EVALUATION OF PHYSICOCHEMICAL AND MICROBIAL PROPERTIES OF WATER QUALITY IN CHANCHAGA RIVER, MINNA NIGER STATE

BY

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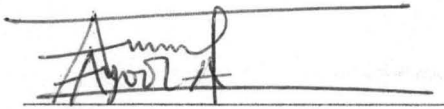OF WATER QUALITY IN CHANCHAGA RIVER, MINNA NIGER STATE

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL
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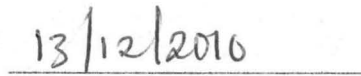TECHNOLOGY, MINNA, NIGER STATE

DECEMBER, 2010

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DECLARATION

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 Information derived from personal communication, published and unpublished work were duly referenced in the text.

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Ayoola, Bayo Joseph
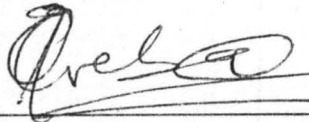
13/12/2016

Date

CERTIFICATION

This is to certify that the project entitled "Evaluation of Physicochemical and Microbial Properties of Water Quality in Chanchaga River Minna, Niger State" by Ayoola, Bayo Joseph meets the regulations governing the award of the degree of Bachelor of Engineering (B. ENG) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

_____   13—12— 2070
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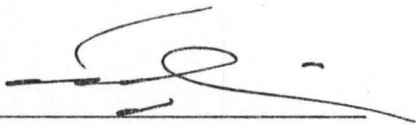Engr. Dr. A. A. Balami   Date

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DEDICATION

This project work is dedicated to Almighty God and also to my parents who sustained my life throughout my degree programme.

ACKNOWLEDGEMENT

ABSTRACT

This project work presents a study on Evaluation of physio-chemical and microbial of Water Quality of River Chanchaga in Minna, Niger State for the purpose of irrigation. The study involved collection of water sample from different points about 10m apart. upstream and down stream respectively. The samples were taken to a laboratory where a standard quality analysis was carried out on the sample based on its physical, chemical and bacteriological properties. The parameters examined include conductivity, temperature, turbidity, pH, total iron, calcium, magnesium, nitrate, sulphate, chloride, dissolved oxygen and phosphate. The results obtained were then compared with WHO and FAO standard.

The average result of the examine parameter include temperature ($26.7^{\circ}c$), TDS (55.44mg/l), DO_2 (4.97mg/l), coliform (11.25mg/l) and alkalinity (16mg/l) which are fit for irrigation purposes respectively and can be recommended that the river may have to be well treated before it can be safe for use within a farmstead.

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CHAPTER ONE

1.0   INTRODUCTION

1.1   General Background

Water is such a good solvent that is difficult to obtain its anything like pure. For most purpose, distilled water is taken as absolutely pure, although this is not strictly true. Water exist in two basic forms namely surface water and ground water, surface water i.e. water in rivers, seas, lakes etc. contains a variety of dissolved gases and solids depending on the rock. Strata over which the water has flowed at the ground surface many bacteria will be picked up as it runoff in the stream or river.

Small amount of decomposition of organic matter, nitrates, nitrite and carbon dioxide will go into the solution. Pollution of water affects the lives of a great many people throughout the world, especially those living in industrialized areas. Among the causes are the large volumes of wastewater. Often, subject to little or no control originating from highly populated cities, the discharge of untreated effluents by industrial complexes, and the use of a wide variety of chemical fertilizers and pesticides in agriculture. It results include harm to human and animals and plant life, unpleasant odours, reduction in the recreational quality of coastal and inland water and beaches.

Under condition of regular ample rainfall, the need for storage may not arise adequate volumes to satisfy demand are pumped directly from a river off take to purification works or other demand centres. The main concern with such an arrangement is to ensure that sufficient water is left in the river at all time to maintain acceptable flow and to supply other users downstream. Natural storage is provided in the ground.

Groundwater resources are replenished by infiltration with percolation through knowledge of the characteristics of the natural aquifers is needed to assess the regularly available quantities and to avoid over exploitation.

In this chapter, schemes involving natural river flow and groundwater resources are described and man-made storage are considered in the following chapter.

1.1.1 River Chanchaga

River Chanchaga is the river used by the Niger State Water Board Minna to feed the whole Minna town after undergoing purification treatment. It is about 13km from its source (Tagwai Dam) where it is been controlled.

Farmers cultivates different types of crops by its bank and it is also used for bathing, washing of clothes (especially the down stream) and drinking, fishing activities also takes place in the river by irrigation purpose by the Niger State. Family aided program at a village called Korankpan in the downstream site.

1.2 Statement of Problem

This study is an assessment on the general water sources base on surface water resources. The assessment and recommendation based on initial cost, operational and maintenance that will be affordable as in cost and safe based on water quality standard for rural dwellers.

Since there is a wide range of natural water qualities, there is no universal standard against which a set of analysis can be compared, except the United States Environmental Protection Agency (EPA) that has determined water quality standards for drinking water contaminants putting into consideration the widest range of contaminants effects and sources. The analysis of the water body under test will hence be compared with the maximum contaminants level for drinking water to avoid health risk.

1.3 Objective of the Study

The objective of this project is to evaluate the physio-chemical and microbial parameters of water quality in Chanchaga Water River. The objective of study includes;

- To determine the suitability of the river for agricultural purposes.

- To compare the river water quality with the FAO and WHO standards.

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1.4 Justification

An examination of ;river water quality is basically an assessment of the physical, chemical and microbes bacterial organism which the river water contains, excessive pollution can jeopardize health and cause sanitary nuisance. It also lead to severe economic and social consequences such as, destruction of aquatic life by poisonous substances, or impair the chemical content of water thereby increasing the cost of the water treatment water quality will therefore merits studies for the following reasons:

i) Health purposes: To protect the health of the consumers through elimination of water-borne infected diseases.

ii) To give advice for proper collection of H_2O in order to aid pollution control.

iii) To remove certain physical characteristic that are aesthetically unpleasant even when they are not harmful. For example, the removal of taste, colour and turbidity.

1.5 Scope of Study

The scopes of the work are as follows:

i) Visiting the site of the river and collecting samples from (four) different points at about 10m distance from the river (i.e. the upstream point, intake section, downstream and outlet section).

ii) Laboratory test which includes:

(a) Physical examination: This involves the determination of its temperature, colour, taste and odour, and turbidity.

(b) Chemical Examination which involves the determination of pH, Total Iron, Calcium, Magnesium, nitrate, Sulphate, Chloride, Phosphate and dissolved Oxygen (DO).

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(c) Bacteriological Examination: This involves using colony count method and most probable number of organisms (M. P. N.) method.

CHAPTER TWO

2.0   LITERATURE REVIEW

2.1   General Review

Historically, civilizations begin and centered within the region of abundant water supplies. Water quality according to (suess, 1982) was not very well documented and people knew relatively little about disease as it related water quality.

Early historical treatment was performed only for the improvement of the appearance or taste of the water. No definite standards of quality other than general clarity or palatability were recorded by ancient civilizations. In the quest for pure water, (baker,1960) quotes a Sanskrit source "It is directed to heat foul water by boiling and exposing to sunlight and by dipping seven times into a piece of hot copper, then to filter and cool in an earthen vessel." Meanwhile, (Fair et al., 1966) described good water as "wholesome and portable". To be wholesome, water must be free from diseases organism, poisonous substances, excessive amount of minerals and organic matter, to be portable, it must be significantly free from colour, turbidity taste and odour.

Roesner and Walesh, (1988) claim that urban runoff contributed to level of nutrients and pollution to receiving water every year.

According to (Hammer, 1977) a polluted water, is that which is found to be unacceptable for its interacted usage. The degree of the unacceptability leans on a number of physical, chemical and biological characteristics.

(Tayo et al. 1980) in their water contact study, in an area of Northern Nigeria heavily infected with Schistosomiasis heamatabium, showed that most contacts with water at a dam site take place fishing, bathing, swimming and playing. Holler, (1989) mention that street refuse deposition is a source of storm water runoff pollution.

Sticks and Corhurst, (1923) study and recorded the movement of E-coli for 20m horizontally through fine sand in direction of ground flow.

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(WHO, 1971) recommended that small water supplies should contain zero E-coli per 100ml.

2.2   Water Constituents

Water is made up of two molecules of hydrogen and oxygen chemically combined together in the ratio of two to one (2:1). In its natural state, tasteless, colourless and odourless but due to physical, chemical and biological alteration, it becomes considerable contaminants in the analysis of water quality, the characteristic impurities are basically defined in term of the physical, chemical and biological.

2.3   Physical Characteristics of Water

This implies colour, temperature, turbidity, taste and odour, and other physical factors capable of changing the surface of water such as the total solid content.

2.3.1 Colour

Analytically, the true colour is described as that which is due to the dissolved matter in the water, while the apparent colour is that which is seeing the presence of suspended matter in the water.

It is usually expressed in hazen units and originate from metallic impurities such as iron which are found in water bearing soil, gravels and rocks. Organic matter such as vegetables and industrial waste like dye are also capable of changing the colour of the water.

The world Health organization (W. H. O.) 1971 international standard suggested a desirable level. For colour of 5 units with a maximum permissible level of 50 units incase of emergency.

2.3.2 Temperature

The study of temperature is necessary for the calculation of the solubility of oxygen and the equilibrium between carbon dioxide and carbonate. The temperature of drinking water also has an influence on its taste and important in connection with bathing.

The temperature of surface water depends on the depth and the season of the year, and also the temperature of the particular area the river is located. It is measured in degree Celsius (^{0}C) with the aid of thermometer.

2.3.3 Turbidity

This is the amount of the suspended particle found in the rivers. The amount of turbidity increases with time i.e. when it is rainy season, the turbidity is usually very high while during the dry season, it is usually a little bit low. Turbidity is measured by nephelometric Turbidity units (N. T. U.) or Jackson Turbidity unit. (J. T. U.) Scale.

2.3.4 Taste and Odour

These normally result from a mixture of different odourants, the causes due to dissolved gases in water and microbiological activity e.g. synura and dunobryons, biological growth such as algae, pest, ozon and fungi also contribute to the taste and odour of water which are closely related.

2.4 Chemical Characteristics of Water

The chemical composition of surface water depends on the characteristics of the catchment area. The common chemical pollution which is important in water is indicated in Appendix I.

2.4.1 Inorganic Constituents

Inorganic constituents may also be present in natural water, in contaminated source water, or in some case, in water which has had contact with piping or plumbing materials – lead, copper and asbestos – are constituent that can derive from distribution and plumbing system. Selected inorganic found in drinking water can cause a variety of health concerns. Some are known as suspected carcinogens. A number inorganic are essential to human nutrition at low

doses, yet demonstrate adverse health effects at higher doses. These include arsenic, selenium, copper, chromium, molybdenum, nickel, zinc and sodium. Two inorganic sodium and barium have being associated with high blood pressure.

2.4.2 Ph Value

PH is a measure of the hydrogen ion activity (H^+) of a solution and is defined by the equation: $PH = -log_a H^+$. PH affects the degree of ionization of toxic substances such as ammonia. The pH scale extends from 0 (very acidic) to 14 (very alkaline) with middle value of 7 which is corresponding to exact neutrality at 25^0C. The effect of pH on the chemical and biological properties of the raw water makes the determination very important. The example of these determination are controlling corrosion and for the controlling of the treatment processes. The instrument used for the determination of pH value is called comparator.

2.4.3 Nitrate

Nitrate is the final product of nitrification and is a major phytoplankton nutrient in marine environments, it is the least toxic or inorganic Nitrogen Compound. They originate from Chemical Fertilizers, breakdown of vegetation and the oxidation of nitrogen compound in effluent.

2.4.4 Iron

Iron exist in true solution as a colloid in suspension as a complex with other mineral or inorganic iron can be found in raw water in distribution network where water do have contact with iron pipe. It makes water to be unpalatable by impacting bitter taste as a result of excess amount in water sample, and it causes brown stains in laundry.

2.4.5 Calcium and Magnesium

The ion of Ca^{++} and mg^{++} causes hardness of water. Water is said to be hard if it forms an insoluble scum before forming a lather with soap.

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Hardness is best computed from separate determination of calcium and magnesium concentration and it is calculated from the equation.

$$CaCO_3, mg/l = 2.497[Ca^{2+}Mgl^{-1}) + 4.118[Mg^{2+}mgl^{-1}).$$

Hard water tends to be more productive biologically than soft water deficient in calcium and magnesium but this can assist eutrophication processes and contribute to such problems as algae blooms and oxygen depletion.

2.4.6 Sulphate

This is one of the major anions occurring in natural water, it is of importance in public water supplies because of its cathartic effect upon humans when it is present in excessive amount. For this reason the recommended upper limit is 250mg/l in water intended for human consumption. Sulphates are important in both public and industrial water supplies because of the tendency of water containing appreciable amount to form hard scales in boilers and heat exchangers. They are indirectly responsible for two serious problems often associated with the handling and treatment of wastewater. These are odour and sewer – corrosion problems resulting from the reduction of sulphate to hydrogen sulphide under anaerobic conditions.

2.4.7 Phosphorus

Phosphorus compounds are carried into natural water with wastewater and storm runoff. They produce a secondary pollution, being essential nutrient. In water where phosphorus is a growth limiting nutrient, it stimulates the growth of photosynthetic aquatic micro and macro-organism sometimes in nuisance quantities. Organically combined phosphorus are first converted to the phosphate which is the phosphate determine without preliminary hydrolysis or oxidative destruction.

2.4.8 Chloride

Chloride occurs in all natural water in varying concentration. The chloride content normally increases. It gains access to natural water in many ways. The solvent power of water chloride from top soil and deeper formations. Human excreta, particularly urine contains

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chloride in an amount about equal to the chloride consumed with food and water. Chlorides in reasonable concentration are not harmful to human. At concentration above 250mg/l, they give a salty taste to water which is objectionable to many people. For this reason chlorides are generally limited to 250mg/l in supplies intended for public use.

2.4.9 Dissolved Oxygen

Water that is in contact with oxygen or with oxygen – containing mixture of gases, contains some dissolved oxygen (DO). Its values, depends on the partial pressure of oxygen in the gaseous phase, on the temperature of water and on the concentration of salts in water quality and waste treatment process control. It may be associated with the corrosive action of water, photosynthetic activity, and septicity, its determination is used in the BOD test.

2.4.10 Organic Constituents

An organic constituent in water is derived from 3 major sources:

a) The breakdown of naturally occurring organic material

b) Domestic and commercial activities and

c) Reactions that occurs during water treatment and transmissions.

The first source predominates and is comprised of lumic materials, micro-organism and their metabolic and petroleum-based, high molecular weight aliphatic and aromatic hydrocarbons. These organic are typically benign, although some are nuisance constituents such as blue green algae. A few of the petroleum products can have adverse health effects.

    i)   Organic derives from domestic and commercial activities are constituents of wastewater discharges, agricultural runoff, urban runoff and leachate from contaminated soils most of the organism contaminations identified in water supplies as having adverse health concerns are part of this group. They include pesticides such as chlordane and carbofuran, solvent such as trichloroethane and tetrachloroethylene, metal degreaser such as

trichloroethane and plasticizer and monomers such as polychlorinated biphenols etc.

ii)   Organic contaminants found during water treatment include – disaffection by product (e.g. trichoroacctonitrate), other compounds such as acrylamide are components of coagulatns e.g. (polyacrylamide) that can leach out during treatment.

2.5   Biological Characteristics of Water

Micro-organism are constantly being washed into surface water from the soil, thus the microbial population of the near side of inland water is very similar to the soil especially after rain. The most common ones existing in water are bacteria, fungi, algae and protozoa.

2.5.1   Bacteria

The nature of the bacteria flora of a fresh water varies. The bulk of such bacteria are heterotrophic while a small proportion are photo-or-chemo-autrotrophic surface water e.g. springs recently emerging from the source the bacterial population consists among non benthic population largely of grain negative, non-spore forming rods, especially Achromobacter and Flavobacterium.

2.5.2   Fungi

These are primarily terrestrial, but some are aquatic most of the water dwelling are phycomycetes. These fungi are saprophytes or parasites on various plants and animals or their parts in water. Fungi may be found on any aquatic plant or animals algae, fish or even other fungi.

2.5.3   Algae

These are primarily aquatic organism and hence are to be found in large number in water. Some algae commonly encountered drinking water include the blue green algae: Micro cystic acroginsa (which yields a material toxic to man and animals).

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2.5.4 Protozoa

Protozoa particularly the ciliate protozoa consume bacteria themselves, they show a pattern of succession in their use of bacteria as food, they absorb soluble nutrients and engulf bacteria which serve as food. It effects in drinking water is that it serve as a causative agent in life threatening infections in patients with Acquired Immune Deficiency Syndrome (AIDS).

2.6 Water Pollution and the Diseases Related to Water

The expression "water pollution" seems to be clear all. Nevertheless it is worth determining its real meanings as this has charged in the course of time. Felfoldy (1972) precise definition is the following water pollution is every impact which changes the quality of our surface and subsoil water to such a degree that the suitability either for human consumption or for the support of mains natural life processes will decrease or cease.

2.6.1 Pollution Sources

Numerous source of pollution may adversely affect water quality. These source are domestic wastewater and industrial wastewater. Both types of wastewater pose threats to water quality which may be classified into health hazards and sanitary nuisance.

Health hazards are threats that directly affect man's physical health as for example, the contamination of drinking water by pathogenic bacteria such as Salmonella kyphosa which causes typhoid fever.

Sanitary nuisance are threats that affects man's senses, but not necessarily his health as for example, the development of obnoxious odours.

Apart from health hazard and sanitary nuisance, water pollution leads to serve economic and social consequence such as destruction of fish life by poisonous substance or excess organic loads that reduce the dissolved oxygen in water to critical levels, or impair the chemical content of the water so that it cannot be used for agricultural purposes or render the water

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unsafe for recreational activities such as swimming. Individuals affected by these results include fishermen, who lose their source of living.

Domestic wastewater is the major source of health hazards in water supplies because it contains waste of human origin. Human waste are very dangerous although their biochemical load is relatively low (250 – 300mg/l BOD in 5 days and 20^0C) compared to industrial waste. Domestic waste water also causes sanitary nuisance and it is commonly agreed that under no circumstance should such wastewater be allowed to contaminate any water sources. However, if the water source is used as a disposal site for water by means of dilution, the wastewater must pass adequate purification treatment before dilution. These are therefore needed to avoid entirely the practice of waste water disposal by means of dilution in bodies of water and to shift instead to disposal by agricultural irrigation. This will mean not only an efficient protection of water resources, but also a valuable reclamation of wastewater and its organic fertilizing content. The use of wastewater for irrigation purposes has, however, certain limitations such as the restriction to crops required for human consumption and special precautions must be taken in handling the waste water.

Local authorities should therefore allocate and preserve the necessary area within their boundaries for waste irrigation purposes. These allocations can be based on an irrigation disposal rate of $50m^2$ of waste water per dry hectare of land.

Industrial pollution originated from the "wet nature of most large industries which requires large quantities of water for both processing and the disposal of waste. Most industries are therefore located near large bodies of water.

The pollution potential of industrial wastewater is far greater than that of domestic wastewater. Furthermore, industrial waste water is not only concentrated but also plentiful. This impact and the means to control it have been thoroughly studied for many years since the industrial revolution began in the 18th century.

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2.7   Diseases related to Water

2.7.1   Water Related Disease Transmission

A water related disease is one which is some way associated with water or impurities within water. We can distinguish between the infections water-related diseases and those related to some chemical property of the water, damage to health, for instance, is in some countries due to inadequate or to excessive fluoride level. Except where excess of a mineral leads to a borehole being closed down or the water being quite undrinkable, this later type of non infectious water related diseases is of great importance in industrialized countries where infection diseases have been greatly reduced in an evaluation of water supplies in a developing country, the search for non infectious diseases is not practicable and it is better to rely on chemical analysis to detect dangerous levels of fluoride and nitrate.

The four mechanisms of water-related diseases transmission and the preventive strategies appropriate to each mechanism are as follows:

Table 2.1: Water Related Disease Transmission Mechanism.

Transmission Mechanism	Disease	Preventive Strategies
a) Water-borne	Typhoid, Cholera	Improve water quality prevent casual use of other unimproved source.
b) Water-washed	Diarrhoea, dysentery, trachoma, scabies	Improve water quality improve water accessibility improve hygiene.
c) Water-based	Schistomiosia	Decrease need for water contact control small population improve quality
d) Water related insect vectors	Malaria fever, yellow fever	Improve surface water management. Destroy breeding sites of insect. Decrease need visit breading sites. Remove need for water storage in the home or improve design of storage vessels.

Sources: world health organization guidelines for water quality, (2008)

a)   Water-Borne Mechanism

A truly water-borne disease is the one which transmitted when the pathogens (the disease causing organism) is in water which is drunk by a person or animal which may then become infected. Potentially water-borne disease include the classification, notably cholera and typhoid, but also wide range of the diseases such as infections hepatitis and bacillary dysentery.

b) Water-washed Mechanism

Water washed diseases are of three main types. Firstly, there are infections of the intestinal tract, such as diarrhoeal diseases, which are important causes of serious morbidity especially amongst infants in hot climates. These water washed enteric infections include typhoid, bacillary and other diseases previously mentioned under water borne diseases.

The second type of water-washed infections includes infections of the body surface of the skin and eyes. Bacterial skin sepsis, scabies and fungal infection of the skin extremely prevalent in many hot climates, while eye infections, particularly trachoma, are also common and may lead to blindness.

A third type comprises infection carried by insect parasite on the body surface, especially lice, which may be reduced by improving personal hygiene and therefore reducing the problem f the infestation of body and clothes.

c) Water based Mechanism

This is one in which the pathogen spends a part of its life in an intermediate aquatic host (for hosts) such as a water snail. All these diseases are due to infection by parasitic worms which depend on aquatic intermediate hits to complete their life circles. An important example is schistomiasis in which the water, pollution by excreta, may contain aquatic snails in which the schistosome larvae develop until infective carcariae are shed into the wear and reinfect man through his skin. Another example especially common in parts of west Africa is guinea worm (Dracunculus medmensis), the larvae of which escape from throughs kin lesions and develop in small aquatic custacea.

d) Insect Vector Mechanism

The fourth and final mechanism is for water diseases to be spread by insects which either bread in water or bite near water, yellow fever, Dengue and Onchocarciasis (river blindness). For example, are transmitted by insects which breed in water while in West Africa, Gambian

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sleeping sickness (trypanosomiasis) is transmitted by the riverine tsetsefly which bites near water.

2.8   Surface Water Sources

Surface water is the term used to describe water on the land surface. It may be running such as in stream, rivers and brooks, or quiescent such as in lakes, reservoirs, impoundments and ponds.

Surface water is produced by runoff of precipitation and by ground water seepage. For regulatory purposes, surface water is defined as all water open atmosphere and subject to surface runoff.

A series of brooks, creaks, streams and rivers carries water from an area of land surface that slopes down toward on primary water course. This drainage are is known as watershed or drainage basin.

Surface water quality is highly influenced by the point within the watershed where water is diverted for treatment. The quality of stream, river, etc will vary accordingly to seasonal flow and may change significantly because of precipitation and accidental spills lakes, reservoirs, impoundment and ponds typically have less sediment than rivers but are subject to greater impacts from micro-biological activity than river sources.

2.8   Water Treatment

Water that is absolutely pure can not be found in nature. As water vapour condense in the air and falls, it absorbs dust and dissolves oxygen, carbon dioxide and other gases. A few bacteria would have entered the water from the air and small amount of the product of the decomposition of organic matter, nitrates, ammonia and carbon dioxide would go into solution such water containing all these impurities are known as raw water.

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CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Project Area

3.1.1 Geographical Location

Minna, being the Niger State Capital lies on the latitude $9^0 32'$N and Longitude $60^0 35'$E.

Meanwhile river Chanchaga is at the southwest zone of Minna. The highest mean monthly

temperature is in March at 30^0C lowest in August at about 25^0C.

Minna is a city where the estimated population is 304,113 people in 2007, in west central

Nigeria. It is the capital of Niger state, one of the Nigeria's 36 federal states, and is the head

quarters of chanchaga local government area.

The mean length of Rainfall is 180 days, the mean on set of the rain is around April (20) and

the mean cessation is around October, 15 i.e. (it takes about 6 months rainfall duration).

The mean annual rainfall is 1300mm with August recording the highest rainfall.

The area is under laid by undifferentiated basement rock mainly quatzo-feldspathic rocks:

granites, gneiss and magmatite.
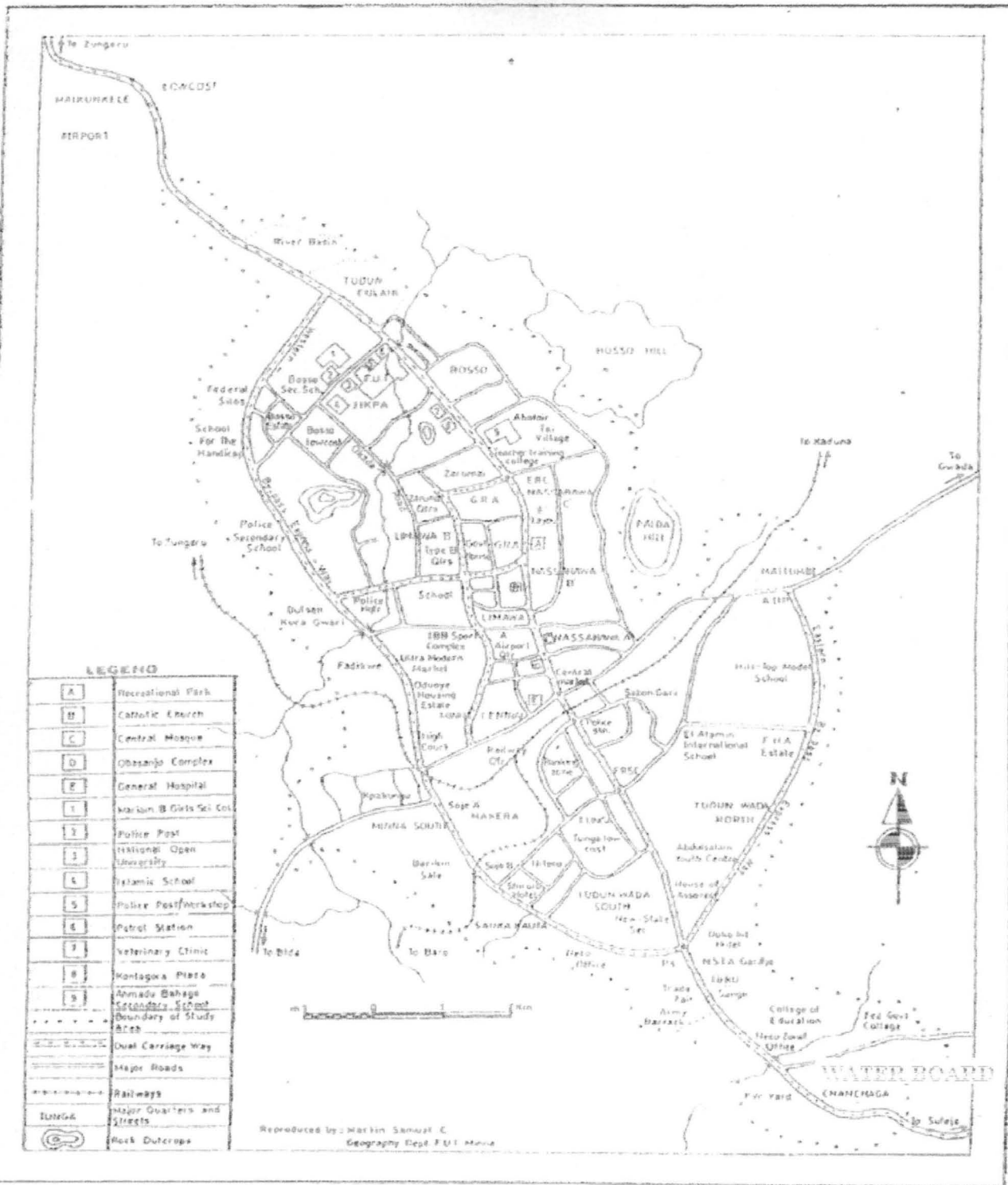
3.1.2 Map of Study Area

Fig.   MAP OF MINNA AND ITS ENVIRON SHOWING
THE STUDY AREA

Fig 3.1 Map of Study Area

3.2   Alkalinity (Titremetric Method)

Procedure:

Measure out 100ml of the sample into a 250ml beaker and titrate using 0.02N H_2SO_4. Put 3-4 drops of bromocresol green indicator and titrate till the colour changes from green to yellow.

Calculation:

Total Alkalinity (T), mg/l as CaCO3 = $^{(A-B) \times 0.02N \times 50,000}/_{Ml\ sample\ (100)}$

    A = ml standard acid used for sample

    B = ml standard acid used for blank

    N = Normality of acid used (0.02M)

    Phenolphthalein Alkalinity (only determined when the pH. of the sample is above8.3)

Phenolphthalein Alkalinity (P), mg/l as CaCO3 = $^{(A-B) \times 0.02N \times, 50,000}/_{Ml\ sample\ (100)}$

    A = ml standard acid used for sample

    B = ml standard acid used for blank

    N = Normality of acid used (0.02M)

Procedure:

Measure 100ml of sample; put 2-3 drops of phenolphthalein indicator. If there is colour change continue with the titration using 0.02M H_2SO_4 until colour changes from pink to colourless. If there is no colour change after putting the phenolphthalein indicator, do not continue the titration (this means, though the pH is above 8.3, there is no phenolphthalein alkalinity). Therefore, Bicarbonate (HCO_3^-), carbonate (CO_3^{2-}), and hydroxide (OH^-) can be estimated from phenolphthalein alkalinity. When phenolphthalein alkalinity is equal zero, carbonate and hydroxide equal zero and bicarbonate equals total alkalinity, but if phenolphthalein alkalinity is not equal zero, follow this relationship:

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Table 3.1: phenolphthalein Alkalinity (Titrimetric method) Relationship

	Hydroxide Alkalinity as $CaCO_3$	Carbonate Alkalinity as $CaCO_3$	Bicarbonate Concentration as $CaCO_3$
P = 0	0	0	T
$P < {}^1\!/_2\,T$	0	2P	T − 2P
$P = {}^1\!/_2\,T$	0	2P	0
$P > \frac{1}{2}T$	2P − T	2 (T-P)	0
P = T	T	0	0

Source: AHPA(2005).

3.3 Chloride (Argentometric Method)

Procedure:

Use a 100ml sample or a suitable portion diluted to 100ml. If the sample is highly coloured, add 3ml Al $(OH)_3$ suspension, mix, let settle and filter. If thiosulphate, sulphide or sulphite is present, add 1ml H_2O_2 and stir for 1 min. Check the pH; it must be between 5.0 and 9.5 in this procedure. If the pH of the sample is below 5.0, add a small amount of calcium carbonate and stir. If the pH is above 9.5, add 0.1 mol /L nitric acid drop by drop to bring the pH to about 8. Stir, and add a small amount of calcium carbonate.

Add 1.0ml K_2CrO_4 indicator solution. Titrate with standard $AgNO_3$ titrant to a pinkish yellow end point. Be consistent in end point recognition.

3.4 Nitrite (Colorimetric Method)

Procedure:

Place 50ml of sample, or an aliquot diluted to 50ml, in a 50ml nessler tube and set aside until preparation of standards is complete. At the same time, prepare a series of standards in 50ml nessler tubes as follows:

Table 3.2: Nitrate Preparation showing series of standards.

Volumes of working nitrite solution	Concentration when diluted to 50ml (mg/l of NO₂-N)
0.0 (blank)	0.0
0.5	0.01
1.0	0.02
1.5	0.03
2.0	0.04
3.0	0.06
4.0	0.08
5.0	0.10
10.0	0.20

Sources: AHPA(2005).

Add 2ml of buffer-colour reagent to each standard and sample, mix and allow colour to develop for at least 15 minutes.

Measure the absorbance of the standards and samples at 540nm. Prepare a standard curve by plotting the absorbance of the standard against the concentration of NO_2-N. Read the concentration of NO_2-N in samples directly from the calibration curve. If less than 50 ml of sample is taken, calculate the concentrations as follows:

$$\text{Nitrite nitrogen (as N)} = \frac{\text{mg } l^{-1} \text{ from standard curve} \times 50}{\text{ml sample}}$$

3.5　Ammonia (Nesslerization Method)

Standardization:

Use when the NH_3-N concentrations in the sample are greater than 5mg/L. Dilute 2.0ml of the stock NH_4Cl standard to 200ml with distilled water. Solution is 10mg NH_3-N/L (working NH_3-N solution).

Table 3.3: Ammonia preparation showing series of standards.

Volume of working NH_3-N solution (ml)	Conc. When diluted to 50ml (mg/l of NH_3-N)
0 (blank)	0.0
5	1.0
10	2.0
15	3.0
20	4.0
40	8.0
50	10.0

Sources: AHPA(2005).

Add 2ml of Nessler's reagent to standard and sample with a safety pipeting bulb. Draw the Nessler from near the surface using extreme caution not to disturb the precipitate that settles to the bottom of the reagent bottle. Mix the Nesslerized sample immediately, waits exactly 20mins. Mix again and read the absorbance at 410nm (if 410nm is not available, use 430nm). Prepare a standard curve by plotting the absorbance of the standards against the concentration of NH_3-N. Read the concentration of NH_3-N in the sample directly from the calibration curve.

3.6　Nitrate as Nitrogen (No_3^- - N) (Cadmium Reduction Method)

Procedure:

Preparation of reduction column: insert a glass wool plug into bottom of reduction column and fill with water. Add sufficient Cu-Cd granules to produce a column 18.5cm long.

Maintain water level above Cu-Cd granules to prevent entrapment of air. Wash column with 2ml dilute NH_4Cl – EDTA solution. Activate column by passing through it, at 7 to 10ml/min, at least 100ml of a solution composed of 25% 1.0mg NO_3-N/L standard and 75% NH_4Cl – EDTA solution.

pH adjustment: adjust pH to between 7 and 9, as necessary, using a pH meter and dilute HCl or NaOH. This insures a pH of 8.5 after adding NH_4Cl – EDTA solution.

Sample reduction: to 25ml sample or a portion diluted to 25.0ml, add 75ml NH_4Cl – EDTA solution and mix. Pour mixed sample into column and collect at a rate of 7 to 10ml/Min. Discard first 25ml. Collect the rest in original sample flask.

Colour development and measurement: as soon as possible, and not more than 15mins after reduction, add 2.0ml colour reagent to 50ml sample and mix. Between 10min and 2hrs afterwards, measure absorbance at 543nm against a distilled water reagent blank. Note: if NO_3^-N concentration exceeds the standard curve range (about 1mg N/L), use remainder of reduced sample to make an appropriate dilution and analyze again.

Standards: using the intermediate NO_3^-N solution, prepare standards in the range 0.05 to 1.0mg NO_3-N/L by diluting the following volumes to 100ml in volumetric flasks: 0.5, 1.0, 2.0, 5.0 and 10.0ml. Carry out reduction of standards exactly as described for samples. Obtain a standard curve by plotting absorbance of standards against NO_3^-N concentration. Compute sample concentrations directly from standard curve.

3.7 Phosphate – Phosphorous (Po_4^{3-} - P), (Ascorbic Acid Method) Procedure

Pipette 50ml sample into a clean, dry test tube or 125ml Erlenmeyer's flask. Add 1 drop of phenolphthalein indicator. If a red colour develops, add 5N H_2SO_4 solution drop wise to just discharge the colour. Add 8ml combined reagent and mix thoroughly. After at least 10min. but no more than 30minutes, measure absorbance of each sample at 880nm, using reagent blank as the reference solution.

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Preparation of calibration curve – prepare individual calibration curves from a series of six standards within the phosphate ranges from 0-6µg. plot absorbance against phosphate concentration.

3.8   Hardness (Edta Complex metric Method)

Procedure:

Measure 50ml sample into a 125 Erlenmeyer flask, add 2ml buffer (sufficient to give a pH of 10.0-10.1). Add 1-2 drops of indicator and titrate slowly stirring continuously until the reddish tinge disappears from the solution. 1ml 0.01M EDTA should be equivalent to mg $CaCO_3$.

3.9   Calcium Hardness

Procedure:

Measure a 50ml sample into a 125ml Erlenmeyer flask.

Add 2 ml of the 1N hydroxide solution (to produce a pH of 12-13 in the 50 ml sample). Add 0.1 to 0.2g of calver II calcium indicator or murexide indicator

Titrate slowly with EDTA disodium salt solution (0.01m) until the colour changes to blue for calver l litre and pink for murexide.

3.10   Sulphate (Turbidimetric Method)

Procedure:

Measure a 100ml sample into a 250ml Erlenmeyer flask.

Add exactly 5ml of conditioning reagent mix, using the magnetic stirrer and stirring bar.

While the solution is stirring, add a small scoop (0.2-0.3g) of $BaCl_2$ crystals and begin timing immediately.

Stir exactly 1min at a constant speed.

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At the end of the stirring period, place the sample in a 5cm cuvette and measure the absorbance at 420nm after exactly 4mins.

Plot the absorbance of the calibration standards against the calibration concentrations and compute the sample concentration directly from the standard curve.

3.11   Iron (Total) Phenanthroline Method

Procedure:

Mix the sample thoroughly and measure 50.0ml into a 125ml Erlenmeyer flask. If this sample contains more than 200µg iron, use a smaller accurately measured portion and dilute to 50ml and add 2ml of conc. HCl and 1ml of hydroxylamine hydrochloride solution.

Drop in a few glass beads and boil until the volume is reduced to 10-20ml. Cool to room temperature.

Transfer to 50ml or 100ml volumetric flask. Add 10ml ammonium acetate buffer solution. Add 2ml of phenanthroline solution and dilute to the mark with distilled water. Mix thoroughly and set aside for 10-15 minutes for full colour development.

Measure the colour absorbance intensity photo metrically at 510nm. Subtract the absorbance of the blank from that of the sample to determine the net absorbance.

3.12   Potassium, Sodium and Lithium Using Flame Photometer

Procedure:

1.   Turn on the fuel at the source. Switch on the air compressor.

2.   Depress the power switch to switch on the flame photometer. The power the LED will be illuminated and an ignition cycle will commence.

3.   If the flame on LED is not illuminated at the end of the ignition cycle, check the setting of the fuel control.

4. Set the filter selector to the required position.

5. Insert the nebulizer inlet tube in a beaker containing 100ml of diluents and allow 15minutes for the operating temperature to stabilize. This will ensure a stable burner temperature when solutions are aspirated, after the warm up period.

6. During the warm up period prepare a set of calibration solutions to cover the required measurement range. To obtain maximum linearity, Sherwood Scientific recommend that the highest standard concentration does not exceed 30 mg/L for Sodium, 10mg/L for Potassium and 10mg/L for Lithium.

7. While aspirating diluents, adjust the blank control so that the display read 0.0

8. Aspirate the highest concentration standard.

9. Allow 20 seconds for a stable reading and then adjust coarse and fine controls for a convenient reading e.g. 20mg/L of Sodium can be set to read 20 on the display.

10. Remove the standard solution, wait 10 seconds, then aspirate a blank solution of diluents for 20 seconds. Adjust the blank control for a 0.0 reading. Remove the blank solution and wait 10 seconds.

11. Repeat paragraph 8,9,10 until the blank reading is 0.0 (within ± 0.2) and calibration reading is within ± 1%. If a chart recorder is being used set zero on the blank solution and set span while aspirating the calibration curve.

12. Aspirate each of the remaining calibration standards for 20 seconds (starting with the lowest concentration to avoid carry over) again allowing 10 seconds between measurements. Note the value of each standard and plot the results on a graph against standard concentration on linear graph paper.

13. Check calibration standards and blank readings.

14. Dilute the unknown solutions with diluents to give a concentration of the element under test within the range of the calibration standards. Several attempts might be necessary to determine the correct dilution ratio.

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15. Aspirate each of the diluted unknowns for 20 seconds, and then note the readings. The concentration of the element in the unknown sample can be calculated by reading the sample concentration from the calibration curve and multiplying it by the dilution factor.

NOTE: use distilled water in place of diluents.

3.13 Chromium (Hexavalent Chromium) Colorimetric Method

Procedure:

Pipette 25ml of the sample or standard into a 125ml Erlenmeyer flask.

Add 1-2 drops of HNO_3 to each of the samples. pH should be 1 ± 0.3

Add 0.50ml diphenylcarbazide to each sample using automatic pipette. Allow 5 to 10min for full colour development.

Read the absorbance against DDW at 540nm, using a 1cm cell

3.14 Manganese (Persulphate Method)

Procedure:

To a suitable sample portion, add 5ml special reagent and 1 drop H_2O_2. Concentrate to 90ml by boiling or dilute to 90ml. Add 1g $(NH_4)_2S_2O_8$, bring to a boil and boil for 1min. Do not heat on a water bath. Remove from the heat source, let stand for 1min. Then cool under the tap. (Boiling too long result in decomposition of excess per sulphate and subsequent loss of permanganate colour; cooling too slowly has the same effect). Dilute to 100ml with distilled water free from reducing substances and mix. Prepare standards containing 0, ..., 1,500µg Mn by treating various amounts of standard Mn solution in the same way.

Photometric measurement:

Use a series of standard from 0 to 1,500µg Mn/100ml final volume. Make photometric measurements against a distilled water blank. Prepare a calibration curve of manganese

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concentration vs. absorbance from the standards and determine Mn in the samples from the curve. Wavelength is 525nm.

3.15   Total Coliforms and Escherichia Coli By Membrane Filtration Technique

Procedure

For each sample, place an absorbent pad into each of two empty sterile Petri dishes. Add sufficient MLSB to saturate the pad, allow soaking in and pouring off any excess fluid.

Prepare any necessary dilutions and filter. Set up two membranes for each sample and place on the pads soaked in MLSB.

Incubate both membranes at 30°C for 4 hours then transfer one membrane to 37°C for total coliforms and the other to 44°C for *E. coli*. Use incubators or water baths for incubation. Accurate temperature control and even temperature distribution are essential, especially for *E. coli* at 44°C. False positive results will be obtained at temperatures below that recommended and some strains will fail to multiply at higher temperatures. Incubate the membranes at 37°C or 44°C for 14 hours to give a total incubation time of 18 hours. If an early indication of a result is required urgently, the membranes may be examined for presumptive positive results after a total incubation time of 12 hours but must be returned to the incubator for the full period of 18 hours before results can be regarded as negative. From a water treatment point of view it may be convenient to incubate a single membrane at 37°C. in this case an immediate operational response should be made to any presumptive positive result and should be treated as *E.coli* until the confirmatory tests for coliforms and *E.coli* have been completed. It should be assumed that any presumptive indication is treated as *E. coli* and remedial action taken.

After incubation, examine the membranes under good light, if necessary with a hand lens. Count all yellow colonies (however faint) irrespective of size within a few minutes of being removed from the incubator. Colours are liable to change on cooling and standing. It is

important to note whether pink colonies are present in numbers which may interfere with the growth of coliforms. The detection of acid production is influenced by the pH of the medium, thus it is important that the medium is of the correct pH. If the growth of pink colonies is considered to be such that they may be obscuring lactose-fermenting colonies, a further sample should be taken and examined by membrane filtration.

4.0 RESULT AND DISCUSSION

4.1 Results

4.2 Discussion of Result

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

Table 4.1 Analysis of Chanchaga river water samples

Parameter	Unit	A	B	C	D
Conductivity	µS/cm	95	78	77	81
Temperature	°C	26.7	27	26.6	26.6
Ph	-	6.98	6.83	6.76	6.66
Turbidity	NTU	168	169	176	183
TDS	mg/L	63.65	52.26	51.59	54.27
DO_2	mg/L	4.89	6.1	4.72	4.2
Chloride	Mg/L	31.99	34.48	39.98	31.99
Total Hardness	mg/L	35.03	31.02	40.03	35.03
Alkalinity	mg/L	15	18	15	16
Arsenic	µg/L	9	9	9	9
Nitrate	mg/L	4.25	4.82	3.76	2.12
$Calcium^{2+}$	mg/L	23.02	26.02	36.02	31.03
$Magnesium^{2+}$	mg/L	12.01	5	4	4
Phosphate	mg/L	4	5	4.5	4
Iron	mg/L	0.06	0.07	0.05	0.05
Salinity	mg/L	95	78	77	81
Sodium	mg/L	7	8.5	5.5	6
Manganese	mg/L	0.119	0.042	0.107	0.09
Potassium	mg/L	0.67	0.67	2.01	0.67
Ammonia	mg/L	0.96	1.09	0.85	0.48
Bicarbonate	mg/L	15	18	15	16
Carbonate	mg/L	0	0	0	0
Coliform	Cfu/100ml	21	4	6	14
E-Coli	Cfu/100ml	1	0	0	5
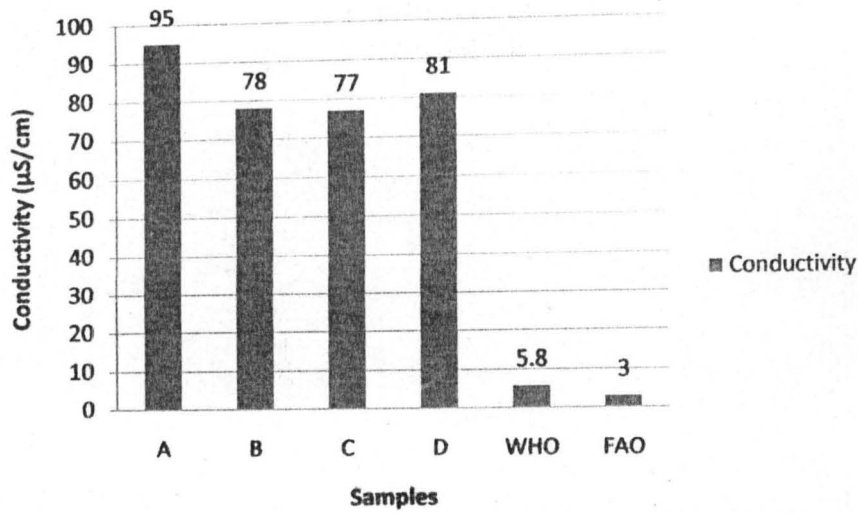
Fig. 4.1 Comparing conductivity of the four samples with WHO (5.8µS/cm) and FAO (3µS/cm).

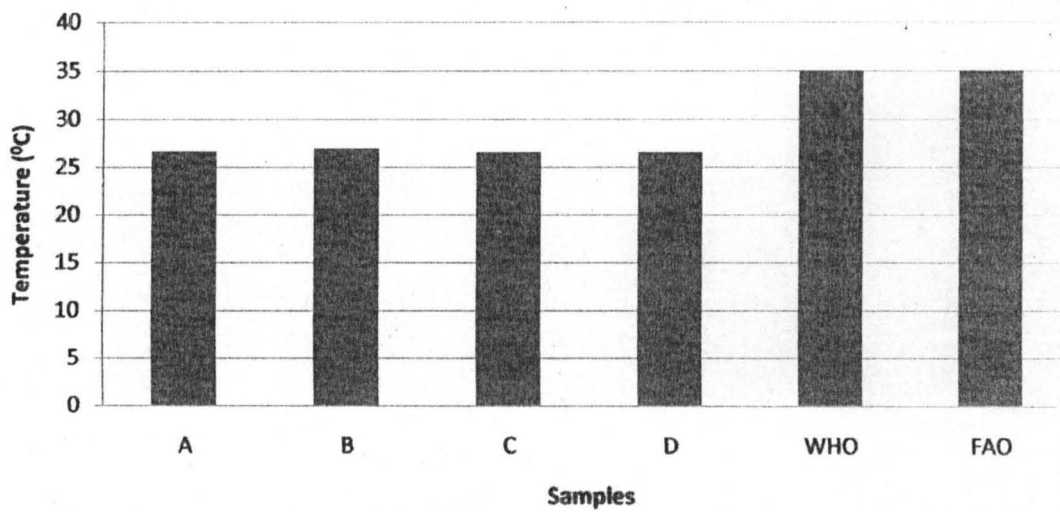Therefore conductivity level of the samples is above the permissible limits.

Fig. 4.2; Comparing Temperature of the four samples with WHO (35^{0}C) and FAO (35^{0}C).

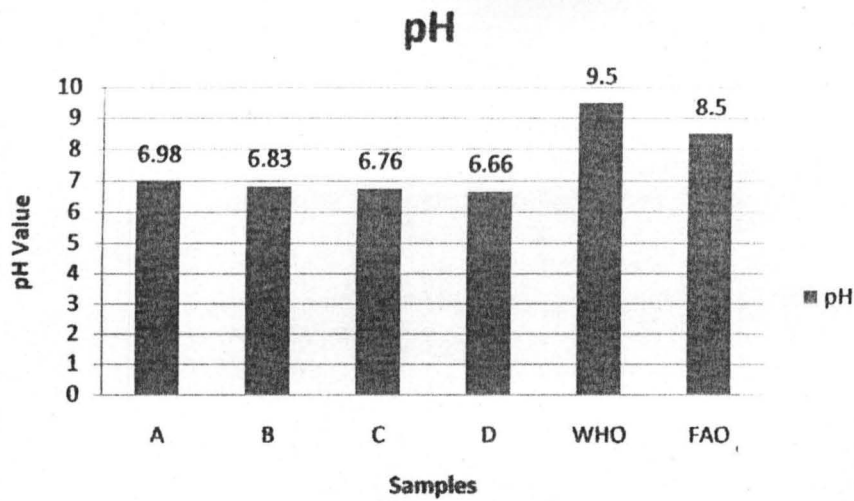This shows that the samples fall below the desirable limit.

pH

Fig. 4.3 Comparing pH of the four samples with WHO (9.5) and FAO (8.5).
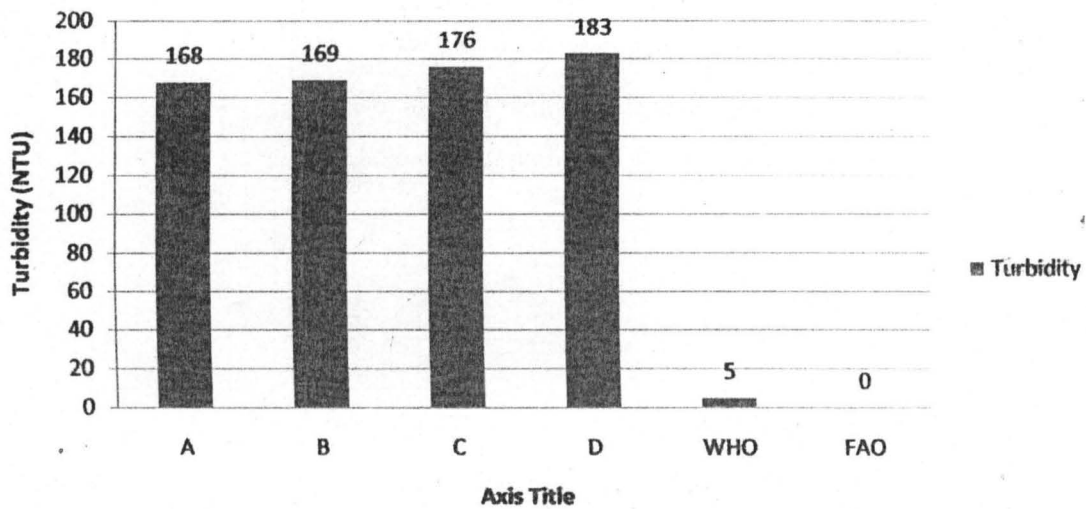
Therefore the samples pH value falls below the desirable limit.

Fig. 4.4 Comparing Turbidity of the four samples with WHO (5 NTU) and FAO (0 NTU).

Therefore the samples turbidity levels are above the permissible limit
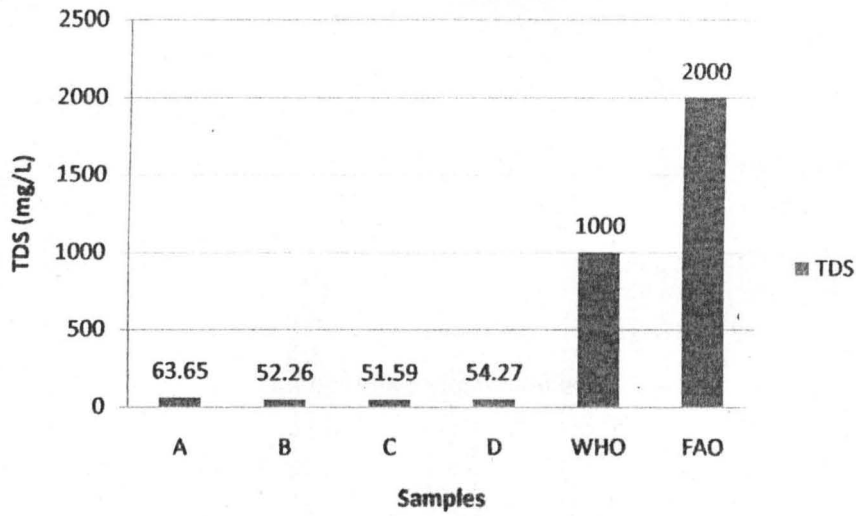
Fig. 4.5. Comparing TDS of the four samples with WHO (1000) and FAO (2000).
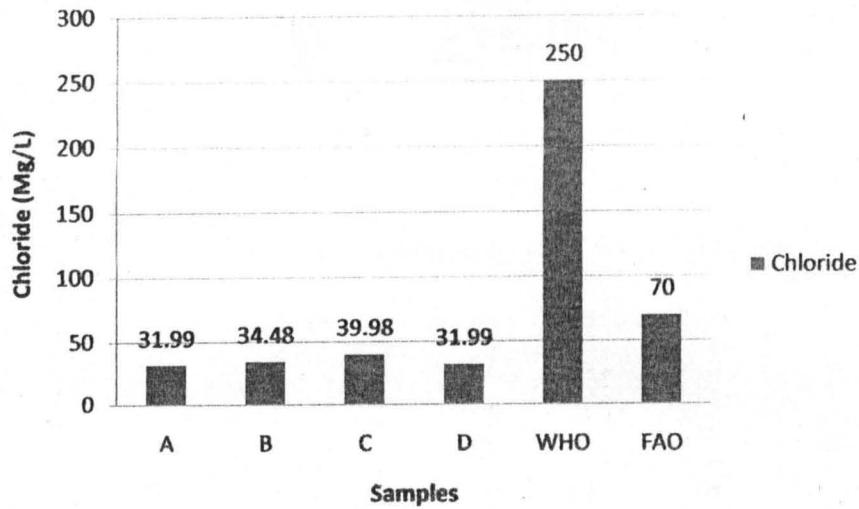
The samples TDS level are less than desirable limit.
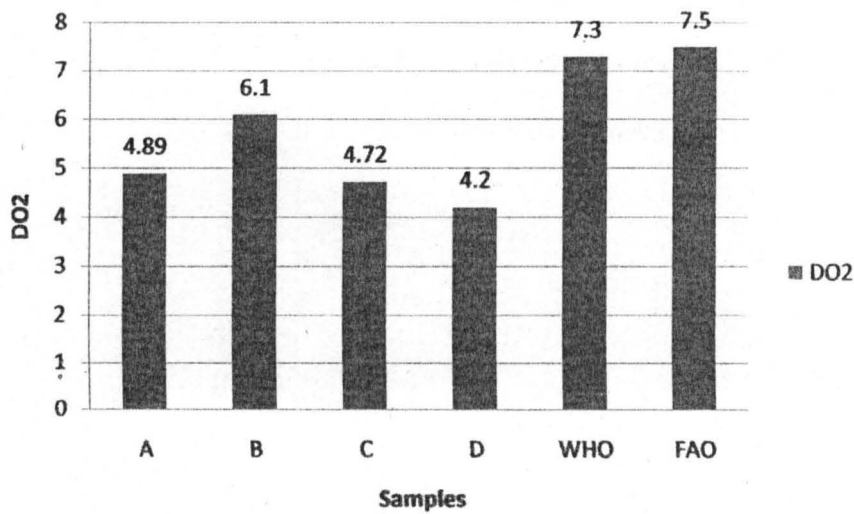
Fig. 4.6 Comparing DO$_2$ of the four samples with WHO (73) and FAO (7.5).

The samples DO$_2$ levels are less than the desirable limit.

Fig. 4.7 Comparing Chloride of the four samples with WHO (250mg/l) and FAO (70mg/l).

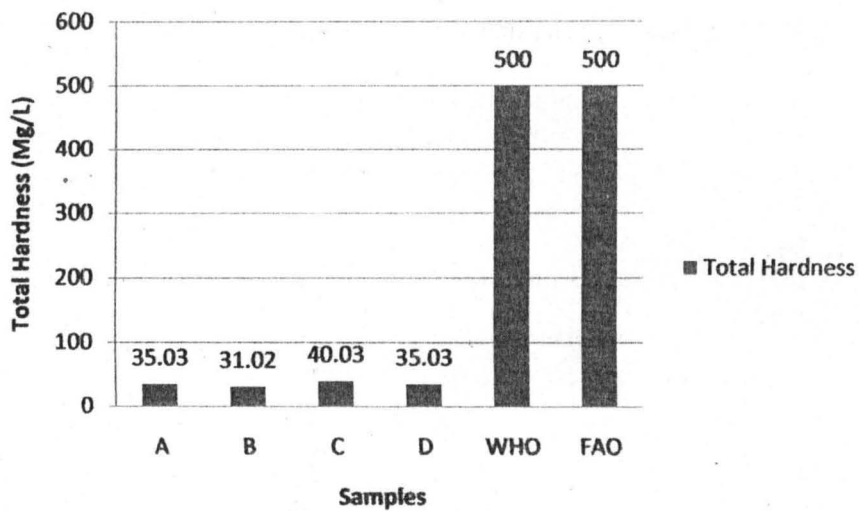Therefore the chloride level of the samples are less than desirable limits.

Fig. 4.8 Comparing Total Hardness of the four samples with WHO (500mg/l) and FAO (500mg/l).

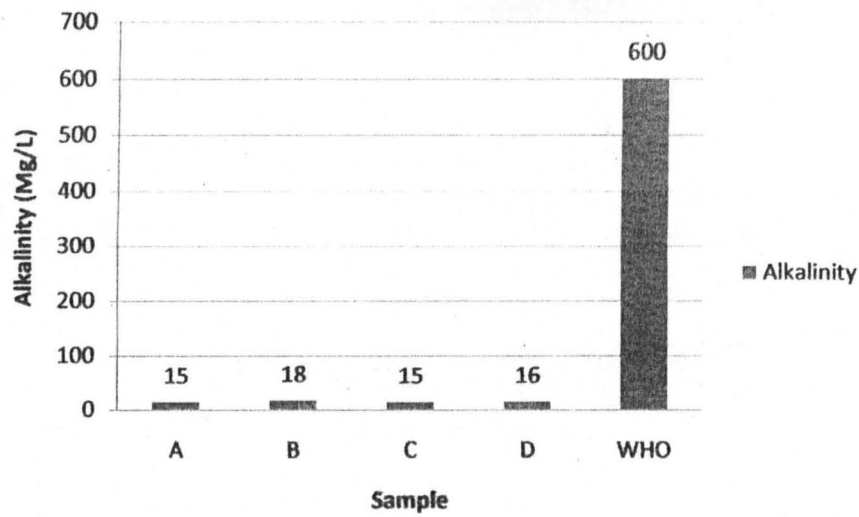Therefore the Total Hardness levels of the samples are less than desirable limits.

. Fig. 4.9 Comparing Alkalinity of the four samples with WHO (600mg/l).

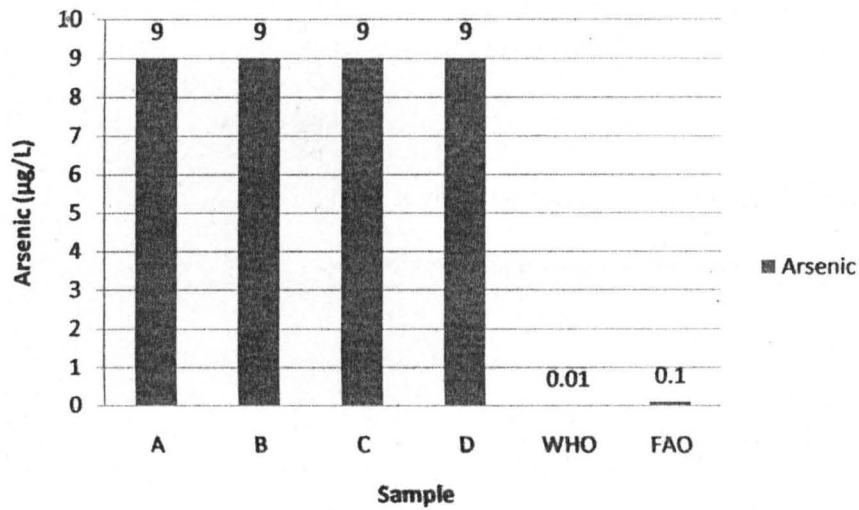Therefore the Alkalinity levels of the samples are less than desirable limits.

Fig. 4.10 Comparing Arsenic of the four samples with WHO (0.01) and FAO (0.1).

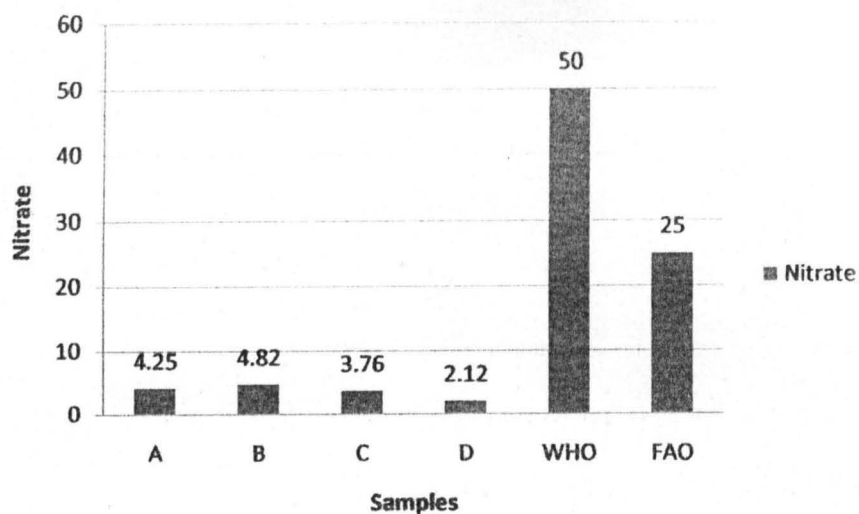Therefore the Arsenic level of the samples is less than the permissible limit.

Fig. 4.11 Comparing Nitrate of the four samples with WHO (50mg/l) and FAO (25mg/l).

Therefore the Nitrate level of the samples is less than desirable limits.
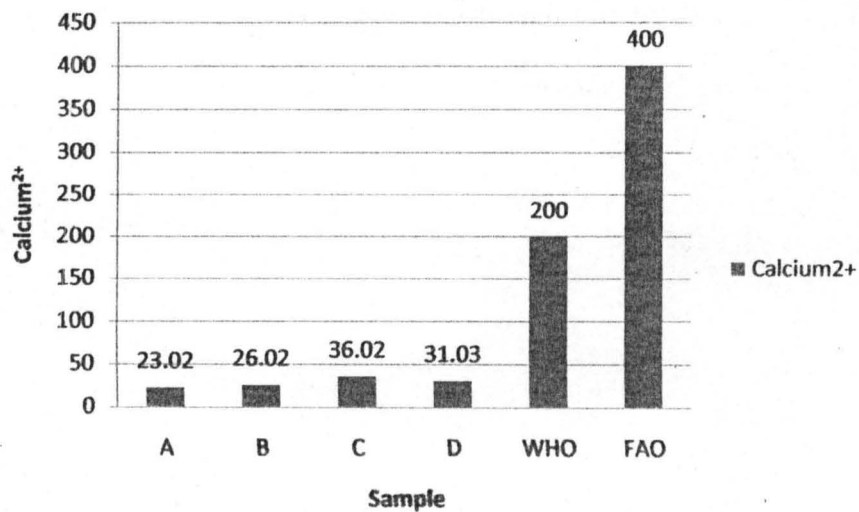

Fig. 4.12 Comparing Calcium^{2+} of the four samples with WHO (200mg/l) and FAO (400mg/l).

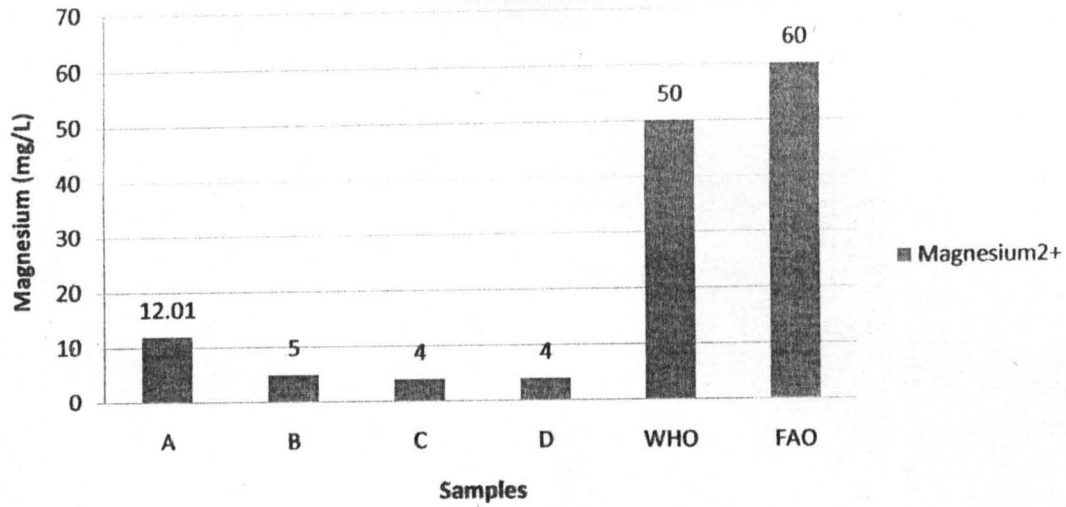therefore the samples are below the desirable limits.

Fig. 4.13 Comparing Magnesium^{2+} of the four samples with WHO (50mg/l) and FAO (60mg/l).

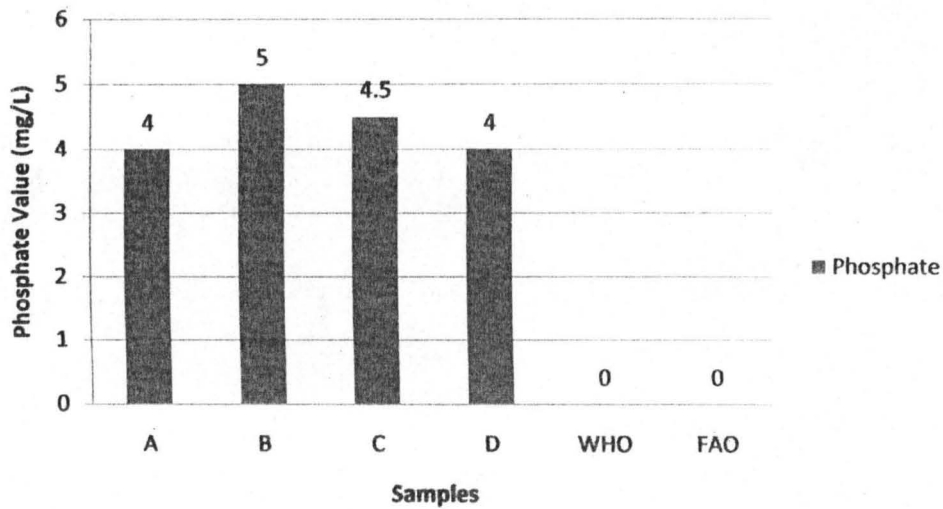The samples are below the desirable limit.

Fig. 4.14 Comparing Phosphate of the four samples with WHO and FAO.

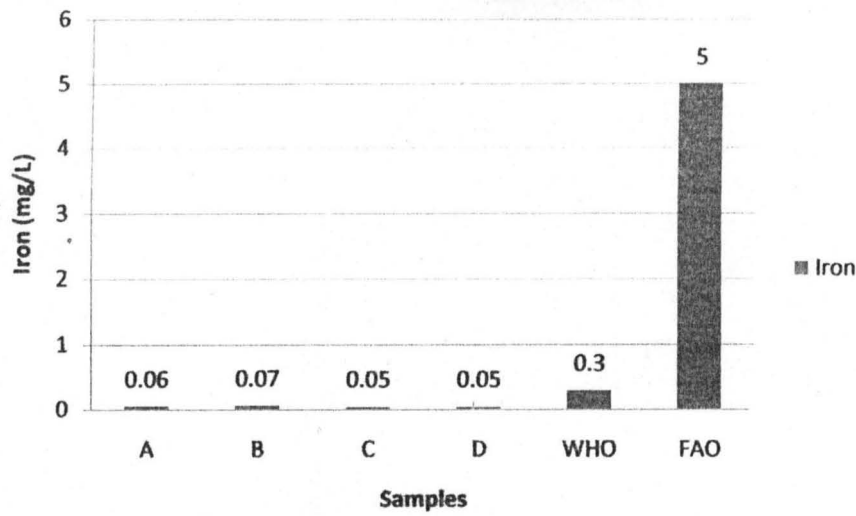Therefore the samples phosphate level is above permissible limit.

Fig. 4.15 Comparing Iron of the four samples with WHO (0.3mg/l) and FAO (5mg/l).

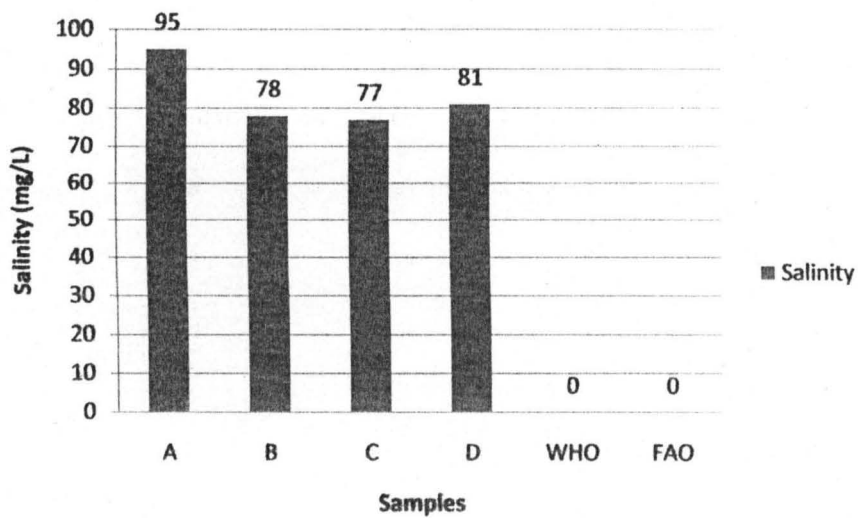Therefore the samples fall below the desirable limits.

Fig. 4.16 Comparing Salinity of the four samples with WHO and FAO.

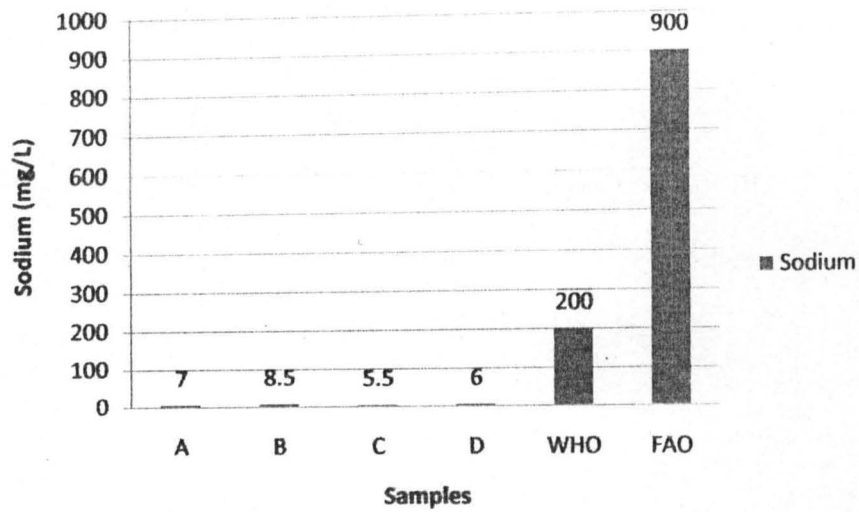Therefore the samples salinity level is more than the permissible limit.

Fig. 4.17 Comparing Sodium of the four Samples with WHO (200mg/l) and FAO (900mgl).

Therefore the samples fall below the desirable limit.
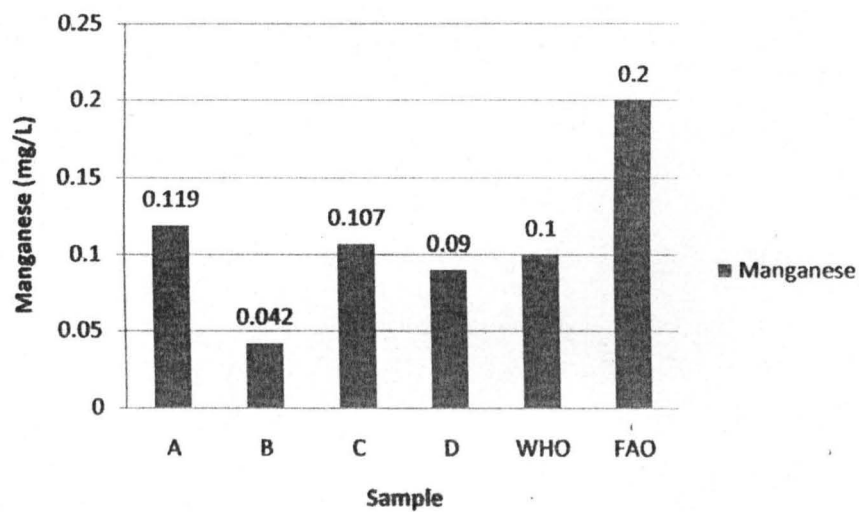
Fig. 4.18 Comparing Manganese of the four Samples with WHO (0.1mg/l) and FAO (0.2mg/l).

This shows that the samples fall within the desirable limit.
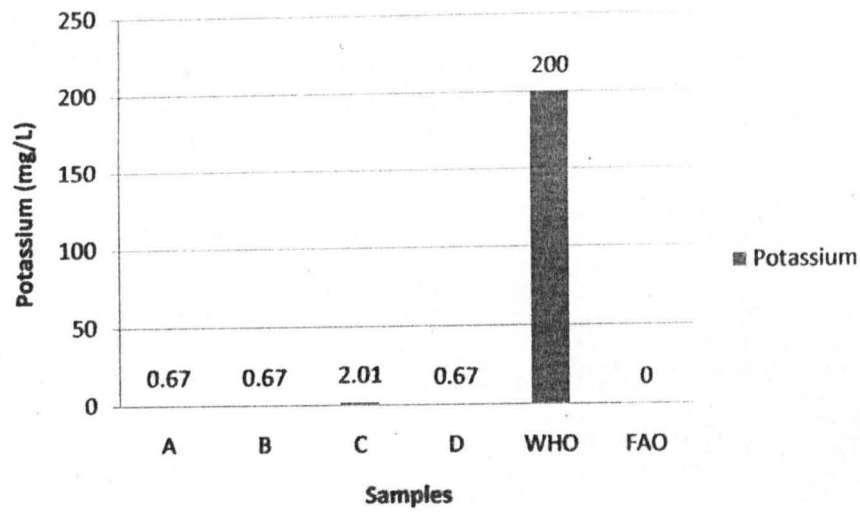
Fig. 4.19 Comparing Potassium of the four samples with WHO (200mg/l) and FAO (0mg/l).

Therefore the potassium levels of the samples are below the desirable level
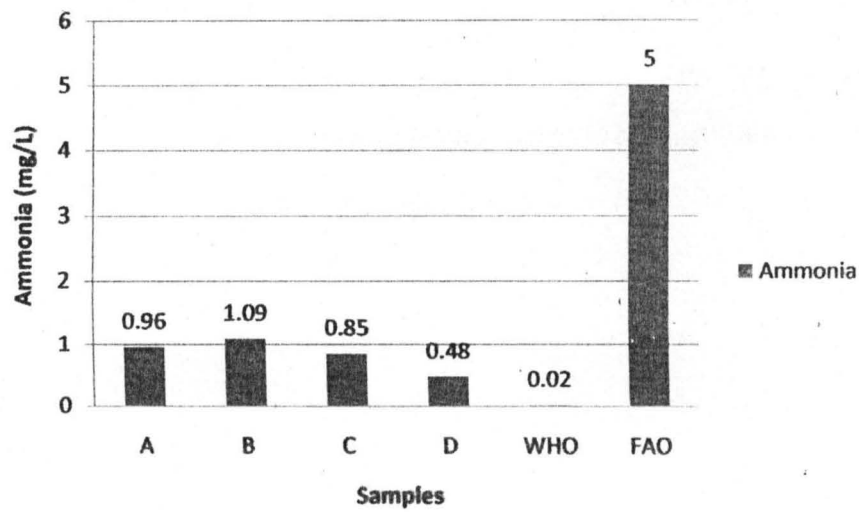
Fig. 4.20 Comparing Ammonia of the four samples with WHO (0.02mg/l) and FAO (5mg/l).

This shows that ammonia level in the samples fall within the desirable limits.

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Fig. 4.21 Comparing Bicarbonate of the four samples with WHO (100mg/l) and FAO (80mg/l).

Therefore, this shows that the bicarbonate level in the samples fall below the desirable limit.
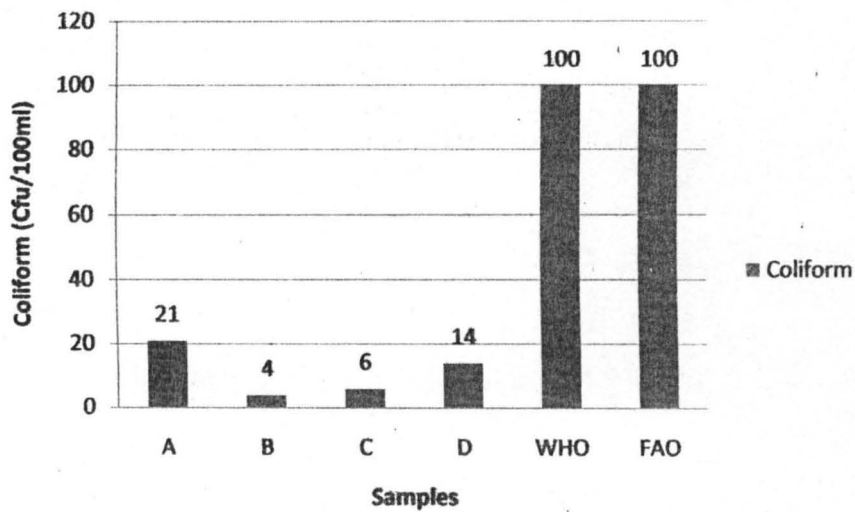
Fig. 4.22 Comparing Coliform of the four samples with WHO (100mg/l) and FAO (100mg/l.)

It can be seen that the samples coliform level fall below the desirable limit.

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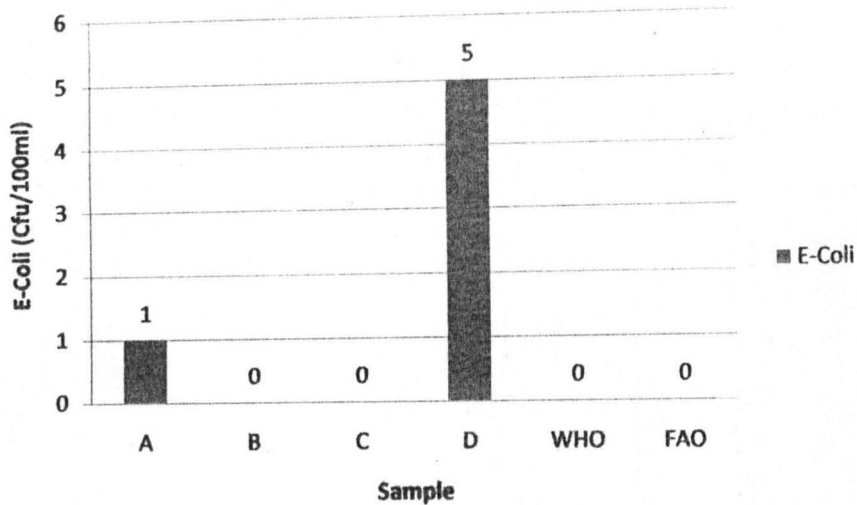
Fig. 4.23 Comparing E-Coli of the four samples with WHO (0mg/l) and FAO (0mg/l).
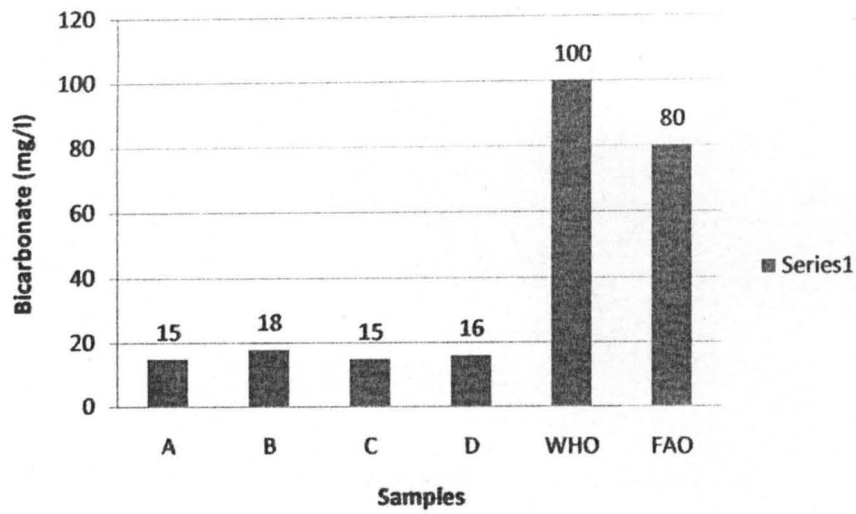
This shows that only samples B and C conforms with the set standard, while samples A and D are above the limit.

From the above bar charts which shows the variation of the collected samples values with WHO and FAO standard values. Any sample values that are not up to WHO and FAO values are referred to as desirable limit that is water which meets the standards set and can be used without any treatment. While those sample value that are above WHO and FAO standard values are referred to as permissible limit which means criteria applied to the quality of water which require some form of treatment can be used.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusions

The development of any community depends on the availability of quality water supply for domestic, agricultural and industrial purposes.

Water needs to be of an appropriate quality for the use proposed, rather than demanding high quality for all uses. This will involve planning processes to allocate water to uses and bargaining to select appropriate water quality lines for uses in particular catchments.

From the study, the following conclusion can be made;

i. The chanchaga river water quality is satisfactory for irrigation purpose.

ii. Based on the examined parameters with WHO standard, the raw water were not that safe for consumption with respect to bacteriological level when comparing with FAO standard.

iii. Treatment of the river water will be required in order to make it suitable for use in the farmstead.

5.2 Recommendations

The managers of water resources are under great pressure from both population growth and the rising level of expectation of the user of water. Concerns about degradation of the water resources itself have led to a raw focus on the sustainable management of water resources. Thus the following recommendation are to be important elements of emerging a new paradigm for water management and of protecting the health of the user especially at the downstream from water borne diseases which is mostly attributed to the rate of sickness and death.

i. Preparation for drafting and implementing water pollution control should start as soon as possible.

ii. Activities like community education, conferences should be organized, newsletter should be written on the effect of water pollution to health. Environmental health engineers should be provided with training facilities to carryout these activities effectively.

iii. There is need for constant river quality analysis to evaluate the extent of pollution changes there by knowing the amount of treatment to be given at particular time.

iv. The villages using the river downstream should be linked to the tap water, or else enough bore holes should be provided to them by the Government to protect them from the danger of using raw water for their consumption.

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APPENDIX

Chloride (Argentometric Method)

Calculation:

$Mg\ Cl^-/L = {}^{A\ x\ N\ x\ 35,450}/_{Ml\ sample\ (100)}$

Where A = ml titration for sample

N = normality of $AgNO_3$

NaCl ·

Mg NaCl/L = (mg Cl^-/L) x 1.65

Nitrite (Colorimetric Method)

$$\text{Nitrite nitrogen (as N)} = \frac{mg\ l^{-1}\ \text{from standard curve} \cdot 50}{ml\ sample}$$

Hardness (Edta Complex metric Method)

Calculation:

Total hardness as $CaCO_3$

$$Mg\ CaCO_3/L = \frac{(A\text{-}B)\ x\ D\ x\ 1000}{ml\ of\ sample}$$

Where: A = ml of Titrant used for the sample

B = ml of Titrant used for the blank (use distilled water as blank and treat like the sample.

Repeat all the procedure for it. Usually the ml of the Titrant used for the blank is always

between 0 to 0.2ml.)

D = mg $CaCO_3$ equivalent to 100ml EDTA used.

  = molarity of EDTA x molar mass of $CaCO_3$.

Calcium Hardness
Calculation:

Calcium hardness as $CaCO_3$

$Mg\ CaCO_3/L = {}^{(A\text{-}B)\ x\ D\ x\ 1000}/_{Ml\ of\ sample}$

Calcium ion as mg Ca^{2+}/L = ${}^{(A\text{-}B)\ x\ D\ x\ 400.8}/_{ml\ sample\ (100)}$

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d. magnesium hardness (mg $CaCO_3$/l) = total hardness – calcium hardness

e. calculated magnesium as mg^{2+}

Mg mg^{2+}/l = magnesium hardness as mg $CaCO_3$/l X 0.244

Iron (Total) Phenanthroline Method
Calculation:

Concentration of Fe = $^{\mu gFe}/_{ml\ sample}$ mg l^{-1}.

Chromium (Hexavalent Chromium) Colorimetric Method
Calculation

Mg Cr^{+6}/L = (Abs_{sample} – Abs_{blank}) (m^{-1}) (df)

Where m^{-1} = concentration/ Absorbance = $^{1-0}$/Abs_{std} - Abs_{blank}

Df = dilution factor.

Manganese (Persulphate Method)

Calculation:

When the entire original sample is taken for analysis,

Mg Mn/L = $^{Mg\ Mn\ (in\ 100ml\ final\ volume)}/_{ml\ sample}$

For light path of 1cm, take manganese (µg) range of 100-1500µg to prepare standard.

Table A.1. World Health Organization guidelines for water quality

Characteristics	Action level
Nitrate and Nitrate Nitrogen	10mg/l
Lead	0.05mgl
Sulphate	400mg/l
Hardness as CaC03	500mg/l
Total dissolved solids	1000mg/l
Copper	1.0mg/l
Iron	0.3mg/l
Sodium	200mg/l
Zinc	5.0mg/l
Colour	15TCU
Turbidity	5TCU
Taste	No objectionable to 90% of
PH	Consumers 6.5 to 9.5 absent in
Coli forms	100mg/l

Source: Geneva, (2008).

APPENDIX B

Table B.1   F.A.O   Water quality criteria for Agricultural use (Irrigation)

Constituent Characteristics	Permissible Criteria	Desirable Criteria
Physical:		
Temperature		55^0 F to 85^0 F
Microbiological (1)		
Fecal Coli form(44.5^0 C)	100/100ml	0/100ml
Enterococci (35^0 C)	20/100ml	0/100ml
Total bacteria (20^0 C)	100,000/100ml	<10,000/100ml
Inorganic Chemical		
Aluminium	20,0 mg/l	<1.0mg/l
Arsenic	10.0mg/l	<1.0mg/l
Beryllium	1.0mg/l	<0.5mg/l
Boron	0.5mg/l	<0.3mg/l
Cadmium	0.05mg/l	<0.005mg/l
Chloride	150mg/l	<70mg/l
Chloride-special requirement		
Chromium	20.0mg/l	<5.0mg/l
Cobalt	10.0mg/l	<0.2mg/l
Copper	2.0mg/l	<0.2mg/l
Lead	20.0mg/l	<5.0mg/l
Lithium	5.0mg/l	<5.0mg/l
Manganese	20.0mg/l	<2.0mg/l

Source: FAO, (2008).

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APPENDIX C

Table C.1. Dissolved Solid in Potable Water: Tentative Classification of Abundance

Major Constituents 1.0 TO 1000MG/L	Secondary Constituents 0.01 TO 10MG/L	Minor Constituents 0.0001 TO 0.1 MG/L	Trace Constituents Generally Less Than 0.001MG/L
Sodium	Iron	Antimony*	Beryllium
Calcium	Strontium	Aluminum	Bismuth
Magnesium	Potassium	Arsenic	Cerium
Bicarbonate	Carbonate	Barium	Cesium
Sulphate	Nitrate	Cadmium*	Gallium
Silica	Fluoride	Chromium*	Gold
	Bromo	Cobalt	Indium
		Copper	Lanthanum
		Germanium*	Niobium*
		Iodide	Platinum
		Lead	Radium
		Lithium	Ruthenium*
		Manganese	Scandium*
		Molylodium	Silver
		Nickel	Thallium*
		Phosphate	Thorium*
		Selenium	Tin
		Titanium*	Tungsten*
		Uranium	Ytterbium
		Vanadium	Yttrium*
		Zinc	Zirconium.