**CHAPTER ONE**

**1.1 BACKGROUND**

Water is one of the most important and most precious natural resources. It is essential in the life of all living organisms from the simplest plant and micro organisms to the most complex living system known as human body. Water is a combination of hydrogen and oxygen atoms, with a chemical formula, H 2O and known to be the most abundant compound (70%) on earth surface. It is significant due to its unique chemical and physical properties. Access to safe drinking water is key to sustainable development and essential to food production, quality health and poverty reduction. Safe drinking water is essential to life and a satisfactory safe supply must be made available to consumers. Water is thus becoming a crucial factor for development and the quality of life in many countries. In individual arid areas it has become a survival factor. Therefore, water intended for human consumption must not contain pathogen, germs or harmful chemicals; because water contaminated with microorganisms is the cause of epidemics. That is good drinking water is not a luxury but one of the most essential requirements of life itself. However, developing countries, like Nigeria, have suffered from a lack of access to safe drinking water from improved sources and to adequate sanitation services. The WHO revealed that seventy five percent of all diseases in developing countries arise from polluted drinking water. Therefore; water quality concerns are often the most important component for measuring access to improved water sources. Acceptable quality shows the safety of drinking water in terms of its physical, chemical and bacteriological parameters. International and local agencies have established parameters to determine biological and physicochemical quality of drinking water. The problems associated with chemical constituents of drinking water arise primarily from their ability to cause adverse health effects after prolonged periods of exposure, of particular concern are contaminants that have cumulative toxic properties, such as heavy metals and substances that are carcinogenic. Mahmoud *et* al 2003. also stated that the most common problems in household water supplies may be attributed to hardness, iron, sulfides, sodium chloride, alkalinity, acidity, and disease-producing pathogens, such as bacteria and viruses. In addition to this International Agency for Research on cancer reported that the use of chemical disinfectants in water treatment or construction materials used in water supply system usually results in the formation of the chemical by-products, some of which are potentially hazardous. This means drinking water is a vehicle for disease transmission. Therefore, it is desirable to control the intake of these potentially toxic chemicals from drinking water because the intake from other sources which are food or air may be difficult to avoid. About 97% water exists in oceans that is not suitable for drinking and only 3% is fresh water wherein 2.97% is comprised by glaciers and ice caps and remaining little portion of 0.3% is available as a surface and ground water for human use (Miller *et* al,.1997). Fresh water is already a limiting resource in many parts of the world. In the next century, it will become even more limiting due to increased population, urbanization and climate change (Jackson *e*t al., 2001).

Over 50% of the Nigerian population depends on Ground water for drinking water. Ground water is also one of our most important source of water, it comes from rain, sleet and hail that soak into the ground. The water moves down into the ground because of gravity, passing between particles of soil, sand, gravel, or rock, until it reaches a depth where the ground is filled or saturated with water. The source of most tanker distributed water in Enugu metropolis water source is ground water (bore holes). Unfortunately groundwater is susceptible to pollutants which affect their physiochemical characteristics and microbiological quality. Groundwater contamination occurs when man made products such as gasoline, oil and chemicals get into the groundwater and cause it to become unsafe and unfit for human use. Materials from the lands surface can move through the soil and end up in the groundwater. For example, pesticides and fertilizers can find their way into groundwater supplies overtime. Toxic substances from mining sites, and used motor oil also may seep into ground. In addition, it is possible for untreated faecal materials open defecate from septic tanks and toxic chemicals from ground storage tanks and leaky landfills to contaminate groundwater.  
Prevention of groundwater pollution requires effective monitoring of physiochemical and microbiological parameters. In most countries, the principal risks to human health associated with consumption of polluted water are microbiological in nature. The bacteriological examination of water has a special significance in pollution studies, as it is a direct measurement of deleterious effect of pollution on human health. Coliform are the major microbial indicator of monitoring water quality. The detection of *Escherichia coli* provides definite evidence of faecal pollution; in practice, the detection of thermo tolerant (faecal) Coliform bacteria is an acceptable alternative.

**1.2 Statement of problem**

In developing countries (e.g. Nigeria) the drinking quality of water is continuously being contaminated and hazardous for human use due to high growth of population, expansion in industries, discharging of waste water and chemical effluents into canals and other water sources. According to recent estimates, the quantity of available water in developing regions of South Asia, Middle East and Africa is decreasing sharply while quality of water is deteriorating rapidly due to fast urbanization, industrialization, land degradation etc.

In addition, the physical condition of water (colour, taste and odour) might render it undrinkable as it can be rejected by end-users. For this reason, water quality assessment and continuous monitoring are of utmost importance.

Enugu metropolis has witnessed remarkable expansion, growth and development activities such as buildings, road, constructions and many other anthropogenic activities that may affect their quality of water

**1.3 Aims and Objectives of Study**

The aim of this study is to determining the parameters present in the tanker supplied water & its quality through physiochemical and biochemical analysis.

1. To identify the presence or absence of toxic chemicals
2. To identify the presence or absence of microbial contaminants
3. To assess if the water quality are in order of the Nigerian drinking water standards.

**1.4 Significance of study**

In Enugu metropolis, most people rely on private water supplies such as wells, tanker supplied water and streams. Quality water is vital to the social, health and economic well being of the people. Monitoring your water quality by having it tested regularly is an important part of maintaining a safe and reliable source. Testing the water allows a knowledgeable approach to address the specific problems of a water supply. This helps ensure that the water source is being properly protected from potential contamination. It is important to test the suitability of your water quality for its intended purpose, whether it is livestock watering, irrigation, spraying, or drinking water. This will assist you in making informed decisions about your water and how you use it. This study is to help provide water quality testing information that will assist residents using a private water supply. It provides information on the importance of water quality monitoring and how you can get it tested.

The quality of a water source may change over time, sometimes suddenly. Many changes can go unnoticed as the water may look, smell and taste the same as it always did. Monitoring your water quality is necessary to ensure your treatment system is working effectively, providing the best quality water for your intended use. The water you are using may or may not have problems with it. Many people are aware of some of their water quality problems. For example, some people may be plagued with high concentrations of iron, which causes aesthetically unpleasing coloring and staining. Unfortunately, not all water quality problems can be easily detected without proper testing. The water may look good but may actually be unsuitable for the specific application you are using it for. Proper sampling, testing and interpretation of the results are required to determine the suitability of your water supply and identify any problems it may have.

**CHAPTER TWO**

**LITERATURE REVIEW**

**2.0 Introduction**

Water is a transparent tasteless, odorless, and nearly colorless chemical substance that is the main constituent of Earth's streams, lakes, and oceans, and the fluids of most living organisms. Its chemical formula is H2O, meaning that each of its molecules contains one oxygen and two hydrogen atoms that are connected by covalent bonds. Strictly speaking, water refers to the liquid state of a substance that prevails at standard ambient temperature and pressure; but it often refers also to its solid state (ice) or its gaseous state (steam or water vapor). Safe drinking water is essential to humans and other life forms even though it provides no calories or organic nutrients. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack accesses to adequate sanitation. However, some observers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability. A report, issued in November 2009 by Ajewole G (2005), suggests that by 2030, in some developing regions of the world, water demand will exceed supply by 50%. Water plays an important role in the world economy.

Declining water quality has become a global issue of concern as human populations grow, industrial and agricultural activities expand, and climate change threatens to cause major alterations to the hydrological cycle. Water quality issues are complex and diverse, and are deserving of urgent global attention and action. Approximately 70% of the freshwater used by humans goes to agriculture. Fishing in salt and fresh water bodies is a major source of food for many parts of the world. Much of long-distance trade of commodities (such as oil and natural gas) and manufactured products is transported by boats through seas, rivers, lakes, and canals. Large quantities of water, ice, and steam are used for cooling and heating, in industry and homes. Water is an excellent solvent for a wide variety of chemical substances; as such it is widely used in industrial processes, and in cooking and washing. Water is also central to many sports and other forms of entertainment, such as swimming, pleasure boating, boat racing, surfing, sport fishing, and diving.

**2.1 Water Quality**

This refers to the chemical, physical, biological and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance, generally achieved through treatment of the water, can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human. Both natural processes and human activities influence the quality of surface waters and groundwater, water naturally contains dissolved substances, non-dissolved particulate matter and living organisms; indeed, such materials and organisms are necessary components of good-quality water, as they help maintain vital biogeochemical cycles. There are few exceptions where naturally occurring substances trigger water quality challenges detrimental to human health. For example in the use of groundwater as its primary source of freshwater, up to 77 million people have been at risk of exposure to arsenic in recent decades. Chemical and physical properties Water (H2O) is a polar inorganic compound that is at room temperature a tasteless and odorless liquid, nearly colorless with a hint of blue. This simplest hydrogen chalcogenide is by far the most studied chemical compound and is described as the "universal solvent" for its ability to dissolve many substances. This allows it to be the "solvent of life". It is the only common substance to exist as a solid, liquid, and gas in normal terrestrial conditions.

**2.2 Sources of Tanker Water**

Since tanker water is obtained from boreholes, groundwater is the main source of tanker water. Groundwater is a fresh water pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. It originates as rainfall, and then moves through the soil and rock into the groundwater system. Groundwater makes up about 1% of the water on earth but groundwater makes up to 35 times the amount of water in lakes and streams. Groundwater occurs everywhere beneath the earth surfaces, but is usually restricted to entire surface of the earth

**2.3 Origin of Groundwater**

Groundwater derived from rainfall and infiltration within the normal hydrological cycle. This kind of water is called meteoric water. The name implies recent contact with the atmosphere. Groundwater encountered at great depths in sedimentary rocks as a result of water having been trapped in marine sediments at the times of their deposition. This type of groundwater is referred to as connate waters. These waters are normally saline. It is accepted that connate water is derived mainly or entirely from entrapped sea water as original sea water has moved from its original place. Some trapped water may be brackish.

**2.4 Groundwater Characteristics**

The chemical, physical and bacterial characteristics of groundwater determine its usefulness for various purposes. Chemical analysis of groundwater includes the determination of the concentrations of inorganic constituent. The analysis also includes measurement of pH and specific electrical conductance. Temperature, colour, turbidity, odour and taste are evaluated in a physical analysis. Bacteria analysis generally consists of tests to detect the presence of coli form organisms. Tebbute (1992) noted that pathogenic organisms are rarely found in groundwater, since poor well construction or being associated with bedrock aquifers in which large openings afford direct connection between the surface and groundwater causes most well pathogenic contamination. *Lloyd and Helmer (1991)* observed that the water quality problem may be associated with and traceable to, any or all of the following:

1. Poor quality source of water,

2. Poor site selection or protection such as apron and lining

3. Construction difficulties and

4. Structural deterioration with age

* 1. **Factors Affecting Groundwater Quality**
  2. **Influence of geological factors:**

Soil’s filtration capacity depends on its mechanical characteristics (including the degree of fracturing, particle size, and porosity) and on its chemical and physical composition (including the presence of clay, soluble organic substances, cations, and pH). Contamination is more frequently detected in sedimentary rock than in igneous or metamorphic rock. Several microorganisms may be adsorbed and remain in the soil for a long time; these are affected by sunlight, temperature, moisture, and organic matter. For example, clay soils, which contain hematite and magnetite, promote the adsorption of viruses. The degree of groundwater contamination is also affected by soil porosity. Sandy soils (defined as porous) may hinder the spread of microorganisms, while karst soils (nonporous) are known to be more vulnerable and most influenced by agricultural activities and wastewater emissions. Porous soil therefore may better improve water quality compared to non-porous soils, because it causes real purification depending on several factors, including thickness, grain size, the chemical composition of soil, the type and quantity of pollutants, the rate of water percolation, and the degree of environment saturation. Groundwater quality also varies as a function of its chemical composition, influenced by the solubility of the soil it passes through and by aquifer depth. In particular, water will be low in salts if it passes through poorly soluble soils, follows short distances, and flows only for a short time. In contrast, water will be rich in salts if it passes through soluble soils (e.g. carbonate rocks) or remains in the subsoil for a long time. (O. De Giglio *e*t al.)

* + 1. **Climate effects**

Seasonal variation and climatic factors affect the quality and quantity of groundwater. Changes in groundwater recharge rate caused by seasonal variation also affect the concentration of water parameters. Under normal environmental conditions (for example, in the absence of heavy rain) microorganisms are retained efficiently by the soil and are only detectable in trace amounts in groundwater. Serious weather events, including high-intensity rain or drought, can greatly influence the water quality, contributing to the dissemination of pathogenic microorganisms to geographic areas in which they were previously absent. In certain regions, recent climate changes have led to a “tropicalizat ion” of rain consisting of uneven rainfall distribution throughout the year and large and intense rains. As a result, gastrointestinal diseases are increasing, depending on temperature and soil overflow, causing the contamination of coastal waters and inland surfaces water. Global climate change also influences the availability of water: poor rain and an altered rainfall distribution during the year cause a significant reduction in the flow of water for aquifer recharge and for irrigation. In particular, in some coastal areas, decreased groundwater resources and their depletion by humans have caused marine intrusion. This increases the risk of microbiological contamination and of salinization of water. Some authors report that high salinity is associated with a remarkable increase in bicarbonate content during the crop-growing season because of more intense biological activity in irrigated soils.

**2.5.2 Anthropogenic influences**

Human activities can cause contamination of aquifers, resulting both from industrial activities (including uncontrolled discharges of potentially toxic chemical substances, processing residues, and waste) and agricultural activities (including the use of herbicides, antiparasitics, and pesticides). In particular, intensive agriculture is often inadequate for the characteristics of the area and the chosen produce, creating a substantial increase of nitrates, which are usually present in low quantities in groundwater. Although nitrogen is a vital nutritive element for the growth of plants, it can be harmful to humans and to the environment in high concentrations. In Europe, Directive 91/676/CEE regulating the use of nitrates aims to prevent pollution of groundwater and surface water caused by agricultural nitrates and to facilitate the use of correct practices. Furthermore, herbicides and pesticides, which are mainly used in agriculture to kill fungi, weeds, parasites and insects, are combined with the fertilization procedure and are often overused. These substances are harmful and dangerous when used in excessive amounts because they overflow the soil and reach surface water and groundwater. The presence of these contaminants in groundwater is affected not only by their physicochemical properties (including biodegradability, potential for absorption, and solubility) but also by climatic, hydrological and agricultural conditions. The intensive raising of livestock in confined areas can also contribute to groundwater contamination through animal manure discharged on areas overlying aquifers. In some regions, it is still customary to spread manure on the ground to fertilize it and make it more productive. Regrettably, this turns the nitrogen contained in the manure into nitrate, contaminating the underlying aquifers, especially when the soil temperature exceeds 5°. Additionally, the amount of nitrogen in groundwater from livestock waste or chemical fertilizers increases when overlain by permeable soil.

Another consequence of human activity is deforestation in favor of agricultural crops, Groundwater quality overgrazing, and, more recently, photovoltaic systems. This causes soil to become more easily erodible, as it is not protected from the washing action of surface water, increasing the frequency of natural disasters, such as floods, and causing drastic variations of hydrological characteristics.

**2.6 Water Pollution & Their Sources**

Water is said to be polluted when its quality is degraded as a result of man’s activities to an extent that it becomes less suitable for its intended use (Chapman, 1992). The foreign substances that impair or degrade the water quality are referred to as pollutants and may be of organic, inorganic, biological or physical origin. The deleterious effect of pollutions include harm to human health, hindrance to aquatic activities and the inability of the water to support agriculture, industrial and other related economic activities. A noted source of pollution in groundwater supplies is the latrine/septic tank, causing an increase in biochemical oxygen demand BOD, chemical oxygen demandCOD, nitrate, inorganic chemicals and pathogens thus leading to outbreak of diseases common in developing nations like Africa, Asia and South America (Chapman, 1992). Sangodoyin (1993) observed that the unsanitary mode of disposal of wastes, such as defecation in streams and the dumping of refuse in pits, rivers and drainage channels as seen in most Nigerian urban settlements, could be expected to affect surface and groundwater quality. The degree of pollution (contamination) will depend on the efficiency of the waste disposal methods, safety of land use patterns, density of disposal systems in an area, composition of waste and soil and a number of other site-specific information. Well liming eliminates contamination and hence improves water quality (Sangodoyin, 1993).

Industrial waste disposal method of discharging effluents unto land, stream and sanitation sewers also have potential of polluting ground water. Other sources of groundwater pollution include tank and pipeline leakage and mining activities. Oil and gas production is often accompanied by substantial discharges of wastewater called brine, which is disposed of using methods such as abandoned pits, evaporation ponds and streams. These methods have the potential of polluting aquifers with brine, leading to an increase in sodium, calcium, ammonia, boron, chlorides, sulfates, trace metals and substantial amounts of total solids (Chapman, 1992). Agricultural sources of pollution include irrigation with a lot of return flow back into the ground (Ogedengbe, 1980). The possible effect on the ground water include an increase in ground water salinity, due to inadequate drainage and direct evapotranspiration of irrigation return flow from soils whose salinity has been increased by salts from fertilizers (Todd, 1980; Chapman, 1992). Others include animal waste from animal pens and slaughter houses where they are confined for purposes of meat and milk production and may carry through storm run-offs, significant amounts of nitrates, salts, organic loads and bacteria to surface and sub-surface water (Sangodoyin and Agbawhe, 1991). Agrochemicals such as fertilizer, pesticides and insecticides also pollute ground water. Nitrate based fertilizers are a significant contribution to groundwater pollution. This is because nitrogen in solution is neither fully utilized by plants nor absorbed by the soils. Stock piles of solid materials from construction sites, individual’s plants residue are potential groundwater pollutants when precipitation falls on these piles, causing a leaching of heavy metals, salts and other organic and inorganic constituents. Sangodoyin (1987) gave the following considerations as a way of reducing groundwater contamination or pollution:

1. A well should be sited uphill of a polluting source. This is with a view to diverting to drain from the well into a polluting source rather than converse.

2. The distance between a well and a polluting source should not less than 30 m (100 feet).

3. Well construction should start towards the end of the dry season.

**2.7 Water & Human Health**

Water is essential to sustain life, and a satisfactory supply must be made available to consumers. Every effort should be made to achieve a drinking water quality as high as practicable. But today one of the major problems of drinking water is that water is not safe. The health problem associated with unclean water enormous of the 3.4 million people killed each year by water-related diseases, 2.1 millions mostly children are die from diarrhea disease stemming from lack of access to safe water, inadequate sanitation and poor hygienic. Water borne diseases are any illness caused by drinking water contaminated by human or animal faces, which contain pathogenic microorganisms. The full picture of water associated diseases is complex for a number of reasons. Over the past decades, the picture of water related human health issues has become increasingly comprehensive, with the emergence of new water related infection diseases and the reemergence of one’s already known. The burden of several diseases group can be only attributed to water determinants. Everywhere, water plays an important role in the ecology of diseases. In developing countries four-fifth of all the illnesses are caused by water. Diarrhea is being the leading cause of childhood death. Safe water in sufficient qualities is required for the fundamental to human health. Safe water and sanitation shape health through potable water supply, safe food, preparation, hygiene, better nutrition and relaxation. The global picture of water highlights that health has a strong dimension with some 1.1billions people still lacking access to improved drinking water sources and some 2.4 billion to adequate sanitation. Today, we have strong evidence that water sanitation and hygiene related diseases amount for some 22, 13,000 deaths, annually and loss of 82,196,000 disability adjusted life years. Poor environmental sanitation and water quality play a significant role in spreading infectious diseases. According to UNICEF 2005 about 4 billion cases of diarrhea per year cause 2.2 million Deaths, with majority of the victims being below five years of age indicating that there is a significant relationship between drinking water quality and child mortality rate. This has been the cause of many dramatic outbreaks of fecal-oral diseases such as cholera and typhoid. However, there are many other ways in which fecal material can reach the mouth, for instance on the hands or on contaminated food. In general contaminated food is the single most common way in which people become infected.

Safe drinking water is one of the most important indicators of food absorption. Many Water-borne infections spread due to use of unsafe drinking water. Worldwide, about 2.3 billion people suffer from diseases that are linked to water problems. Water related diseases kill millions of people each year, prevent millions more from leading healthy lives and undermine development efforts. Nearly half of the urban residents in Africa, Asia and Latin America suffer from one or more of the main diseases associated with the inadequate provision of water and sanitation. Thus, it needs to be remembered that the augmentation of water supply alone does not ensure good health, proper handling of water and prevention of contaminations are equally important.

**2.8 Water Quality Indicators**

Water quality indicators are laboratory test methodologies to assess suitability of water for use. Tests selected and desire test results vary with the intended use or discharge location. Test measure physical, chemical and biological characteristics of water.

**2.9 Microbial quality:**

Safe guarding the microbial quality of drinking water is said by the experts to be the most important objective, even ahead of its physical and chemical quality, since water represents an obvious mode of transmission of enteric diseases (Bland, 1980; Skinner and Shecon, 1997). According to the WHO (1971), the greatest danger associated with drinking water is contamination by sewage, human and animal excreta. Microbial qualify is determined using various methods of bacterial examination. The indication organism’s method as invented by Percy Frankland in London in 1981 is basically the concept of using organisms usually abundant in human and animal excrement, as evidence of contamination and possible presence of other potentially dangerous microorganisms (WHO, 1984).

The use of indicator organisms for determination of the microbial quality of water saves the time, labor and expenses involved in attempting to test for all pathogens that a water sample might possible contain. For an organism to be ideal for use as an indicator, it must meet the following criteria:

1. The method of isolation, identification and enumeration should be simple and unambiguous.

2. It should be resistant to chlorine and have a higher survival rate in water than pathogens.

3. It should be more neutral than all pathogens in the environment.

The significant that can be attached to the presence or absence of a particular fecal indicator varies with each be specifically associated with faeces (WHO, 1984). The WHO (1984) recommended standards for testing contamination during transportation o3r storage is an MPN count of less than 10 per 100 ml for total coli forms and 2.5 per 100 ml for *E. coli.* The body also recommends that the widespread of faecal contamination in developing countries, the nation surveillance agency should set medium term targets for the progressive improvement of water supplies.

**2.10 PHYSIOCHEMICAL QUALITY:**

The term physicochemical quality is used in reference to the characteristics of water which may affect its acceptability due to aesthetic considerations such as colour and taste; produce toxicity reactions, unexpected physiological responses of laxative effect, and objectionable effects during normal use such as curdy precipitates (WHO, 1995).

* 1. **Taste and odour:**

Taste and odour depend on the stimulation of the human receptor cells, which are located in the taste-buds for taste and nasal cavity for odour (WHO, 1984). Taste and odour are complimentary, for example when tasting water; both the olfactory and gustatory nerves are active. In all taste it is actually flavor that is being measured flavor refers to the combination of taste, odour, temperature and feel. The close association between taste and odour may be illustrated by the lack of flavour of many food substances, when the sense of smell is lost during a head cold (Emslie-smith, 1988). Taste and odour problems account for the largest single class of consumer complaints in drinking water supplies, due to the water source, the treatment method, distribution system or a combination of all three (WHO,1984). Taste in drinking water is measured by taste tests such as the threshold test or taste rating tests. The odour tests are carried out for odour in drinking water. The sense of smell is more sensitive than the best analytical method, for example the guideline for cyanide in drinking water would be 1/100th of the present limit if based on the odour threshold of 0.001 mg/l (WHO, 1984). Factors affecting taste and odour include:

* + 1. **Temperature**

The growth rate of microorganisms, some of which produce bad tasting metabolites is positively associated with temperature. The odour of substance is also temperature influenced because of relationship between Water temperature varies with season, elevation, geographic location, and climatic conditions and is influenced by stream flow, streamside vegetation, groundwater inputs, and water effluent from industrial activities. Water temperatures rise when streamside vegetation is removed. When entire forest canopies were removed, temperatures in Pacific Northwest streams increased up to 80°C above the previous highest temperature. Water temperature also increases when warm water is discharged into streams from industries.een odour and vapor pressure, therefore odour measurement usually specify temperature.

* + 1. **pH**

pH is a measure used to indicate degree of acidity of a water solution. The pH scale ranges from 0 to 14. A pH of 7 is considered neutral, with values less than 7 being acidic, and values greater than 7 being basic. Low pH values are found in natural waters rich in dissolved organic matter. The tannic acid released from the decomposition of vegetation causes the tea coloration of the water and low pH. High pH values in lakes during warmer months are associated with high plant densities. The relationship between photosynthesis and daily pH cycles is well established.

Photosynthesis consumes carbon dioxide during the day, which results in a rise in pH. In the dark, phytoplankton respiration releases carbon dioxide which forms a weak acid in the water. In productive lakes, carbon dioxide decreases to very low levels, causing the pH to rise to 9-10 SU. Continuous flushing in streams prevents the development of significant phytoplankton populations and the resultant chemical changes in water quality. A range of potential water quality problems such as mining and farming runoff can cause changes to pH. Extremes of pH (less than 6.5 or greater than 9) can be toxic to aquatic organisms. pH influences the taste and odour of a substance significantly, especially when it controls the equilibrium concentration of the neutral and ionized forms of a substance in solution. The average threshold increases from 0.075 to 0.450 mg/l as the pH increases from 5.0 to 9.0 (WHO, 1984).

* + 1. **Residual chlorine**

A balance is sought such that the level of residual chlorine is high enough for microbial safety without leaving an objectionable taste in drinking water.

* + 1. **Total dissolved solids (TDS)**

All natural waters contain some dissolved solids due to the dissolution and weathering of rock and soil. Dissolved solids are determined by evaporating a known volume of water and weighing the residue. Some but not the entire dissolved solids act as conductors and contribute to conductance. Waters with high total dissolved solids (TDS) are unpalatable and potentially unhealthy. Water treatment plants use flocculants to aggregate suspended and dissolved solids into particles large enough to settle out of the water column in settling tanks. A flocculent is a chemical that uses double-layer kinetics to attract charged particles. Total Dissolved solids comprise of organic matter and inorganic salts, which may originate from sources such as sewage, effluent discharge, and urban run-off or from natural bicarbonates, chlorides, sulphate, nitrate, sodium, potassium, calcium and magnesium. The major determinant of the TDS level in water is the geochemical characteristics of the ground it comes in contact with, for example granite and silicon sands, and well leached soils have TDS less than 360 mg/l, the WHO (1984) gave the palatability of drinking water according to its TDS level with rating given by Bruvold as less than 500 mg/l s excellent level and greater than 1700 mg/l as unacceptable. TDS is related to other water quality parameters like hardness, which may occur if the high TDS content is due to the presence of carbonates.

* + 1. **Turbidity**

Turbidity is an expression of certain light scattering and light absorbing properties of the water sample caused by the presence of clay, silt, suspended matter, colloidal particles, plankton and other microorganisms (WHO, 1984). Turbidity can be measured by turbidity and nephelometry. Turbidity of water affects other water quality parameters such as colour, when it is imparted by colloidal particles. It also promotes the microbial proliferation, thus affecting negatively the microbiological quality of water. It also affects the chemical quality of drinking water through the formation of complexes between the turbidity causing humic matter and heavy metals (WHO, 1984).

* + 1. **Colour**

Colour in drinking water is caused by the presences of coloured organic substances, usually humic, which originate from the decay of vegetation in organism and with the degree to which that organism can surface water. Iron and manganese also give water a red and blue colour respectively by the action of bacteria, which oxidize them to their ferric and manganic oxides respectively. Colour is measured by visual comparison of the sample with platinum cabalt standards where one unit of colour is that produce by 1 mg/l platinum of chloraplatinate ion.

* + 1. **Dissolve oxygen**

Fish and other aquatic animals depend on dissolved oxygen (the oxygen present in water) to live. The amount of dissolved oxygen in streams is dependent on the water temperature, the quantity of sediment in the stream, the amount of oxygen taken out of the system by respiring and decaying organisms, and the amount of oxygen put back into the system by photosynthesizing plants, stream flow, and aeration. Dissolved oxygen is measured in milligrams per liter (mg/l) or parts per million (ppm). The temperature of stream water influences the amount of dissolved oxygen present; less oxygen dissolves in warm water than cold water. For this reason, there is cause for concern for streams with warm water. Trout need DO levels in excess of 8 mg/liter, striped bass prefer DO levels above 5 mg/l, and most warm water fish need DO in excess of 2 mg/l. The level of dissolved oxygen in water is used as an indication of pollution and its potability. This thus forms a key test in water pollution control activities and waste treatment process control activities and waste treatment process control. The recommended guideline value for drinking water is a level not below 8 mg/l (WHO, 1984). Lower levels indicate microbial contamination or corrosion.

* + 1. **Biochemical Oxygen Demand (BOD)/Chemical Oxygen Demand (COD)**

Natural organic detritus and organic waste from waste water treatment plants, failing septic systems, and agricultural and urban runoff, acts as a food source for water-borne bacteria. Bacteria decompose these organic materials using dissolved oxygen, thus reducing the DO present for fish. Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. Biochemical oxygen demand is determined by incubating a sealed sample of water for five days and measuring the loss of oxygen from the beginning to the end of the test. Samples often must be diluted prior to incubation or the bacteria will deplete all of the oxygen in the bottle before the test is complete. The main focus of wastewater treatment plants is to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste. The excess bacteria grown in the system are removed as sludge, and this “solid” waste is then disposed of on land.

Chemical oxygen demand (COD) does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values, but COD measurements can be made in a few hours while BOD measurements take five days.

If effluent with high BOD levels is discharged into a stream or river, it will accelerate bacterial growth in the river and consume the oxygen levels in the river. The oxygen may diminish to levels that are lethal for most fish and many aquatic insects. As the river re-aerates due to atmospheric mixing and as algal photosynthesis adds oxygen to the water, the oxygen levels will slowly increase downstream. The drop and rise in DO levels downstream from a source of BOD is called the *DO sag curve*.

* + 1. **Hardness**

This is simply the resistance of water in forming lather with soap. Hard water thus requires a considerable amount of soap to produce lather. The principal ions causing hardness are calcium and magnesium. When the anion is carbonate, it is referred to as temperature, since it can be removed by boiling, unlike when the anions are sulfates, chlorides and nitrates. Groundwater is often harder than surface water and may have levels up to several thousand mg/L because of it high solubilizing potentials, particularly for rocks containing gypsum, calcite and dolomite. Source of hardness include sewage and run-off from soils particularly limestone formations, building materials containing calcium oxide and textile and paper materials containing magnesium.

**2.11 Toxic Chemicals (Heavy Metals)**

Chemical contaminations of drinking water supplies occur along with contaminants of other inorganic and organic constituents.

* 1. **Nitrates and Nitrites**

They are considered together because conversion from one form to the other occurs in the environment and the health effects of nitrates are generally as a consequence of its ready conversion to nitrites in the body. The WHO (1984) guideline for nitrates in drinking water are typically below 50 mg of nitrate-N per litre, levels exceeding these are indicative of pollution. Nitrite levels can be reduced doing water treatment by the oxidizing effects of chlorine.

* + 1. **Lead**

Lead is a natural constituent of the earth crust at an average concentration of about 16 mg/kg. Lead levels in drinking water are relatively low, because convectional water treatment procedures remove a significant amount of lead. Low pH and softness increases lead content of water by promotion corrosion. The maximum intake of lead from food, air and water is 3 mg/week (0.05 mg/kg of body weight) for adults (WHO, 1984).

* + 1. **Iron**

Iron is the most abundant element by weight in the crust, it occurs in water in its ferric and ferrous states, particularly in well-aerated conditions. Rock and mineral dissolution acid mine drainage, land fill leachates, sewage and iron related industries are causes of high iron levels in groundwater, lakes and reservoirs, particularly where reducing conditions are present (Okun,1983).

* + 1. **Others**

Other toxic chemicals include Ammonia in no ionized form (NH3) and ionized form (NH4+); arsenic, asbestos, barium, boron, cadmium, chromium, copper and aluminum. Others include fluoride, mercury and organic contaminants.

**2.12 Water Quality Standard in Nigeria**

In 2005, the National Council on Water Resources (NCWR) recognized the need to urgently Establish acceptable Nigerian Standard for Drinking Water Quality because it was observed that the “Nigerian Industrial Standard for Potable Water” developed by Standards Organisation of Nigeria and the “National Guidelines and Standards for Water Quality in Nigeria” developed by Federal Ministry of Environment did not receive a wide acceptance by all stakeholders in the country. Since water quality issues are health related issues, the Federal Ministry of Health, collaborating with the Standards Organisation of Nigeria (the only body responsible for developing National Standards in Nigeria) and working through a technical committee of key stakeholders developed this Standard. The Nigerian Standard for Drinking Water Quality covers all drinking water except mineral water and packaged water. The standard applies to:

* Drinking water supplied by State Water Agencies,
* Drinking water supplied by community managed drinking water systems
* Drinking water supplied by water vendors and water tankers Drinking water used in public or privately owned establishments
* Drinking water used in food processing by manufacturers.

Drinking water from privately owned drinking water system and use solely for the family residence Mineral water and packaged water shall comply with Nigerian Industrial Standards for Natural Mineral Water (NIS 345:2003) and Potable Water (NIS 306:2004) and used for regulation and certification by the National Agency for Food and Drug administration and Control and SON respectively (It is important to mention here that the standards for mineral water and packaged water have different allowable limits for various parameters presented here).

**2.13 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 Standard for Drinking Water Quality are simply divided into physical / Organoleptic, chemical organic and inorganic constituents, and microbiological parameters.

All drinking water shall at any time meet the minimum requirements set out in Table1, Table 2 and Table 3. 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.

Table 1: PHYSICAL / ORGANOLEPTIC PARAMETERS

**2.14 Parameters and Maximum Allowable Limits**

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Unit | Maximum permitted levels | Health impacts |
| Colour | TCU | 15 | None |
| Odour | \_ | Unobjectionable | None |
| Taste | \_ | Unobjectionable | None |
| Temperature | Celsius | Ambient | None |
| Turbidity | NTU | 5 | None |

**2.15 Chemical Parameters**

Table 2: INORGANIC CONSTITUENTS

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Unit | Maximum permitted level | Health impact |
| Aluminum (A) | Mg/L | 0.2 | Potential Neuro-degenerative disorders |
| Arsenic (As) | Mg/L | 0.01 | Cancer |
| Barium | Mg/L | 0.7 | Hypertension |
| Cadmium(Cd) | Mg/L | 0.003 | Toxic to the kidney |
| Chloride (Cl) | Mg/L | 250 | None |
| Chromium(Cr6+) | Mg/L | 0.05 | Cancer |
| Conductivity | UL/cm | 1000 | None |
| Copper(Cu+2) | Mg/L | 1 | Gastrointestinal disorder, |
| Cyanide(CN-) | Mg/L | 0.01 | Very toxic to the thyroid and the nervous system |
| Fluoride(F-) | Mg/L | 1.5 | Fluorosis, Skeletal tissue (bones and teeth) morbidity |
| Hardness as (CaCO3) | Mg/L | 150 | None |
| Hydrogen sulphide (H2s) | Mg/L | 150 | None |
| Iron(fe+2) | Mg/L | 0.3 | 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 |
| Magnesium (mg+2) | Mg/L | 0.20 | Consumer acceptability |
| Maganese (mn+2) | Mg/L | 0.2 | Neurological disorder |
| Mercury(Hg) | Mg/L | 0.001 | Affects the kidney and central nervous system |
| Nickel(Ni) | Mg/L | 0.02 | Possible carcinogenic |
| Nitrate(No2) | Mg/L | 0.2 | Cyanosis, and asphyxia („blue-baby syndrome”) in infants under 3 months syndrome”) in infants under 3 months |
| Ph | \_ | 6.5-8.5 | None |
| Sodium(Na) | Mg/L | 200 | None |
| Sulphate(so4) | Mg/L | 100 | None |
| Total dissolved solids | Mg/L | 500 | None |
| Zinc(zn) | Mg/L | 3 | None |

Key word: NTU- Nephelometric Turbidity

TCU- Transmission control unit

**2.16 Water Analysis**

Water analyses are carried out to identify and quantify the physiochemical, biochemical and microbiological components and properties of water samples. The type of analyses depends on the purpose of the analysis and the anticipated use of water. For the purpose of using water for human consumption the following analysis are carried out.

* 1. **Physiochemical Analysis**

**2.16.1** Chlorine residual

The disinfection of drinking-water supplies constitutes an important barrier against waterborne diseases. Although various disinfectants may be used, chlorine in one form or another is the principal disinfecting agent employed in small communities in most countries. Chlorine has a number of advantages as a disinfectant, including its relative cheapness, efficacy, and ease of measurement, both in laboratories and in the field. An important additional advantage over some other disinfectants is that chlorine leaves a disinfectant residual that assists in preventing recontamination during distribution, transport, and household storage of water. The absence of a chlorine residual in the distribution system may, in certain circumstances, indicate the possibility of post-treatment contamination. Three types of chlorine residual may be measured: free chlorine(the most reactive species, i.e. hypochlorous acid and the hypochlorite ion); combined chlorine(less reactive but more persistent species formed by the reaction of free chlorine species with organic material and ammonia); and total chlorine(the sum of the free and combined chlorine residuals). Free chlorine is unstable in aqueous solution, and the chlorine content of water samples may decrease rapidly, particularly at warm temperatures. Exposure to strong light or agitation will accelerate the rate of loss of free chlorine. Water samples should therefore be analyzed for free chlorine immediately on sampling and not stored for later testing. The method recommended for the analysis of chlorine residual in drinking water employs *N*,*N*-diethyl-*p*-phenylenediamine, more commonly referred to as DPD. Methods in which *o*-tolidine is employed were formerly recommended, but this substance is a recognized carcinogen, and the method is inaccurate and should not be used. Analysis using starch–potassium iodide is not specific for free chlorine, but measures directly the total of free and combined chlorine; the method is not recommended except in countries where it is impossible to obtain or prepare DPD.

* + 1. **pH**

It is important to measure pH at the same time as chlorine residual since the efficacy of disinfection with chlorine is highly pH-dependent: where the pH exceeds 8.0, disinfection is less effective. To check that the pH is in the optimal range for disinfection with chlorine (less than 8.0), simple tests may be conducted in the field using comparators such as that used for chlorine residual. With some chlorine comparators, it is possible to measure pH and chlorine residual simultaneously. Alternatively, portable pH electrodes and meters are available. If these are used in the laboratory, they must be calibrated against fresh pH standards at least daily; for field use, they should be calibrated immediately before each test. Results may be inaccurate if the water has a low buffering capacity.

* + 1. **Turbidity**

Turbidity is important because it affects both the acceptability of water to consumers, and the selection and efficiency of treatment processes, particularly the efficiency of disinfection with chlorine since it exerts a chlorine demand and protects microorganisms and may also stimulate the growth of bacteria. In all processes in which disinfection is used, the turbidity must always be low—preferably below 1 NTU or JTU (these units are interchangeable in practice). It is recommended that, for water to be disinfected, the turbidity should be consistently less than 5 NTU or JTU and ideally have a median value of less than 1 NTU.

Turbidity may change during sample transit and storage, and should therefore be measured on site at the time of sampling. This can be done by means of electronic meters (which are essential for the measurement of turbidities below 5 NTU). For the monitoring of small-community water supplies, however, high sensitivity is not essential, and visual methods that employ extinction and are capable of measuring turbidities of 5 NTU and above are adequate. These rely on robust, low-cost equipment that does not require batteries and is readily transportable in the field, and are therefore generally preferred.

* + 1. **Aesthetic parameters**

Aesthetic parameters are those detectable by the senses, namely turbidity, colour, taste, and odour. They are important in monitoring community water supplies because they may cause the water supply to be rejected and alternative (possibly poorer-quality) sources to be adopted, and they are simple and inexpensive to monitor qualitatively in the field.

* + 1. **Colour**

Colour in drinking-water may be due to the presence of coloured organic matter, e.g. humic substances, metals such as iron and manganese, or highly coloured industrial wastes. Drinking-water should be colourless. For the purposes of surveillance of community water supplies, it is useful simply to note the presence or absence of observable colour at the time of sampling. Changes in the colour of water and the appearance of new colors serve as indicators that further investigation is needed.

* + 1. **Taste and odour**

Odors in water are caused mainly by the presence of organic substances. Some odors are indicative of increased biological activity, others may result from industrial pollution. Sanitary inspections should always include the investigation of possible or existing sources of odour, and attempts should always be made to correct an odour problem. Taste problems (which are sometimes grouped with odour problems) usually account for the largest single category of consumer complaints.

Generally, the taste buds in the oral cavity detect the inorganic compounds of metals such as magnesium, calcium, sodium, copper, iron, and zinc. As water should be free of objectionable taste and odour, it should not be offensive to the majority of the consumers. If the sampling officer has reason to suspect the presence of harmful contaminants in the supply, it is advisable to avoid direct tasting and swallowing of the water.

**2.17 Other Analysis of Relevance to Health**

Although the great majority of quality problems with community drinking-water are related to fecal contamination, a significant number of serious problems may occur as a result of chemical contamination from a variety of natural and man-made sources. In order to establish whether such problems exist, chemical analyses must be undertaken. However, it would be extremely costly to undertake the determination of a wide range of parameters on a regular basis, particularly in the case of supplies that serve small numbers of people. Fortunately, such parameters tend be less variable in source waters than fecal contamination, so that alternative strategies can be employed.

The range of health-related parameters may include:

* fluoride (where it is known to occur naturally)
* nitrate (where intensification of farming has led to elevated levels in groundwater)
* lead (in areas where it has been used in plumbing)
* chromium (e.g. in areas where it is mined)
* arsenic (in areas where it is known to occur naturally)
* Pesticides (where local practices and use indicate that high levels are likely).

If these or any other chemicals of health significance are thought to be present, they should be monitored and the results examined in the light of the Nigeria water quality guideline values and any relevant national standards. Some health-related parameters may be measured in community supplies by means of portable test kits based on conventional titrations, comparators, or photometers. If this is done, the reagents must be of high quality and carefully standardized. Other parameters require conventional laboratory analysis by spectrophotometry, atomic absorption spectroscopy, or chromatography, using standard methods

**CHAPTER THREE**

**MATERIALS & METHODS**

**3.1 Sample Locations**

The researcher went to the location of target to observe, take notes and collect the water samples. Water samples were collected using sterilized 1.5liter of plastic bottles. The water samples were collected directly from the tankers and transferred to the laboratory at about 270C within 30 minutes.

**3.2 Sample information**

Table 3: sample information

|  |  |  |
| --- | --- | --- |
| Samples | Sample collection locations | Tanker water sources |
| 1 | Abakpa | 9th mile borehole |
| 2 | Abakpa | 9th mile borehole |
| 3 | Abakpa | 9th mile borehole |
| 4 | Abakpa | 9th mile borehole |
| 5 | Abakpa | 9th mile borehole |
| 6 | Trans ekulu | 9th mile borehole |
| 7 | Trans ekulu | 9th mile borehole |
| 8 | Trans ekeulu | 9th mile borehole |
| 9 | Trans ekulu | 9th mile borehole |
| 10 | T-junction | MYC water borehole |
| 11 | T- junction | MYC water borehole |
| 12 | T-junction | MYC water borehole |
| 13 | T-junction | MYC water borehole |
| 14 | T-junction | MYC water borehole |
| 15 | Old Artisan | Ninth mile borehole |
| 16 | Old Artisan | 9th mile borehole |
| 17 | Old Artisan | 9th mile borehole |
| 18 | Old Artisan | 9th mile borehole |
| 19 | New haven | 9th mile borehole |
| 20 | Independence layout | 9th mile borehole |

**APPARATUS**

Lovibon vessel

Colour disc (Hazen disc)

Conductivity meter

Glass electrode

pH meter (electrometric)

Measuring cylinder

Beakers

Hot plate

Filter paper

Petri-dishes

Hand gloves

Pipette

Atomic Absorption Spectrophotometer (AAS)

**REAGENTS**

O-Tulidine

Potassium chloride

**3.3 METHODS OF ANALYSIS**

Analysis of the water samples were carried out in three different categories namely;

1. Physiochemical analysis
2. Biochemical analysis

The physical analysis was done by using physical analytical equipment.

Some biochemical analysis was done by analytical equipment, while metal analysis was done with the aid of spectron 20 machine.

**3.4 Physiochemical Analysis for Water**

**3.4.0 Determination of pH**

**Procedure:**

pH was measured by removing the electrode from storage solution, rinsed and blot dry with soft tissues, the electrode was placed in the initial potassium chloride and the pH was standardized according to manufacturer’s instructions. The pH of the sample was determined after establishing the =1. Stir the sample gently while measuring pH to insure homogeneity.

**3.4.1 Determination of Taste**

**Procedure:**

The taste of the water samples were determined using the taste buds in mouth.

**3.4.2 Determination of odour**

**Procedure:**

The odour of the water samples was determined using one of the sense organ which is the nose.

**3.3.3 Determination of colour**

**Procedures:**

The colour of the water samples was determined using a Hanzen disc comparator

**3.4.4 Determination of Electrical Conductivity (EC)**

**Procedure:**

The electrical conductivity of the samples was determined using the conductivity meter (DDS-307A Conductivity meter). (APHA1998).

Conductivity is measured with a probe and a meter. A voltage is applied between the two electrodes in the probe immersed in the sample of water. The drop in the voltage caused by the resistance of the water is used to calculate the productivity per centimeter.

Conductivity (G), resistivity(R) is determined from the voltage and current values according to ohm’s law.

That is R= V/I

G=I/R =I/V

Where G= Conductivity

I= Current

V= Voltage

The meter converts the probe measurement to micro mhos per centimeter and displays the result for the user.

**3.4.5 Determination of Temperature**

**Procedure:**

The temperature of the samples was determined using the conductivity meter (DDS-307A Conductivity meter). (APHA1998).

The temperature was determined using the conductivity meter by switching the conductivity to temperature using the switch button on the meter. Temperature is measured with a probe and a meter.

**3.4.6 Determination of Turbidity**

**Procedure:**

The nephelometer was calibrated according to operating instructions. The samples were agitated until air bubbles disappeared and was poured into the cell. The results was display directly on the turbidity meter.

**3.4.7 Determination of Fluoride**

Fluoride was determined using Nice water testing commercial kit.

**Procedure:**

5ml of water sample was measured in the test tube, 5 drops of Fluoride reagent –1 (F-1) was added and well mixed with continuous shaking, the colour that forms is compared with the Fluoride colour chart and record for Fluoride value.

**3.4.8 Determination of Total Hardness**

Total Hardness was determined using Nice water testing commercial kit.

**Procedures:**

25ml of water sample was measured in the test bottle, 10m drops of Total Hardness reagent – 2 (TH-2) was added and thoroughly mix followed by few specs of Total Hardness reagent- 1(TH-1) with continuous shaking until distinct pink colour develops.

For soft water, Total Hardness reagent – 4 (TH-4), was added drop by drop until the colour changes from pink to blue.

Count the number of drops of TH-4 required for colour change.

Total Hardness = no. of drops x 2

**3.4.9 Determination of Chlorine and Residual Chlorine**

Chlorine and Residual Chlorine was determined using Nice water testing commercial kit.

**Procedure:**

25ml of water sample was measured in the test bottle, 5 drops of Chloride reagent –1 (Cl-1) was added and well mixed with continuous shaking until distinct yellow colour develops. Chloride reagent – 2 (Cl-2), was added drop by drop until the colour changes from yellow to red.

Count the number of drops of Cl-2 required for colour change.

Chloride (as Cl), mg/l = no. of drops x 10

**3.5 Heavy Metal Analysis**

Heavy metal analysis was conducted using Varian AA240 Atomic Absorption Spectrophometer according to the method of APHA 1995 (American Public Health Association)

* **Working principle:** Atomic absorption spectrometer's working principle is based on the sample being aspirated into the flame and atomized when the AAS's light beam is directed through the flame into the monochromator, and onto the detector that measures the amount of light absorbed by the atomized element in the flame. Since metals have their own characteristic absorption wavelength, a source lamp composed of that element is used, making the method relatively free from spectral or radiational interferences. The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample.

**CHAPTER FOUR**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | General appearance | Taste | Odour | pH | Temperature | Residual Chlorine  (mg/l) | Total Dissolved Solid  (mg/l) | Turbidity  (NTU) | Conductivity  µs/cm | Colour  (Hz) | Total Hardness  (mg/l) | Chlorine  (mg/l) | Fluoride  (mg/l) |
| 1 | Clear | ok | odour free | **3.09** | 27.1 | 0.00 | 0.81 | **16** | 0.41 | 1 | 60 | 40 | 1 |
| 2 | Clear | ok | odour free | **2.60** | 27.5 | 0.00 | 8.92 | **67** | 4.45 | 1 | 30 | 70 | 1 |
| 3 | Clear | ok | odour free | **3.41** | 27.4 | 0.00 | 8.77 | **59** | 4.38 | 1 | 50 | 60 | 1 |
| 4 | Clear | ok | odour free | **4.06** | 27.7 | 0.00 | 6.40 | **17** | 0.82 | 1 | 40 | 60 | 1.5 |
| 5 | Clear | ok | odour free | **4.00** | 27.4 | 0.00 | 8.84 | **55** | 4.42 | 1 | 42 | 60 | 1.5 |
| 6 | Clear | ok | Odour | **4.74** | 27.4 | 0.00 | 9.06 | **44** | 4.52 | 1 | 20 | 40 | **2** |
| 7 | Clear | ok | odour free | **4.57** | 27.5 | 0.00 | 1.43 | 10 | 0.72 | 1 | 60 | 60 | **2** |
| 8 | Clear | ok | odour free | **2.75** | 27.5 | 0.00 | 8.76 | **59** | 4.39 | 1 | 30 | 60 | 0.0 |
| 9 | Clear | ok | odour free | **4.51** | 27.4 | 0.00 | 1.81 | **22** | 0.90 | 1 | 50 | 30 | 1.5 |
| 10 | Clear | ok | odour free | **2.98** | 27.6 | 0.00 | 9.19 | **32** | 4.59 | 1 | 40 | 60 | 0.0 |
| 11 | Clear | ok | odour free | **4.00** | 27.5 | 0.00 | 9.20 | **50** | 0.80 | 1 | 50 | 40 | 1.5 |
| 12 | Clear | ok | Odour | **4.00** | 27.4 | 0.00 | 1.41 | **17** | 0.92 | 1 | 30 | 60 | 1 |
| 13 | Clear | ok | odour free | **3.07** | 27.7 | 0.00 | 6.47 | **30** | 4.30 | 1 | 40 | 60 | 1 |
| 14 | Clear | ok | odour free | **3.51** | 27.7 | 0.00 | 0.82 | **15** | 0.62 | 1 | 42 | 70 | 1 |
| 15 | Clear | ok | odour free | **4.84** | 27.7 | 0.00 | 6.46 | **68** | 0.41 | 1 | 30 | 40 | 1 |
| 16 | Clear | ok | odour free | **2.92** | 27.1 | 0.00 | 1.86 | **56** | 5.52 | 1 | 40 | 60 | **2** |
| 17 | Clear | ok | odour free | **3.09** | 27.6 | 0.00 | 8.92 | **16** | 0.50 | 1 | 50 | 30 | **2** |
| 18 | Clear | ok | odour free | **4.51** | 27.5 | 0.00 | 8.70 | **34** | 6.02 | 1 | 60 | 60 | 1.5 |
| 19 | Clear | Ok | odour free | **2.65** | 27.6 | 0.00 | 0.62 | **45** | 5.60 | 1 | 20 | 60 | 1.5 |
| 20 | Clear | Ok | odour free | **2.68** | 27.5 | 0.00 | 8.70 | 10 | 4.30 | 1 | 60 | 60 | **2** |
| WHO | clear | - | Unobjectionable | 6.5-8.5 | Ambient | - | 500 | 10 | 1000 | 5-25 | 100 | 250 | 1.5 |
| NAFDAC | clear | - | Unobjectionable | 6.5-8.5 | Ambient | - | 500 | - | 1000 | - | 150 | - | 1.5 |

**RESULTS**

**4.1 Physiochemical Analysis**

Table 4: Comparing samples physiochemical analysis result with WHO and NAFDAC standard

4.2 Heavy metal results

Table 5: Heavy Metals

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | Lead PPM (mg/l) | Nickel (mg/l) | Cadmium (mg/l) | Mercury (mg/l) |
| 1 | **0.25** | **0.055** | **0.079** | 0.00 |
| 2 | 0.01 | **0.32** | **0.041** | 0.00 |
| 3 | 0.00 | 0.00 | **0.04** | **0.37** |
| 4 | 0.00 | **0.025** | **0.035** | **0.188** |
| 5 | **0.042** | **0.0031** | **0.042** | **0.417** |
| 6 | **0.245** | **0.041** | **0.052** | 0.00 |
| 7 | **0.245** | 0.00 | **0.029** | 0.00 |
| 8 | **0.245** | 0.00 | **0.036** | 0.00 |
| 9 | **0.245** | **0.009** | **0.048** | 0.00 |
| 10 | **0.245** | **0.033** | **0.047** | 0.00 |
| 11 | 0.1 | **0.060** | **0.03** | **0.30** |
| 12 | **0.24** | **0.029** | **0.042** | **0.168** |
| 13 | 0.00 | **0.038** | **0.030** | 0.00 |
| 14 | **0.245** | **0.040** | **0.048** | 0.00 |
| 15 | **0.245** | 0.00 | **0.003** | 0.00 |
| 16 | 0.01 | **0.040** | **0.60** | 0.00 |
| 17 | **0.245** | 0.00 | **0.050** | **0.318** |
| 18 | 0.01 | **0.034** | **0.032** | **0.28** |
| 19 | 0.00 | 0.00 | **0.038** | 0.00 |
| 20 | **0.245** | **0.043** | **0.642** | 0.00 |
| WHO | 0.01 | 0.003 | 0.02 | 0.001 |  |
| NAFDAC | 0.01 | 0.003 | 0.02 | 0.001 |

Fig1: Physiochemical test: pH, turbidity and fluoride for samples 1-10

This figure shows that the above mentioned parameters are above their control standard

Fig 2: Physiochemical test: pH, Turbidity and fluoride for samples 11-20

This figure shows that the above mentioned parameters are above their control standard.

Fig 3: Heavy metal content for samples 1-10

This figure shows that the above mentioned parameters are above their control standard

Fig 4: Heavy metal content of samples 11-20

This figure shows that the above mentioned parameters are above their control standard

**CHAPTER FIVE**

**5.0 DISCUSSION**

In this study water samples were collected from different tankers. The samples were collected in sterile 1.5 liter bottles. The samples were transferred to the laboratory at about 30 minutes after sample collections. The water samples were immediately analyzed to determine the temperature, Ph and electro conductivity. This was done immediately because factors can affect the Ph and temperature of the water samples. A pH meter was used to determine the pH of the water samples, pH was measured by removing the electrode from storage solution, the electrode was then rinsed and blot dried with soft tissues, after which the electrode was placed in the initial potassium chloride and the pH was standardized according to manufacturer’s instructions. The electrode was placed in the sample water and results were obtained. All the water samples had a pH range of (2.60-4.84) as shown in table 4. After the pH was determined the researcher tasted the water samples to determine if the samples had an odd taste. After which the water samples were recorded to taste ok.The odour of the water samples was also determined by using one of the sense organ which is the nose to perceive if the water samples had odour.The colour of the water samples were then determined using a Hanzen disc comparator, the samples were pour into a small beaker using a comparator disc to determine the range of sample colour.The electrical conductivity of the samples was determined using the conductivity meter (DDS-307A Conductivity meter). (APHA1998).The Conductivity was measured with a probe and meter. The water samples were pour into a beaker and the electrode was placed inside the beaker to determine the electro conductivity of the water samplesThe temperature of the samples was determined using the conductivity meter (DDS-307A Conductivity meter). (APHA1998).

The temperature was also determined using the conductivity meter by switching the conductivity to temperature using the switch button on the meter. The water samples were poured into a beaker and the probe was placed inside the beaker, the temperature of the water samples were then recorded. In order to determine the turbidity content of the water samples the nephelometer was calibrated according to operating instructions. The samples were then agitated until air bubbles disappeared and was poured into the cell, the results were displayed directly on the turbidity meter. The Fluoride content of the water samples was determined using the Nice water testing commercial kit. 5ml of the water samples was measured in the test tube, 5 drops of Fluoride reagent –1 (F-1) was added and well mixed with continuous shaking, the colour that forms is then compared with the Fluoride colour chart and results for Fluoride value was taken, according to table 3 samples 6,7,16, 17 and 20 were above the WHO and NAFDAC standard for fluoride. For Total Hardness was determined using Nice water testing commercial kit. 25ml of water sample was measured into the test bottle, 10m drops of For soft water, Total Hardness reagent – 4 (TH-4), was added drop by drop in a test bottle containing the water samples until the colour changes from pink to blue. The number of drops of TH-4 required for colour change was counted. Total Hardness = no. of drops x 2. Chlorine and Residual Chlorine was also determined using Nice water testing commercial kit. 25ml of water sample was measured in the test bottle, 5 drops of Chloride reagent –1 (Cl-1) was added and well mixed with continuous shaking until distinct yellow colour develops. For the determination of heavy metals; the Heavy metal analysis was conducted using Varian AA240 Atomic Absorption Spectrophometer according to the method of APHA 1995 (American Public Health Association).

Also according to the results obtained from various water samples for heavy metal analysis; for Cadium all water samples were above the WHO and NAFDAC control standard, for Lead, samples 1,5,6,7,8,9,10,14,15,17and 20 were above the WHO and NAFDAC control standard and also for Mercury, samples 3,4,5,11,12,17 and 18 were also above the WHO and NAFDAC control standard.

* 1. **RECOMMENDATION**

1. It is therefore recommended to the state government that they should create public awareness to educate their citizens on the adverse effects of drinking tanker supplied water could cause on human health.
2. Public water supply by the government should be invested, improved and made available to the citizens, to help eradicate the use of tanker supplied water for crucial domestic use.
3. The government should enforce laws on all tankers to ensure that obtain water from purified sources.
4. More research should be carried out for thorough investigation for the presence of any other contaminant in tanker supplied water.

**5.3 CONCLUSION**

Clean safe and adequate drinking water is vital for the survival of all living organisms and the smooth functioning of ecosystems, communities and economies. Factors affect the quality of water making it unfit for human consumption, purification process can be applied to make this water fit again for consumption.

From the results above, it is observed that the level of some physiochemical and biochemical parameters was above the WHO and NAFDAC standard for drinking water.

Since the main source of tanker supplied water is borehole, due to some anthropogenic activities that affect the quality of groundwater, tanker water may be considered unsafe for human consumption.

**REFERENCES**

Ackah M, Anim AK, Gyamfi ET, Acquah J, Nyarko ES, et al. (2012) Assessment of the quality

of sachet water consumed in urban townships of Ghana using physico-chemical indicators: A preliminary study. Advances in Applied Science Research 3:2120- 2127.

Agency (EPA). 2016-03-17.

Ajewole G (2005) Water. An overview. Nigeria institute of food science and technology, Nigeria

2: 4-15.

American Water works Association (AWA) (1991) Health effect of disinfectants and

disinfection by products. Denver Co., New York, pp: 86-98.

An analysis of existing information and future research. 1997 Georgia Water Resources

Angelo Mark P. (2016-08-31). "Slaughter waste effluents and river catchment watershed

contamination in Cagayan de Oro City, Philippines" .ResearchGate. **9** (2). ISSN 2220-6663 .

APHA (2005) Standard methods for the examination of water and waste water. Washington, DC:

American Public Health Association.

Arghyam (1991) Indian Standards for Drinking Water. Bureau of Indian Standards, New Delhi,

India, IS: 10500.

Assurance Data." Prepared by USGS Branch of Quality Systems, Office of Water Quality.

Athens, Georgia.

Babbitt, Harold E. & Doland, James J. Water Supply Engineering (1949) **ASIN:** B000OORYE2;

McGraw-Hillp.388

Balbus JM, Embrey MA (2002) Risk factors for waterborne enteric infections. Curr Opin

Gastroenterol 18: 46-50.

Barnes, K.H., J.L. Meyer, and B.J. Freeman, 1998. Sedimentation and Georgia’s Fishes:

Canencia, Oliva P; Dalugdug, Marlou D; Emano, Athena Marie; Mendoza, Richard; Walag, Chanda DK (1999) Hydrology Journal 7: 431-439.

Center for Coastal Monitoring and Assessment: Mussel Watch Contaminant Monitoring".

Ccma.nos.noaa.gov. 14 January 2014. Archived from the original on 7 September 2015. Retrieved 4 September 2015.

Chapter 8. Data Analysis". Handbook for Monitoring Industrial Wastewater (Report).

Conference, March 20-22, 1997, the University of Georgia, Athens Georgia.

Danish W (2003) Technical support document on drinking water standard objectives and

Degremont J (1991) Water treatment handbook. Lavoisier, Paris, pp:10-15.

Department of the Environment, Welsh Office (DEWO) (1989) Guidance and safeguarding the

quality of public water suppliers. Her Majesty’s Stationery Office London.

Dickens CWS and Graham PM. 2002. The Southern Africa Scoring System (SASS) version

Durfor CN, Becker E (1964) Public water supplies of the 100 largest cities in the United States.

In Geological Survey Water-Supply, US Government Printing Office, Washington, 1812, p: 364.

Eddy NO, Ekop AS (2007) Assessment of the quality of water treated and distributed by the

Akwa Ibom state water company. E-Journal of Chemistry 4: 180-186.

February 2016 at the Wayback Machine. Water Engineering Development Centre,

Loughborough University, Leicestershire, UK.

Fermentation using Lauryl Tryptose Broth (LTB) and EC Medium (Report). EPA. April2010.

EPA 821-R-10-003.

Franson, Mary Ann (1975). Standard Methods for the Examination of Water and Furusawa,

Takuro; Maki, Norio; Suzuki, Shingo (2008-01-01). "Bacterial contamination of drinking water and nutritional quality of diet in the areas of the western Solomon Islands devastated by the April 2, 2007 earthquake⁄tsunami" . Tropical Medicine and Health. **36** (2): 65–74. doi:10.2149/tmh.2007-63.

Goldman, Charles R. & Horne, Alexander J. Limnology (1983) McGraw-Hill ISBN007023651-8

chapter 6

Guidelines for drinking water quality, fourth edition". World Health Organization.

Hanaor, Dorian A. H.; Sorrell, Charles C. (2014). "Sand Supported Mixed-Phase TiO2

Photocatalysts for Water Decontamination Applications" . Advanced Engineering Materials. **16** (2): 248–254. arXiv:1404.2652 . doi:10.1002/adem.201300259 .doi:10.1002/adem.201300259 .

Havelaar A, Blumenthal UJ, Strauss M, Kay D, Bartram J (2001) Guidelines: the current

Hodgson K, Manus L. A drinking water quality framework for South Africa. Water SA. 2006;32(5):673–678 [1] .

Holmbeck-Pelham, S.A. and T.C. Rasmussen. 1997. Characterization of temporal and

International Organization for Standardization (ISO). "13.060: Water quality" . Geneva, Switzerland. Retrieved 2011-07-04.

International Organization for Standardization (ISO). "91.140.60: Water supply

International Water Management Institute, Colombo, Sri Lanka (2010)."Helping restore the

quality of drinking water after the tsunami." Success Stories. Issue 7. doi:10.5337/2011.0030

IOWATER (Iowa Department of Natural Resources). Iowa City, IA (2005). "Benthic

Macroinvertebrate Key." ISBN 0-07-037959-9 pp.454–456

Johnson, D.L., S.H. Ambrose, T.J. Bassett, M.L. Bowen, D.E. Crummey, J.S. Isaacson, D.N.

Johnson, P. Lamb, M. Saul, and A.E. Winter-Nelson (1997). "Meanings of environmental

Linsley, Ray K. & Franzini, Joseph B. Water-Resources Engineering (1972) McGraw-Hill Ltd, Onitsha. 3rdedn.,p: 292.

Method 1680: Fecal Coliforms in Sewage SludgeBiosolids) by Multiple-Tube

Methods for Measuring the Acute Toxicity of Effluents and More information about water

quality in the United States is available on EPA's "Surf Your Watershed" website.

Mccasland, M.; Trautmann, N.; Porter, K. And Wagenet, R. (2008). Nitrate: Health Effects In

Drinking Water. Available From <Http://Pmep.Cee.Comell.Edu/Facts.Slides>

Self/Facts/Nit[Heef](http://pmep.cee.comell.edu/Facts.Slides–Self/Facts/Nit-Heef-%20%20%20%20%20%20%20%20%20%20%20%20%0d%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20Grw85.Html.%20Accessed%2005/04/2008)- [Grw85.Html. Accessed 05/04/2008](http://pmep.cee.comell.edu/Facts.Slides–Self/Facts/Nit-Heef-%20%20%20%20%20%20%20%20%20%20%20%20%0d%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20Grw85.Html.%20Accessed%2005/04/2008).

National Archives, London, UK. "The Water Supply (WaterQuality) Regulations 2000."2000 \

No. 3184. 2000-12-08.

National Water Quality Inventory Report to Congress" . Water Data and Tools. EPA.2016-08-

18.

Natural Disasters and Severe Weather. "Water Quality After a Tsunami" . Centers for Disease

Control and Prevention. Retrieved 2017-04-27.

Nigeria. Environ Res J 2: 107-110.

Obi CN, Okocha CO (2007) Microbiological and physicochemical analysis of selected borehole

waters. Journals of enginery applied science 257: 920-929.

of Vijayawada rural and urban in Krishna district, Andhra Pradesh, India. International Journal of Environmental Sciences 2: 710-714.

Onifade AK, Ilori RM (2008) Microbiological analysis of sachet water vended in Ondo state,

Osci Y (2005) New School Chemistry for Senior Secondary Schools. African First Publisher

Overall evaluations of carcinogenicity: an updating of IARC Monographs volumes 1 to 42.

IARC Monogr Eval Carcinog Risks Hum Suppl 7:1-440.

Position. Water quality: Guidelines, Standards and Health.pp: 17-42.

Potential and investment opportunities, Awassa.

Proceedings of the 1997 Georgia Water Resources Conference. March 20-22, 1997,

Receiving Waters to Freshwater and Marine Organisms (Report). EPA. October 2002. EPA-821-R- 02-012.

Program Overview: 303(d) Listing" . Impaired Waters and TMDLs. EPA. 2016-10-24.

Republic of South Africa, Department of Water Affairs, Pretoria (1996). "Water quality

Retrieved 2 April 2013.

Saleh MA, Emmanuel E, Joseph J, Wilson BL (2001) Chemical evaluation of commercial

bottled drinking water from Egypt. Journal of Food composition and Analysis 127-152.

SNNPRPIP (2008) The southern nations, nationalities and peoples’ regional state resource

spatial variability of turbidity in the Upper Chattahoochee River. K.J. Hatcher, ed.

State of California Environmental Protection Agency Representative Sampling of Ground

Water for Hazardous Substances (1994) pp.23–24 systems" . Retrieved 2011-07-04.

terms." Journal of Environmental Quality. 26: 581– 589. doi:10.2134/jeq1997.004724250 02600030002x

U.S. Clean Water Act, Section 303(d), 33 U.S.C. § 1313 ; Section 305(b), 33 U.S.C. §1315(b)

U.S. Clean Water Act, Section 303, 33 U.S.C. § 1313 .

U.S. EPA, "Whole Effluent Toxicity Methods."

United States Geological Survey (USGS), Denver, CO (2009). "Definitions of Quality-

Venkateswara BR (2011) Physicochemical analysis of selected ground water samples

Water Quality: Frequently Asked Questions." Florida Brooks National Marine Sanctuary, Key

West, FL.

What are Water Quality Standards?" . Washington, D.C.: U.S. Environmental Protection

5 rapid bioassessment for rivers “African Journal of Aquatic Science”, 27:1–10.

Wastewater 14th ed. Washington, DC: American Public Health Association, American Water

Works Association & Water Pollution Control Federation. ISBN 0-87553-078-8

WHO (2000) Disinfectants and disinfectant by products. Environmental health criteria 216,

Geneva: world health organization.

WHO (2004) Guidelines for Drinking-water Quality. Geneva: World Health Organization.

WHO (2006) In Water, Sanitation and Health World Health Organization.

World Health Organization (2004). "Consensus of the Meeting: Nutrient minerals in drinking-

water and the potential health consequences of longterm consumption of demineralized and remineralized and altered mineral content drinking-waters." Rolling Revision of the WHO Guidelines for Drinking-Water Quality (draft). From November 11–13, 2003 meeting in Rome, Italy at the WHO European Centre for Environment and Health.

World Health Organization (2011). "WHO technical notes for emergencies." Archived 12