QUALITY ASSESSMENT OF WATER SUPPLY SOURCES: A CASE STUDY OF OTUKPO L.G.A OF BENUE STATE

BY

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2003/17996EA

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MINNA.

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A PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING DEGREE (B. ENG) IN AGRICULTURAL AND BIORESOURCES ENGINEERING

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MINNA, NIGER STATE.

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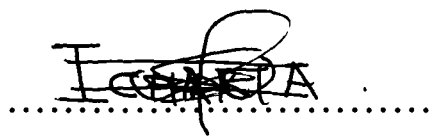
DECLARATION

I, Ichakpa ode -Ichakpa of the Department of Agricultural Engineering & Bio-resources, School of Engineering and Engineering Technology, Federal University of Technology, Minna hereby declare that this research work "Ballistics" was undertaken by me under the supervision of Engr P. Adeoye



27-11-2008

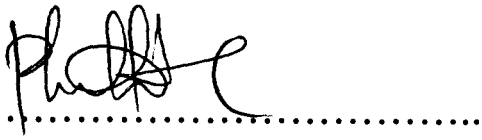
Ichakpa ode - Ichakpa.

2003/17996EA

Date

CERTIFICATION

This is to certify that this project work is an original work undertaken by Ichakpa ode - Ichakpa (2003/17996EA) under the supervision of Mr P. A. Adeoye and has been prepared with regulations governing the preparations of projects in the Department of Engineering, Minna.



01/12/08

Mr P. A. Adeoye — Date

(Project supervisor)

1/12/2008

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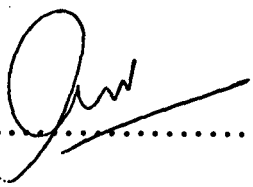

18/4/08

External Supervisor — Date

DEDICATION

This work is dedicated to Almighty God whose love, protection, divine ennoblement have enabled me bring it to a successful end.

To my sweet mother, whose prayers and encouragement have been my pillar throughout my academic years.

ACKNOWLEDGEMENTS

To you that I have given wisdom, go into the world and make an impact says the Lord God Almighty. Indeed I am referring to no other person than Mr P. A. Adeoye whom apart from the fatherly role he played; I also learnt humility from him. I thank you for reaching out to me and for the advice, continuous support you gave for the successful completion of this work. I am most grateful sir.

My utmost gratitude goes to my father Dr ode- Ichakpa, my mother Mrs Patience Ichakpa, for her prayers, financial and moral support. To my brothers; inalegwu, Oche and wonderful sister Ada thank you all for your love and support.

A special thank you to Princess Emma Austin for your love and Unflinching support throughout this project.

Many thanks to my friends; Sule, Musa, Dulla, Izunna, Pa Joe , Kayode.

I Above all, I thank the Father for creating me and still sparing my life, the Son for bringing me grace and eternal life and the Holy Spirit for being with me at all times.

"Unto Him be all the glory, praise and honour" Amen

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ABSTRACT

The quality level of Otukpo drinking water sources was examined. Samples from different locations that show a good geographical spread of the town were used to establish the quality level of the sources of drinking water in Otukpo. Samples were taken from; 2 boreholes (A and B), 3 wells (E, F and G), 2 rivers (C and D) and one tap water source (H). The research focused on some physical and chemical parameters of the sample excluding heavy metals. The chemical parameter examined include: total hardness, chloride, phosphate, sulphate, calcium, magnesium, and nitrate. Also bacteriological test was carried out to determine the level of bacterial contamination in the water. The pH of the samples fall within the WHO limit of 6.5 to 9.2; except for samples E and G which were below 5.78 and 5.74 respectively. Conductivity, turbidity and alkalinity of some samples were much higher than permissible limits except for samples A and B which were within and samples E and G which were below alkalinity limit. Phosphate levels of the samples were within permissible limit of 0.03 except samples C, D and E which were higher. Coliform growth was observed in all the samples and E.Coli growth in sample G. It is therefore concluded that the water supply sources analysed were safe for drinking since most of the analysed parameters were within permissible limits. However, because coliform growth was observed in all the samples and Ecoli growth in samples F and I, it is recommended that the water source be subjected to bacteriological treatment before consumption.

CHAPTER ONE

1.0 GENERAL INTRODUCTION

1.1 BACKGROUND INFORMATION

Water is the combination of Hydrogen and Oxygen atoms in ratio 2:1. Its molecular formula is H_2O which is linear in shape. Water is called the "universal solvent" because it dissolves more substance than any other liquid. Pure water has a neutral pH of 7, which is neither acidic nor basic.

Water is unique and it is the only neutral substance that is found in all 3 states of matter namely liquid, solid (ice) and gas (steam). In its pure form it freezes at 0°C and boils at 100°C. Water has a high specific capacity. This means that water can absorb a lot of heat before it begins to get hot. This explains why water is valuable in car radiators as coolant.

The significance of water to all biological life has made it inseparable to their existence and health, to the extent that life cannot flourish on earth without it. As a pertinent component of life, this vital substance is needed for drinking, cooking, washing and watering livestock's, irrigating the fields as well as supplying the factories.

Only in the seventeen century did European scientists reached a clear understanding of the origin of water and its natural cycle. This cycle has three compounds:

a. The sea and to a very small extent, vegetation (Evaporation and Evapotranspiration driven by solar energy).

b. The clouds; Transfer, condensation and precipitation.

c. Continental surface water (spring, river and lake) and groundwater which with the exception of fossil water, runs into the sea after a certain period of time.

1.2 OBJECTIVE OF THE STUDY

The objectives of this work are:

i. Determination of quality of water sources as well as the state of purity of boreholes under study with respect to the parameters to be analysed.
ii. To compare the values of the analysed parameter with those of WHO.
iii. To make necessary recommendation with respect to the state of purity and safety of these water sources for human consumption.

1.3 SCOPE OF STUDY

Parameters to be considered are:

- Temperature
- Colour
- Turbidity
- Conductivity
- pH
- Alkalinity
- Taste and odour
- Chloride
- Nitrate
- Sulphate
- Phosphate
- Biological Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)

- Bacteriological test
- Calcium/Magnesium

1.4 LIMITATIONS

Heavy metals in the water sources examined were not analysed due to the non availability of atomic absorption spectrophotometer to be used.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 SOURCES OF WATER AND THEIR IMPURITIES

The two sources of water are surface water and ground water.

2.1.1 Surface Water

Surface water is found in rivers lakes and ponds. Substances found in surface water depend upon the water shed. Every human activity affecting watershed components can have a strong impact on the surface water pollution.

In one way people influence surface water composition is by adding potential pollutions sources to the watershed. How they land in a watershed is used by people whether is in farms houses or shopping centres, have direct impact on the surface water quality collected from the watershed. When it rains, storm water carries with it the effect of human activities as it drains of the land into the local water ways. As rain washes over a parking lot, it might pick up litter, road salts, and motor oil and carry these pollutants to a local stream. On a farm, rain might wash fertilizers and soils into the pond. (Terry, 1996).

2.1.2 Ground Water

Ground water is water flowing with aquifers below the water table. Within the aquifers the water flows through the pore spaces in unconsolidated sediments and the fractures of rocks. Ground water is recharged from, and eventually flows to the surface naturally; natural discharge often occurs in springs and seeps and can form swamps. Ground water is also often withdrawn from agricultural, municipal and industrial use through man made wells.

Ground water can be a long term "reservoir" of the natural water cycle as opposed to short water reservoir like the atmosphere and fresh surface water.

Ground water is naturally replenished by surface water from precipitation, streams and rivers when this recharge reaches the water table. It is estimated that the volume of ground water is fifty times that of fresh water, the ice caps and glaciers are the only large reservoirs of fresh waters on earth. Usable ground water is contained in aquifers which are subterranean area (or layers) of permeable materials (like sand and gravel) that the ground water flows. (Allan & John, 1972).

Typically ground water is thought as liquid water flowing through shallow aquifers, but technically, it can also include soil moisture, permafros (frozen salt), immobile water in very low permeability bedrock and deep geothermal or oil formation water. Ground water is believed to provide lubrication and buoyancy which allows thrust faults to move. Nearly any point in the earths subsurface has water in it to some degree (it may be very dry or mixed with other fluids)

2.1.3 How Ground Water and Surface Water Connect

Ground water and surface water are fundamentally interconnected. In fact it is often difficult to separate the two because they "feed" each other. This is why one can contaminate the other. To understand the connection better, one has to look at the various zones and actions. A way to study this is by understanding how water recycles - the hydrologic (water) cycle.

As rain or snow falls to the earth's surface;

a. Some water runs off the land to river, lakes, streams, and oceans (surface water)
b. Water also can move into other bodies below the ground by percolation
c. Water entering the soil can infiltrated deeper to reach groundwater, which can discharge to surface water or return to the surface through wells, springs and marshes. It then becomes surface water again. Upon evaporation, it completer the cycle.

2.2 WATER POLLUTION

According to the American College Dictionary, pollution is defined as to make foul or unclean. Water pollution occurs when a body of water is adversely affected due to the addition of large amounts of materials to the water body. When it is unfit for its intended use, water is considered polluted.

Water pollution can best be defined as the introduction by man into the environment substance and energy liable to cause hazards on human health, harm to living resources and ecological system, damage to structure or amenity or interference with legitimate uses of elements (Mason, 1996).

2.2.1 Types of Water Pollution

i. Toxic Substance: A toxic substance is a chemical pollutant that does not occur naturally in aquatic ecosystems. The greatest to toxic pollution are herbicides and industrial compounds.
ii. Organic Substance: Organic pollution occurs when an excess of organic matter, such as manure or sewage enters the water

body. When organic matter increases in a pond, the number of decomposers will increase. These decomposers grow rapidly and use a great deal of oxygen during the growth. This leads to a depletion of oxygen as the decomposition process occurs.

Lack of oxygen can kill aquatic organism. As the aquatic organisms die, they are broken down by decomposers which leads to further depletion of oxygen levels, a type of organic pollution can occur when inorganic pollutants such as nitrogen and phosphates accumulate in aquatic ecosystems. High level of these nutrients cause an over growth of plants and algae. As the plants and algae die, they become organic material in the water. The enormous decay of this plant matter, in turn lowers the oxygen level. The process of rapid plant growth followed by increased activity by decomposers and a depletion of the oxygen level is called eutrophication.

iii. Thermal Pollution: Thermal pollution can occur when water is used as a coolant near a power or industrial plant and then is returned to the aquatic environment at a higher temperature than it was originally. Thermal pollution can lead to a decrease in the dissolved oxygen level in the water while also increasing the biological oxygen demand of aquatic organism.

iv. Ecological Pollution: Ecological pollution takes place when chemical pollution, organic pollution or thermal pollutions are caused by nature rather than by human activity. An example of ecological pollution would be an increased rate of siltation of a waterway after a landslide which would

increase the amount of sediments in runoff water. Another example would be when larger animals such as deer, drowns in a flood and a large amount of organic material is added to the water as a result. Major geological events such as a volcano eruption might also be sources of ecological pollution.

2.2.2 Specific Sources of Water Pollution

i. Farming: Farms often use large amounts of herbicides and pesticides, both of which are toxic pollutants. These substances are particularly dangerous to life in rivers, steams and lakes where toxic substances can build up over a period of time.

Farms also frequently use large amount of chemical fertilizers that are washed in the waterways and damage the water supply and life within it. Fertilizers can increase the amount of nitrates and phosphates in the water, which can lead to the process of eutrophication (Eboh and Oni, 1987).

Allowing livestock to graze near water source often result in organic waste products being washed into the waterways. This sudden introduction of organic material increases the amount of nitrogen in the water, and can also lead to eutrophication.

Siltation is due to runoff from the exposed soil of agricultural fields. Excessive amount of sediment in waterways can block sunlight, preventing aquatic plants from photosynthesizing, and can suffocate fish by clogging their gills.

ii. Business:

- Clearing of land can lead to erosion of soil into the river.

- Waste and sewage generated by industry can get into the water supply, introducing large organic pollutants into the ecosystems.
- Many industrial and power plants use rivers, streams and lakes to dispose waste heat. The resulting hot water can cause thermal pollution. Thermal pollution can have disastrous effect on life in an aquatic ecosystem as temperature increase it decreases the amount of oxygen in the water, thereby reducing the number of animals that can survive there.
- Acid precipitation is caused when the burning of fossil fuels emits sulphur dioxide into the atmosphere. The sulphur dioxide reacts with the water vapour in the atmosphere, creating rainfall which contains sulphuric acid and referred to as acid rain (Anis, 1978)

iii. Homes:

- Sewage generated by homes of runoff from septic tanks into nearby waterways, introduce organic pollutants that can cause eutrophication.
- Fertiliser, herbicides and pesticides used for lawn care can runoff and contaminate the waterway. As with agricultural fertilisers, home fertilizers can lead to eutrophication of lakes and rivers.
- Improper disposal of hazardous chemicals down the drain introduce the toxic materials into the ecosystem; contaminating the water supplies in a way tat can harm aquatic organisms.

- Leaks of oil and antifreeze from a car on a drive way can be washed off by the rain into nearby waterways, polluting it (Klein, 1962)

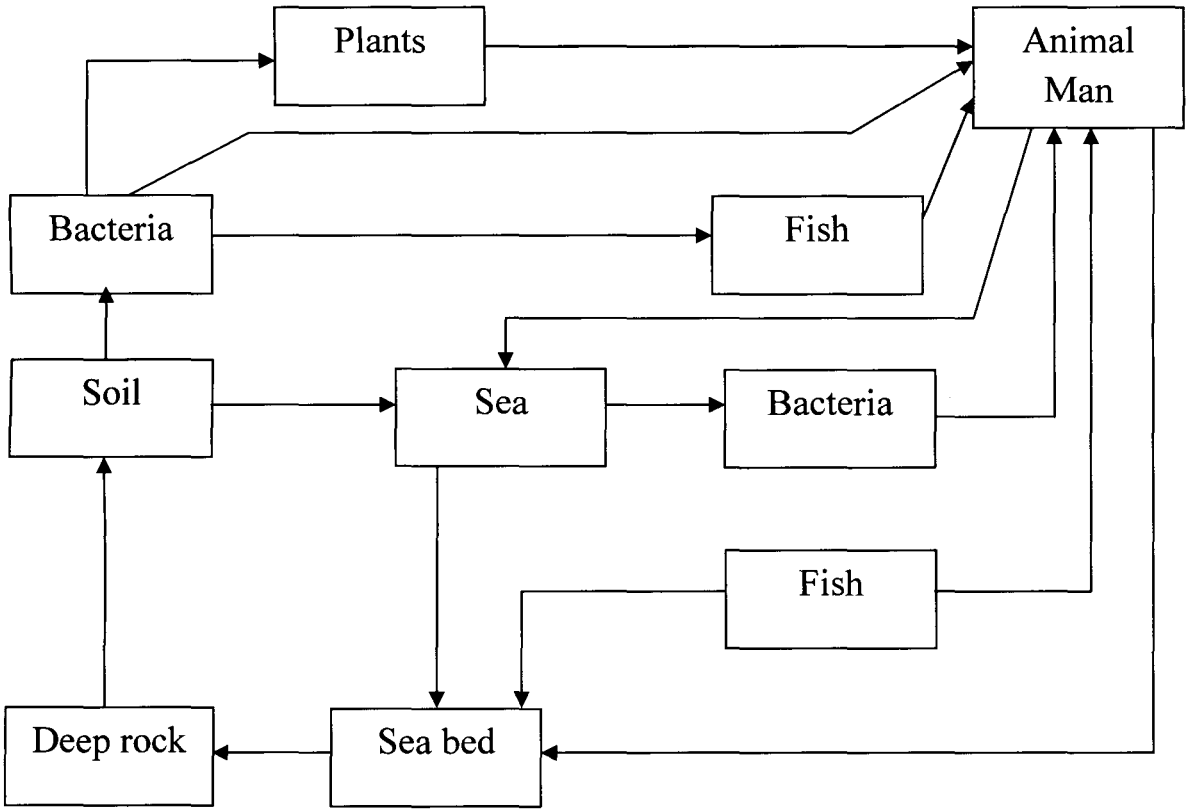

Fig 1: The pathway Of Contamination

2.2.3 Forms of Water Pollution

Water quality can be affected by different forms of pollution, chemical, biological and physical pollution. These pollution factors can influence natural and human environment whether directly or indirectly by creating conditions that limit water utilisation for specific purposes. Where possible, states identify the pollutants that degrade water quality and indicators that documents impacts of water quality degradation. Indicators of water quality degradation include physical, chemical, and biological parameters.

Other forms of pollutions are petroleum, radioactive substances and heat. Petroleum often pollutes water bodies in the form of oil. Radioactive substances are produced in the form of waste from nuclear power plants, and from the industrial, medical, and scientific use of radioactive material. Specific forms of waste are uranium and thorium mining and refining. Heat is a pollutant because increased temperatures result in the death of many aquatic organisms, this increase in temperatures are caused when a discharge of cooling water by factories and power plants occurs.

2.2.4 Forms of Water Pollutants

2.2.4.1 Chemical pollutants

Chemical pollutants can be divided into non-persistent (degradable) and persistent (degradable slowly). Persistent pollutant is the most rapidly growing type of pollution and includes substances that degrade very slowly or cannot be broken down at all; they may remain in the aquatic environment for years or longer periods of time.

Persistent pollutants include some pesticides (e.g. DDT and dieldrin), some leachate components from landfill sites, petroleum and petroleum products, PCBs, dioxins, cadmium. The damage they cause is either irreversible or reparable only over decades or centuries.

Non persistent pollutants include domestic sewage, fertilizers and some industrial wastes. These components can be broken down by chemical reaction or by natural bacteria into simple, non-polluting substances such as carbon dioxide and nitrogen.

Chemical pollution includes:

a. **Total Dissolved Solids (TDS)**: TDS are correlated fairly well to the total mineral content of the water (deposits left after

evaporation of water sample), primarily, salts, carbonates, and metals. Nutrients (nitrates phosphates), iron and manganese, toxic organic fluorides, corrosion, colour, odour and taste are all total dissolved solids.

i. Nutrient: Nutrients include nitrates found in sewage and fertilisers and phosphates found in detergent and fertilisers. In excess levels, nutrients over stimulate the growth of aquatic plants and algae.

Excessive growth of the organism, in turn, can clog navigable water, use up dissolved oxygen as they decompose, and block light to deeper water. This seriously affects the respiration of fish and aquatic invertebrates, leading to a decrease in animal and plant diversity as well as our use of the water for fishing, swimming and boating.

- Nitrates: The nitrate anion NO_3^- is not absolved by soil and moves with infiltrated water. Nitrates are present in water particularly in regions where agricultural fertiliser is intense. Other important routes of entry of nitrogen into bodies of water are municipal and industrial waste water, septic tanks, feed lot discharges, animal waste (including birds and fish) and discharges from car exhausts. Monitoring nitrate level in drinking water is extremely important with infants, because of their high intake of water with respect to body weight. Nitrates in the infants are converted by the body to nitrites that oxidize blood haemoglobin to methemoglobin. The altered blood cells can no longer carry oxygen, which can result to brain damage or suffocation. (Hedlin, 1972).

- Phosphates: Phosphorus is on of the key elements necessary for growth of plants and animals. Phosphorus in elemental form is very toxic and is subject to bioaccumulation phosphates PO_4^{3-} are formed from this element. Phosphates exist in three forms orthophosphate, metaphosphates and organically bound phosphates. Ortho forms are produced by natural processes and are found in sewage. Meta forms are used for treating boiler waters and in detergents. In water they change into the other forms. Organic phosphates are important in nature; their occurrence may result from the breakdown of organic pesticide which contains which phosphates are not toxic to people or animals unless they are present in very high levels.

ii. Iron and Manganese: The presence of iron and manganese in large quantities are very easy to notice because of the reddish brown stain these mineral causes. The stain shows on laundry sinks and every other object touched by the water.

Iron is the fourth most abundant element, by weight, in the earth's crust. Natural water contains variable amounts of iron despite its universal distribution and abundance. Iron in groundwater is normally present in the ferrous or bivalent form, forming a clear colourless solution until it comes into contact with oxygen. Oxygen changes iron to the ferric state Fe^{3-} which reacts with alkalinity in the water or exposure to air and forms an insoluble brown ferric hydroxide precipitate. Iron is a trace element required by both plants and animals. It is necessary for vital oxygen transport mechanism in the blood of all vertebrate and some invertebrate animals.

Manganese tends to precipitate at levels greater than 0.05ppm and form black flakes. These flakes will deposit themselves in the same way iron stains and can clog pipes. Evidence of manganese staining is usually most prominent in the dishwasher. The detergent used to wash the dishes raise the pH of the water high enough (-8) to allow the manganese to easily precipitate. A second place to see a manganese problem is o n the top of the water in the toilet storage tank. The manganese will form a film that is sometimes mistaken for oil on the water. If you touch the surface f this water the film will break into flakes with jagged edges. Iron and Manganese in combination with natural or man made organic compounds will cause even more staining problems. Organic compounds react with iron and manganese to form very stable and difficult to remove dark coloured materials.

iii. Fluoride: Varying amounts of fluoride are found in water supplies. It can affect teeth during the period when permanent teeth are being formed. At levels between 0.7 and 1.2ppm fluoride will prevent teeth decay and is essential for proper development of bones. However, high fluoride in water can cause a brown colour on teeth.

iv. Toxic Organic: Toxic organic compounds include a wide range of substance, all of which contains carbon. The common types of industrial organic substances found in water are petroleum products, solvents, pesticides halomethanes such as methylene chloride (CH_2Cl_2) and DDT (1,1,1-trichloro-2,2-bis) (P-chlorophenyl ethane), polychlorinated biphenyls (PCBs), dioxin, polyaromatic hydrocarbons (PAHs)

Among them, compounds containing chlorides generally referred to as organic halides or chlorinated hydrocarbons have been found to be very toxic, acutely at high concentration and chronically at very low concentration. Volatile organic halides may be formed also during the chlorinated treatment.

b. Suspended Solids:

i. Heavy metals (such as mercury, lead and cadmium) may originate from industrial discharge, run off from city streets, mining activities, leachate from land fills, and variety of other sources. These toxic chemicals, which are generally persistent in the environment, can cause death or reproductive failure in fish, shellfish, and wildlife, in addition, they can accumulate in animals and fish tissue, be absorbed in sediments, or find their way into drinking water supplies posing long – term health risks to humans.

Pesticides and herbicides used on crop lands, lawns and in termite control can be washed into ground and surface waters by rainfall, snow melt, and irrigation practices. These contaminant area generally persistent in the environment and may accumulate in fish, shellfish and wildlife to level that pose a risk to human health and environment. Pesticides are among the principal contaminants causing drinking water well closures in the southern and western regions of the country.

ii. Sulphates. Sulphates are associated with gypsum formation and are common in several areas. Sulphates of calcium and magnesium can cause hardness in water. Sulphate levels ate 50ppm or greater can have a laxative effect and cause an

astringent aftertaste to the water. High sulphate level can also have a corrosive effect on plumbing. (Roberts, 1982)

Water containing sulphate my also contain bacteria which produce hydrogen sulphide. The foul rotten egg smell found in some water comes from hydrogen sulphide.

c. Organic Materials:

i. Chlorides. Chlorides are salt compounds resulting from the combination of the gas chloride and a metal. Some common chlorides include sodium chloride (NaCL) and magnesium chloride ($MgCl_2$). Chlorine alone as Cl_2 is highly toxic, and is commonly used as a disinfectant. In combination with metals such as sodium, it becomes essential for life. Some amount of chloride is required for normal cell function in plants and animal life. High chloride can cause human illness and also affect plant growth at levels in excess of 1000mg/l. Taste threshold is about 250 mg/l for most people. However, calcium and magnesium are not usually detected by taste until levels of 1000 mg/l are reached. Public drinking water standard requires chloride level not to exceed 250 mg/l

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 SAMPLING METHODS

The value of any laboratory test depends upon the sampling method. The samples collected were a representative of the river, wells and borehole to be analysed. The samples were collected using 2 - litre containers that has been properly sterilised and rinsed with distilled water. Samples were collected at monthly intervals from July - September between 9:00-10:00 A.M

Some parameters were determined almost immediately after the sample collection and for other; the samples were stored in refrigerators for the duration of the analysis which took place between 24-48 hours from the time of collection.

3.2 SOURCES OF SAMPLES

Samples used were obtained from the following areas in Otukpo Township.

- A—Borehole (Otukpo Township)
- B—Borehole (Upu in Ichakpa's compound)
- C—River (Upu)
- D—River (Otada)
- E—A well in Upu "London"
- F—A well in Otada
- G—A well in Otukpi'cho
- H—Water Board along David Mark road (Otukpo Township)

3.3 MATERIALS

pH meter, E587 conductivity meter, clean odour-free glass bottles, water bath, cotton wool, 250ml Erlenmeyer flash, 25ml burettes beakers, conical flasks, spectrophotometer DRI2000s model, graduated mixing cylinders, delivery tubes, pipettes, membrane filter, filter holder, filter flask, aspirator, turbidometer/TDS, measuring cylinder, calibrated dropper, towel, 6Oml BUD bottle, Buckner funnel, filter paper, oven, hot plate, crucibles, analytical balance, reagent bottles, COD vial, 10mI and 1ml pipettes, dilution tubes, Petri dish incubator, masking tape Kraft paper, wagtech photometer, nitrate test tube, lactose pad.

3.4 REAGENTS

Buffer solution (pH10 and pH4), distilled water, calcium carbonate, phenolphthalein indicator, methyl orange indicator, sulphuric acid standard solution, silver nitrate, potassium dichromate, wagtech ammonia No I tablet, wagtech ammonia No 2 tablet, alkaline glycollate tablet, iron HR tablet, ethylene diamine tetra acetic acid (EDTA), erichrome black T indicator, ammonia buffer, hydrochloric acid, barium chloride, dissolved oxygen I and 2 reagents.

3.5 METHODS OF DETERMINATION

3.5.1 Determination of pH

The pHs of the samples was determine using wagtech pH meter electrometry at 25°C.The pH meter, with a glass combination electrode and automatic temperature compensation probe is calibrated with buffers at pH 4 and 10 at 25°C. The pH value of the sample aliquot was recorded upon display.

3.5.2 Determination of Temperature

The temperature of the samples was taken at in sittu using a mercury thermometer.

3.5.3 Determination of Conductivity

Specific conductance of a solution is the ability of the solution to carry electric current and has some relationship to the ionic concentration of the solution. The specific conductance was measured by a conductivity meter with platinum electrodes and was equilibrated to 25°C before the sample measurement was made. The conductivity meter was calibrated on a per use bases. The probe was dipped into the sample and the readings were taken on display accordingly.

3.5.4 Determination of Odour

The samples were poured into different clean odour free glass bottles and warmed to room temperature using water bath. The samples were shaken and the stopper of the bottle was removed. The odour was tested by bringing each bottle to the nose and the odour characteristics were recorded.

3.5.5 Determinants of Colour

Colour determination was made using panel of ten (5) people.

3.5.6 Determination of Turbidity

The determination of turbidity of samples was carried out using a turbidometer.

In wagtech turbidometer, a strong light beam is sent upwards through a transparent tube containing a shaken sample. The light, reflected at 90° to the axis, is captured by photocell and their electrical response is

proportional to the sample turbidity. The instrument contains a special turbidity material supplied with the instrument for standardisation First, a clean and dry sample was obtained. The vial was rinsed with approximately 10ml of the sample water, and gently inverting several times. A thin film of silicon oil was applied on the sample vial arid later wiped with a soft cloth to obtain an even distribution over entire vial surface. The turbidity meter was placed on a flat and level surface. The samples were placed inside the vial. Then push the vial until it is hilly snapped in. Cover the vial with light shuld cap. The meter was then on and the reading was noted and recorded on display.

3.5.7 Determination of Chloride (mg/l)

Procedure:

50ml of each of the water samples was placed in a conical flask, 1ml of potassium chromate was added as an indicator and the solution *was* titrated against standard silver nitrate in the burette. On titration, a rose red end point was observed indicating the presence of chloride.

Calculation:

$$Cl\ (mg/l) = \frac{\text{ml of } AgNO_3 \text{ used x } 1000}{\text{ml of sample}}$$

3.5.8 Determination of Iron (mg/l)

Determination of iron in the samples was carried out using colorimetry. The wagtech iron HR test is based on single tablet reagent containing an alkaline thioglycollate. The test is carried out simply by adding a tablet to a sample of the water under test. The thioglycollate reduce ferric iron to ferrous iron and this together with any ferrous iron already present in the

sample reacts to give a pink colouration. The intensity of the colour produced is proportional to the iron concentration.

Procedure

i. Fill test tube with sample to the 10ml mark
ii. Add one iron HR tablet, crush and mix to dissolve
iii. Stand for one minute to allow full development
iv. Select wavelength 570nm on photometer
v. Take photometer reading in usual manner
vi. Iron calibration chart was consulted to correct the reading

3.5.9 Determination of Nitrate (mg/I)

In the wagtech nitratest method, nitrate is first reduced to nitrite; the resulting nitrite is then determined by a diazonium reaction to form a reddish dye. The reduction stage was carried out using the unique zinc–based nitratest powder, and nitrate tablet which aids rapid flocculation after the one minute contact period. The test is conducted in a special nitratest tube; a graduated sample container with stopper bottom to facilitate settlement and decanting of the sample. The nitrite resulting from the reduction stage is determined by reaction with suiphanilic acid in the presence of N – (1 – naphthyl) – ethylene diamine to form a reddish dye.

The reagents are provided in a single nitricol tablet. The nitratest tube was filled with sample to the 20m1 mark. One Level spoonful of nitratest powder and one nitratest tablet was added. The tube was capped and shaked for a minute. The tube was allowed to stand for about a minute and was gently inverted for about three or four times to aid flocculation. The tube was allowed to stand for 2 minutes to ensure complete settlement.

The clear solution was decanted into a round test tube, filling to the 10ml mark. One nitrocol tablet was added and crushes to dissolve. It was allowed to settle for 10 minutes to allow colour development. A wavelength of 570nm was selected on the photometer. Photometer reading was taken and nitrate calibration chart used in correcting the values.

3.5.10 Total Hardness (mg/l) Determination

Total hardness of the samples was determined by the complexometric titration of an aliquot of the sample using ethylene diamine tetraaceic acid (EDTA) in the presence of a suitable indicator. When the indicator erichrome black T is added to a solution containing calcium and magnesium ion; at pH 10.0 ± 0.1 the solution will be pink to wine red in colour depending on the concentration of the ions present. On titrating with EDTA, the solution will turn blue when sufficient EDTA has been added to complex all the calcium and magnesium. To ensure a satisfactory end point, a small amount of the complexometrically neutral Mg salt of EDTA is incorporated in the buffer solution.

Procedures

A suitable volume (V1ml) of the sample was pipetted into a 250m1 conical flask. 2m1 ammonia buffer was added into each 50m1 of the solution and 1.0 ml of sodium sulphide solution was also added. Erichrome black T indicator solution was dropped until a pink to wine red colour was obtained. The flask was placed against a white background and titrates immediately with 0.O1M EDTA, swirling continuously. As the end point is approached a blue colour was observed with a reddish tinge. The next few drops of EDTA were added until the last of reddish

tinge disappeared and that's the end point. The litre value was recorded as (V_2ml).

Calculation

$$\frac{100 \cdot 09 \times 1000 \times M \times V_2}{V_1}$$

3.5.11 Determination of Alkalinity (mg/l)

The alkalinity of the sample was determined using burette titration method. 25ml of the sample was measured using graduated cylinder and was transferred into a 250ml Erlenmeyer flask and diluted to 50ml with distilled water. Six drops of phenolphthalein indicator solution was added to the sample and shaken. A 25ml burette was tilled to the zero mark with O.020N sulphuric acid standard solution and titrated against the sample while swirling the flash until the solution changed from pink to colourless.

Calculation

$$\frac{\text{ml of } H_2SO_4 \times N \times 50 \times F}{1000}$$

Where N is the normality, F is the factor 1000

3.5.12 Determination of Calcium (mg/l)

Calcium determination was done using EDTA titration.

Procedures

2. 0ml of NaOH solution was added to the sample then 0.2g indicator (Calve 11) was also added. The aliquot was titrated with a standardised EDTA (disodium dihydrogen ethylnediamine acetate) solution. The colour changes from pink to purple when the calcium was reT1ovcd. The samples were compared to identically prepare standard and blank solution.

3.5.13 Determination of Magnesium (mg/l)

The magnesium concentrat10I in the sample was calculated 1omfl the values of the total hardness (determined by EDTA titration) and calcium dissolved.

Calculation

Total hardness – calcium content

3.5.14 Determination of Phosphate (mg/l)

Phosphate was determined using Armstrong reagent. First the combined reagent was prepared by adding sulphuric acid solution, potassium antimony tantrate solution, ammonium molybdate solution and ascorbic acid solution together appropriately 8ml of the combined reagent was added into 50m1 of each sample. The flask containing the solution was allowed to stand for 20 minutes after which the absorbance was measured using photometer at 71Onm with reagent blank as reference solution. The absorbance was recorded.

3.5.15 Determination of Sulphate (mg/l)

Procedure

100mI of the sample was measured into a 250ml Erlenmeyer flask. Then 20ml of buffer dilution was added and the solution was stirred. While stirring a spoonful of $BaCl_2$ crystals was added. The mixture was stirred for 60 seconds at a constant speed. After this, the solution was poured into absorption cell of a photometer. The photometer was set at 43Onm and was read as displayed. The sulphate concentration was compared to the calibration curve prepared.

3.5.16 Determination of Dissolved Oxygen (mg/l)

Procedure

i. Fill the dissolved oxygen bottle (round bottle with glass stopper) with the water to be tested. To avoid trapping of air bubbles in the bottle incline the bottle slightly and insert the stopper with a quick thrust. This will force air bubbles out. It. bubbles become trapped in the bottle in step 2 or 4 the sample should be discarded before repeating the test.

ii. Use the dipper to open one dissolved oxygen I reagent powder pillow and one dissolved oxygen 2 reagent powder pillow. Add the content of each of the pills to the bottles. Stopper the bottle carefully to exclude air bubbles. Grip the bottle Stopper firmly shakes vigorously to mix. A flocculant precipitate will be formed. If Oxygen is present in the sample the precipitate will he brownish orange in Colour. A small amount of powder remaining will not affect the result.

iii. Allow the sample to stand until the flocculant has settled halfway in the bottle. Leaving the upper half of the sample is clear. Shake

the bottle again let it stand until the upper half of the sample is clear. Stand for four or live minutes.

iv. Use the clipper to open or dissolve oxygen 3 reagent powder pillow. Remove the stopper from the bottle and add the content carefully stopper the bottle and shake to mix. The flocculant will dissolve and a yellow colour will develop if oxygen is present.

v. Fill the plastic measuring tube level lull of the sample prepared in step 1-4. Pour the Sample into the mixing bottle.

vi. Add sodium thiosulphate standard solution drop by drop to the mixing bottle firmly to mix after each drop. I bid the dropper vertically above the bottle and count each drop as it is added continue to add drops until the sample changes for yellow to colourless. Each drop used to bring about the colour change in step 6 is equal to 1mg/l dissolved oxygen (DO).

3.5.17 Determination of BOD (mg/l)

First, the dilution water was prepared in the following way. Water was stored and saturated (in a large aspirator whose mouth was plugged with clean cotton – wool) with sufficient dissolve oxygen. After 24hours, the following reagent were added to it, phosphate buffer solution which was prepared by dissolving I .4g potassium hydrogen phosphate ($KHPO_4$) and 3.6g of potassium hydrogen phosphate ($KHPO_4$) in 83ml distilled water and made up to I.67ml, calcium chloride ($CaCI_2$) and iron(iii)chloride ($FeCI_3$)) solutions. The mixture *was* shaked tor it to mix.

BOD Procedure

25m1 of the sample was measured and diluted with 225mnl of the dilution water. 25m1 of the diluted sample was again measured and

diluted with 225ml of dilution water. Two dissolve oxygen bottles were tilled with the prepared/diluted sample. The initial dissolved oxygen was determined immediately in one of the bottles; the other bottle was incubated for 120hrs (5 days) in the dark at 20°C in a cooled incubator. After 5 days, the dissolved oxygen was determined and the five day biochemical oxygen demand (BOD) was computed from the dissolved oxygen values, initial and 5 -day DO, and the percent dilutions using the formula

BOD Mg/l= $(DO-DO_d) \times B/A$

Where D0 = Dissolved oxygen found in the sample on the initial day. DO_d = Dissolved oxygen fluid in the diluted sample after titration on the final day. A =volume of sample before dilution, B = volume of sample after dilution.

3.5.18 Determination of COD (mg/I)

The chemical oxygen demand was obtained using $K_2Cr_2O_7$ digestion. Most organic compounds are oxidised by potassium dichromate under acid condition. A sample aliquot was refluxed for two hours in concentrated H_2S0_4 with a known amount of' $K_2Cr_2O_7$ containing sulphanic acid against the interference of nitrites.H_2SO_4 against the interferences of chloride and Ag_2SO_4, as a catalyst for the organic compound. The sample was cooled and the excess dichromate was titrated with standard ferrous ammonium sulphate (Fe $(NH_4)_2$ $(SO_4)_2$), using ferrion (a complex of ferrous ion I, 10 phenantroline) as an indicator, the amount of oxidisable organic matter is proportional to the dichromate consumed. A reagent blank was identically analysed. The

concentration COD was calculated from the difference between the sample and blank aliquots.

3.5.19 Total Dissolved Solids (mg/I)

The total dissolved solids of the samples were determined by multiplying the conductivity values of each sample by constant 0.666.

3.5.20 Determination of Total Coliform (MPN/100L)

The total coliform test was carried out using membrane Filtration method. 100ml of the sample was filtered. The litter paper was then placed on saturated lactose pad that has been incubated for two hours at 35°C, and then incubated for 20 to 22hrs at 35°C ± 0.5°C. After 24hrs incubation, the colonies were counted on the membrane filter using magnifying in microscope.

The coliform group is defined as all bacteria that produce a red colony with a metallic (golden) colour within 24hrs at 35°C on an endo-type medium containing lactose. Sterilisation procedures were adhered to at all stages of the experiment.

3.5.21 Determination of Faecal Coliform Bacteria (MPN/100L)

A measured volume of the sample (100ml) was filtered through a sterile cellulose ester membrane where the pore *size* is small enough to retain the organisms to be enumerated. The membrane was placed on an absorbent pad saturated with membrane laryl sulphate broth (containing lactose and phenol red as indicator of acidity) and incubated for 4 hours at 30°C, then l4hrs at 440°C. After the l8hrs colonies were counted using a microscope. The colours of organisms with characteristic colour and morphology were counted.

CHAPTER FOUR

4.0 ANALYSIS OF RESULT AND DISCUSSION

4.1 RESULTS

The results of the analysis carried out on the difficult water samples are summarized in the tables below.

Statistical analyses of the results for borehole samples are represented below:

Table 1: Sample A

PARAMETERS	MEAN VALUES	VARIANCE	STANDARD DEVIATION ±
pH	7.7	0.0047	0.069
Turbidity FTU	0.0	0.0	0.0
Temp. (°C)	24	0.0	0.0
Conductivity µs/cm	18.6	0.0	0.0
Total d. solid (mg/l)	12.0	0.0	0.0
Alkalinity	24.7	0.89	0.94
Nitrate (mg/l)	2.93	0.002	0.047
Chloride (mg/l)	20.66	0.22	0.47
Iron (mg/l)	0.097	0.002	0.041
Total Hardness(mg/l)	33.36	148	12.17
Calcium (mg/l)	16.4	2.55	1.6
Magnesium (mg/l)	7.074	0.015	0.12
Sulphate (mg/l)	8.7	1.977	1.406
Phosphate (mg/l)	0.45	0.036	0.19
Coliform(MPN/100ml)	78.3	181.55	13.47
E.Coli (MPN/100ml)	0.00	0.00	0.00

Table 2: Sample B

PARAMETERS	MEAN VALUES	VARIANCE	STANDARD DEVIATION ±
pH	7.5	0.016	0.13
Turbidity FTU	0.24	0.019	0.14
Temp. (°C)	24	0.0	0.0
Conductivity µs/cm	16.5	0.34	0.58
Total d. solid (mg/l)	10.99	0.33	0.57
Alkalinity	22.6	3.56	1.89
Nitrate (mg/l)	3.6	0.72	0.85
Chloride (mg/l)	27.66	0.88	0.94
Iron (mg/l)	0.05	0.00	0.00
Total Hardness (mg/l)	24.3	0.33	0.58
Calcium (mg/l)	7.6167	0.021	0.14
Magnesium (mg/l)	7.2848	0.098	0.31
Sulphate (mg/l)	9.69	0.23	0.48
Phosphate (mg/l)	0.51	0.02	0.14
Coliform(MPN/100ml)	44.77	10.89	3.3
E.Coli (MPN/100ml)	0.00	0.00	0.00

Table 3: Sample C

PARAMETERS	MEAN VALUES	VARIANCE	STANDARD DEVIATION ±
pH	6.9	0.005	0.07
Turbidity FTU	6.63	2.07	1.44
Temp. (°C)	24.67	0.89	0.94
Conductivity µs/cm	197.00	1.67	1.29
Total d. solid (mg/l)	131.3	0.72	0.85
Alkalinity	24.7	0.89	0.94
Nitrate (mg/l)	1.7	0.803	0.896
Chloride (mg/l)	29.66	3.718	1.928
Iron (mg/l)	0.15	0.00	0.00
Total Hardness(mg/l)	12.695	6.09	2.47
Calcium (mg/l)	7.98	0.18	0.42
Magnesium (mg/l)	3.4	0.026	0.16
Sulphate (mg/l)	14.63	0.169	0.41
Phosphate (mg/l)	2.42	0.06	0.24
Coliform(MPN/100ml)	274	0.0	37.4
E.Coli(MPN/100ml)	0.00	0.00	0.00
COD (mg/l)	28	0.0	0.0
BOD (mg/l)	27	0.0	0.0

Table 4: Sample D

PARAMETERS	MEAN VALUES	VARIANCE	STANDARD DEVIATION ±
pH	7	2.03	1.42
Turbidity FTU	28.770	114.57	10.70
Temp. (°C)	24	0	0
Conductivity µs/cm	45.60	40.2	6.3
Total d. solid (mg/l)	30.4	17.99	4.2
Alkalinity	3.16	2	1.4
Nitrate (mg/l)	0.397	0.001	0.03
Chloride (mg/l)	13.32	16.22	4.83
Iron (mg/l)	0.1	0.005	0.07
Total Hardness(mg/l)	6.3	6.05	2.5
Calcium (mg/l)	4.59	0.29	0.54
Magnesium (mg/l)	3.19	1.17	1.08
Sulphate (mg/l)	13.47	0.61	0.781
Phosphate (mg/l)	2.57	0.1	0.316
BOD (mg/l)	20.67	2.89	1.7
COD (mg/l)	288	359	18.9
Coliform (MPN/100ml)	3.00	6.00	2.40
E.Coli (MPN/100ml)	8.67	2.23	1.49

Table 5: Sample E

PARAMETERS	MEAN VALUES	VARIANCE	STANDARD DEVIATION ±
pH	5.78	0.007	0.008
Turbidity FTU	6.07	14.740	3.840
Temp. (°C)	24.00	0.000	0.000
Conductivity µs/cm	137.00	60.600	7.790
Total d. solid (mg/l)	91.22	27.000	5.196
Alkalinity	20.70	0.040	0.190
Nitrate (mg/l)	3.13	0.009	0.090
Chloride (mg/l)	28.32	11.450	3.380
Iron (mg/l)	0.08	0.002	0.040
Total Hardness (mg/l)	10.68	0.900	0.950
Calcium (mg/l)	6.39	1.030	1.010
Magnesium (mg/l)	3.82	0.570	0.755
Sulphate (mg/l)	44.66	36.030	6.000
Phosphate (mg/l)	0.58	0.0006	0.020
Coliform(MPN/100ml)	78.00	18.670	4.320
E.Coli (MPN/100ml)	0.00	0.000	0.000

Table 5: Sample F

PARAMETERS	MEAN VALUES	VARIANCE	STANDARD DEVIATION ±
pH	6.62	0.004	0.007
Turbidity FTU	4.11	16.90	4.10
Temp. (°C)	24	0.333	0.577
Conductivity µs/cm	101	14.07	3.75
Total d. solid (mg/l)	67.16	6.96	2.6
Alkalinity	40	0.00	0.00
Nitrate (mg/l)	29	8.67	2.9
Chloride (mg/l)	1246	14.18	3.77
Iron (mg/l)	0.12	0.002	0.04
Total Hardness(mg/l)	100.93	2.3	1.5
Calcium (mg/l)	69.982	0.003	0.05
Magnesium (mg/l)	29.449	5.628	2.372
Sulphate (mg/l)	38.5	32	5.65
Phosphate (mg/l)	0.43	0.0006	0.02
Coliform(MPN/100ml)	210	15	3.87
E.Coli (MPN/100ml)	0.00	0.00	0.00

Table 6: Sample H

PARAMETERS	MEAN VALUES	VARIANCE	STANDARD DEVIATION ±
pH	6.87	0.008	0.09
Turbidity FTU	3.560	18.41	4.29
Temp. (°C)	24	0.0	0.0
Conductivity µs/cm	94	334	18
Total d. solid (mg/l)	51	15.2	3.9
Alkalinity	25.6	54	7.36
Nitrate (mg/l)	1.31	0.002	0.045
Chloride (mg/l)	17.98	32.08	5.66
Iron (mg/l)	0.005	0.00	0.00
Total Hardness(mg/l)	26.01	241.9	15.55
Calcium (mg/l)	11.31	1.14	1.07
Magnesium (mg/l)	4.67	0.059	0.24
Sulphate (mg/l)	6.17	2.39	1.55
Phosphate (mg/l)	0.6	0.006	0.007
Coliform(MPN/100ml)	59.33	80.89	9
E.Coli (MPN/100ml)	0.00	0.00	0.00

4.2 DISCUSSION

The statistical analysis of the raw results of the analysis carried out on different water sample is presented in table 1 to 8. The pH for the samples fall within the permissible limit except for samples E and sample G whose mean pH values are 5.78 and *5.74* respectively. These values are low when compared with WHO standard of 6.5 to 9.2. A pH range of 6.0 to 9.0 appear to be unsuitable for the aquatic invertebrates. Many enzymes and other protein are denatured by pH which differ much for pH 7, these disrupts the functioning of organism and may even kill them. Conductivity of the samples are high except for samples A, B, D that arc slightly low. Fish and other animals in river with high conductivity value may not thrive well. The turbidity of the samples when compared with WHO standard was found to be high except for samples A, B and H. This is a clear indication of the presence of suspended matter in the samples. Alkalinity in samples E and G are obviously low. Alkalinity (less than 24ml as CaCO3) has a low buffering capacity and can therefore be susceptible to alteration in pit, for example, from atmosphere, acidic deposition. This may account for why their pH is slightly acidic. The phosphate level also are above the WHO standard except for sample A,B and H. This can lead to population explosion among certain types of plant and algae, which has the potential for eutrophication of these water bodies.

The high level of phosphates in samples 13, C, D may be as a result of farming and washing activities going on around the rivers. Apart from the above chemical variables all other chemical parameters are within the allowed limit of W.H.O. This could be due to the fact that there are no much industrial activities in Otukpo also; the locations of the sampling points for wells have a good soil texture. The major problems

observed from the samples are bacteriological pollution. The levels of coliform growth in the samples show a lot of man made cause of pollution. The boreholes with coliform 40-92 shows that they are not save for drinking. The river as a surface waters are liable to bacterial infection. The wells also with coliform ranging from 74— 215 poses a great treat to the consumers. The presence of coliform in these samples might be due to lack of sanitation around the well. Sample I was observed to have a mean colonies of 8.6 E-coli because of the closeness of latrine pit and other human activities as observed at the point. The total hardness as CaCO3 levels of the samples ranges between 6.30 - 1 OO.93ppm, which is below the WHO recommended level (500 ppm). All the samples are very low in CaCO3.

Soil water bus values less than 6.Oppm this means that sample ii with lOO.93ppm hardness is not good for domestic consumption.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDAT10N

5.1 CONCLUSION

The result obtained from the water analysis showed that the quality of some drinking water sources in Otukpo is not portable as specified by the international standard. The observed pH, alkalinity, turbidity, and hardness of some of the samples imply the need for chemical treatment before use. Also considering the level; of coliform colonies counted, as shown in the table, it becomes imperative to advise that the samples be disinfected before consumption. Samples E and G with pH values below 6 may also be fatal to ulcer patients and therefore is considered not fit human consumption. As human population continuous to grow and technology is exploited, it is anticipated that pollution of water will be on increase. Therefore, adequate protection of water against pollution should be enforced otherwise man and other aquatic animals will be exposed to danger. Although, some of the parameters analysed are higher than expected, this is not surprising considering the period of the analysis which is between July to September ending; this is the peak period of raining season. In conclusion, it is anticipated that the concentration of most of these parameters will decrease drastically as we enter into the dry season when there will be no flooding waters.

5.2 RECOMMENDATIONS

i. It should be ensured that latrine pits are dug far away from wells and boreholes

ii. Animal breeding and cultivation should not be done close to wells and boreholes

iii. It should also be ensured that there are no cracks in the cement floor of the boreholes. This is to ensure that surface water does not sip into it.

iv. Boreholes and wells should be kept away from roads to avoid dust and other particles entering into the water.

v. Enough sanitation should be carried out around these sites.

vi. Since the rivers serve a; water source to the people, farmers should therefore stop farming around the rivers.

vii. The idea of washing farm produce, clothes and cars in the rivers should be discouraged.

viii. The people should be sensitised on the importance of proper sanitation around water sources

ix. Sanitary officers should supply refuse disposal buckets for each house in the community and make it a mandate that houses must have toilets which must be located far from wells and boreholes.

x. The Government at both Federal and State levels should consider it a matter of urgency the setting up of an environmental protection agency which will be an authority principally concerned with water pollution monitoring.

xi. The state Government should set up a committee that can train people on how to monitor the water sources pollution.

W.H.O STANDARD FOR DRINKING WATER (2000)

CHEMICAL CHARACTERISTICS

PARAMETERS	Minimum Acceptable	Maximum Acceptable
Acidity (PPM) $CaCO_3$	Nil	Nil
Alkalinity (PPM)$CaCO_3$	30	500
Total Hardness	30	200
Calcium Hardness	75	200
Chloride	200	600
Sulphide	200	400
Sulphate	200	500
Total Chlorine	-	0.2
Nitrite	Nil	Nil
Nitrate	5	30
Ammonium	-	0.5
Phosphate	-	0.03
Iron (PPM)	0.1	1
Dissolved Oxygen DO (PPM)	-	-

PHYSICAL PROPERTIES

SOURCE: UNITED NATIONS ENVIRONMENTAL PROGRAMME

Appearance	Clear	Clear
Colour TCU	3	15
Odour	Odourless	Odourless
pH at 20	6.5	9.2
Turbidity (FTU)	-	-
Conductivity (SCM)	0.9×10^{-4}	120×10^{-4}
Total (PPM)	500	1500
Dissolved Solids (PPM)	-	500

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