical, physical and biological characteristics of the water and its intended use (Blyth and Freitas, 1984). Water quality may however be determined by such parameters as visual appearance, smell, taste and water free from disease causing micro-organisms and chemicals (Okafor N., 1985).

Resource outputs are producing a wide spectrum of potential criteria, including microbial criteria to measure water quality conditions for the variety of purposes (Geldreich E.E., 1981).

2.2 Theory of groundwater flow

In 1856, scientist called Darcy did an experimental work on the flow of water in sand and derived a law known as “Darcy’s law”, which expressed the relationship between velocity of percolation, permeability of water yielding material, transmissivity hydraulic gradient. Darcy’s law serve as the basis for numerous quantitative methods of groundwater resources evaluation.

Darcy’s law for groundwater flow is given by:

$$Q = \frac{Kadh}{dx}$$

$$= \frac{Kah_2\text{-}h1}{I_2 - I_1}$$

Where: Q = flow (horizontal) through the aquifer m^3/s

K = hydraulic conductivity, m/s

A = cross-sectional area, m^2

h_2 - hi = head drop, m

$I_2 – I_1$ = length difference along horizontal x-direction between h_2 and h_1 (m)

Dupuit (1963) was the first scientist to develop a steady state formula for the flow of water into a well. In 1870, then developed equations for flow towards wells.

Mathematically,

Dupuit equation:

$$h_2 = h_2L - \frac{X}{L}(h_{2L} - h_{2R})$$

Slitvher (1898) showed the relationship between grain size of rock and permeability and the motion of ground water (Ekechukwu K. C., 1998).

2.3 Types of Aquifer

A geologic formation capable of yielding sustainable amount of water is called an aquifer. If water cannot pass through the confining layer, the layer is called an aquiclude’, but if water can pass in and out of the confining layer, it is called an ‘aquitard’ (Hamill and Bell 1986). The two main types of aquifer are confined and unconfined aquifer.

COnfined Aquifer: Here groundwater is confined under pressure greater than the atmospheric by overlying relatively impermeable strata. water enters the aquifer through an area where the confining bed rises to the surface (Ekechukwu K.C, 1998)

Unconfined Aquifer: When a water table varies in undulating form, and in slope, which depends on the area of recharge and discharge. Well pumping and permeability changes in the water table correspond to changes in the volume of water in storage within the aquifer. The perched aquifer is an example of an unconfined aquifer. It occurs whenever a groundwater body is separated from the main body of water by a relatively impermeable stratum of small area extent and by the aeration zone.

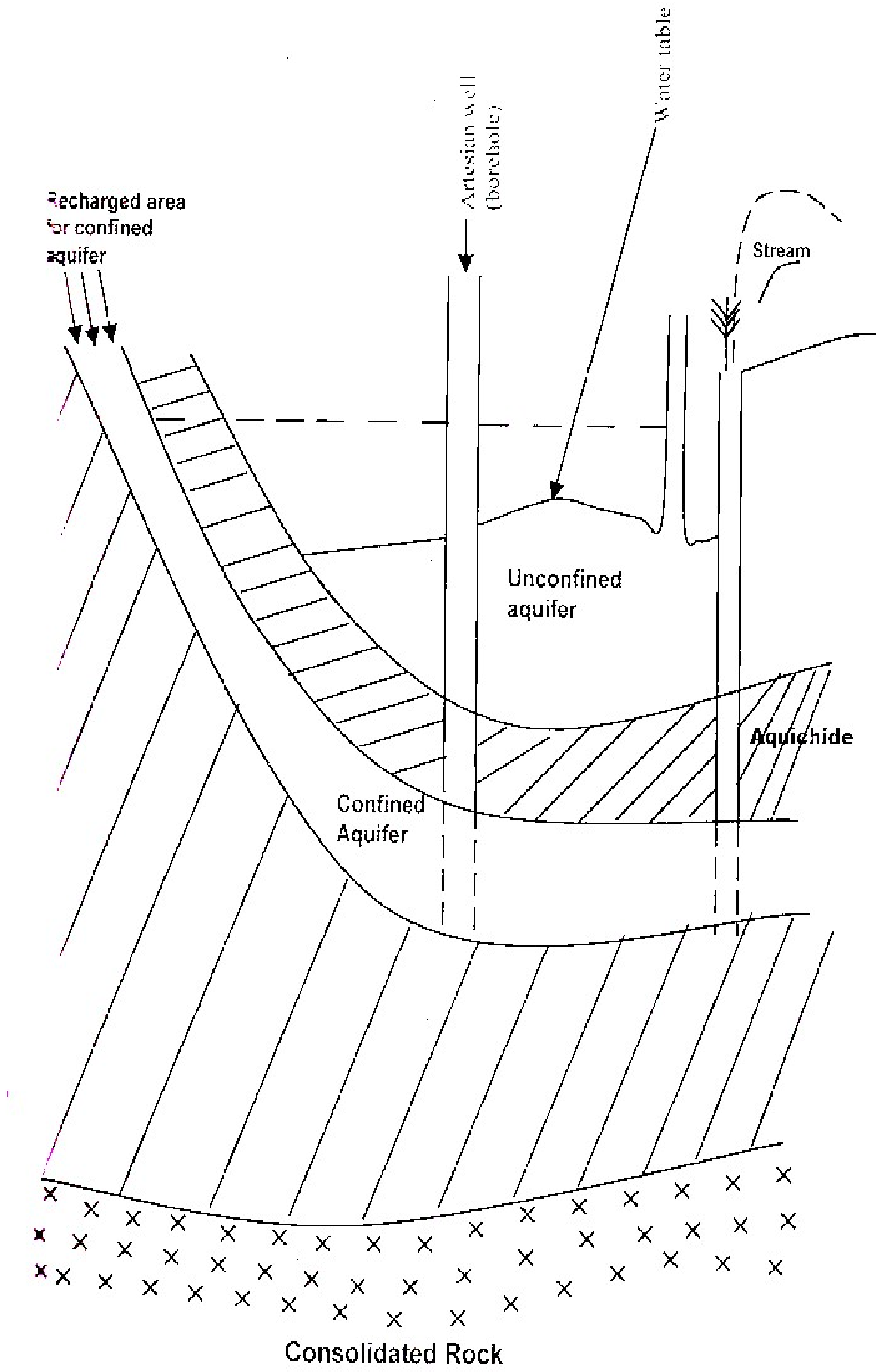


Fig 1: stratification of Aquifer

2.4 Sources of Water Supply

The source of water commonly determines the nature of the collection, purification, transmission and distribution works. Common sources of water are: Rain water, surface and ground water.

Rain Water: Rainwater is rarely used for municipal water supplies because of non-availability of large surface areas where it can be collected (roofs). It may be used for very small communities, which do very hard and unpalatable (Fair G. M., 1971).

Surface Water: Rivers, lakes, ponds and impounded reservoirs are classified under surface water.

River/stream water do supply water to community especially in rural leas throughout the year or where it is not enough, during times of flood it might be stored and then supplied to the community.

Deep lakes and ponds have sufficient large surfaces area, which can be utilized for municipal water supply.

Impound Reservoirs: When the discharge to rivers and streams increases during floods and heavy rain, water is stored in the soil adjacent to streams and rivers and it is called bank storage. The bank storage either supplies water to the watercourse or receives water from the river depending upon the level of water in the river. The excess run off may be stored in impounded reservoirs for water supply during dry periods by building a dam across a stream.

Groundwater: Ground water is formed by rainfall, which permeates into the ground through the pore of rock formation and finally reaches the underground water table. This water replenishes the soil moisture, or is used by growing plants and returned to the atmosphere by transpiration and the water from streams, lakes and reservoirs, which percolate through the soil to the underground water table (Fair G. M., 1971). Ground water varies in purity depending on the geological conditions of the soil through which it flows. If water source is groundwater, the degree of treatment is greatly affected by the type of water bearing strata, as shown in table 1.

TABLE 1: IMPURITIES FOUND IN SOME ROCK

ROCKS	QUALITY OF WATER
Granite	Dissolved substances negligible more or less chemically pure
Gneisses	Comparatively larger potash content
Slate	Organic matter is small quantities
Diabase syenite	Slight presence of iron if rocks are weathered
Pure Quartz	Very soft water
Pure and stone	Small quantities of dissolved matter, free from humans, often very pure, soft water.
Limestone	Hard dissolved matter present
Gypsum and Anhydrate	Sulphate is present, hard water
Salt dome	Dissolved matter in large quantities
Marble, Dolomite	Very hard water
Loass, basic crystalline rock	Rich in dissolved matter especially lime from human

Source (fair et al 1971). The effect of the water bearing strata on ground water quality.

2.5 Water Characteristic

Analysis of water is aimed at determining the level of impurity and the types of treatment units required for effective purification before usage. The analysis aimed at determining the physical chemical and Biological characteristic of water (Bouwe, 1978), which helps in determining the quality of the water.

2.5.1 Physical Characteristics

The physical characteristics of water determines its aesthetics acceptability, however, the major physical characteristics of water are its taste, odour, temperature, colour and total dissolved solid (TDS).

Taste and Odour: Odour in water is caused by volatile substances associated with organic matter such as algae, hydrogen sulphide (H_2S). Chlorination may produce odour in water though use as treatment material Pure should be tasteless. Taste and odour present in some groundwater may be as a result of the presence of inorganic compounds such as salt (chloride and metals, iron and magnesium) which might have been percolated during infiltration of the water near an industrial or a waste disposal zone.

Temperature: Temperature indicates the level of dissolved oxygen and also bacterial activity in water. The higher the temperature, the dissolved oxygen and lower the survival rate of microorganism (Bouwe, 1978). It is used to identify the Magnitude of density, viscosity vapour pressure and surface tension of water. It is however one of the most important parameters in natural surface water systems. The temperature of ground water is slightly stable, compared to surface water, which is influenced ay seasonal and daily weather changes.

Colour: Good water must be colourless. Colour in water is due to the presence of decaying matters and iron. Normally, iron imparts brown colour to water and is removed by precipitation by converting it from ferrous to ferric state. Dissolved oxygen oxidizes ferrous iron and precipitates it as ferric hydroxide (Fair G.M., 1971).

The problem with coloured water is that they are rendered aesthetically unfit for several activities like laundering, dyeing, packing and food industries. They also provide a hiding cover for pathogenic organisms.

Total Dissolved Solid (TDS): In this aspect, it might be regarded as solid in general. These are made up of undissolved and dissolved solids, fixed and volatile solids. The suspended solid are further divided into settleable and non-settleable solid. The total solids in water sample are the residue after evaporation of the sample at 103-105°C (Bouwe and m –an, 1978).

Turbidity: Turbid water is cloudy and hinders visibility of the bottom of the glass containing the water. Turbidity in water is due to suspension, which are removable by the addition of coagulants (alums). Removal of turbidity before disinfections is very essential for prevention of particles with the disinfections process.

2.5.2 Chemical Characteristics

Substances commonly determined in chemical analysis are ions, which comprises, cations (Positively charged ions) and anions (negatively charge ions). The cations determined in the course of the analysis are calcium, magnesium, sodium and potassium while anions are sulphate, fluoride, nitrate and those leading to alkalinity which are e-Dressed in terms of an equivalent amount of carbonates and bicarbonates. The origin of these ions and how they affect the quality of are discussed as follows:

(i) **Fluorides:** Sources of fluoride in groundwater are minerals like calcium fluoride, certain amphiboles, cryolites in (igneous rock) a fluoraspan (in sedimentary rock). Fluorides in lesser concentration such as 0.6 and 0.17 (mg/l) in drinking water has a beneficial effect on the structure and resistance to decay of children teeth. But in excess of 1.5 mg/l in some areas causes mottled enamel in children's teeth. Fluoride in excess of 6.0mg/l causes pronounced mottling and disfiguration of teeth.

(ii) **Sulphate:** Sources of sulphate in groundwater are sulphide ores and gypsum. Sulphate combine with calcium to form an adherent-eat retarding scale. Water containing about 500 mg/l of sulphate taste bitter and water containing about 1000 mg/L may be cathartic (Todd, 1980).

(iii) **Chloride:** The main source of chloride in natural ground water are sedimentary rock (evaporate), minor source are igneous rock chloride in excess s of 1000mg/L imparts salty taste and may cause physiological damage in food processing industries that usually require less than 250 mg/L.

(iv) **Iron and manganese:** manganese in natural groundwater comes often from soil and sedimentary rock, mica, biotitic and amphibole nomblende minerals while the source of iron are igneous rock, amphiboles, ferromagnesian micas, ferrous sulphide or iron pyrite (FeS_2) magnetite (Fe_20_4) sand stone rocks, oxides carbonate and sulphides or clay minerals. Iron and manganese in excess of 0.2 mg/L precipitates after exposure to air, causes turbidity, stain plumbing fixtures, laundry and cooking utensils and impact objectionable tastes and colour to food and drinks. Presence of manganese also fosters growth in reservoirs, filters and distribution system.

(v) **Calcium and magnesium:** The sources of calcium in groundwater are amplibole, feldspars, pyroxenes, aragonite, dolomite and clay minerals while sources of magnesium are amphiboles, Olovine, pyroxenes, Magnetite and clay minerals.

Calcium and magnesium combine with bicarbonate, carbonate, sulphate and silica to form heat retarding, pipe clogging scales in boilers other heat exchange equipment, calcium and magnesium combine with ions of fatty acid in soaps to form soap suds. The more calcium and magnesium the more soap required to form suds. A high concentration of magnesium and calcium has a laxative effect especially on the new s of supply (Todd, 1980). Hardness in ground water was a result of calcium and magnesium combining with carbonate and sulphate.

(iv) **Sodium and potassium:** Source of sodium in groundwater are feldspar minerals and evaporites such as mirabilite (Na_2S0_4. 10 H_2O) and industrial waste. The sources of potassium are feldspar, some micas and clay minerals.

More than 50mg/L sodium and potassium in the presence of suspended matter causes foaming, which accelerates scale format ion and corrosion in boilers. Sodium and potassium carbonate in recalculation cooking water can cause deterioration of wood in cooling towers and more than 65mg/L often can cause problem in the manufacturing industries.

Groundwater high in exchangeable sodium is very undesirable for agriculture because it can make the soil to becomedeflocculated and tend to have a relatively impermeable crust. This condition is promoted by water of high sodium absorption ratio (S.A.R) and its reverse is water containing high proportion of Calcium and magnesium.

$$\text{S.A.R.} = \frac{\text{Na}}{(\text{Ca} + \text{mg})/2}$$

Also water of high sodium content is troublesome to person on low salt diet.

(vi) **Carbonate and Bicarbonate:** Sources of carbonate and carbonate in water are limestone and dolomite. On heating bicarbonate it change to steam, carbondioxide and carbonate. The carbonate combines with alkaline earth metals, principally calcium carbonate which retards flow of heat through pipe walls and restricts of fluids in pipes. Water containing large amount of bicarbonates are alkaline in nature and undesirable especially in some industries.

(viii) **Nitrate:** Nitrate in natural groundwater comes from

organic sources such as plant debris and animal excrement,

Legumes (Bacteria living in sc:' nodules which fix nitrogen gas from atmosphere). Atmosphere (Nitric Oxide produced by lightening discharges) and industrial and agricultural chemicals. These nitrates thus formed are in excess of the plant needs and then leach into groundwater. Nitrate ground water is also potentially dangerous to infants and livestock; it causes abortion in pregnant cattle and poisoning infant animals including humans if taken excess, which can result in serious health problems and even death.

Potential Hydrogen: This is a measure of the intensity of acidity or alkalinity of a solution. Potential Hydrogen is defined as the negative to logarithm of hydrogen ion concentration. For example, the Potential Hydrogen of pure water at ordinary temperature, expressed as Log_{10} as given as $\mathrm{pH}=-\mathrm{Log}_{10}\,[\mathrm{H}]+$ (Nwagbara, 2002).

If acid is added to water, its hydrogen ion increases and its pH will therefore decrease. Thus, a pH in the range 1-6 and 8-14 indicates acidity and alkalinity respectively.

Alkalinity: This is a solution in its acid neutralizing capacity or the amount of acid required to lower the Potential Hydrogen to 4.3, the alkalinity city of water is principally due to salts of weak acids or strong bases such as hydroxides, carbonates and bicorbonates. These substances act as buffers which lowers the Potential Hydrogen.

Acidity: The acidity of water is its capacity to donate protons. Acidity of natural waters is attributed to the presence of carbondixide or strong mineral acids. Definitionally, an acid is a substance that dissolves in water with the formation of hydrogen ions or a substance containing hydrogen which may be replaced by metal to form salts.

2.5.3 Biological Characteristics

Standard test to determine the safety of water for drinking purposes involves identifying whether or not bacteria belonging to the so form group are present. One of the reasons for this is that, this group of bacteria is relatively easy to recognize. The results of coli form test are reported in terms of the most probable number (MPN) of coli form group organisms present in a given volume of water (Hamill, 1986).

The total coli form MPN test is statistical estimation of the concentration of coli form organisms present in 100ml of the sample coli form organisms comprise of all the salts and gases the aerobic, anaerobic, facultative, Gram-ve, non-spore forming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C. Viruses in water are more critical than bacterial in that they tend to survive longer. In addition, one virus unit may cause an infection when ingested.

2.6 Factors influencing groundwater quality

The quality of groundwater is influenced by various factors which include both natural and human. The parameters affecting groundwater quality are the geologic nature of the aquifer which comprise of the disturbances of the soil mantle-by ploughing during cultivation, road making, stream initiation/channelization, mining creak protective vegetation. The socio-economic activities industrialization) arising from the modern and sophisticated technology which has introduced many synthetic materials into our environment. The physical, chemical and biological properties of various waste water (Elemba C.O, 1998).

Geology: The geology of a place affects the composition of the e-s found in the aquifer example; the lathyritic soils rich in iron and manganese may be dissolved by water causing chemical contamination of the water.

The nature of the aquifer determines to a large extent the salts and gases that would be dissolved by the percolating water. Example, T 5 addition of carbondioxide into water, when percolation takes place, it lower the pH of water. Similarly, when toxic substances are leached ion mineral formations, such as flouropatities, the waters in which they go into solution become chemically contaminated. If the water bearing body is made up of limestone, chalk or calcite, the possibility that such water would have a high content of calcium carbonate which causes them to be ‘hard’.

Industrial Sources: Modern economic activity requires transportation and storage of materials, which is use in production processes. Some of these materials may lost through spillage, leakage or improper handling. The disposal of wastes associated with the above activities contributes to another source of groundwater contamination. Usually some businesses without access to sewer systems rely on shallow underground disposal. They use cesspools or dry holes or send the wastewater into septic tanks. Any of these forms of disposal can lead to contamination of underground sources of drinking water.

Dry and cesspools introduce waste directly into the ground; septic system cannot treat industrial waste. Waste water disposal of certain types of businesses such as automobile services stations, dry cleaners, electrical component or machine manufactures, photo lessors and metal plates or fabrications are of particular concern because the waste they generate is likely to contain toxic chemical. Other industrial sources of contamination include cleaning hazardous material in uncovered areas or in area that do not have parts with drains or catchenent basins. Underground and above ground storage tanks holding petroleum products and solvents can develop leaks from corrosion, improper installation or mechanical failure of the pipes and fittings. All these can create many opportunities for groundwater contamination.

Agricultural Run-Off: The application of pesticides, herbicides and fertilizers are key agricultural activities that affect the quality of groundwater. When pesticides, herbicides and fertilizers are dissolved into percolating water, substance like nitrates go into solution and are carried to the water stored in the sub soil.

The leaching of nitrogen compounds from sanitary landfills live-stock, excretion and a nitrate in irrigation return flow also contributes to the pollution of waters in the sub soil. This pollution is due to the presence of nitrate underlying agricultural areas, taste, odours and colour, those causing lack of aeration in the sub soil and those increasing corrosiveness, hardness and those affecting temperature.

Domestic Waste Water: This is the spent water from the kitchen, bathroom, lavatory, toilet and laundry mineral and organic matter derived from human excretion, paper, soap, food wastes and other substances are leached into the soil by percolating water.

When waste waters and sewage are discharged into surface water it serves as a means of recharge to an aquifer which are likely to be polluted by the organic and mineral matter contained in the wasters.

2.7 Uses **of groundwater**

Agricultural use: The suitability of groundwater for agricultural use on depends on the salt concentration effects on plants. Salts may plant growth in that; they reduce the uptake of water by metabolic reactions or by modifying osmotic processes. The changes brought about in soil fabric which as a result of salt effect, affect permeability and aeration and have influence on plant growth. In the other hand, captions can cause deflocculating of clay minerals in a soil which damage its crumb structure and reduce its infiltration capacity and (Bell, 1986).

Domestic use: Domestic water uses include drinking, washing, flushing ' closets, watering of lawns and flowers and car washing or human consumption, water must be free from organism and chemical substances in concentration enough to affect health. Drinking should be aesthetically acceptable; it should not possess unpleasant or objectionable taste, odour, colour or turbidity. For s of taste as an example, the maximum concentration of chloride in drinking water is 250 mg/L and, to avoid staining of laundry and plumbing fixtures, the concentration of iron in drinking water is 0.3 mg/L. In the of temperature, cool water is preferred. The standards of some quality parameters for domestic use are shown in table 2 (World Health Organization 1993).

Table 2: World Health Organization (1993) potable water quality requirements (standard).

PARAMETERS	**STANDARD**
Colour Pt/co	15
Electrical conductivity (ms/cm)	100
Total hardness as $CaCo_3$ (mg/L) (gm)	250
Total dissolved solid TDS (mg/L)	250
Potential hydrogen concentration	6.5-8.5
Sulphate (mg/L)	250
Calcium (mg/L)	200
Magnesium (mg/L)	150
Free chlorine (mg/L)	0.3
Nitrate (mg/L)	4.0
Total iron (mg/L)	0.3
Lead (mg/L)	0.05
Total microbial load per ml	5-10
Total coliform (MPN/100Ml) ml	0-2
Esherichia coli count (MPN/100ml)	0

Source: *Imo State Environmental Protection Agency (ISEPA).*

Industrial Use: The quality of water required in different industrial processes varies appreciably. It can differ within the same industry. The three parameters important in terms of industrial water are salinity, hardness and silica. Hardness, total dissolved solids, colour and turbidity must be low in terms of industrial water use. Water used in the textile industries should contain a low amount of iron manganese and other heavy metals that may cause staining. For chemical industry, the quality of water required varies widely depending on the processing involved. Similarly water required in the pulp and paper industry is governed by the type of products manufactured. As industries require water variety of uses, they required it to meet the needs of their employees for drinking, sanitation, fire protection and laundry. Water is required in the manufacturing processes for energy conversion, heat transfer and transmission industrial process and incorporation in product. It is also used as a medium for dissolving and diluting soluble substance, as a transporting agent for substances in soluble or suspension (Ayoade, 1988).

2.8 Borehole Design

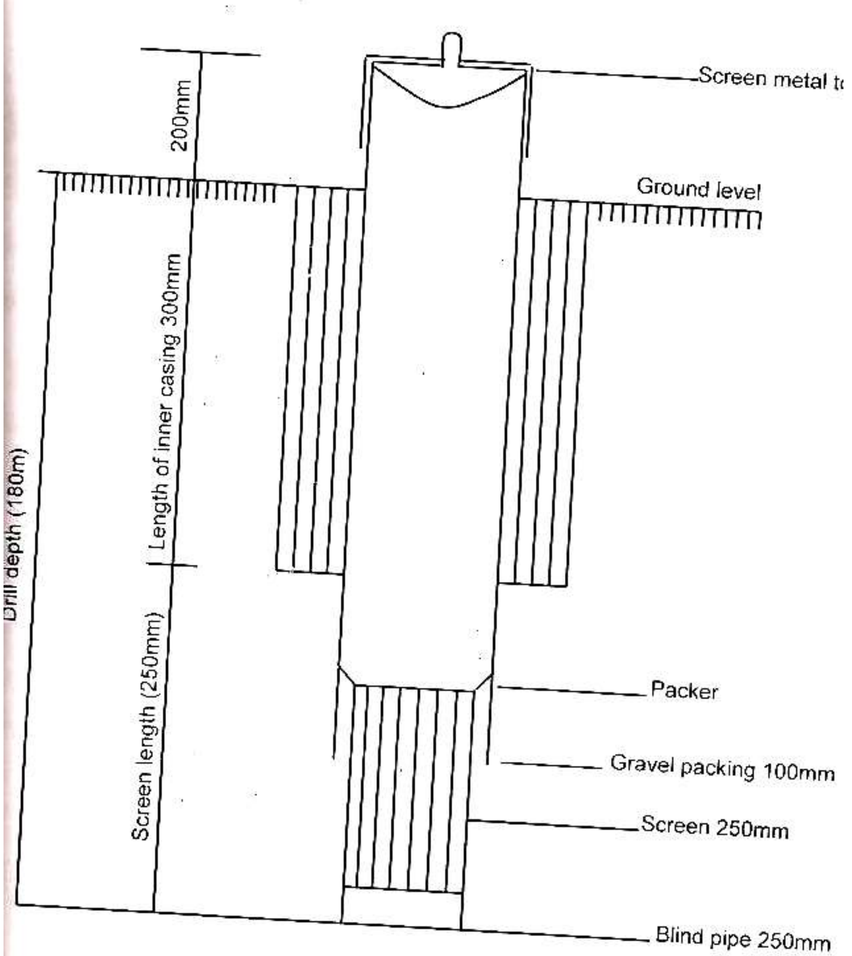
The design is usually influenced by type of drilling rig. For successful pumping, borehole requires an experienced hydrogeologist to locate a site. This is through carrying out soil test. A competent drilling contractor actor, use of modern techniques and materials, selection of good and correct pump.

It also involves the selection of appropriate casing size and material, the length, diameter and material for the screen, estimation of well depth, the size of the screen slot and choosing the construction method.

Boreholes are normally drilled for diameters ranging from 1.5- to 60cm and the depth 30m and above for water of good quality. A borehole is drilled into the saturated aquifer underground to get ground water The walls linked by concrete casings to prevent collapse of its side, in addition the chemical used such as Bentonite is also a lining material for the prevention of collapse. The bottom of the casing is porous by the use of screens to allow the groundwater to flow into the bore-holes while the entrance of sand grains is stopped.

The water from the boreholes is brought to the surface by the use of pumps (submersible pump). Water from the boreholes is supposed to undergo some specific treatment processes which should depend on the constituent element and condition, but consumers do take it without any treatment.

A properly designed and constructed borehole has a life span of 30years. The total cost of the well depends on the drilling, casing screening materials. The yield of a borehole depends on aquifer characteristics. The diameter of the casing helps in accommodating and also to ensure an up hole velocity (<1.5mls). The ng 2 shows a typical borehole section.



2: **Typical bore hole section**

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Hydrogeological Characteristics of the Study Area.

The study was carried out in Owerri West Local Government Area of Imo state. It is situated in the West Eastern part of Nigeria. The study area is located in the Benin formation (Fig 3.1). The formation consists of a considerable thickness of red earth (laterite) composed of iron-strained ragolith below, which is thick, very friable sands and minor intercalation of clay beds and lenses, sands are mostly medium to coarse grained, pebbly and poorly stored. The intercalations of sand and clay units give rise to a multi aquifer system within the upper 200m of the formation.

The three aquifer systems identified are:

1. The upper aquifer, which is unconfined and extends to a depth of 40m.
2. The middle aquifer, which is semi confined with varying thickness from 50m, south and 80m, North.
3. The separating aquitard which is sandy clay of 3m to 15m thick. But the main source of borehole water supply in the area is from semi-confined aquifer. It is characterized by subequatorial climate with an average yearly rainfall of 2500mm, most of which falls between

June and September. A high relative humidity of 70% to 80%, mean temperature of 27^0c with a daily range of 6.5^oc. The elevation of the area is within latitudes 5^0 15N and 5 and $5^0 45^1$N, and longitudes $5^0 45^1$E and

$7^0 15^1$E.

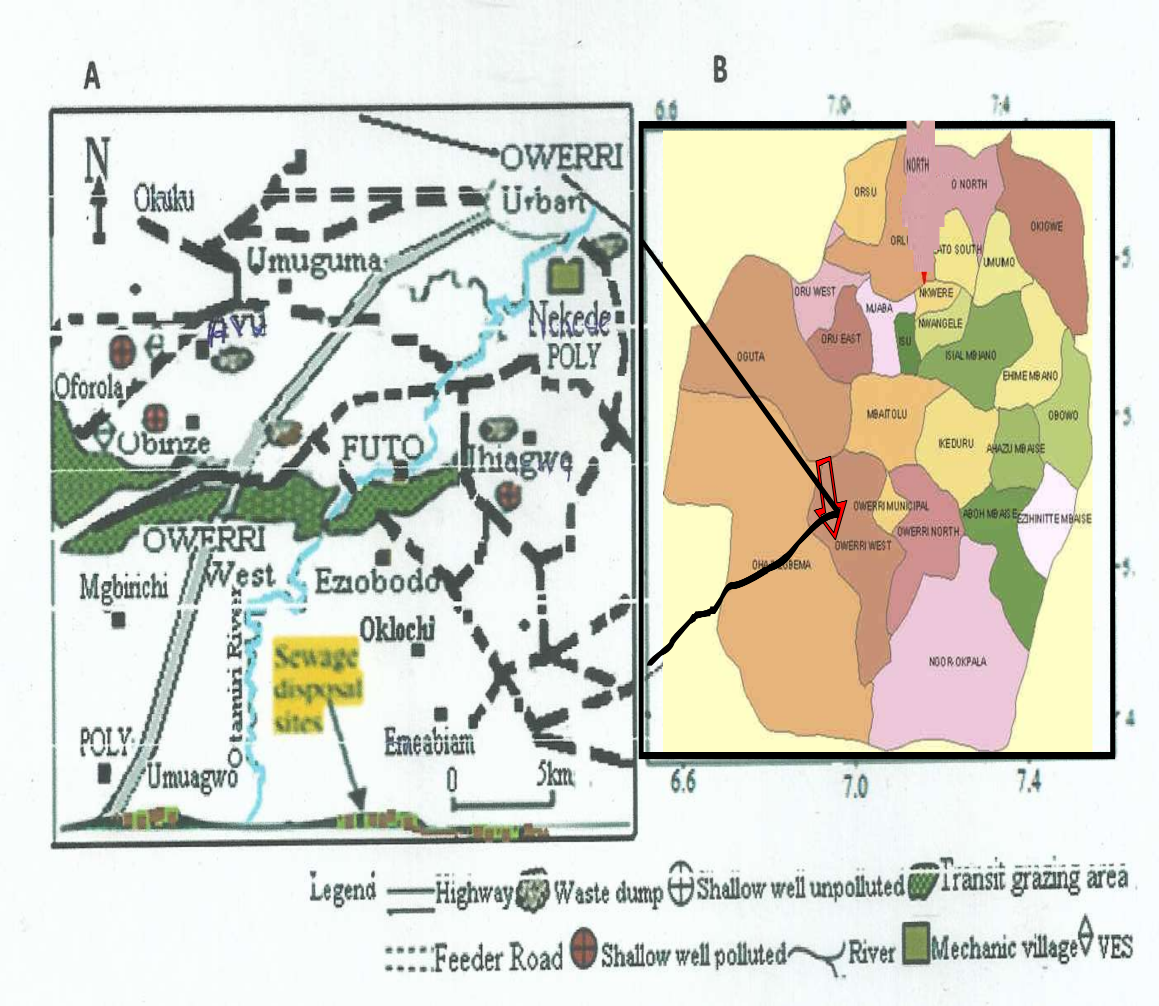


Fig. 3 (A) Geologic Map of Owerri West Local Government in Imo showing study area.

Fig. 3(B) Map of Imo State.

3.1 Nature of Data

3.1.1 Primary Data

This comprises of data collected from the eight boreholes in FUTO and her environment (Eziobodo i & ii; FUTO hostel i & ii ‘B; Obinze i & ii; and Ihiagwa i & ii). Four of the boreholes are located close to the pit toilet with possibility of having coliform deposits in the groundwater, while another four, two are located in close proximity to a waste dumpsite, and the other two in a residential household.

3.1.2 Secondary Data

Secondary data collected comprise of questions and information gathered from the place where samples were collected {Eziobodo i & ii, FUTO hostel “B” i & ii, Obinze i & ii and Ihiagwa i & ii). Some of the questions are:

- What is the water used for?
- The depth at which water can be reached.
- Geologic information of the area in question the mean annual temperature, the mean relative humidity, the mean annual rainfall and the elevation.

3.2 Mode of water sample collection and preservation.

Water samples were collected from eight boreholes, two each from Eziobodo, FUTO hostel, Obinze and Ihiagwa. The time of collection was between 8 and 8.30 in the morning.

For the physical and chemical analysis, eight plastic bottles of 2 liters capacity were used to collect the water samples, and the bottles were properly labelled, thoroughly washed, left to dry and then filled to the brim with the relevant water sample and was corked. For bacteriological analysis, care was taken to avoid accidental "contamination of water samples during collection. Bottle containers sterilized in an autoclave at 121°c for 30 minutes were properly labeled and used for sample collection.

Before water sample collection,' the water was allowed to rush out from the boreholes for 3 minutes to ensure that a representative was obtained. The samples were then collected by allowing the water to flow directly from the pump into the collecting bottle and then were corked.

3.3 SAMPLING

Four water samples were collected. The sample source are as follows:

Sample A1---------------------- Ezi obodo
Sample A2---------------------- Ezi obodo
Sample B1---------------------- FUTO hostel
Sample B2---------------------- FUTO hostel
Sample C1 ----------------------- Obinze
Sample C2----------------------- Obinze
Sample D1 ----------------------- Ihiagwa
Sample D2----------------------- Ihiagwa

The samples were labeled with the aid of the cello tape and pen and placed on the samples' bottle. There was little or no difficulty in slanging the samples for laboratory analysis because the samples were appropriately labeled.

All water samples were then carried in a cooler filled with ice blocks to FUTO Chemistry Laboratory and the analysis commenced immediately. At the end of each day, water samples were preserved in refrigerator**.**

3.4.1 DETERMINATION OF SOLUBLE IRON

Apparatus and Reagent:- Spectrophotometer, Distilled water, ferrous ammonium sulphate, pipette, sample cell, water, 100ml flasks.

Method:- 25 ml of each of the sample were poured into 100ml flasks, same amounts {25ml} of the reagents were added and were made up to 100ml and allowed to stand for 24hours. The optical densities were read on the spectrophotometer and the corresponding concentrations of iron in the samples were read off from the calibration graph. The concentration of soluble iron was calculated from the following relation:

$$\text{Concentration of iron } \{Fe^{3x}\} = \frac{\text{mg iron (in mg/L)}}{\text{ml of sample}}$$

3.4.2 Lead Determination.

Apparatus and Reagents: - lead free water, ammonium citrate, hydroxylamine hydrochloride, thymol blue indicator solution, separator funnel.

Method:- lead free water was used to dilute the standard lead solution and 25ml of it was transferred into the separatory funnel. 10ml of ammonium citrate reagent and 2 drops of thymol blue indicator solution were added into the separatory funnel. The potential hydrogen (pH) was adjusted from 8.5 to 9, while the solution in the separatory funnel was shake

vigorously for 30 seconds until the colour change remained unchange, that is green at the last portion of the funnel. The reading taken as:

$$\text{concentration of Pb} = \frac{\text{mg pb}}{\text{Ml sample}}$$

Where

Mg/L Pb = milligram per liter of lead (unit of measurement)

Ml sample = milliliter of sample

3.4.3 Calcium determination

Apparatus And Reagents:- Hydrochloric acid, sodium hydroxide, murexide indicator, conical flask, pipette, burette.

Method:- To 50ml of the sample, 0.1m hydrochloric acid solution was added in sufficient quantity to decompose the bicarbonate alkalinity of the sample. The mixture was boiled to expel carbondioxide. It was cooled and 2ml of 1m of sodium hydroxide (4g in 1 liter of distilled water} were added to produce a potential hydrogen PH of 12. A few specks of murexide indicator (200mg of ammonium purpurate mixed together with 100g of sodium chloride to 48 to 50 mesin) were added and the mixture was titrated slowly with 0.01m standard EDTA titrate

(1ml = 400.8 ug calcium) to a colour change from pink to purple, of the result is as; and

Calculation of the result is as; an

$$Ca^{2+} \text{ mg/L} = \frac{\text{ml EDTA titre x f x 0.7145 x 1000}}{\text{Ml of sample}}$$

Where:

Ml of sample = 50 ml

F = factor of the EDTA titrant.

The result to each sample is shown in table 3.

3.4.4 Magnesium Determination

Apparatus and reagents:- hydrochloric acid, sodium hydroxide, mureide indicator, conical flask, pipette, burette. Procedure: 3ml of hydrochloric acid was added to the end point of the calcium ion (Ca^{2+}) titration, 6ml of concentrated ammonia solution was added. A small amount of murexide indicator was added and titrated with EDTA until a faint blue colour appeared (from wine red to blue)

The results shown in table 3 was calculated as:

Concentration of magnesium

$$= \frac{\text{EDTA titre. Ml x 0.4343 x 1000 x F}}{\text{ml of sample}}$$

Where ml of sample = 50 ml (milliliter)

F = factor of EDTA titrant

Mg/L = unit of measurement (milligram per litre).

3.4.5 Suphate/Nitrate/Free Chlorine Determination.

To determine the values of sulphate, nitrate and free chlorine in free water samples, the spectrophotometer was used. For sulphate determination, the sulfaver iv method was used. The store program number 680 was entered with wave length 420mm. Two sample cells containing 10ml of de-ionized water (the black) and water sample respectively were filled. One sulfaveriv reagent powder pillow was added to the sample cell containing the water sample to the tested. The contents were mixed using a magnetic stirrer maintained at a constant speed for 2 minutes reaction period. The first sample cell (the bank) was use for zeroing after which the second sample cell was place to get the value of sulphate in the sample water and the optical densities were measured. The results were then expressed as mg sulphate per litre of sample using the relation:

$$\text{Concentration of sulphate} = \frac{\text{mg sulpate x 1000}}{\text{ml of sample}}$$

For nitrate, after carrying out the procedure {primary stock and secondary stock solution}, Nitrover 5 reagent powder pillow was added to the sample cell and stirred vigorously for about one minute. An amber colour developed showing the presence of nitrate. The dial wavelength of spectrophotometer adjusted to 500m after standardizing with distilled water at the wavelength of 100nm. The result was then obtained stained by placing the sample into the cell holder and reading the value on the spectrophotometer while the optical densities were measured for each sample. Nit rover 5-nitrate chart was used to determine the milligram (mg) of nitrate nitrogen involved. The nitrate content of the samples in mg/L were obtained from the relation; as follows and the results shown in table 3.

$$\text{Concentration of nitrate} = \frac{\text{mg nitrate}}{\text{Ml of sample}}$$

For free chloride determination, one hundred milliliter (ml) of the water sample were measured into each 250ml conical flask and 1 ml of potassium chromate solution was added and the solution was titrated inst silver nitrate solution and constantly stirred until unit the slightest perceptible reddish coloration [persisted. A blank titration using distilled water was carried out to allow for the presence of chloride in any of the agents. The potassium chromate was an. indicator (DDE, 1972). The titre values minus the titre value for the blank gave the ppm of chloride are in the sample after calculation from the following formula;

$$\text{Concentration of cl} = \frac{(A-B) \times N \times 35450}{\text{ml of sample}}$$

Where:

A = ml titration for sample

B = ml titration for blank

N = normality of sliver nitrate

ML = milliliter.

3.4.6 TOTAL DISSOLVED SOLIDS DETERMINATION

The samples were evaporated and dried in weighed dishes at 105°c to constant weight. The increase in weight over the empty dish represented the total solids content. One hundred milliliter (ml) of the sample were used and the evaporating dishes were left to cool in a desiccators before the weightings were done. The results were expressed in milligram total solids per litre of sample.

3 4.7 Potential Hydrogen Determination

The potential hydrogen (PH) of the samples were taken in the laboratory using an already standardized meter with glass electrode model 7020 from clc.

3.4.8 Colour Determination

The colours of the samples were observed by filling watched Nessler tubes with the water samples to the 50ml mark and comparing them with the standard disc, NSA, using a Nessleriser.

The colours were read out from the dies directly in Hazen units. The samples were diluted with distilled water until the colour was within the range of the standards in the disc. The value obtained was multiplied by dilution factor.

3.4.9 Conductivity Determination

The specific conductance of the samples were measured using he battery operated conductivity bridge model mc-1 Mark V electronic switchgear at room temperature. The values were read out directly in micrombos/centimeter.

3. 4.10 Total Hardness Determination

Fifty milliliter (ml) of the samples was pipetted into a 250ml flask and a few drops of hydrochloric acid solution were added to decompose any hydrogen carbonates that would interfere with the determinations.

The solution was boiled expel carbondioxide and then cooled to $50^{O}C$. The solution was titrated against EDTA standard titrate to a blue colured endpoint. The total hardness was calculated from the relation.

Hardness/EDTA/as mg/l calcium carbonate

$$= \frac{\text{ml EDTA x F x 1000 x 0.1 x 17.0}}{\text{ml of sample}}$$

Where:

$$F = \frac{\text{mg calcium carbonate}}{\text{Ml of EDTA}}$$

NOTE:

EDTA = Ethylene -diamine tetra acetic acid

mg = milligram

Ml = milliliter

F = factor of the EDTA titrant

3.4.11 Bacteriological Determination

(i) Total coliform Bacteria

Total coliform bacteria were cultured on prepared macconkey agar medium in milipore plate.

(ii) Total viable microbial load were cultured, using nutrient agar as the culture medium. The membrane filtration technique was used and the procedure for these determinations are as follows:

The media - nutrient Agar and Macconkey agar were prepared in Separate conical flask by dissolving them in appropriate quantity of distilled stilled water. After mixing and dissolving in the flask, the flask was plugged with a cotton wool and aluminum foil and autoclaved at temperature 121-°c for 30 minutes.

After autoclaving, the media were heated using a Bunsen burner and poured into separated Millipore plate which has been sterilized. It was then allowed to cool and solidify. The membrane filter to be used was then sterilized by boiling in a water bath, and 100ml of the water sample was poured filtered using sterile Millipore membrane filter paper 0-45 urn pore diameter). After filtering, the filter paper was transferred into the Millipore plate containing the solidified medium and, to the incubator which has been cleaned with hydrogen peroxide

(H_20_2).

After 24 hours of incubation (35°C), the Millipore plate was brought out and the total number of coliform bacteria and viable bacteria were determined. This is with the aid of the colony counter and Microscope

Table 3. Physicochemical and Biological Characteristics Showing water quality of underground water samples collected from the sample areas

Quality Parameter Values	**Analysis**								
	A1 Ez io bo do	**A2** Ez io bo do ii	**B1** FU T O Ho ste l i	**B2** FU T O Ho ste l ii	**C1** Obin ze i i	**C2** Ob inz e ii i	**D1** Ihia gwa i i	**D2** Ihia gwa ii ii	**p-Value**
Colour pt/co scale	5	5.20	15	15.10	10	10.10	15	15.20	Ns
Ph Potential hydrogen	5.21	5.24	4.71	4.71	4.94	4.96	4.85	4.90	Ns
Electrical conductivity $\mathcal{M}$s/cm	16	16.20	11	11.50	39	40	14	14	Ns
Sulphate(mg/l)	1.584	1.590	5.940	6.10	2.376	2.380	3.564	3.600	Xx
Total hardness as Caclo3 mg/l	19.68	19.70	12.40	12.47	15.58	16.00	44.28	44.30	Xx
Calcium mg/l	4.38	4.40	8.76	8.80	5.84	5.88	14.6	14.7	Xx
Magnesium hardness as Caco3 (mg/l)	1.75	1.78	1.20	1.22	8.76	8.79	2.92	2.95	Xx
Chloride mg/l	5.0	5.10	5.0	5.0	7.0	7.0	8.0	8.10	Ns
Nitrate (mg/l)	0.0001	0.0001	0.0011	0.0012	0.0006	0.0007	0.0002	0.0003	Xx
Total Iron(mg/l)	0.51	0.51	0.51	0.52	0.87	0.87	1.96	1.97	Ns
Lead (mg/l)	0.016	0.016	0.022	0.023	0.030	0.031	0.016	0.017	Ns
Total dissolved solids (mg/l)	10	11	7	7	25	26	9	10	Xx
Total microbial load per ml	800	810	530	532	3000	3000	410	412	Xx
Total coli form count mpm/100ml	25	25	5	7	15	16	13	14	Xx
Escherichia coli count mpm/100ml	11	12	2	2	5	6	8	8	Xx

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

The results of the physical, chemical and bacteriological characteristics of borehole water sample from Eziobodo i & ii FUTO hostel i & ii. Obinze i & ii and Ihiagwa i & ii were represented as sample A1, A2, B1, B2 C1, C2 and D1, D2 respectively.

The comparism of the quality parameters of the borehole water samples as shown in table 3 are as follows.

The colours in sample B (FUTO hostels 'B' i & ii) and sample D Ihiagwa i & ii) were the same. The electrical conductivity values were highest in sample C (Obinze i & ii), compared to that of other locations Sample D (Ihiagwa i & ii) has the highest concentration of calcium tricarbonate (hardness, (mg/L) among the other samples. Total dissolved solids (TDS) (mg/L) has greater value in sample C (Obinze i & ii) than the other samples. The potential hydrogen concentration (Ph) is higher in sample A (Eziobodo i & ii), followed by sample C

(Obinze i & ii). Sulphate concentration (mg/l) is higher in sample B (FUTO hostel 'B' i & ii) while sample D (Ihiagwa i & ii) has highest value of calcium concentration (mg/l) which may affect the total hardness concentration of the water. Magnesium concentration (mg/l) is higher in sample C (Obinze i & ii), chloride concentration (mg/L) is higher in sample D (Ihiagwa i & ii) while Nitrate Concentration has highest value in sample B (FUTO hostel 'B' i & ii). Total iron, lead concentration (mg/l) is higher in sample D (Ihiagwa i & ii) and sample C Obinze i & ii respectively. For total coliform bacteria and *Escherichia coli* count (MPN/100ml) were very high in sample A Eziobodo i & ii) while total microbial load were too numerous to count in sample C (Obinze) i & ii.

4.2 DISCUSSION

TABLE 4: Comparism of groundwater quantity of the study area with World Health Organization standard.

	Analysis Values								**W.H.O Standard (1993)**
Quality Parameters	A1	A2	B1	B2	C1	C2	D1	D2	W.H.O±
Colour pt/co scale	5±0.01	5-2±0.02	15±0.1	15±0.02	10±0.01	11±0.02	15±0.01	15.2±0.02	15
PH	5.21±0.01	5.22±0.02	4.71±0.01	4.8±0.02	4.94±0.01	4.96±0.02	4.85±0.01	4.90±0.02	6.5-8.5
Electrical conductivity Hs/cm	16±0.01	162±0.02	11±0.02	11±0.03	39±0.02	39.2±0.01	14±0.12	14.2±0.03	100
Sulphate (mg/l)	1.584± 0.24	1.584± 0.26	5.5940± 0.21	5.942± 0.22	3.564±0.021	3.566±0.022	3.564±0.12	3.565±0.02	250
Total hardness	19.68±0.14	19.69±0.16	12.46±0.02	12.47±0.03	15.84±0.12	15.86±0.14	44.28±0.02	44.30±0.03	250
Caco3 (mg/l)	4.38±0.01	4.39±0.02	8.76±0.02	8.76±0.03	5.84±0.001	5.86±0.002	14.6±0.001	14.6±0.002	200
Magnesium hardness as Caco3 (mg/l)	1.75±0.01	1.75±0.02	1.2±0.02	1.3±0.03	8.76±0.02	8.76±0.03	2.92±0.01	2.92±0.02	150
Chloride (mg/l)	5.0±0.01	5.1±0.02	5.0±0.01	5.0±0.02	7.0±0.02	7.0±0.03	8.0±0.01	8.0±0.02	0.3
Nitrate (mg/l)	0.0001±0.01	0.0001±0.02	0.0001±0.002	0.0001±0.003	0.0006±0.001	0.0006±0.002	0.0002±0.01	0.0002±0.002	4.0
Total iron(mg/l)	0.51±0.01	0.52±0.002	0.51±0.001	0.52±0.002	0.87±0.001	0.88±0.02	1.96±0.01	1.96±0.02	0.3
Lead(mg/l)	0.016±0.01	0.017±0.02	0.022±0.001	0.22±0.002	0.030±0.002	0.031±0.002	0.016±0.001	0.017±0.002	0.05
Total dissolved solids	10±0.01	10±0.02	7±0.001	7.2±0.001	25.±0.001	25.2±0.001	9±0.01	9±0.021	250
Total miaobial load per ml	800±0.01	800±0.002	530±0.01	531±0.001	3000±0.001	3000±0.002	410±0.001	410±0.002	5 -10
Total coliform count mpn/wml	25±0.001	25±0.002	5±0.01	5.2±0.002	15±0.002	15.2±0.003	13±0.002	13.2±0.002	0 -2
Escherichia coli count mpn/wml	11±0.001	11.2±0.002	2±0.001	2.1±0.002	5±0.002	5.1±0.002	8±0.002	8.1±0.003	0

The physical chemical and bacteriological characteristic of borehole water samples from Eziobodo, i & ii FUTO hostel i & ii, B Obinze i & ii and Ihiagwa i & ii (samples A1, A2, B1, B2, C1, C2, D1, D2 respectively), and the World Health Organization (WHO, 1993) portable water quality standard are presented in table 4. It shows that:

The values for Colour, electrical conductivity, total hardness and total dissolved solid concentrations from all the sampled bore-hole waters fall within. World Health Organization maximum standard, allowable for the respective parameters.

Sulphate, calcium, magnesium and Nitrate concentrations in all the sampled bore-hole waters are also within World Health Organization acceptable standard and therefore found to normal and good for drinking. The potential hydrogen (pH) concentration in all the sampled borehole water is slightly acidic and below the allowable WHO (1993) standard range. Total iron, chlorine and concentrations in the sampled bore-hole water were found to be above World Health Organization's portable water standard and pose the following threats to lives of consumers.

1. **Total Iron:** The presence of high values of iron above that recommended by world health organization in the ice water samples will impart metallic taste as well as negative aesthetic water qualities

such as reddish or greenish brown stains on sink and bathroom fittings. Also, iron bacteria are living organism that feed on dissolved iron forming greenish slimy slum that could clog water distribution pipes. These provide a medium for pathogens in drinking water.

Consumers of water from borehole containing high iron concentration will face the problem of acting limbs, back pains, nervousness, drowsiness, nasal congestion and nose bleeding from time to time. Also when used in laundry, it results in discolouration of clothings.

2) **Chlorine:** Chlorine is used as a disinfectant to drinking water. When the concentration of it exceeds the maximum allowable concentration set by World Health Organization, it poses the risk of developing large amount of potentially carcinogenic and mutagenic by-products. Also cause unpleasant taste and odour.

3) **Lead:** Any trace of lead in water above the World Health Organization's standard causes damage to central and peripheral nervous system, kidney and highly toxic to infants and pregnant women. But in the analysis result, the lead concentration in all the sampled water met the standard of world health organization.

Total microbial load, total coliform and *Escherichia coli* bacteria: counts in all the sampled bore-hole water were found to be above world health organization standard. They were too numerous to count especially total microbial load in sample C (Obinze i & ii). This implies that all the sampled borehole water are heavily contaminated.

The sources of contamination can be traced to the indiscriminate and deliberate dumping of refuse and closeness of the septic tanks to the bore-holes. Similarly during rainy seasons, the littered human faeces and animal droppings around the borehole contaminates the infiltration flow OF water to the ground water table. On human consumption, poses health effects of gastro-intestinal infection, dysentery, hepatitis, typhoid fever and cholera.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Both physicochemical results and microbial counts showed reasonable variations from each sample, which implies that the chemical parameters and microbial counts were below would Health Organization Standard.

Water is vital to all forms of life on earth. Lack of fresh water for drinking, industrial use, Agricultural use and other essential uses of water, is a limiting factor hindering development in many parts of the globe (UNESCO, 1991). Lack of safe water supply and adequate sanitation leads to health problems which might result to death.

The major issues associated with the use of water are the concern for its quality and quantity. The presence of some metals and coliform bacteria in water above the world health organization standard in the analysis carried out showed that the boreholes in FUTO and the neighboring communities (Eziobodo, Obinze and Ihiagwa) are non-hygienic for consumption because it exposes consumers to various forms of health risk

The pollution of water supplies is a major health problem today and this is through human activities. The unhygienic habit of sitting boreholes near septic tanks, refuse dumps should be stopped. In other words, boreholes should be located faraway from pollution sources. Similarly, the careless disposal and defaecation of human faeces and the domestic animal droppings should be checked by regulators such as environmental protection Agency (EPA).

5.2 Recommendation

From the results of the analysis performed, the boreholes in FUTO and the neighboring communities therefore calls for proper treatment before distribution. The treatment such as chlorination which is the cheapest and most widely used method for water disinfection. Furthermore, in water treatment, iron concentration should be removed from the water by addition of sufficient oxygen to allow the ferrous ion to oxidize to ferric ion. This normally occur in aeration tank. Sulphate, example aluminum sulphate helps in coagulation process whereby colloidal particles destabilizes and particle growth occur during flocculation. In flocculation process, the light floes floats on top of the water and is removed through the use of mechanical device called scrapper. While the heavy floes sediments were removed through back flushing. Another process called sedimentation process allows particulates to settle then filtered during filtration process. After filtration, chlorination should be followed and this helps in the harmful removal of bacteria. It can also be removed by boiling.

Lastly, in sitting boreholes in future, the distance to septic tanks, garbage chimps should be taken note of or put into consideration. Adequate and efficient toilet systems should be provided by the individuals in the communities and for students in the hostel. This is to check indiscriminate defaecation

Figure 19 below is a flow diagram of groundwater treatment before distribution.

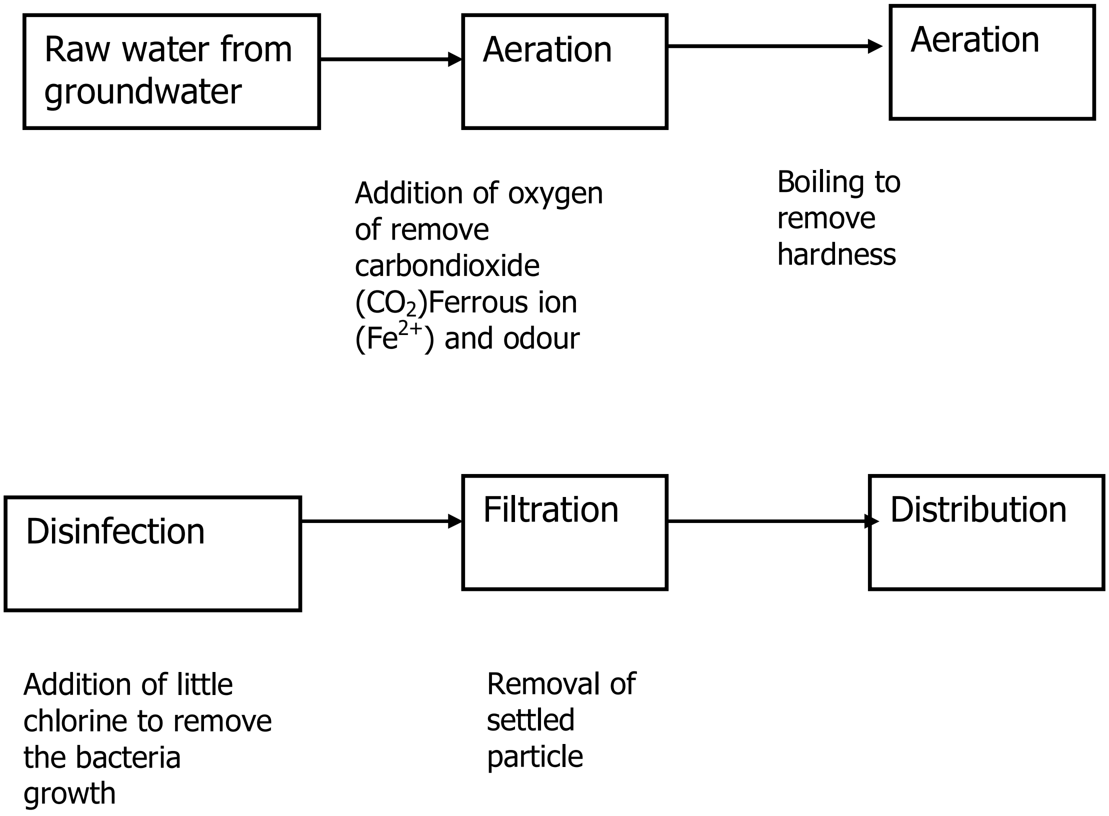


Figure 19: Treatment of Groundwater

REFERENCES

Agunwamba, J. C. (2000) Water Engineering System Immaculate Publications Limited, Eungu 331pp.

Anyanwu N. O. (2001) "Bacteriological Examination of water from Hand - Dug wells and Boreholes located in Ado Ekiti" African Journal of Environmental Studies, vol 2 No 1 pp 176 - 182.

Allian (1986) Physics-based Modelling of lakes, Reservoirs and impoundments, Johs Wiley, New York.

Ayoade, J.O. (1988) Tropical Hydrology and water Resources Macmillan Publishing Company, 400pp.

Balogun, O. (1988) Groundwater potentials of Rido Village. Unpublished M-Tech-Thesis Department of Geophysics Federal University of Technology, Akure, Nigeria.

Badmus, B.S. (2001) "Leachate Contamination Effect on Groundwater Exploration" African Journal of Environmental Studies Vol. 2, No 1 pp 38-41.

Bowue Harman (1978) Groundwater . Hydrology, International student edition, McGraw Hill Kogakushe Ltd New York 480pp.

Blyth, F. G. and Freitas. M. H (1984) A Geology for Engineers 7th Edition Edward Arnold Publications. London 325pp.

Burrows (1968) Environmentally sound water management, Oxford University Press Delhi.

Camp. T.R. and Meserve, R.L. (1984) Water and its impurities Dowden Hutchinson and Rose Inc., New York pp. 15.

Carpenter, P.L. (1984) General Microbiology W.B. Saudars Publishing Company London 350 pp.

Charry and Freeze (1979): Models for water Quality management, Mc Graw-Hill, New York.

Deeyer Mont (1979) The Nalco Water Handbook McGraw Hill book Publishing Company, pp 171-178.

Diamant, B.Z (1980) Water-Quality characteristics of Boreholes in selection location in Port Harcourt. Unpublished B. Eng. (Hons.) Project Dept of Civil Engineering, Federal University of Technology Owerri, Nigeria.

Fair, G.M. (1971) Elements of water supply and Waste water Disposal (2nd edition) John Wiley Publications New York 752 pp.

Geidreich, E.E. (1981) Current status of Microbiological water quality criteria JAM water works Association 47 (7) 23-26.

Gower G.H. (1980) Water Quality in catchments Ecosystem, John Wiley Publication pp 253-358

Hammer, M.J. and Kenneth, A.M. (1981) Hydrology and Quality of Water resource, John Wiley Publication, New York 486 Pp.

Hamill, L and Bell, F.C. (1986) Groundwater Resource Development. Butterworths Publication, London 344 pp.

Kayode Dada, A. (2001) “Groundwater Quality in Illorin township” Africa Journal of Environmental Studies Vol. 2, No. 2 Pp. 4-7.

Nwagbara, O.C. (2002) Water Quality characteristic (Bacteriological) of the Elechi Creek Port Harcourt. Unpublished M. Tech (Hons) Thesis Department of Environmental Technology, Federal University of Technology Owerri, Nigeria.

Ofoegbu, C.O. (1988) “Groundwater and Mineral Resources of Nigeria” Journal of Waster Science, viewed and John publications, West German pp. 20-25.

Ojelabi E.A. (2001) “Geographical and Chemical Analysis of Groundwater samples in Ago-Iwoye Area, South West Nigeria” African Journal of Environmental studies Vol. 2 No. 1 pp 77-80.

Okafor N. (1985) Aquatic and waste Microbiology. Fourth dimension publishing company, Enugu, Nigeria pp. 8-78.

Osibanjo, O. (1996) “Present Water Quality status in Nigeria” FEPA Monography in Water Quality Edited by Aina, E.O. and Adedipe, No. 6, pp 35059.

Pelezer, J. M. and Chan, E.C.S. (1077) Microbiology McGraw Hill Book Company, London. 698 pp.

Ray, K.L. (1988) “Hydrology for Engineers” Hydrology and Water Quality McGraw Hill publishing Company, New York 450 pp.

Steel, E.W. (1953) Water supply and Sewages McGraw Hill Book Company Ltd., New York 350 pp.

USEPA (2003) National primary Drinking water standards, USEPA, New York.

Willipedia (2003): Water Quality and its control, John Wiley, New York.

World Health Organization (1971) International Standard for Drinking Water (3rd Edition) Geneva, Switzerland.

Yates, M.V. (1985) “Septic Tank Density and Groundwater Contaminant” Groundwater, Vol. 23 No. 5

Ekechukwu K.C. (1988): Assessment of water of quality from boreholes in Eket unpublished B. Engr. (Hous) project department of civil technology owerri, Nigeria

Environmental Review (2002), vol 3 No 1 environmental group Nnamdi Azikiwe University Awka, Nigeria pp 175-185

Elemba, C.O 1982 – water quality characters of boreholes in selection location Port Hacourt. Unpublished B. Engr (Hons) project department of civil Engineering, Federal University of Technology Owerri, Nigeria.

Hammer M.J and Hammer M.J Jr (1996) – water and waste water technology third edition prentice hall international incorporated pp 183-156