QUALITY ASSESSMENT OF BOREHOLE WATERS IN OYE EKITI

BY

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CERTIFICATION

I certify that the work described in this project was carried out under my supervision by Oyinlola Tolulope Oladayo , matriculation number CHE/11/0310 in the department of Industrial Chemistry.

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DEDICATION

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CHAPTER ONE

1.0 INTRODUCTION AND LITERATURE REVIEW

Water is life' is a popular saying amongst the people of Saharan African. This colourless, odourless and tasteless liquid is essential for all forms of growth and development - human, animal and plant. Also, water is a fundamental basic need for sustaining many human economic activities. It is used in vast quantities for drinking purposes, and even in greater quantities for washing, bleaching, dyeing, and cooling, in turbines to generate electricity and in other industrial processes. As the human population increases, as people express their desire for a better standard of living, and as economic activities continue to expand in scale and diversity, the demands on fresh water resources continue to grow. As important as water may be, it's economic importance as a medium of water related disease, which constitutes a significant percentage of the diseases that afflict human, must not be over-looked, every 20 seconds, a child dies from a water-related disease [WHO 2009].

Water is one of the most abundant and essential resources of man, and occupies about 70% of earth's surface. Most of fresh water bodies all over the world are getting polluted, thus decreasing the portability of water. All life is depending on water and it exists in nature in many forms like ocean, river, cloud and rain etc. Water in its pure state is acclaimed key to health and the general contention is that water is more basic than all other essential things to life (Edungbola and Asaolu, 1984).

Physically, ground water is generally clear, colourless, with little or no suspended matter and has a relatively constant temperature. Ground water is the water beneath the surface where all the voids in the rocks and soil are filled. It is a source of water for wells, boreholes and springs. A borehole is an hydraulic structure which when properly designed and constructed, permits the economic withdrawal of water from an aquifer. It is a narrow well drilled with machine. Borehole water is the water obtained from borehole drilled into the aquifer or ground water zone, which is usually a fully saturated subterranean zone, some distance below the water table (NWRI, 1997). It is also generally free from the very microorganisms which cause diseases. Ground water is already used extensively in Nigeria through wells and boreholes. Unfortunately borehole water like water from other sources is never entirely pure. It varies in purity depending on the geological conditions of the soil through which the ground water flows and some anthropogenic activities. Until very recently, ground water has been thought of as being a standard of water purity in itself, and to a certain extent, that is indeed true (Miller, 1992). Such high quality of water may be needed only for drinking purposes while for other uses like agriculture and industry, the quality of water can be quite flexible and water polluted up to certain extent in general sense can be regarded as pure. The quality of water varies depending on location, origin and the prevailing climate. Researches over the years have shown that bacteria can be transported some distance through the ground by liquid leached from municipal solid wastes, land fill, latrine or septic tanks, and could thus contaminate drinking water supplies drawn from the ground (Pete and Lave, 1999).

Apart from the essential role played by water in supporting human life, it also has, if polluted, a great potential for transmitting a wide variety of diseases. In most developing countries like India where dangerous and highly toxic industrial and domestic wastes are disposed of by dumping them on the earth; into rivers and streams with total disregard for aquatic lives and rural dwellers, water becomes an important medium for the transmission of enteric diseases in most communities. Poisonous chemicals are known to percolate the layers of the earth and terminate in ground waters thereby constituting public health hazards. Changes in borehole water quality may be due to ground water pollution. Water pollution is the modification of the physical, chemical and biological properties of water restricting or preventing its application (Sax, 1994).

Waterborne diseases are known to decimate human population (Train, 1976 & Davis and Cornwell, 1991). Waterborne diseases such as typhoid and paratyphoid fevers (salmonellosis) as most of the enteric diseases are transmitted through water. Other principal microbial water borne diseases include cholera, bacillary dysentery (shigellosis) and infectious hepatitis, dracontiasis and schistosomiasis (Udoessien, 2003). Others are food poisoning, amoebic dysentery, giardiasis, gastro enteritis, hepatitis A and poliomyelitis. The effects of water pollution by chemicals include cancer, arthritis, skin irritation and eruption, heart diseases, central nervous system problems, skin rashes, kidney problems and bronchitis. Not only does water support a wide range of activities, it plays a central symbolic role in rituals throughout the world and is considered a divine gift and also it's considered a purifier in most religions (Foel and Nennewan, 1986).

Water Quality Standard

The incidents of water borne disease and epidemics nationwide arising from drinking water of doubtful quality have become of great concern. The primary purpose of the guideline for drinking water quality is the protection of public health (WHO, 2006). Water quality standard is a measure, principle or rule established by authority set to protect the water resource for uses such as drinking water supply, recreational uses and aesthetics, agriculture (irrigation and livestock watering), protection of aquatic life and industrial water supplies.

In order to maintain water quality, guidelines for drinking water was set up by the World Health Organisation. A guideline value represents the level (a concentration or number) of a constituent that ensures aesthetically pleasing water and does not result in any significant risk to the health of the consumer (WHO, 1984 and 1985).

Quality of Drinking Water

In general, certain requirements must be met for water to be fit for human consumption. If these requirements are met, the water can be described as 'wholesome', 'potable' or simply, 'water supply'. According to Eja (2002), the requirements are:

(i) Freedom from organism and chemical substances which might be injurious to health. This is the most important requirement. (ii) Drinking water should be of such composition that consumers do not question the safety of the water. This requirement implies that turbidity, colour and odour should be low. Macro organisms (e.g. warms, aquatic and fly nymphs) should be absent. (iii) Drinking water should be suitable for house keeping and for this reason, iron and manganese content should be low, because these substances colour laundry (like shirt) during washing. Iron causes a brown colour, while manganese causes a black colour. Hardness should be low, because water with a high hardness causes scale formation in water heaters by precipitation of calcium carbonates. Moreover, a high hardness implies that a high dosage of detergents is required for washing. (iv) Drinking water should not be aggressive to materials such as lead, copper, asbestos, cement and concrete, cast iron, galvanized steel, PVC (Polyvinylchloride) and PE (Polyethylene). This is because pipes, tubes and apparatus used in distribution systems and plumbing installations may consist of these materials. Pipes, tubes and apparatus affected by water cause many problems.

For drinking water to be safe, the concentration of undesirable substances should not exceed the levels established by World Health Organization (World Health Organization 1985) as shown in the Table 1 below

Table 1: WHO Permissible Values (1985)

Parameters	**WHO LIMIT**
Color	5 – 25 units
Taste and odor	Unobjectionable
Turbidity	5 units
pH	6.0 – 8.5
Electrical conductivity (μmhoscm^{-1})	50
Alkalinity (mg^{-1}) $CaCO_3$	100
Total solids (mg^{-1})	1000
Total dissolved solids (mgl^{-1})	1000
Total suspended solid (mgl^{-1})	500
Total hardness (mgl^{-1}) $CaCO_3$	500
Calcium hardness (mg^{-1}) $CaCO_3$	500
Magnesium (mg^{-1}) $CaCO_3$	500
Sulphate (mgl^{-1})	400
Nitrate (mgl^{-1})	50
Phosphate (mgl^{-1})	1.0
Chloride (mg^{-1})	250
Iron (mgl^{-1})	0.3
Manganese (mgl^{-1})	0.05
Lead (mgl^{-1})	0.05
Copper (mgl^{-1})	1.0
Zinc (mgl^{-1})	5.0
Cadmium (mgl^{-1})	0.05
Fecal coliform count/100ml	0
Total coliform count/100ml	0

1.1 SCOPE OF STUDY

Analysis of samples of borehole waters to find temperature, color, pH electrical conductivity, total solids (TS), total dissolved solids (TDS), total hardness, calcium hardness, magnesium hardness, alkalinity, chloride, NO_3 , Pb, Cu, Zn, Cd, Fe contents, and total coliform (TC) counts.

1.2 AIMS

- To improve man's health, through the taking of potable water.
- To determine the extent of contamination of the waters.
- The level of treatment needed to improve the water from the boreholes before drinking.
- The level of some physio-chemical and microbiological parameters present.

1.3 OBJECTIVES OF STUDY

The objectives of the study were to examine the physico-chemical and bacteriological quality of water from ten boreholes in Oye ekiti, and to determine the corrosion potential of the water.

1. 4. POLLUTION

One defines a weed as a plant growing in a wrong place. By analogue, pollution can be defined as a chemical in a wrong place. Moreover, it must be present in an amount sufficient to produce an unwanted effect (Robert, 1997). It is the contamination of the earth's environment with materials that interferes with human's health, the quality of life or the natural functioning of ecosystem (living organism and their physical environments).

1. 4.1. POLLUTANTS

The enormous unwanted products of modern technology as applicable to industry, transport, agriculture, power generation and so on, are constantly placing stress on the environment and breaking vital links in web of biological and physical processes that power and sustain the ecological system in which man finds himself. These unwanted products are called pollutants.

Pollutants therefore, are materials that are introduced into the environment, especially by the action of man in more than its natural concentration and have net detrimental effect on the environment or something of value in the environment as described by Okonkwo and Eboatu (2006). Some of these pollutants sometimes find their way into the human system through food chain. In the human body, they may undergo biotransformation, or excreted without the risk of toxicity depending on the chemical characteristics of the pollutant and dose. However, some resist chemical and biological transformation and accumulate in tissues, including the nerves to cause toxicity. The adverse effects of these pollutants on the nerves give rise to neurotoxicity (Harrison and Kennedy 2006).

The main sources of pollution and contamination are shown below in Table 2.

Table 2: Sources of Pollution and Contamination (Harrison and Kennedy 2006).

	TYPES OF POLLUTION	**EXAMPLES**
1	Sewage disposal systems	Sewage lagoons, septic systems, cesspools, barnyards/feedlots.
2	Surface waste disposal sites	Landfills / garbage dumps, surface waste dumps.
3	Underground waste disposal sites	Storage tanks (low, medium and high levels wastes), pit latrines, tunnels, waste subsurface injections.
4	Spills, washing and intrusions	Oil/gas/waste spills, auto workshop washings, research/ laboratory washings, sweater/salt water intrusion.
5	Mining sources	Acid mine drainage, gas explosions seepages, mine dumps, excavations out flows.
6	Natural mineral/ore deposits	Saline pond/lake, hot springs/mineralized waters, anhydride/pyrite deposits.

1.5. CONTAMINANTS/POLLUTANTS AFFECTING GROUNDWATER QUALITY

The degree of pollution of a given water resource system is a function of its water quality characteristics. The usefulness of water to serve a required purpose is determined mainly by the effects of concentration levels of the constituents. Some of these contaminants/pollutants are those emanating from:

i. Agricultural contamination

ii. Sanitary landfills and garbage dumps

iii. Biological contamination

iv. Heavy metal contamination

1.5.1 Agricultural Contamination

The use of pesticides, herbicides, fertilizers and other materials to increase agricultural yields has some great negative effects on groundwater quality. Pesticides and herbicides applied to fields may find their way into groundwater when rain or irrigation water leaches the dissolved constituents downward into the soil, and are toxic (Tchobanoglous and Burton 1991). Insecticides such as methyl isocyanate cause respiratory, digestive, reproductive, nervous system disorder and eye impairments (Levine 1991). Nitrate from its fertilizer, one of the most widely used agricultural fertilizers, is harmful in drinking waters even in relatively small quantities. The nitrate is very soluble and although some may be used by plants, much of the dissolved nitrate escapes unused into deeper parts of the soil and into ground water. Sewage and fertilizer application can increase nitrate levels in some aquifers (Egboka 1984). Nitrate is toxic to humans even in amounts as small as 10 to 15ppm.

Uranium and fluorine in phosphate fertilizers and probably rubidium in potash fertilizer are soluble under most conditions and will eventually find their way into the groundwater zone (Enger and Smith 1991).

1.5.2. Sanitary Landfills and Garbage Dumps

Much of the solid waste that is now disposed of on land is placed in sanitary landfills. Solid wastes include domestic, municipal, human and animal wastes. In humid areas, buried waste in sanitary landfills and dumps is subject to leaching by percolating rainwater. The leaching is accompanied by chemical reactions that tend to consume all available oxygen, while releasing carbondioxide, methane, ammonium, bicarbonate, chloride, sulphate and heavy metals. The liquid mix of these constituents is referred to as leachate (Okonkwo and Eboatu 2006). Leachates emanating from landfills contain contaminants and toxic constituents derived from solid wastes as well as from liquid industrial wastes placed in landfill (Okonkwo and Eboatu 2006). The most common contaminants from household products include phosphates and boron in laundry detergents, copper and other elements as organometallic compounds in garbage; metals in urine and excreta; copper, lead, zinc and nickel from stainless-steel pipes and well casings. Such metals may eventually reach the groundwater flow systems and pollute them. The tremendous increase in the use of septic tanks for home sewage disposals, has contributed a great deal of dissolved polluting materials such as nitrates to ground water (Hallberg and Kenny 1992). The total number and chemical concentrations of these constituents can be variable depending on the initial composition of the waste climatic conditions. Table 3 shows that leachates contain large numbers of inorganic contaminants and also have high total dissolved solids.

Table 3: Representative Ranges for Various Constituents in Leachate from Sanitary Landfills

Parameter	Representative concentration range, mg/l
K^+	200 – 1000
Na^+	200 – 1200
Ca^{2+}	100 – 3000
Mg^{2+}	100 – 1500
Cl^-	300 – 3000
SO_4^{2-}	10 – 1000
Alkalinity	500 – 10,000
Fe (total)	1 – 1000
Mn	0.01 – 100
Cu	<10
Ni	0.01 – 10
Zn	0.1 – 100
Pb	<5
NO^{3-}	0.1 – 10
PO_4^{3-}	1 – 100
Organic Nitrogen	10 – 1000
Total dissolved solids	500 – 40,000
Chemical oxygen demand	1000 – 20,000
Ph	4 – 8

1.5.3. Biological Pollutant/Contaminants in Ground Water

Biological pollutants of groundwaters include dissolved organic constituents and microorganisms that seep or leach into groundwaters from polluted surface waters. Microorganisms may contribute to pollution in many ways, namely they may themselves be pathogenic; aesthetically they may produce undesirable biomass, or they may generate toxic metabolites in the groundwater. The microorganisms may be either pathogenic or nonpathogenic (Chang 1991).

In both cases, they produce undesirable effects in the groundwater itself and in the distribution network (where water may be distributed for domestic uses) and the populations using it.

Pathogenic microorganisms; pathogenic microorganisms are present in groundwaters, especially in the vicinity of facilities that are discharging sewage effluents or contaminated surface waters, septic tanks, agricultural wastes and refuse tips. Microorganisms, however, must survive the tortuous task of passing through the soil cover, which constitutes an excellent natural process for water filtration and treatment. Even with this barrier, it follows that the nearer these sources of pollution are to groundwater sources, the greater the chance of successful seepage of these microorganisms. Shallow wells and some deep boreholes are prone to contamination by these Pathogens (Offidile 1992). The majority of waterborne pathogenic microorganisms enter water supplies as a result of fecal contamination. Therefore the ability to defect fecal contamination at low levels is the main safeguard in preserving the potability of water supplies (Canter and Knox 1985). Coliform bacteria are common in the environment and are generally not harmful. However, the presence of these bacteria in drinking water is usually a result of a problem with the treatment system or the pipes which distribute water, and indicates that the water may be contaminated with germs that cause disease. Fecal coliform and E.coli are bacteria whose presences indicate that the water may be contaminated with human or animal wastes. Microbes in water can cause short-term effects such as diarrhea, nausea, headaches or other symptoms. Pathogenic microorganisms normally associated with water supply are shown in table 4.

Table 4: Pathogens Associated with Water Supplies

	Pathogens	Diseased caused
A	Bacterial	
	Salmonella typhis	Typhoid fever
	Salmonella paratyphi A and B	Paratyphoid fever
	Salmonella typhimurium	Salmonellosis
	Shigella dysenteriae	Bacillary dysentery
	Mycobacterium tuberculosis	Tuberculosis
	Vibrio cholerae	Cholera
	Enteropathogenic Escherichia coli	Enteritis
B	Viral	
	Hepatitis A virus	Viral hepatitis Type
	Enteroviruses (Polio, Coxsackle A and B and echo)	Respiratory tract infection
C	Protozoan and metazoan	
	Enteamoeba histolytica	Amoebic dysentery
	Giardia lamblia	Giardiasis
	Ascaris lumbricoides	Helminthiasis

1.5.4. Heavy Metal Contamination

Heavy metals are those metals that are detrimental harmful to man, plants and animals. These metals disturb the normal biological or biochemical processes in living organisms (Chester and Voutsinou 1981). Heavy metals are metallic elements with specific gravity greater than 5, such as cadmium, copper, lead and zinc (Symous, Bradley and Cleveland 2000). A feature that heavy metals have in common is that they tend to accumulate in the bodies of organism that ingest them. Therefore, their concentrations increase up the food chain. For instance, some marine algae may contain heavy metal at concentration up to one hundred times that of the water in which they are living. Small fish eating the algae develop higher concentrations of heavy metals in their flesh; larger fishes who eat the smaller fishes concentrate the metals still further and so on up to fish eating birds or mammals (Egereonu and Ibe 2003). Very few people seem to realize that metals lost to our environment pose human health problems. Japanese itri-itri disease was traced to the consumption of rice grown in cadmium contaminated irrigation water, while brain damage and incidence of lung cancer have been attributed to lead and nickel contamination respectively (Hampel and Hawley 1985, Lorch 1987). The liver, the kidney, respiratory and reproductive systems are mostly affected by heavy metals. The health effects of heavy metals can be either acute or chronic.

Acute effect; usually follows a large dose of a chemical and occurs almost immediately. Examples are nausea, lung irritation, skin rash, vomiting, dizziness and in the extreme, death.

Chronic Effect: These are effects that occur after exposure to small amounts of a chemical over a long period. Examples include cancer, birth defects, organ damage, disorders of the nervous system and damage to the immune system. Some of the heavy metals commonly found to be toxic include cadmium, chromium, copper, lead, mercury, nickel, etc. The accumulation of the hazardous heavy metals in groundwater is due to the dissolution, seepage and leaching of environmental components into water forms (Sodhi 2005). Their sources are coal, petroleum, smelting operations, fossil fuel combustion, sewage sludge disposal, fertilizer application, volcanic eruptions, and forest fires (Sodhi 2005).

Sources and health effects of some heavy metals in water quality shown in table 5, that their sources are mostly due to mineral processing, manufacturing of inorganic products and large scale use of coal in power production (Miller 1989).

Table 5: Sources and health effects of some heavy metals (Miller 1989)

Metals	Sources	Effects
Cadmium (Cd)	Coal, petroleum, mining and smelting operations, fossil fuel combustion, sewage sludge disposal, fertilizer application, paint pigments etc.	Kidney dysfunction,hypertension, anaemia, lever damage, vomiting carcinogenic, diarrhea muscle cramps, nausea
Copper (Cu)	Natural deposits, plumbing materials	Essential nutrient, high doses, causes gastrointestinal disturbance, nausea and vomiting, liver and kidney damage
Lead (Pb)	Volcanic eruptions, sea salt sprays, forest fires mining and smelting operation, leaded gasoline, batteries	Enzyme inhibition, kidney impairment, neurological disorders, teratogenic effect birth defects
Mercury (Hg)	Coal, mining and smelting operations fossil fuel combustion, electrical appliances, insecticides, fungicides pharmaceuticals	Kidney malfunction, renal effect, teratogenic effect, neurological disorders, enzyme inhibition, carcinogenic
Iron (Fe)	Natural deposits,industrial wastes,domestic wastes	Essential nutrient, at high doses causes gastrointestinal disturbances, brown stains in laundry.
Manganese (Mn)	Occurs mostly with Fe deposits,	As with iron

1.6. WATER QUALITY PARAMETERS

Water quality parameters are things which can be measured to find out the quality of the water in a waterbody.

PARAMETERS TO BE ANALYSED

For the assessment of water pollution status of the water bodies, the following water quality parameters are important: (1) pH (2) Specific Conductance (3) Temperature (4) Total dissolved solid (TDS) (5) Turbidity (6) Total Alkalinity (7) Dissolved oxygen (DO) (8)Nitrate (9) Total Hardness (10)iron (11)Chloride (12)Chemical oxygen demand (13) Copper (Cu) (14) Lead (Pb) (15) Cadmium (Cd) (16) Zinc (Zn) (17) Manganese (Mn)

PH

pH is the measure of the acidity of a solution of water. The pH scale commonly ranges from 0 to 14. The scale is not linear but rather it is logarithmic. For example, a solution with a pH of 6 is ten times more acidic than a solution with a pH of 7. Pure water is said to be neutral, with a pH of 7. Water with a pH below 7.0 is considered acidic while water with pH greater than 7.0 is considered basic or alkaline. The pH of a water body varies with the soil and rock types in surrounding areas and the sorts of substances entering the water.

CONDUCTIVITY

Conductivity is a numerical expression of an aqueous solution's capacity to conduct an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence and relative concentrations, and on the temperature of the liquid. Solutions of most inorganic acids, bases, and salts are relatively good conductors and is measured by passing a current between two electrodes (a known distance apart) that are placed into a sample of water. The unit of measurement for electrical conductivity is expressed in either micro Siemens per centimetre (µS/cm) or milli Siemens per centimetre (mS/cm). A sudden change in electrical conductivity can indicate a direct discharge or other sources of pollution into the water. In other words, this parameter gives an idea of the salt concentration in water.

ALKALINITY

Alkalinity is the sum total of components in the water that tend to elevate the pH to the alkaline side of neutrality. It is measured by titration with standardized acid to a pH value of 4.5 and is expressed commonly as milligrams per liter as calcium carbonate (mg/L as $CaCO_3$). Alkalinity is a measure of the buffering capacity (ability to resist changes in pH) of the water, and since pH has a direct effect on organisms as well as an indirect effect on the toxicity of certain other pollutants in the water, the buffering capacity is important to water quality. Commonly occurring materials in water that increase alkalinity are carbonates, bicarbonates, phosphates and hydroxides.

NITRATE

Nitrogen enters the ground from several sources. Certain plants such as legumes fix atmospheric nitrogen and transfer it to the soil where it is used by plants. Some of the surplus nitrogen is removed in solution by downward percolating soil water. Other sources of soil nitrogen are decomposing plant debris, animal waste, household solid waste and nitrogen fertilizers. Additional nitrogen may enter groundwater from sewage discharge on land. Also, many industrial solid wastes contain high concentrations of nitrogen. Natural nitrate concentrations in groundwater range from 0.1 to 10mg/l [Adeyemo, Ayodeji, and Aiki-Raji, 2002]. Nitrate in concentration greater than 45mg/l is undesirable in domestic water supplies because of the potential toxic effect on young infants. Methemoglobinemia is a disease caused by nitrate, which is converted to nitrite in the intestines [Adeyemo, Ayodeji, and Aiki-Raji, 2002]. The safe nitrate limit for domestic water is set at 45mg/l [WHO, 1984]. Nitrate cannot be removed from water by boiling but must be treated by distillation.

DISSOLVED OXYGEN (DO)

D.O. is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. D.O. enters water by diffusion from the atmosphere and as a by- product of photosynthesis by algae and plants. The concentration of D.O. in epilimnetic waters continually equilibrates with the concentration of atmospheric oxygen to maintain 100% D.O. saturation. Excessive algae growth can over-saturate (greater than 100% saturation) the water with D.O. when the rate of photosynthesis is greater than the rate of oxygen diffusion to the atmosphere.

Hypolimnetic D.O. concentration is typically low as there is no mechanism to replace oxygen that is consumed by respiration and decomposition. Fish need at least 3-5 mg/L of D.O. to survive.

TEMPERATURE

Temperature is a measure of the degree of hotness or coldness of a substance. The apparatus generally used for measuring temperature is ether the mercury in glass
Centigrade thermometer or the Fahrenheit thermometer.

Water temperature changes with the depth of the water and the season of the year. The surface of the water is likely to be warmer than the deeper water because the surface water gets more heat from the sun. Waterways are likely to heat up in hot weather, especially if they are shallow and there's not much water flow. As the temperature rises biological activity increases: animals are more active and plants increase their growth. This is not necessarily a bad process. It is often part of the natural cycle of the system.

TURBIDITY

Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms. The measurement of turbidity is a key test of water quality (Gari 2002). In drinking water, the higher the turbidity, the higher the risk that people may develop gastrointestinal diseases. This is especially problematic for immune-compromised people, because contaminants like viruses or bacteria can become attached to the suspended solid. It is commonly recorded in nephelometric turbidity units (NTUs).

TOTAL HARDNESS

Hardness in water is defined as the presence of multivalent cations. Hardness in water can cause water to form scales and a resistance to soap. It can also be defined as water that does not produce lather with soap solutions, but produces white precipitate (scum), according to the equation below;

$$2C17H35COONa + Ca \longrightarrow (C17H35COO)_2\ Ca + 2Na \qquad \text{(scum)}$$

Hardness of natural water varies widely depending upon the geology of the catchments and type of aquifer in the case of groundwater. Lacey (1982) believed that increasing hardness in water is correlated with decreasing cardio-vascular mortality in males.

Hardness is due to the presence of carbonates and bicarbonates of calcium and magnesium, including sulphates and chlorides of the cations. Calcium, which is essential for nervous system and for the formation of bones, is commonly present in all water bodies where it usually comes from the leaching of rocks [Agunwamba, 2000]. On the other hand Magnesium is usually less abundant in water than calcium, perhaps due to the fact that magnesium is found in the earth's crust in much lower amounts as compared to calcium [UNEP 1999]. High concentration of magnesium in drinking water gives unpleasant taste to the water [WHO, 1996].

IRON

Most groundwater supplies contain some iron because iron is common in many aquifers and is found in trace amounts in practically all sediments and rock formations. The iron content of groundwater is important because small amounts seriously affect water's usefulness for some domestic and industrial purposes. The World Health Organization recommends that the iron content of drinking water should not be greater than 0.3mg/L because iron in water stains plumbing fixtures, stains cloths during laundering, incrusts well screens and clogs pipes [Deutsch, 2003].

CHLORIDE:

Determination of chloride is important where water is brackish. Normally, water is not expected to have chloride. However since chlorine is also used for water treatment, the method of estimation of chloride is included herein. A limit of 100 mg/l of chloride has been recommended as maximum permissible limit for drinking water [WHO, 1996]. This limit has been laid down primarily based on taste considerations. Most chlorine occurs as chloride in solution. High concentrations of chloride can make waters unpalatable, and therefore, unfit for drinking.

CHEMICAL OXYGEN DEMAND (COD)

COD is another measure of organic material contamination in water specified in mg/L. COD is the amount of dissolved oxygen required to cause chemical oxidation of the organic material in water. Both BOD and COD are key indicators of the environmental health of a surface water supply. They are commonly used in waste water treatment but rarely in general water treatment. (Milacron Marketing Co.).

COLIFORM BACTERIA

A group of gram-negative rod-shaped bacteria that are found in vertebrate gastrointestinal tract (digestive system); their presence in water is an indication of faceal pollution. Absence or presence of coliform group of bacteria has been the principal indicator of suitability or unsuitability of any kind of water for domestic or other uses. The presence of coliform group of bacteria such as Escherichia coli, streptococcus faecalis (Enterococcus) and bacteriophages, is the principal indicator of pollution. If present in any water body, it means that the water is unsuitable for consumption, certain types of microorganisms can serve as indicators of pollution. Chief among these are the coliform bacteria which survive better, longer and are easier to detect than other pathogens [Kegley and Andrew, 1998, Agunwamba, 2000].

HEAVY METALS

Heavy metals are classed as those having densities greater than 5g/km3 (or 5kg/m3), Ademoroti 1996. Heavy metals are toxic even in trace amount. These are found mostly in groups III – V of the period table. The amount of these metals present in any type of water may be satisfactorily determined by atomic absorption spectroscopy (AAS). The method is rapid and do not require extensive separation techniques. Atomic absorption spectroscopy resembles emission flame photometry. In both methods, a sample is aspirated into a flame where it becomes atomized. The only difference is that flame photometry measures the intensity of light emitted but in the case of AAS, a light beam is directed through the flame into a monochromator and then onto a detector that measures the intensity of light absorbed. AAS is more sensitive in that it depends upon the presence of free unexcited atoms. But in flame photometry, the ratio of unexcited to excited atoms at any moment is very high. As each metallic element has its own characteristic absorption wavelength, a source lamp made up of that element is employed and which makes the method relatively free of spectral or radiation interferences (Vogel 2000).

1.7. STUDY AREA:

The study area is Oye-ekiti Ekiti State Nigeria. Oye is one of the 16th kingdoms of Ekiti land. Oye-Ekiti people are a group of the south-western Yoruba, inhabiting the administrative headquarters' of the present Oye Local Government area of Ekiti State. The Old Oye kingdom comprises of five villages namely Oye, Ire, Egosi, Eshetta, (Egosi and Eshetta have come together as Ilupeju) and Arigidi Ekiti (now Ayegbaju) and covers an area of about 64 square miles (National Archive, Ibadan). The population of Oye- Ekiti according to the 1952 national census was 13,696, (National Archive, Ibadan), 57,196 in 1963 and in 2006 the population was 168,251 (National Population Commission 2006).

Oye-Ekiti is located at a general altitude around 1500 feet with hills and granite outcrops rising to about 200 feet. It is covered by thick forest with very small patches of high forest and is surrounded by hills which provide her protection in times of war. In fact, the hills were a blessing to the people especially during the Benin invasion in the 19th century (Akintoye 1921).

There are no distinctive ethnic groups in the Local Government as a greater percentage of the people residents are of the Yoruba Language race. Nearly all the people speak Yoruba Language with negligible dialectical variations. There are varieties of Agricultural product in the Local Government Area, prominent among the cash crops are:

- Cocoa
- Timber
- Cashew
- Kolanut
- Cassava
- Rice
- Plantain
- Yam
- Banana
- Oranges
- Coconut
- Walnuts

1.8. SAMPLE COLLECTION:

Water samples used for study were collected from ten different boreholes located in Oye. The samples were collected using pre-cleaned polyethylene bottle (1 liter capacity) for each and labeled accordingly as thus – Fuoye phase 2 (A)Fuoye phase 1 (B)William hostel (C)Along school road borehole (D)Baba dara block (E) Ogbometa (F)General hospital (G) Temidire (H)Yem-kem house (I) Olaebimi block (J).

1.9. SAMPLE PRESERVATION AND TREATMENT:

Some physical parameters were analyzed on the borehole water samples at the site of collection. The temperature of each sample was measured and recorded using a thermometer calibrated in degree Celsius. Also the pH, dissolved oxygen and the specific conductance were taken. The samples were then transferred to the laboratory in an improvised ice box where they were kept in the refrigerator to preserve the quality of the sample prior to analysis. All the apparatus used for analysis were properly washed and rinsed and the reagents are all of analytical grade. Standard method of analyses was employed in the various physico-chemical parameters determined. Electrical conductivity meter was used to measure the conductivity of the water samples. The chemical parameters: calcium, magnesium, alkalinity, chloride and total hardness were determined by titrimetric method. For pH determination of the water samples, a digital pH meter standardized with buffer solutions pH 4 and 9 was employed. All measurements were completed recorded on the table.

CHAPTER TWO

2.0 MATERIALS AND METHOD

All reagents and chemicals used in this work were of analar grade from BDH, they include:

i. H_2SO_4

ii. Methyl Orange

iii. $K_2Cr_2O_7$

iv. $AgNO_3$

v. NaOH

vi. EDTA

vii. Murexide indicator

viii. Colour developer

ix. Ferrous ammonium sulphate

x. Ferroine

xi. HNO_3

xii. HCL

The following instruments were used :

i. pH meter (Hanna instrument, HI 8014, made in Europe(Romania)

ii. Atomic Absorption Spectrophotometer (Phoenix-986, Biotech Engineering management limited)

iii. COD Apparatus (QBT1, Palintest limited)

iv. Turbidity meter (Hanna instrument, HI93703)

v. Thermometer

2.1. METHODS

The total of 10 boreholes were investigated. These were selected from different locations in Oye Ekiti to see the level of conformity to the WHO water standard for drinking; the physico-chemical parameters were ascertained as indicated below

Sample Number	Sample Location
1.	Fuoye phase 2
2.	Fuoye phase 1

3.	William hostel
4.	Along school road
5.	Baba dara block
6.	Ogbometa
7.	General hospital
8.	Temidire
9.	Yem-kem house
10.	Olaebimi block

2.2. PROCEDURE FOR ANALYSIS

Chemical Examination

2.2.1. pH determination

Materials and Apparatus

pH Meter

Distilled Water

Beaker

Procedure

The electrode of the pH meter was first properly rinsed with distilled water and then with the water sample. The water sample was properly shaken and some quantity poured in a beaker, and the electrode of the pH meter was placed upright inside the beaker containing the water sample. The electrode was left in the in these position for few seconds before switching on the pH meter. The first steady state of the counter in the meter was taken as the pH value.

2.2.2. Electrical Conductivity Determination

Materials and Apparatus

Electrical conductivity meter

Distilled water

Beaker

Procedure

The electrode of the conductivity meter was rinsed with distilled water and rinsed again with the water sample. Then the beaker was filled to the mark with the water sample. The first steady number on the meter counter when the conductivity meter was switched on was recorded as the conductivity of the water in umhos/cm.

2.2.3. Determination of Alkalinity

Alkalinity of is generally due to the presence of carbonate and hydroxide ions, bicarbonate may also contribute to alkalinity. Alkalinity is determined by the titration with 0.02M H_2SO_4 using methyl orange and phenolphthalein as indicators. Phenolphthalein indicator is used if the pH of the water sample is 8.3 and above, otherwise methyl orange is used, and the total alkalinity is calculated.

$$2CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + Ca(HCO_3)_2$$

$$Ca(HCO_3)_2 + H_2SO_4 \longrightarrow CaSO_4 + 2CO_2 + 2H_2O$$

$$Ca(OH)_2 + H_2SO_4 \longrightarrow CaSO_4 + 2H_2O$$

Apparatus and Reagents

Pipette	0.02M H_2SO_4
Conical flask	Methyl orange
Burette	

Procedure

The water sample was properly shaken and 50ml was pipette into a conical flask, following with the addition of methyl orange indicator into the flask. The solution was titrated with 0.02M H_2SO_4 from the burette to a pinkish yellow from orange at endpoint. The titre value was recorded and total alkalinity was calculated.

Calculation

$$\text{Total Alkalinity (mg/l)} = \frac{A \times M \times 50{,}000}{\text{ml sample}}$$

Where A = Average volume of 0.02M H_2SO_4 used

M = Molarity of H_2SO_4

$= 0.02M$

ml sample = volume of water sample used

$= 50ml$

Therefore total alkalinity = $\frac{A \times M \times 50,000}{50}$

2.2.4. Determination of Total Dissolved Solids (TDS)

Total dissolved solid (TDS) refers only to solids in solution, i.e. the total dissolved solids are those solids remaining in the filtered sample of after all the suspended solids have been removed by the means of a filter.

Procedure

This was determined as with total solids except that filtered water sample are used.

Calculation

Total Dissolved Solids (TDS) = $X \times 10,000$(mg/l)

Where X = Total dissolved solids in gram

2.2.5. Determination of Total Suspended Solids (TSS)

Total suspended solids are determine as the difference between Total solids (TS) and Total dissolved solid (TDS).

TSS = TS - TDS

2.2.6. Determination of Chloride Content

In a neutral or slightly alkaline solution, potassium chromate can indicate the end point of the silver nitrate titration of chloride. Silver chloride is quantitatively precipitated before red silver chromate is formed.

$Cl^- (aq) + Ag^+(aq) \longrightarrow AgCl(s)$

Materials and Apparatus

Conical flask

Burette

Pipette

Volumetric flask

Funnel

Analytical balance

Reagents

Standard $AgNO_3$ solution (1M), standard $AgNO_3$ solution (0.014M), potassium chromate indicator.

Procedure

50ml of water sample was pipette into a conical flask and few drops of sodium hydroxide solution if the pH is 7 and H_2SO_4 if the pH is 10 into the flask, followed by the addition of two drops of potassium chromate into the flask. Then the sample in the flask was titrated with the silver nitrate solution from the burette to a pinkish end point. Note the amount of silver nitrate rundown.

Calculations

$$\text{Chloride content (mgl}-1\text{)} = \frac{(A - B) \times M \times 35450}{\text{ml of sample}}$$

Where A = Average titre, ie volume of $AgNO_3$ used

B = Blank titre value =

M = Molarity of $AgNO_3$ =

ml of sample = 50ml

2.2.7. Determination of Calcium Hardness

Calcium occurs in water mainly due to the presence of limestone, gypsum, dolomite and gypsiferrous materials. Calcium reacts with disodium salt of ethylene diamine tetra-acetic acid (EDTA) in the presence of a selective indicator at high pH (12 to 13) and magnesium is allowed to precipitate as its hydroxide, as shown in the equations below:

Ca^{2+} (aq) + 2EDTA (aq) $\longrightarrow$ Ca (EDTA)2(aq)

Mg^{2+} (aq) + 2NaOH (aq) $\rightarrow$ Mg(OH)2(s) + $2Na^{+}$(aq)

Apparatus and Reagents

Burette sodium hydroxide

Pipette murexide indicator

Conical flasks standard EDTA

Procedure

50ml of the water sample was thoroughly shaken and pipetted into a conical flask and 2ml sodium hydroxide solution was added, followed by addition of two drops of the murexide indicator. This solution was then titrated with EDTA solution until the color changes from pink to purple at end point. The titre value was noted.

Calculation, Calcium Hardness (mg/l) = $\frac{A \times 1000}{\text{Vol. of sample}}$

Where A = Average volume of 0.01EDTA used

Vol. of sample = 50ml

2.2.8. Determination of Magnesium Hardness

Since hardness in water mostly due to the presence of calcium and magnesium ions; Mg hardness is determined as thus:

Mg hardness (mg/l) = (Total hardness – calcium hardness)mg/l.

2.2.9. Nitrate Determination

Apparatus and Reagents

Washing solution (EDTA)

Colour developer (Nitrite)

Cadmium-reduction column

Measuring Cylinder

Procedure

Using Cadmium-Reduction Method

25ml of the sample is measured and 75ml of the washing solution and the two solutions are mixed together and then passed through the cadmium column and then collected the remaining in the sample flask. Discard the first 25ml and collect the remaining in the sample flask.

Then add 2ml of the colour developer to the reduced sample and mix between 10mins and afterwards we measured the absorbance at 543nm against a distilled water reagent blank and its put in the comparator to determine the nitrate present.

2.2.10. Heavy Metals Determination

The metal ions were determined using atomic absorption spectrophotometer of the Phoenix-986 scientific model, air – acetylene flame at a flame temperature of 2600°C and flame height of 6mm. the wavelength of each lamp disc at which reading were taken for each metal ions are Cu(324.8nm), Zn(213.9nm), Pb(217.0nm),Cd(228.8nm) and Fe(510nm).

2. 2. 11. Chemical Oxygen Demand Determination

Apparatus and Materials

COD apparatus

Digester ($K_2Cr_2O_7$)

Conc H_2SO_4

COD tube

Procedure

Take 1.5ml of the digester ($K_2Cr_2O_7$) into a COD tube. Pipette 2.5ml of the sample into the same COD tube containing the digester. 3.5ml of conc H_2SO_4 is then added to the COD tube containing the two solutions and then pace into a COD apparatus at 151°C and leave for 2hrs. Allow to cool, if there is colour change from yellow to blue-black there is traces of COD if not COD is not present. Allow to cool and then titrate using FAS (ferrous ammonium sulphate) was poured in the burette and two drops of ferroine (indicator) was added to the sample. If the colour change from blue-green to reddish-brown COD is present, if it did not change it is not present.

$$\text{Molarity of FAS solution} = \frac{\text{volume } 0.0417\text{M } k_2Cr_2O_7 \text{ solution titrated, ml} \times 0.25}{\text{Volume FAS used in titration, ml}}$$

CHAPTER THREE

3.0 RESULTS AND DISCUSSION

The Table 6 gives the concentrations of different parameters of the water samples. For water to be potable, the concentrations of undesirable substances must not exceed the levels set by the World Health Organization (WHO).

Table 6 Physicochemical data of Oye Water

S/N	TESTS	RESULT										RECOMMENDED LIMITS(WHO)
		A	B	C	D	E	F	G	H	I	J	
	PARAMETERS											
1	Temperature	28?C	31?C	29?C	29?C	28?C	32?C	28?C	29?C	29?C	29?C	-
2	pH	6.2	6.0	6.0	6.0	6.4	6.2	7.0	6.0	6.6	6.0	6.5-8.5
3.	Turbidity	ND	ND	ND	0.11	0.08	0.02	0.04	ND	0.01	0.81	5.0
4	Dissolved oxygen(mg/l)	15	16	16	15	16	16	16	15	16	16	-
5.	Specific conductivity(μmhos/cm)	$0.11x10^3$	$0.07x10^3$	$0.08x10^3$	$0.1x10^3$	$0.09x10^3$	$0.08x10^3$	$0.11x10^3$	$0.09x10^3$	$0.19x10^3$	$0.1x10^3$	$1.0x10^3$
6	Chloride (mg/l)	23	20	23	12	22	23	20	12	36	22	100
7	Calcium (mg/l)	64	50	40	18	54	40	70	48	104	52	75
8	Magnesium (mg/l)	04	08	08	26	58	10	14	20	222	02	30
9	Total hardness (mg/l))	68	58	48	44	112	50	84	68	126	54	100
10	Nitrate (mg/l)	1.4	1.05	1.2	2.02	1.15	1.8	2.5	1.2	2.2	1.15	10
11	Total alkalinity (mg/l)	ND	10	26	40	44	04	88	38	54	04	100
12	Total dissolved solid (mg/l)	80	50	50	70	60	60	80	60	130	70	500
13	Manganese (mg/l)	ND	0.01	0.02	ND	0.004	0.02	0.02	0.01	ND	0.005	0.05
14	Iron (mg/l)	0.08	0.08	0.1	ND	0.04	0.06	0.07	0.1	0.03	0.1	0.3
15	Chromium (mg/l)	ND	0.005	ND	0.004	ND	ND	0.003	ND	0.004	ND	0.05
16	Zinc	ND	0.082	0.111	ND	ND	ND	0.192	0.211	0.117	ND	5.0
17	Cadmium (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.003
18	Copper	0.031	ND	ND	0.102	ND	0.021	ND	ND	0.12	ND	1.0
19	Lead (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.11
20	COD	32	16	12	16	20	8	36	16	16	36	10

1. pH

The pH of Oye water is within the range of 6.0-7.0 showing that the groundwater of these areas are acidic. Thus, depicting that the groundwater of the areas can cause corrosion of pipes and other corrodable materials. The lowest pH value of 6.0 was recorded in sample B, C, D, H, J, while the highest pH in sample G.

2. Total Hardness, Calcium Hardness and Magnesium Hardness

The result obtained show that the studied areas have total hardness, calcium hardness and magnesium hardness which ranged from 68 – 54, 04 – 02, 64 – 62mg/l respectively which are within the recommended limit of 100mg/l. Eight of the groundwater can be generally classified as soft water (0 – 55mg/l), while G and I are hard water because they are high above recommended limit. Hardness of water spoils the fabrics of clothes, causes chocking and clogging troubles of pipelines, causes formation of scales in boilers leading to wastage of fuel and the danger of overheating of boilers.

3. Alkalinity

The alkalinity of groundwater is its ability to neutralize acid. The main ions which contribute to alkalinity are carbonates, CO_3^{2-} and bicarbonate, HCO_3^-. The total alkalinity of the study areas lie between 04 – 88mg/l. The values obtained are within the recommended limit for alkalinity and this makes the water fit for drinking.

4. Total Dissolved Solids (TDS)

The values for TDS range from 50 – 130mg/l which are within the recommended limit of 500mg/l. The higher values could be attributed to more human activities. Also the level of TDS increases the hardness of water.

5. Chloride

The salty taste of some water is due to the presence of chlorides in the form of sodium chloride (NaCl), containing 100mg/l of chlorides. The range of chloride concentration of 12 – 36mg/l, was recorded for the study area and are within recommended limit.

6. Nitrate

The nitrate content of groundwater from the areas of study lie between 1.05 – 2.5mg/l. It is highest in sample and lowest in sample B. The nitrate levels in the study area falls within the recommended limit for most nitrates in water. For public drinking water supplies, a level of 10mg/l nitrate has been established as the maximum allowable concentration, therefore nitrate concentration above the value of 10mg/l is dangerous to pregnant women and poses a serious health threat to infants less than three to six months of age because of its ability to cause methaemoglobinaemia or blue baby syndrome in which blood loses its ability to carry sufficient oxygen [Nduka, Orisakwe and Ezenweke 2009]. Nitrate concentration in water sample may be increased as a result of the action of nitrate forming bacteria on nitrites to nitrates under aerobic conditions and lightening converting large amounts of atmospheric nitrogen (N_2) directly to nitrates.

7. Heavy metals

The levels of Cu and Zn obtained range between 0.031 – 0.12 and 0.082 – 0.111mg/l respectively, and are within the recommended limit Cu and Zn are nutritionally essential but higher values can lead to gastrointestinal disturbances.

Pb and Cd are toxic even in the trace amount and they are not defined in the samples that were analysed. Elevated metal concentrations (Cd and Pb) can be attributed to anthropogenic influences such as industrial wastes, human activities, lead gasoline, small-scale entrepreneur activities which include open-air solid waste combustion, saw mills, wood works auto-repair workshops especially at Coal Camp.

Natural waters contain variable but minor amounts of iron despite its universal distribution and abundance. Fe concentrations in the study ranges between 0.06 – 0.1mg/l which are within recommended limit. Fe can enter a water system by leaching natural deposits, from iron bearing industrial wastes, effluents from picking operations or acidic mine drainage. A bitter or astringent flavour is tasted by some people when Fe levels of drinking water exceed 1mg/l. Domestic water supplies containing more than 0.3mg/l total iron should be rejected due to staining, taste considerations and gastrointestinal disturbances. The brownish precipitate or sediments found in ground water is mostly due to oxidation of Fe^{2+} to Fe^{3+} in form of $Fe(OH)_3$, which present unaesthetic appeal.

3.1 CONCLUSION

From the results obtained, water sample E and I contain hardness above recommended limit. Also, all the water samples are corrosive due low pH (acidic water), and water sample A,B, C, D, E, G, H, I, J, contains high level of COD (chemical oxygen demand) above recommended limit, but all the remaining parameters are within the recommended limit. Any civilized society should consider the provision of safe drinking water a priority, this is so because safe drinking water is a basic need to human development, health and well-being. Chemical contaminants of drinking water such as lead, cadmium, nitrate, nitrite and N-nitrosamines are also potentially harmful to man [Jain, Bhatia, and Vijay 1995, Frederick, 1990]. Based on the results, the groundwater resources, without treatment is fit for drinking and domestic uses.

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