Studies on the Physico-Chemical and Bacteriological Qualities on Njaba River in Nnenasa in Isu Njaba L.G.A of Imo State

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CERTIFICATION

This is to certify that this work "**Studies on the Physicochemical and Bacteriological Qualities of Njaba River in Nnenasa in Isu Njaba L.G.A of Imo State"** was carried our by **EZERIOHA ETHERLBERT** (Reg. No: 20075590269) in partial fulfillment for the award of the Master of Technology (M.Tech) degree in Environmental Technology in the Department of Environmental Technology of the Federal University of Technology, Owerri

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DEDICATION

This work is dedicated to the God Almighty who enabled me and to my loving mother, Madam Benedeth Ezerioha, and my darling wife –Princess Maureen Ethelbert- Ezerioha, who has always been there for me.

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ABSTRACT

A comprehension analysis of a river system such as that of Njaba river reveals so much about physical, chemical and biological characteristics of a typical lotic aquatic ecosystem. An analysis of this river system was conducted between February and October, 2010 and so much findings were discovered as regards its physicochemical as well as bacteriological properties. Because a lot of external factors interplay on the quality of the river system, attention was place on these anthropogenic activities and water utilization patterns to ascertain environmental indicators that influence the status of its quality. Frequent environmental reconnaissance surveys were conducted based on samples collected from the river. Results obtained from laboratory analysis showed the Njaba River had high conductivity due to the presence of free ion acid radical. The presents of a high level of copper concentration was attributed to this. This had a lot of determine the kind of microbial activities predominant in the river system. The results obtained showed a high level of total coliform bacteria. Some of the anthropogenic activities attributed for this results included defecation. Solid waste disposal, cassava fermentation, washing of entrails from animals etc. it is recommended that appropriate monitoring techniques and laws be applied by the government so as to conserved these aquatic resources.

Key words: Njaba River, solid waste, coliform, water quality, diseases,

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of study

Water plays a very vital role in sustenance of life on Earth and because of this, it is important to preserve and effectively monitor its quality. The presence of water accounts for more than 21 percents of the entire earth surface.

The evaporation of water from water bodies and soils, its infiltration, percolation, precipitation and runoff consequently affects the volume of water available at any given point in time. This is called Hydrologic cycle. It describes the continuous movement of water, on, above and below the surface of the Earth. This process ensures that mass of water on Earth remains fairly constant over time. However, the partitioning of the water into the major reservoirs of ice, fresh water, saline water and atmospheric water is a variable depending on a wide range of climatic changes.

The quality of water and its availability is considered important by man, because water plays a very important role in human activities ranging from domestic to industrial uses.

The hydrologic cycle always lead to self purification of water in river systems. However, when copious amount of organic matter is introduced to water systems in such a way that it exceeds the rate at which natural systems balance or removes these pollutants, much pressure is exerted on oxygen i.e. oxygen demand, leading to the proliferation of micro-organisms which impairs the river water quality and its suitability for use.

To ensure the quality of water, several legislations have been promulgated. For example, there is a clean water act of Nigeria, which was enacted in 1972. It is a standing legislation which was introduced to restore and maintain the chemical, physical and biological quality of the nation's surface water. There is equally, the Nigerian river basin development authority act of 1972, which is stipulated and articulated measures to improve and protect water resources. The authority was charged with the function of controlling pollution of lakes and rivers within their areas of jurisdiction

On the global stage, the United Nations organization had in the past designed

1981-1990 as the International drinking water supply and sanitation decade, and consequently, launched a second programme, called safe water 2000.

In spite the fact that there is availability of water surrounding most communities in the developing world, the people are still far from having efficient or safe water supply and largely depend on river water. The continued contamination of these rivers with pathogenic, organic and inorganic contaminants leads to an increase in the number of water related diseases such as amoebic diarrhea, typhoid fever, cholera, bacillary dysentery, infectious hepatitis schistosomiasis (bilharzia), etc.

The world health organization (1992) reported that about 85% of all the illness in the developing nations is water related and that a quarter of children born in developing countries would possibly die before the age of five, from water related diseases. Unsafe drinking water is the major underlying cause of high child mortality rate in the country.

1.2 Statement of Problem

There is abundance of fresh water in Nigeria and her entire land mass. There are two major rivers, the Niger and Benue Rivers criss-crossing the country. Other small rivers and tributaries exist, such as the Imo River, Anambra River, Cross River etc. Within the area of this research work, there are equally other smaller rivers like the Otamiri River, Nwaorieubi Rivers Nwangele River etc. These crisscross smaller communities where anthropogenic and industrial activities are predominant. These activities include solid waste disposal from various agricultural activities, bathing, sewage disposal and other industrial effluents discharged up stream or downstream. These contaminate the rivers leading to the reduction in the water qualities standards as well as the floral and faunal characteristics. Many villagers depend on these rivers for their drinking water, ingesting this polluted water over time has been found to be inimical to health.

1.3 Aims and Objectives of the Study

The objectives of the study are as listed below.

1. To determine the physico-chemical and bacteriological quality of Njaba River.
2. The comprehensive analysis of the physicochemical bacteriological qualities of the river under study.
3. Provision of a comprehensive log of anthropogenic activities along the river riparian zones and to crelate these activities to the qualities status of the river.
4. A comparism of the Njaba River water quality parameter with those of Local Standards like the Nigeria Institute of Standard as well as that of international bodies like the World Health Organization's drinking water standards.

1.4 Significance of Study

The importance of the study is as articulated below.

1. It is to properly educate the populace concerning the health implications of poor sanitary conditions as related to river as well as to provide them adequate steps to take before drinking water from river sources.
2. To provide a baseline data of Njaba River for future references.

3. Enable policy makers and government to make important decision in water quality management.

4. To form a background study for future research works in the area of water quality management.

1.5 The Scope of Study

The research work is centered on the physico-chemical and bacteriological quality of Njaba River. It involves the gathering and analysis of parameters such as Colour, Odour, Total coliform, Turbidity, Total hardness, Total solid as well as Taste. The various anthropogenic activities that infringe on the Njaba River water quality were identified, compared and correlated.

1.6 Limitation of the Study

The limitations of this study are as shown below.

1. The extraction of information from the members of the Nnenasa community was difficult as a result of their numerous superstitious belief systems. Some of the indigenes worship the goddess of the river and was not forth coming with information concerning it.

2. The research work was carried out during the wet season and precipitation stood as a huge barrier. This is because the concentrations of contaminants were diluted

within this period and often varies, as opposed to dry season when evaporation and zero rainfalls lead to higher concentration of contaminants.

3. Numerous visits paid to the study area were exhausting and expensive as well.

4. There is inadequate funding on the part of the researcher at the time of laboratory analysis because some of the tests were expansive.

5. The retrieval of some essential information on the river, its riparian community's information was gotten from local residents of Okwudor and Umaka communities. So, there is some dependence on village account.

CHAPTER TWO

2.0 Literature Review

2.1 The Environment

The environment is regarded as the totality of all external conditions that exert binding influences on the life and development of organisms (platt , 1980).

Gilpin (1976) suggested that it is the regional circumstance surrounding any living organism.

The components of the environment include abiotic and biotic factors. These components interfere with one another in a complex manner. Biotic components refer to living things of biological origin (Allaby 1998). These include man, plants, viruses, fungi etc.

Sarnoff (1971), reported that abiotic components of the environment is one which is devoid of life. These include all those physical and non-living things, which exert influence on living organism (Platt, 1980). Examples are: Temperature, light, ionizing radiation, water salinity topography etc.

2.2 Types of Environments

There are different types of environment and these are categorized as follows.

(i) Land or Terrestrial Environment

(ii) Air or Atmospheric Environment

(iii) Water or Aquatic Environment (Ezekwesili, 1999)

2.2.1 The Terrestrial Environment

This is the the biophysical environment which is characterized by the dominance of land forms and vegetative features as a result of the influence of climate, edaphic and biotic factors. It is usually divided into zones or vegetative regions with its distinctive peculiarities of plants and animals forms.

The vegetative regions could be natural or man-made through processes like aforestation. The vegetative regions of the world include:

(i) Tropical rain forest

(ii) Savanna grassland

(iii) Monsoon

(iv) Deserts

(v) Mediterranean

(vi) Coniferous (targal)

(vii) Deciduous forest

(viii) Temperate grassland vegetations (Dike and Oloweze, 2006)

2.2.2 The Atmospheric Environment

This consists of the gaseous layer surrounding the earth. It is made up of layers and zone with specific and unique attributes. The air environment includes the arboreal environment which encompasses the tree tops.

2.2.3 The Aquatic Environment

The aquatic environment includes all the world's oceans, seas and estuaries around their fringes and down to the major lakes. It covers the smallest ponds, marshes and swamps that are often found associated with them (Barnes et al, 1991). It is simply an ecosystem located within a body of water.

Organism living in water show great variation and are subject to physical conditions that differ from those of the terrestrial biota (Camougis 1981).

(Ezekwesili, 1999), disclosed that there could be fluctuations in this environment and that most organisms that are domicile in it are adapted with special features that enable them to swim and utilize dissolves oxygen.

Comougis (1989) disclosed that the producers with the aquatic ecosystems are composed of tiny microscopic plants called phytoplankton, and macroscopic plant called the microplankton.

Among the consumers are relatively small animals called zooplankton. Others includes organism attached to or resting on the bottom of the water like fishes and reptiles (Odum, 1971).

The decomposers are made up of various species of fungi and bacteria which break down organic materials.

A hydrosphere is the total amount of water on a planet. The hydrosphere includes water that is on the surface of the planet, underground, and in the air. A planet's hydrosphere can be liquid, vapor, or ice.

Apart from the fresh water, there is marine water and brackish water - which is a mixture of fresh and salt water. An example of brackish water is an estuary formed where rivers flows into the sea.

Table 1, Distribution of the World's Water Resources:

Location	Percentage
Stream channels	0.01
Atmosphere	0.04
Lakes/swamps/ponds	0.35
Ground water and soil moisture	22.4
Glaciers and ice cap	77.2
Oceans	97.3

Generally, the world fresh water systems make up about just 2.7% while the Oceans accounts for about 97.3%. Bissau, 1968 pp.10

2.3 Fresh Water –Ecosystem

Fresh water ecosystem is part of the Earth's aquatic system. Empirical results show that fresh water is water whose salinity is less than 0.5% (Allaby, 1988). They include lakes and ponds, rivers, streams, springs, and wetlands. They can be contrasted with marine ecosystems, which have a larger salt content. Fresh water ecosystems refer to all the living things at all tropics levels in a body of fresh water such as stream, lake and pond. It equally covers all the inorganic and organic dead matter which is vital to balance this environment (Sarnoff, 19971).

Fresh water spans only about 2. 1% of the earth's surface as reported by Krogh, 2002 while Sarnoff, 1971 postulated that Fresh water covers less than 2% of the Earth surface, approximately 2.5 x 10^0km2. In this work, we agree with Krogh since his work is of more recent.

About 10% of all aquatic species are found in fresh water habitats due to its low salinity.

Fresh water plants and animals tend to show greater general adaptability and ecological versatility than their marine relative.

Freshwater ecosystems can be divided into Lentic ecosystems (still water) and lotic ecosystems (flowing water) and Wetlands.

.2.3.1 Lentic Waters

These are Still or standing waters that range in area from the smallest wood land pond to large bodies of water such as the great lake (Portora at. Al, 1988). Lakes can be formed from impoundments resulting from the construction of dams, and as such precipitation affects their volume to a large extent. Lakes can also be formed naturally from volcanic activity, landslide, glacial activity, river activity, wind etc (Wetzel, 1975).

Poslethwait et al (1996) disclosed that since some of Lentil water are fed by river, as they enter lake, most suspended particles settle to the bottom.

Deep lakes are stratified into three distinct zones, each with its peculiar communities of organisms. These include littoral, limonitic and profudal zone. Cole (1975) disclosed that the littoral zone or shore region is shallow, usually well lighted and inhabited by rooted aquatic plants extending to some late waves depth. This zone has abundant producers like water lilies, cattails and consumers such as insects, snails, amphibians, etc (Poslethwait et al. 1995).

The limonitic zone is the open layer where photosynthesis can occur, it is the top layer where light can penetrate (Poslethwait et al, 1992).

Life in this zone is dominated by plankton (floating microorganism) and nekton (actively swimming animals).

Cole (1975) said that the producers, here are planktonic algae, the consumers include microscopic crustaceans and rotifers.

The profundal zone can be defined as the part deep enough to exhibit temperature stratification (Cole, 1985). This zone is otherwise called the down bottom region (Wetzel, 1978). The deep Profundal zone supports mainly insect larvae, scavenger fishes, decomposers (Poslewait et, al 1982) and bottom dwelling animals called the benthos.

2.3.2 Lotic Waters

Flowing fresh water environments are referred to as lotic water, to contrast them with standing water (lentic water) Townsend, 1980).

A lotic ecosystem has flowing water, e.g. creeks, stream, rivers, brooks etc. They are very diverse in their forms ranging from a spring that is only a few centimeters wide to a major river that is kilometers in width (Allan, 1995). The major distinction between the lotic and lentic environments is the relative residence times of water within them (Townsend, 1980). The habitats also differ because since the water flows, it is usually more oxygenated. Tortora et al (1980) reported that, flowing water can be divided into three distinct zones

(i) The Rapid Zone or Upper Course Rapid Zone:

The upper course or rapid zone originated from underground springs and runoff water, and consists of brooks and small swiftly moving streams.

(ii) The Pool Zone or Middle Course

This includes the foot hill area where the streams have lost some of their velocity but are still swiftly moving.

(iii) The Plain Zone or Lower Course:

The lower course joined to form a slow moving river that meanders across a plain and eventually empties into a larger river or the ocean.

The best measure of the volume carried by a river is its discharge. This is the amount of water that passed a fixed point in a given amount of time and usually expressed as liters or cubic feet of water per second. The Amazon is by far the largest river.

Table 2: Major Rivers of the World

Rivers	Countries in River Basin	Average annual Discharge at Mouth (m3/5)
Mekong	China, Laws Burma, Cambodia, Thailand	18,300
Yangtze	Tibet, China	28,000
St. Lawrence	Canada, USA	10,200
Parama	Paraguay, Argentina	18,000
Orinoco	Venezuela, Colombia	45,300
Ob	Russia	12,000
Mississippi	USA	18,400
Mackenzie	Canada	9,600
Lena	Russia	16,000
Irrawady	Burma	16,000

Gauges	Nepal. India, Bangladesh	11,600
Congo	Congo	39,200
Bramaputra	Tiber, India, Bangladesh	19,000
Amazon	Brazil, Peru	175,000
Amur	China, Russia	11,000

Source: Curingham et al, 2003, pp. 429

Table 3: Some important Rivers within Nigeria Catchments.

River	State
Niger	Niger
Benue	Benue
Imo	Imo
Cross river	Cross river
Abia river	Abia
Orashi	Oguta, Imo
Aham	Obowo, Imo
Njaba	Njaba, Imo
Otamiri	Owerri municipal
Onukwu Emekuku	Emekuku, Imo
Qua iboe	Akwa Ibom
Eke onimiri	Ikeduru, Imo

Harrison (2004) disclosed that streams and rivers show great variations in their dissolved mineral consent (Harrison 2004). Such is represented in the table below.

Table 4: Average composition of Dissolved Mineral in River water of the World.

Mineral	**Ppm**
Iron	0.7
Magnesium	4.1
Sodium	6.3
Nitrate	1.0
Potassium	2.3
Chloride	7.8
Sulphate (so4)	11.2
Silica (sio2)	13.1
Calcium	15.0
Bicabanates (hco3)	58.0

2.5 Classification of Rivers

Holmes (1978) provided the following classes according to stream gradient;

(i) Youthful river - A river with steep gradient that has very few tributaries and flows quickly. Its channels erode deeper rather than wider, e.g. Brazas river

(ii) Mature River - A river with a gradient that is less steep than youthful river. It is fed by many tributaries and its channels erode wider rather than deeper. E.g. Mississippi river

(iii) Old River - A river with a low gradient and low erosive energy which are characterized by stood planes, e.g. Nile River

2.6 Pollution of Rivers and Streams

River pollution has been discovered to occur when the water is altered in composition or condition, directly or indirectly as a result of the activities of man. This alteration makes the water less suitable for any or all of the purposes for which it would have been suitable for, in its natural state (Isaac, 1967).

Any body of water is capable of assimilating a certain amount of pollution without serious effects because of the dilution and self purification properties of the water (Tebbutt 1998). Since additional pollution alters the water's suitability for various uses, Hammer and Hammer (2006) said that the control of quality is required to ensure that the best employment of the water is not prevented by indiscriminate use of water courses for disposition of wastes.

Tebbutt, (1998) observed that serious pollution which often occurs in industrialized areas can have very profound effects on a river system and that it is economically impossible to prevent river pollution.

Pollution has the following affect on the body of water.

(i) It poisons or has adverse effect on the aquatic life

(ii) Destruction of its aesthetic value thus hindering it's availability for recreation.

(iii) Creation of nuisance - odours and colour

(iv) It causes hindrance to navigation by the bank of water due to the deposited solid (Tebbutt, 1988)

(v) Contamination of water supplies

2.7 Sources of River Pollution

There are several sources of pollution which work together to reduce overall river quality (Dopp, 2006).

Hammer and Hammer (2004) classified water pollution into two depending on the sources of the contaminants. These are namely:

- Point sources
- Non point sources.

(i) A point source pollution is a single, identifiable source of pollution. It could be a waste water discharge from outfall or drainage channels, the points of industrial effluent discharges etc (Bothin and Keller, 1998). Industrial wastes are commonly discharged to rivers and the sea in this way.

(ii) Non point sources are intermittent and diffuse. They do not a specific location where they are discharged from (Cummingham et al, 2003). They are generally influenced by factors such as a Land use, climate, topography, hydrology, etc (Bothin and Keller, 1998). An example is the agricultural land use drainage from cultivated field, livestock pastures, erosion from surface mining etc

2.8 Classification of Water Pollution

Water is said to be polluted if it is influenced or affected by any of the under listed factors.

(i) Oxygen demanding wastes

(ii) Plant nutrients

(iii) Infectious agents and disease causing organism

(iv) Synthetic organic compounds

(v) Inorganic minerals and chemical compounds

(vi) Radioactive substances

(vii) Sediments

(viii) Heat

Oxygen demanding waste

Waters 'enriched' with wastes or nutrients from human, domestic or wildlife are likely candidates for oxygen depletion. According to finding recorded by Tebbutt (1998), these are pollutants that may affect the oxygen balance of the water. The oxygen demanding wastes include:

(a) Thermal pollution which is capable of upsetting the oxygen balance because the saturation of dissolved oxygen reduces with increasing temperature.

(b) Waste substances which consume oxygen, these may be organic material which is biochemically oxidized.

(c) Substance which prevents oxygen transfer across the air-water interface e.g. oils and detergents.

The effects of oxygen demanding waste in rivers depends to a large extend on

the volume, flow and temperature of the river as aeration readily occurs in a rapidly turbulent flowing river, which is therefore, often able to recover quickly (Cummingham at al, 2003). However, there will be initial depletion of dissolved oxygen (the oxygen sag) but when the oxygen contents is restored by aeration further downstream, the water will be of improved quality (Isaac, 1967)

2.9 Plant Nutrients

Nitrogen and phosphorus have ways of stimulating plant growth. The elements of Nitrogen and phosphorus are released from a number of practices which are related to land use. The amount of these nutrients in urban streams is usually high because of the use of materials such as fertilizers, detergents and the products of sewage treatment plants (Bothin and Keller, 1998). A process known as eutrophication occurs when there is an increase in nutrient levels. This causes undesirable effects of algae blooms or excessive growth of planktons. This introduces unpleasant odour or taste to the water. In the extreme cases, it can lead to the formation of toxic product that can endanger aquatic life or cause bioaccumulation and biomagnifications in fishes (Larkin et al, 1981).

2.10 Infectious Agent

An infectious agent is something that infiltrates another living thing. These are bacteria, Fungi and viruses. These organisms are parasitic and commonly found in raw human sewage. These agents play active roles in the spread of water borne disease (Larkin et al 1987). Among the most deadly water borne diseases are typhoid, cholera, bacteria and amoebic dysentery, enteritis, polio, infectious, hepatitis and schistosomiasis (Cummingham et al, 2003)

2.11 Synthetic Organic Compounds

These are anthropogenic organic compound created through industrial synthesis; these chemicals are less volatile than natural occurring substances. These chemicals are basic part of pesticides or by-product of incineration etc. They can enter the body of river through run-off, Example of these is the dioxins and poly chlorinated biphenyls.

These are dangerous pollutants of rivers and it is necessary that the level of the pollutants are monitored and controlled.

2.12 Inorganic Minerals and Chemical Compounds

These are minerals or geologically based compound that does not contain carbon – hydrogen bond i.e. C-H bond.

Most of inorganic minerals and chemical compound are metals. Majority of inorganic compound and minerals are highly soluble in water.

Some toxic inorganic chemicals which are released from natural processes such as lightening discharge which release nitrite into the environment. The weathering of rocks also releases toxic inorganic chemicals which are carried by runoffs into lakes or rivers (Cummingham et al, 2003). Some of these dangerous compounds include asbestos, heavy metal such as mercury and acids (Larkin et al 1981)

Other inorganic materials such as salt and chlorides materials such as salt and chlorides are usually non toxic at low concentrations but when certain thresholds are exceeded, may become concentrated enough to lower water quality or adversely affects the biological communities (Cumminghan et al, 2003). Their overall impact may be catastrophic to the fishes and other aquatic life. It equally can render water useless for either industrial use or human consumption (Cummingham et, al 2003)

2.13 Radioactive Substance

A radioactive substance is a material that emits radiation.

This radiation includes Alpha particle, Beta and Gamma rays, when they decay.

A radioactive decay or radioactivity is a process by which the nucleus of a unstable atom looses energy by emitting radiation.

Radioactive materials are particularly dangerous because they persist for a long time owing to their decay time (Larkin et, al., 1981). These substances are classified as hazardous pollutants because of their toxicity to living tissues even at low exposures / dosages.

Secondly, they are carcinogenic, toxic, mutagenic, teratogenic to human or other life forms;

Thirdly, they are ignitable with a flash point less than 60^{o}C. They are generally corrosive, explosive and highly reactive substances (Cummingham et al, 2003). The sources of radioactive materials include wastes associated with nuclear power plants; uranium and thorium mining and refining Site, medical and industrial use.

Sediments

This consists of rock and mineral matters ranging from gravel particles greater than 2mm in diameter to finer sand, silt, clay and even colloidal particles (Bothin and Keller, 1998.) The common sources of these are soil erosion from agricultural land and construction sites, washing of sand and gravel, quarrying operations and mine Sherries (Hammers and Hammers 2004)

Inert suspended solids in high concentrations can lead to problems of blanketing of river bed thereby preventing the growth of fish food (Tubbutt, 1998).

Deposition of suspended solid can also seriously damage spawning site where salmon and trout bury their eggs in gravel and they become asphyxiated (Hammer and Hammer 2004).

Heat

Thermal pollution occurs when industries remove water from a source, utilize it for cooling purpose and then discharge the heated water back to its sources (Enger and Smith 2000). This raises the temperature of receiving water, thereby increasing oxygen demand.

The two reasons for this are:

(i) Solubility of oxygen in water, reduce with increasing temperature

` (ii) Because of increase biological activities, more oxygen tends to be used up. Theses would consequently affect water quality and aquatic life adversely (Cummingham et al 2003).

On the general note, infectious agent, radioactive substances, organic chemicals and inorganic chemicals/compounds have been observed to be responsible for serious health problems, while sediments, plant nutrients, oxygen – demanding wastes and thermal pollution causes ecosystem disruptions (Cummingham et al, 2003 pp. 430).

2.13 Water Quality

Water quality is defined as the chemical, physical and biological characteristics of water with respect to its suitability for a particular. Purpose water that may be suitable for certain usage might be unacceptable for other purpose depending on it characteristic and its requirements for the particular use (Symons et al, 2000)

According to Okedi (1997), the impurities deplete natural water quality are dissolved and suspended which are found in the environment, communities, waste water from industrial and discharge from agricultural activities.

However, the most fundamental need is for water to be suitable for drinking, personal hygiene and food preparation and should not pose and risk what so ever to human health (Biswas 1998)

2.13.1 Water Quality Parameters

These are measurable physical, chemical, biological and radiological characteristics of water. It is the measure of the condition of water vis-à-vis the requirement of one or more biotic species or human beings. The water quality parameters include the Temperature, pH, Turbidity, Conductivity and dissolved oxygen.

They constitute such characteristics that make water palatable and unobjectionable as well as potable. Mendie (2005) disclosed that water parameters can be broadly classified into three: The physical, chemical and biological parameters.

2.13.2 Physical Parameters

Mendie (2005) stated that physical parameters used in water analysis includes; Colour, Turbidity, Odour and Taste of water. These give useful indices of contamination that can easily be detected by the senses of sight, smell and taste. Metcalf and Eddy (1991) disclosed that the most important physical characteristics of water is it total solid content which is composed of floating matter, settle able matter, colloidal etc.

Dissolved solid and total suspended solids:

Okedi (1997), disclosed that dissolved solid concentrations gives a quantitative measure of the difference between total solids and suspended solid.

It is used to assess the suitability of various water sources for alternative uses, whether domestic, industry or farming etc.

Electricity charged dissolved particles make ordinary natural water a good conductor of electricity (Harrison, 2004).

Turbidity

This is a measure of how particles suspended in water affects the water clarity. It is an import parameter that indicates the level of suspended sediment and erosional level. It usually increases during the rainy season due to debris and run-offs carried into the river. Turbidity in water primarily causes a cloudy or moistly appearance of the water (Mendie, 2005).

Metcalf and Eddy (1991) disclosed that turbity is a measure of the light transmitting properties of water.

Colour

Pure water is colourless. So, coloured water has some form of pollution. Colouration of water may be due to the presence of humus and loaming substance, protein and hydrocarbon-like compounds, organic acids etc. (Micolaze et al, 1989).

Harrison (2004) reported that the greenish colour in water is primarily of vegetative origin and is extracted from leaves and aquatic plants. It is equally produced in region or part of the river or stream where there is visible Algae growth. Mendie (2005), observed that brownish to reddish-brown water is due to iron content while a darkish colour is connected with muddy terrains due to fermentation and decaying organic materials.

The colour parameter is measured in true colour units (tcu) or platinum cobalt (pt/co) unit.

Taste and Odour

Water in its pure state is taste and odourless. The common taste in water is therefore imparted by organic and inorganic compounds/substances.

At times the taste and smell of water are as a result of the presence of decomposing organic materials and volatile chemicals (Okedi, 1992). Tebbutt (1998) observed that they are due to dissolved impurities after inorganic in nature e.g phenols and chlorophenols.

A saline taste is due to high chloride content 25omg/l, while algae growth may result in an objectionable taste (Mendie, 2005).

According to Harrison (2004), water tastes are general classified into four groups, Sweet, Sour, Salty and Bitter.

Harrison (2004) traced taste and odour to a member of factors, which includes:

(i) Industrial waste pollution from substances, such as phenol

(ii) Chlorination

(iii) Dissolved gasses

(iv) High mineral concentration

(v) Iron, management and other metallic products of corrosion

(vi) Living organisms

(vii) Decaying organic matter

Temperature

This is vital because of its effect on other properties such as speeding up of chemical reactions, reduction in solubility of gasses, amplification of tastes and odours etc (Tebbutt, 1998)

Metcalf and Eddy (1991) disclosed that abnormal high temperature could foster the growth of undesirable water plant. Increase in temperature tends to lead to increased oxidation. It imposes a high oxygen demand, thereby depleting the oxygen content of the water (Dunne et al 1998)

Generally, solubility of dissolved oxygen is water tends to reduce with increasing temperature range as shown below.

Table 5: Solubility of Oxygen by Temperature Range.

Temperature	solubility of oxygen (mgl)
0	-
5	12.8
10	11.3
15	10.0
20	9.0
25	8.2
30	7.4

Sources: Dunne et al, 1928

Conductivity

Conductivity of a substance is **defined** as 'the ability or power to conduct or transmit electricity. The electrical conductivity of a solution largely depends on the water salinity or the amount of dissolved salts present (Tebbutt, 1998). This is measured in (ns/ cm). This is a numerical expression of the ability of a material to carry an electric current (Mendie, 2005). Salt dissolves in water to form electrolyte , which is made up of ions, each with a positive and negative charge. The ions in particular conduct electricity. So water conductivity is appropriately proportional to the total dissolved content as:

$$K = \frac{\text{conductivity (s/m}}{\text{TDS(mgl)}}$$

2.13.3 Chemical Parameters

Chemical characteristic tend to be more specific in nature than some of the physical parameter when assessing a given sample (Tebbutt 1998). They cover the new chemical entities found in raw water and their ultimate levels, however must fall within the acceptable units (Mendie, 2005)

Chemical contaminants are quantified in terms of organic or inorganic constituents that may be present (Okedi, 1997)

PH

The PH is a measure of hydrogen ion concentration in water, specifically the negative logarithm in moles per liter (Mendie, 2005). It indicates the acidity or alkalinity of the medium.

The intensity of acidity or alkalinity of a sample is measured on the pH scale, which indicates the concentration of hydrogen ions present (Tebbult, 1998).

The pH of an aquatic system can be conveniently measured with a pH meter, and various pH papers and indicator solutions. An acidic or highly alkaline water is undesirable because of corrosion problem (Tebbutt, 1998).

Alkalinity

The measure of the capacity of water to neutralize acids is its alkalinity (Okedi 1997). This is due to the presence of bicarbonate, $HCO^{-}x$, carbonate, CO_3^{2-} or hydroxide, OH^{-} in water (Tebbutt, 1998). Their sum makes what is called total alkalinity (Nnikoladz et al, 1989). And this is normally expressed in terms of equivalent calcium carbonate in mgl. (Okedi, 1997). Strongly alkaline water has objectionable “Soda” taste and cause excessive drying of the skin (Harrison, 2004).

Acidity

The terms acidity is reserved for a group of constituents that can be titrated with a strong base (Mendie, 2005). The most usually cause of acidity are free carbon dioxide in water and organic acids (Twort et, al 1974).

Another wide spread cause of acidity is decomposing organic matter of vegetable, especially peaty origin. Acidity of water equally occur when rain falls through a polluted industrial atmosphere to produce Sulphuric acid (Twort et al, 1974)

Carbon Dioxide (CO_2)

Carbon dioxide is a colorless and odorless gas vital to life on Earth. This naturally occurring chemical compound is composed of a carbon atom covalently double bonded to two oxygen atoms. Carbon dioxide exists in Earth's atmosphere as a trace gas at a concentration of about 0.04 percent (400 ppm) by volume. The presence of carbon dioxide is significant because it affects the ph of water (Okidi, 1997). Free bound carbon dioxide which is different from that existing in combination with calcium and magnesium, and it is of much importance as regards to the corrosive property of water (Twort et al, 1974).

Carbon dioxide is an important greenhouse gas. Burning of carbon-based fuels since the industrial revolution has rapidly increased its concentration in the atmosphere, leading to global warming. It is also a major cause of ocean acidification because it dissolves in water to form carbonic acid

Hardness

This is defined as the amount of dissolved calcium and magnesium in the water. Hard water is high in dissolved minerals, both calcium and magnesium.

Total hardness consists of temporary/ carbonate hardness and permanent / non carbonate hardness (Twort et al, 1974). It occurs due to the presence of bicarbonate, Sulphates of magnesium and those of their chlorides, other trivalent Metalions of zinc, manganese and calcium (Okedi 1997).

Temporary hardness is removed by boiling and this forms scales inside kettles and stills (Twort et al, 1974)

Harrison (2004) observed that hard water cause other problems such as wasting of soap and synthetic detergents, leaving unsightly soap scum rings in the bath tub, spotting and streaming glass ware etc. See table below.

Table 6: Hard Water Description

Concentration	Description
0 - 50 mg/l	Soft
50 - 100mg/i	Moderately Soft
100 - 150mg/i	Slightly Soft
150 - 200mg/i	Moderately hard
Over 200mg/i	Hard
Over 300mg/i	Very Hard

Sources: Twort et al, 1974 pp189

Dissolved Oxygen (DO)

This is quantity of oxygen dissolved in a body of water as an indication of the degree of health of the water and its ability to support a balanced aquatic ecosystem; also, the amount of free (not chemically combined) oxygen dissolved in water, wastewater, or other liquid, usually expressed in milligrams per liter, parts per million.

Oxygen is important to all forms of aquatic life, including those organisms responsible for the self- purification processes in natural waters.

The oxygen content of natural water varies with temperature, turbulence, the photosynthetic activity of algae and plants and atmospheric pressure (Chapman, 1992).

Metcalf and Eddy (1991) observed that the rate of biochemical reactions that use oxygen increase with increase temperature. Dissolved oxygen levels tend to be more critical in the summer months due to high temperature and many aquatic activities.

Chapman (1992) was of the opinion that determination of DO concentration is a fundamental part of a water quality assessment. Concentrations below 5mg/l may adversely affect the functioning and survival of biological communities and below 2mg/l, may lead to the death of most fishes.

The measurement of DO can be used to indicate the degree of pollution by organic matter, the destruction of organic substance and the level of self purification of the water (Chapman, 1992).

Biochemical Oxygen Demand (BOD)

This is Standard method for indirect measurement of the amount of organic pollution (that can be oxidized biologically) in a sample of water. BOD test procedure is based on the activities of bacteria and other aerobic microorganisms (microbes), which feed on organic matter in presence of oxygen.

The BOD is primarily a test applied to sewage effluents, but it is of interest because it is used as an indicator of the degree of pollution of river and stream (Twort et al, 1975)..

The most widely used parameter is the 5-days BOD (BOD) at 20^0C (Metcalf and eddy, 1991). However it is of limited value in measuring the actual oxygen demand of surface waters, and extrapolation of test result to actual steam oxygen demand in highly questionable, since the laboratory environments amount reproduces the physical, chemical and biological stream conditions (Metcalf and Eddy, 1991).

Chemical Oxygen Demand (COD)

This is the standard method for indirect measurement of the amount of pollution (that cannot be oxidized biologically) in a sample of water.

The chemical oxygen demand test procedure is based on the chemical decomposition of organic and inorganic contaminants, dissolved or suspended in water.

Chemical Oxygen Demand (COD) many organic substance such as animals wastes and compost are easily decomposed by chemical reactions with oxygen in water (Kegly and Andrews, 1988).

The oxygen equivalent of the organic matter that can be oxidized is measured by using a strong chemical agent (potassium dichromate) in an acidic medium such as concentrated Sulphuric acid (Metcalf and eddy, 1991)

Tubbutt, (1998) observed that the result obtained usually show COD>BOD in magnitude and the BOD: COD ratio increase as biological oxidation proceeds.

Chlorides

Chloride is one of the most common anions found in tap water. It generally combines with calcium, magnesium, or sodium to form various salts: for example sodium chloride (NaCl) is formed when chloride and sodium combine. Chloride occurs naturally in ground water, but is found in greater concentrations where seawater and run-off from road salts (salts used to de-ice icy roads) can make their way into water sources. As such, well owners near snowy roads or road salting storage facilities are especially at risk for high levels of sodium chloride.

These are salts of hydrochloric acids and are responsible for salty taste in water. Chlorides in natural water result from the leaching of chloride-containing rocks and soils with which the water comes in contact and in coastal areas. From salt water intrusion (Metcalft and eddy, 1991) sea water has a chloride content of approximately 20,000mg/l and therefore t he determination of chloride in water situated near the coast gives a very sensitive test for any possible infiltration by sea water (Twort et al,, 1974)

In addition, agricultural, industrial and domestic waste discharge to surface water, are a source of chlorides (Metcalf and eddy, 1991).

Although chlorides are harmless at low levels, well water high in sodium chloride can damage plants if used for gardening or irrigation.

Chlorine

As a halogen, chlorine is a highly efficient disinfectant, and is added to public water supplies to kill disease-causing pathogens, such as bacteria, viruses, and protozoans, that commonly grow in water supply reservoirs, on the walls of water mains and in storage tanks.[13] The microscopic agents of many diseases such as cholera, typhoid fever, and dysentery killed countless people annually before disinfection methods were employed routinely.

Chlorine is obtained from salt (NaCl). It is a gas at atmospheric pressures but liquifies under pressure. The liquified gas is transported and used as such.

Chlorination is a process of adding chlrrine into water to kill some bacteria or pathogens. The maximum amount of its free occurring state that may be permitted to remain in a water supply depends upon taste, odour, and corrosion (Twort et, al, 1974).

Mendie (2005) pointed out that excess chlorine leads to the formation of chlorinated phenols that may be carcinogenic or teratogenic and imparts objectionable tastes in the presences of algae.

Manganese

Harrison (2004) disclosed that manganese is present most frequently as a manganousion (mm^{2+}). It is a troublesome element in water even when present in small quantities (Twort et al, 1974). Manganese is often found in iron-bearing water but in most rare than iron, even in law concentrations, it produces extremely objectionable stain on everything which is comes in contact with (Harrison, 2004). Manganese favours the growth of certain bacteria and the decaying mass of them causes bad taste and adour (Harrison, 2004) manganese cause clogging, staining (dark brown) etc (Twort et al, 1974) .

Iron

Iron exists in three basic forms: the elemental metallic iron, in ferrous (fe^{2+}) and ferric (fe^{3+}) state (Harrison, 2004). Ferrous iron usually occurs in water drawn from well due to the solubility action of carbon dioxides on iron deposits in the ground. At very low concentration, it is highly objectionable in water supplies for domestic and industrial uses.

As iron oxidizes upon exposure to the air, it settles out and characteristic rust (reddish –brown) colour appears below.

Twort et al (1994) reported that water which contain iron is termed "Ferruginous"

Iron bacteria thrive in iron-bearing water and the decaying mass of them can cause bad tastes and odour (Harrison, 2004)

Nitrates and Nitrites

Nitrates frequently indicates polluted water due to the presence of organic matter, while nitrite is an intermediate stage in the oxidation of nitrogen (Tebbutt, 1998). They are normally present in water runoffs from cultivated lands, to which nitrate fertilizers have been applied as nutrients essential for plant growth.

Nitrate in drinking water causes a disease known as Methaemoglobinaemia or blue baby syndrome in infants.

This disease occurs when nitrate reacts with the blood carrier hemoglobin to reduce its oxygen carring capacity (Kegley and Andrew 1998)

It is most prevalent in bottle fed infants and water from wells in rural areas is of special concern. Controlling nitrate levels in drinking water sources to below around 50mg/litre is an effective preventive measure.

Phosphates

Phosphates originate primarily from the sewage effluents including their detergent content. It may also come from farmyard manures or from industrial effluents (Twort et al, 1974).

Because of noxious algal blown that occur in surface water, there is presently much interest in controlling the amount of phosphorus compounds that enter surface water in domestic and industrial discharge and natural runoff (Metcalf and Eddy 1991). The common compounds are orthophosphates. ($H_2PO\text{-}_4$. HPO^{2-}_4, PO^{3-}_4). Polyphosphates such as

$Na_3\ (PO_3)_6$ used in synthetic detergent formulations: and organic phosphorus (Hammer and Hammer, 2004).

Sulphates

Sulphates are found in most water supplies. It is usually caused by atmospheric pollution at industrialized areas, which contribute to appreciable amounts of sulphate in rain water (Twort et al, 1974).

High sulphate concentrations pose special problems and they generally means extreme hardness (e.g calcium sulphate) high sodium salt concentrations (e.g Magnesium Sulphate and high acidity (Harrison 2004)

Fluorides

Fluorides could both be detrimental or beneficial, depending on their concentration in water (Harrison, 2004). Excessive fluoride ions in drinking water causes dental fluorosis or mottling of teeth while communities whose drinking water contains no fluoride have a high prevalence of dental crises (Hammer and Hammer, 2004).

Aluminium

This is found in some natural water in a detectable amount, it can also enter water from the use of aluminum cooking utensils, tenses or pipes (Twort et al, 1974). Another sources of aluminum compound in a water supply arises incorrect dosing of aluminum sulphate as a coagulant.

Sodium

Sodium chloride which is common salt is normally taken to be an evidence of pollution from sea water by salt water intrusion or sewage, if the quantity found exceeds the normal, sodium salt have little or no effect, in large amounts and they tend to increase the corrosive action of the water.

Silica

Silica exists in most water up to 40 mg/l (as $S1O_2$) in hard waters. The consent of river water may fluctuate from 5 to 20mg/l (Twort et al 1774). Silica has little effect on the water used by the average family, in the industrial field however, it does produce extremely hard.

Heavy Metals

Trace quantities of many metals such a nickel, chloromium, zinc, mercury, magnesium, copper, lead and calcium are important constituents of most waters (Metcalf and Eddy, 1991). Most of those metals are well-known cumulative poisons and are sometimes classified as priority pollutants (Harrison, 2004).

Trace organics

Many organic compounds have been detected in raw water sources and most of them are due to human activities from industrial, construction and agricultural operations. These substances include benzene, chlorophenols (PAHS) and trihalomthenes (THMS). Some of these substance are persistent the cause the death of fishes and other aquatic biota (Twort et, al 1974).

Oil and Grease

A variety of organic substance including hydrocarbon, fats, oils, waxes and high- molecular weight fatty acids are collectively referred to as oil and grease (Hammer and Hammer, 2004). Because of low solubility, grease separate from water adhering to the interior of pipes and tank walls.

Microbiological characteristics

By definition, micro organisms are those organisms too small to be seen with the naked eyes. There are large numbers of aquatic organism within this category (Tebbutt, 1998). The most principal groups or organisms found in surface water are classified as eukaryotes, eubacteria and arch bacteria (Metcalf and Eddy, 1991). Some of these organisms may be pathogenic or non pathogenic.

Bacteria

These are single- called prokaryotic (Metcalf and Eddy, 1991). Disease causing bacteria are called pathogenic while non pathogenic bacteria are normally harmless (Okedi; 1997). They range in size from approximately 0.5 to 5mm and reproduction in by binary fission (Hammer and Hammer, 2004).

In water, coloform bacteria, eschechia coli are used as indicator of pollution by human waste (Metcalf and Eddy, 1991) and its presence goes beyond the concern of it's own pathogen city, it points to the presence of other gross pathogens (Mendie, 2005) Twort et al (1974) disclosed that bacteria include cholera caused by vibrio cholera, typhoid fever caused by salmonella typhoid, paratyphoid fever caused by salmonella dysentery etc.

Viruses

Viruses are obligate parasites consisting at a strand of genetic materials deoyribouncleic acid (DNA) or ribonucleic acid (RNA) with a protein coat

(Metcalf and Eddy, 1991). They do not have the ability to synthesize new compounds, instead, they invade the living (host) cell where the viral genetic material redirects cell activities to the production of new viral particles at the expense of the host cell (Okedi, 1997)

Twort et al (1974) disclosed that viral disease include poliomyelitis and infectious hepatitis.

Fungi

Fungi are aerobic, multicellular, non photosynthetic and eukaryotic organisms (Metcalf and Eddy, 1991)

Most of them are saprophytes, obtaining their food from dead organic matter. They are capable of degrading highly complex organic compounds and some are pathogenic in humans. They can be responsible for tastes and odours in water supplied.

Protozoa

These are single-called eutharyotic micro organisms without cell wall (Metcalf and Eddy, 1991). A number of protozoa are pathogenic e.g giardia lamblia, the cause of giardiasis.

Algea

Algea are microscopic photosynthetic plants of the simplest forms, having neither roots, steams non leaves (Hammer and Hammer 2004) they can be of great, nuisance in surface water because when conditions are right, they will rapidly reproduce and cover stream. Reservious and lakes in large floating colonies called blooms (metcalf and eddy, 1991) entrophic lake occurs as a result of algal bloom, giving off odours and taste (okedi 1997).

CHAPTER THREE

3.0 MATERIALS AND METHODS

This covers the steps taken in the process of gathering the materials, the methodology applied in the laboratory analysis, the collection of the project results and analysis.

The first determinant is the selection of area that will give a representation of different human environment, the different anthropogenic activities that will greatly influence the physico chemical and bacteriological qualities of a River. Njaba River was selected as all the element that will lead to good research study were present in this axis – the quiet river site, the river site close the market, abattoir, cassava fermentation, car washing etc and the site close to sand excavation.

The next thing that was done after Site selection is the Site visitation on several occasions. This is done for a period of one month, to study the people and sample areas. Questions were asked and pattern of life/activities of the Nnenasa indigents were monitored on different time – Morning, Afternoon and Evening for anthropogenic activities.

The next thing was the collection of samples from three sampling areas – **Sample A** from the Forest area with almost no activities, **Sample B & C from Savannah vegetation area** – near market and near sand excavation site – Several representative sample were gotten and high precaution observed during sample collection depending on the type of test.

The test samples were subjected under different type of tests using different Laboratory equipment.

Finally the result was gotten from the individual sample test, analysis and conclusion was eventually drawn from this.

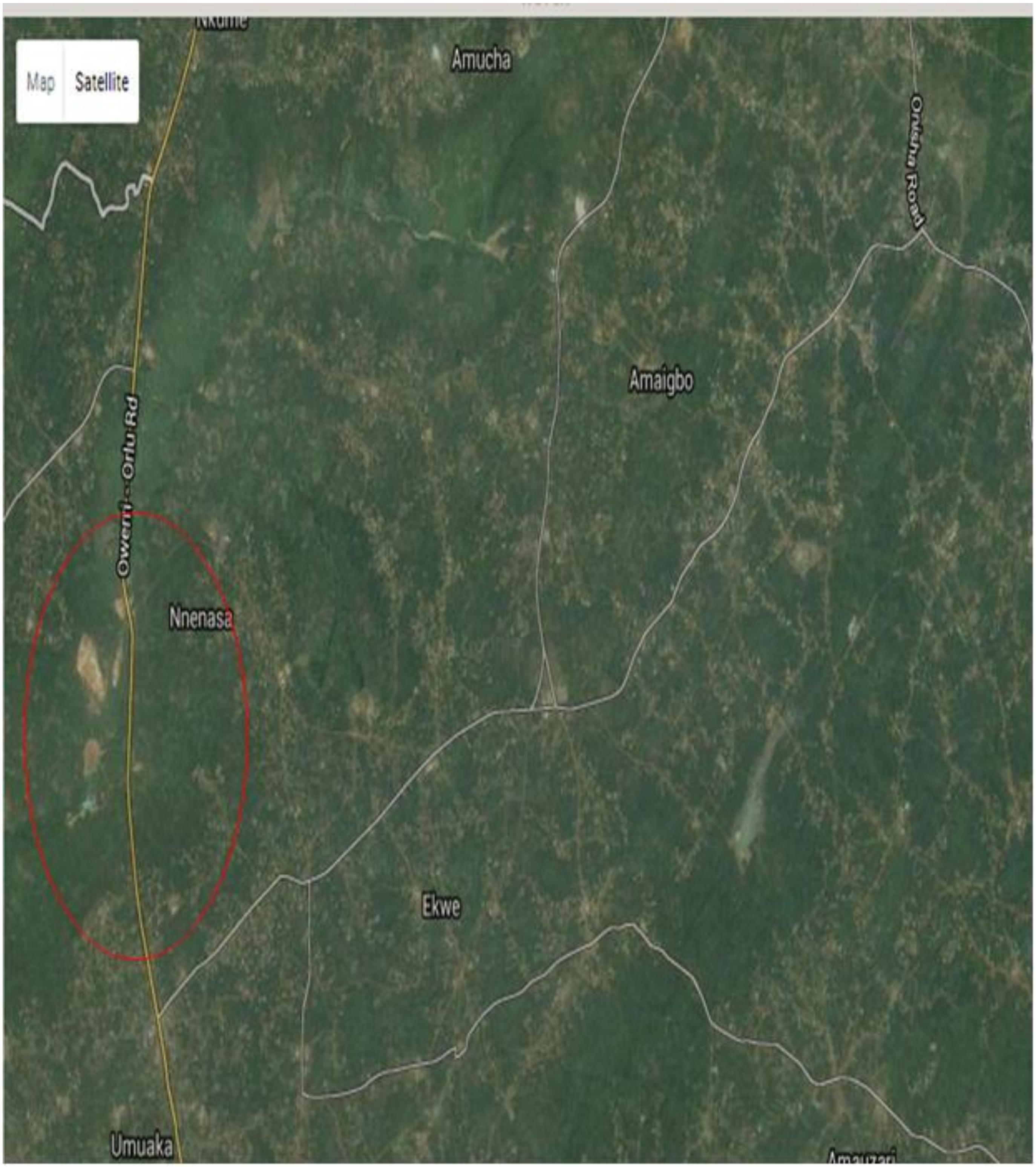
3.1 Study Area

For the purpose of this study, the selection of area was dependent on a representative environment, where a body of river is present, where different anthropogenic activities takes place with the possibility of impacting the physico-chemical and bacteriological qualities of a river. Hence, Nnenasa area was selected as the study Area and Njaba River as the river of interest.

Study Area: Nnenasa in Isu Njaba LGA of Imo State

Nnenasa is conveniently located in the border between Okwudor and Nkume, along the busy Orlu Owerri Federal highway. It is sited within 15 km from Owerri, and 7 km from Orlu. The town is underlain by laterite extensive elastic deposit. The town is covering an area of **83,9439SQ.KM.** As a result of interspaced infrastructural development and its urban status. With the riparian areas of the Isu Njaba River are several anthropogenic activities that impinge on the quality of the river due to the composition of domestic, commercial and industrial wastes disposed into the river system. Nnenasa is located in the southern part of Isu local government area of Imo state. The town lies on an undulated plain, with a natural boundary caused by the flow of the Njaba River. The Njaba River separates the town from Amucha, Okwudor and some parts of Umuaka. See Satellite Map below.

Figure 1: Satellite Map of Nnenasa Area – Isu Njaba LGA.



3.1.1 TOPOGARPHY

Nnenasa community is the headquarter of Isu Njaba LGA. The Local Government is made up of huge rain forest and valleyed topography in most places between Umuaka and Okwudor. it hinterland is located in the Northern part of the eastern coastal lowlands. Theses coastal plains are to tertiary plains and the south of the scar plenets and the scarphenels are predominantly area and deposition (Fingerhuth and partners 1977).

3.1.2 Climate

Nnenasa community in Isu Njaba LGA of Imo State is located at the sub-equatorial zone. The community experience about 244 cm/year of rainfall.

There are two distinct seasons:

(a) The dry season, which lasts from October until April is determined by high

temperatures and low humidity, and is affected by warm winds coming from the Sahara Desert to the north.

(b) The long rainy season which starts from May to October? It is usually characterized by heavy rainfall and high humidity. The community recieves between 2,000 and 3,000 mm (118.1 in) of rain per year, which is same as the rainfall receives in South Eastern Nigeria.

3.1.3 **Vegetation and Soils**

Plant group found in the study area can be classified into forest
and savannah.
This was put into consideration during the collection of samples for analysis.

The vegetation in the area marked (Upstream - mapped A) is a forest region with significant tree cover or canopies and under growths. The soil is a humus soil.

The region around the stream (Middle – B & Down Stream C) is a savannah vegetation with grasses located in between the trees that are inter-spaced.. The soils are predominant tertiary sandy clay which is highly leached.

3.1.4 Economic Activities

They practice subsistence farming with products such as oil palm. Palm wine, cassava and edible fruits. Others are civil servant and sand excavators.

3.1.5 The Anthropogenic Activities and Water Utilization Pattern of Njeba River.

The term is often used in the context of environmental externalities in the form of chemical or biological wastes that are produced as by-products of otherwise purposeful human activities. Anthropogenic activities are human impacts in the environment.

In order to measure the anthropologenic activities of man on Njaba river, a lot of visitation of the site were undertaken. We generally observed and classified the human activities around the Njaba River based on five parameters namely: Occasional, Regular, Frequent, Very Frequent and Nil.

Marketing: There is a market near the Njaba River. In this market, there is an abattoir and restaurants. Some butchers were seen washing the meat in the river. Cow dung and the contents of butchered animal intestines are usually washed in the river. The topography is sloppy towards the river and this implies run-oofs from the market will always empty into the river and affects the quality.

Bathing & Cloth washing: This is rampant in Njaba especially the Midstream -B portion – Picture 2. Upon visitation, one would have the impression that entire communities living around always wash their cloths in the river bank. There were a lot of people seen, equally bathing at the bank of the Njaba river. Cars are equally washed around the middle part of the Njaba River. These activities can significantly alter the water quality.

Sewage disposal: On one of the occasion, we observed a sewage truck discharge its content Downstream C the Njaba river in the evening – Picture 2.. We were informed that Government officials are usually around to discourage this activity but occasionally, it still does happen. Apart from that, people equally defecate around the banks of the river in some areas over gown by weeds. This eventually finds itself inside the river and contributes to its pollution.

Excavation of Latrite/Quarrying: This happens at the Site downstream the river. We usually observe many tippers going to carry sand/Latrite. Some of the time, these vehicles break down and they are service there. The engine oil and other hydrocarbon constituents are usually dumped into the river.

Farming/Irrigation: the people of Nnenessa and Okwudor are subsistent farmers. In a bid to have a good yield, they apply fertilizers. The compounds of this fertilizers normally run-off into the river and alters the water concentration. This happens frequently during rainy or when people try to physically irrigate their farmland by using generators and hoses to draw the river water.

3.1.6 Methodology

Frequent visits to the sites and sampling for laboratory research formed the framework of this project. While the regular sites visits provided some information on the activities at the river, the laboratory analysis was used to determine the river quality.

3.2 Selection of Sampling Stations

Sampling at the river were done upstream, midstream, and downstream with interests on the point of solids waste and sewage disposal.

3.3.1 Physico –Chemical and Microbial Parameters of the River

The important parameters which were analyzed include:

- Colour
- Odour
- Appearance
- Ph
- Temperature
- Conductivity
- Tds

- Tss
- Turbidity
- Dissolved oxygen
- BOD
- COD
- Total viable bacteria
- Total coliform bacteria
- Nitrates
- Sulphates
- Phosphates
- Total hardness
- Iron
- Copper

3.4 Field Techniques

The samples for physico-chemical analysis were collected with 2 liter plastic containers at different points – **Upstream (A), Midstream (B) and Downstream (C)**. See attached Satellite map below – Figure 2.

Figure 2: Satellite Map of Research Area Showing Sampling Regions.

The reason is for wide coverage and equally to get a representative samples for analysis, so as to arrive a robust result of water changes which could be caused by anthropogenic water usage. The samples for dissolved oxygen and biochemical oxygen demand were collected with 25 ml amber coloured BOD bottles while the samples for microbial analysis were taken using a pre- sterilized 5litters container preserved in an ice chest from the site to the laboratory to slow down the oxidation process, which could affect the outcome of the result.

The rest of the water sample was collected with a 10litter plastic container.

It is necessary to state that all the samples were collected beneath the water surface where there is thorough mixing and possibility of getting a representative sample high.

Anthropogenic activities data gathering:

The method employed for the gathering of the anthropogenic activities is by direct observation/monitoring, conducted by visiting the Site at staggered hours and for one month. We visited the market and sand/quarrying sites on numerous occasions and interviews a lot of people that we met on ground.

3.5 Laboratory Methodology

(I) Colour, Odour and Appearance

HACH DR/2010 spectrophotometer was used to determine the sample colour.

25ml of filtered deigned water was introduced into a sample cell bottle and used as blank. The samples were shaken vigorously and 25ml was introduced into another sample cell bottle.

The programme number 120 and wavelength 455mm were entered and the blank was used for zeroing. The sample was placed into light shield and the value was read in platinum cobalt unit (pt/co).

For odour and appearance, visual analysis was done using the sense of smell and sight.

(ii) pH and Temperature

Suntex pH and temperature meter was used to determine these parameters. The probe was calibrated using buffer solution with 7.00 for alkalinity and 4.00 for acidity. The probe was rinsed with de-ionized water. The probes inserted into sample and powered on to read the pH value. The moda bottle was pressed twice to read the temperature value in DegC.

(iii) **Conductivity and Total Dissolved Solids (TDS)**

Using Suntex conductivity / TDS meter, the probes were rinsed with de-ionized water and inserted into 50ml of the sample contained in a beaker. The conductivity was read in us/cm. When the cup button was pressed. The TDS button was pressed and it value was read digitally in mg/l

(iv) **Total Suspended Solid (TSS)**

HACH DR/2010 spectrophotometer was used. 25ml of filtered de-ionized water was put in sample cell bottle and used as a blank for zeroing. The sample was shaken vigorously and 25ml was introduced into another sample cell bottle. The programme number 630 and wavelength 810mm were entered and the blank was used for zeroing. The sample was placed in the light shield. Closed and the value was read in mg/l

(v) **Turbidity**

Using the spectrophotometer, 25ml of filtered de-ionized water was put into a sample cell bottle and used as blank for zeroing. The progamme number 750 and wavelength 860mm was obtained from the spectrophotometer. The blank was placed in the light shield and the value was read in nephelemteric turbidity (ntu)

(vi) **Nitrate**

Using cadmium reduction method, the programme number 355 wavelength 507mm was selected from the spectrophotometer and 25ml of de-ionized water was used as blank. 25ml of the sample was introduced into a sample cell bottle and the content of one nitraver 5 reagent power pillow was added and swirled thoroughly to mix so as to obtain a homogenous texture. The shift timer was pressed and timed for one minute, at the beep of the timer; it was set off five minutes. The blank was used for zeroing and the treated sample was placed in the light shield covered, and the nitrate value was read in mg/l

(vii) **Sulphate**

Programming number 680 and wavelength 450mm were entered on the spectrophotometer. One suphaver 4 powder pillow was added to 10ml of the sample contained in a sample cell bottle and swirled to mix thoroughly. The timer was set for 5 minute and 10ml of de-ionized water in a sample cell bottle was used for zeroing. The treated sample was put in the light shield, covered and it value was read digitally in mg/l

(viii) Biochemical Oxygen Demand (BOD)

The initial dissolved oxygen of the sample was taken. A known quantity of the sample was incubated in the dark at $20^{o}c$ for five days after which the dissolved oxygen content was determined. The variation between the initial and the final DO provided the BOD's of the sample in mg/l (APHA, 1971)

(IX) Dissolve Oxygen

The winker's lodometric method which involves the chemical fixation of oxygen described by (APHA, 1971) was used in determining of the DO, in mg/l (APHA, 1971).

(X) Chemical Oxygen Demand (COD)

The sample was refluxed with a strong oxidizing solution of dichromate for 2 hours. Excess dichromate was back titrated with ferrous indicator, the amount of oxygen considered gave the COD in mg/(APHA, 1971)

(xi) **Total Hardness**

The ethylenediamire tetra acetate (EDTA) titration method using Eriochrome black indicator and ammonia buffer solution was used to determine the hardness in tern of mg/l caco3 (APHA, 197)

(xii) **Iron**

The spectrometric programme value number 265 and wavelength of 510nm used. The sample was shaken thoroughly and an amount of 10ml was introduced into 2 sample cell bottle each. One was kept as blank and the other; one ferrous reagent powder pillow was introduced and swirled in order to get a homogenous solution. The shift timer was set for 3 minutes and the blank was used for zeroing. The treated sample was placed in the light shield and the value was read in mg/l

(XIII) Copper

On the spectrophotometer, the programme number 135 and wavelength 560mm was introduced into 2 10ml of the sample cell bottle each. Other was kept blank and the other, a content of cuver 1 reagent powder pillow was added and mixed thoroughly. The shift timer was used for 2 minutes and the blank was used for zeroing. The treated sample was placed in the light shield and the value was read digitally in mg/l.

(iv) **Bacteriological Determination**

(i) Total Coli form Bacteria: these were cultured using MacConkey agar medium in membrane filtration technique.

(ii) Total Viable Bacteria: these were cultured with nutrient agar

medium in membrane filtration.

(iii) Salmonella shigella bacteria: these were cultured with prepared salmonella Shigella agar medium in membrane filtration method.

The procedure for membrane filtration technique used is as follows:

The Media-Nutrient agar MacConkey agar and Salmonella Shigella agar were prepared by dissolving them in a conical flask with appropriate quantity of distilled water. The flask was plugged with cotton wool and aluminum foil and autoclaved at 121 for 30 minutes. The Media was poured into sterilized Petri-dishes and allowed to cool and solidify.

A sterile membrane filter was folded into a conical shape, placed in a sterile funnel and 100ml of sample was passed through it.

With a pair of sterilized forceps, the wet membrane filter was dropped on top of the solidified anger plate and incubated for 24hours at 37^{o}C. The member of colonies formed within the holes of the filter was counted for total viable bacteria, total coliform bacteria and salmonella shigella. The results obtained were express in cfu/100ml.

CHAPTER FOUR

4.0 Results, Analysis and Discussion

4.1 Anthropogenic Activities and Water Utilization Pattern at Njaba River.

Table 7: Anthropogenic Activities of Communities around Njaba River

Activities	**Frequency**
Fishing	☐ ☐
Cassava fermentation	☐ ☐ ☐
Transportation	-
Drinking	☐ ☐ ☐
Irrigation and farming	☐ ☐ ☐
Swimming	☐ ☐ ☐
Defecation	☐ ☐ ☐
Bathing	☐ ☐ ☐ ☐
Solid waste disposal	☐ ☐

Cloth washing	□ □ □ □
Animal washing	-
Excavation and quarrying	□
Automobile	-
Mechanic shop	□ -
Recreation	□
Marketing	□ □ □ □
Religion	□ □
Food washing	□ □ □
Sewage/wastewater disposal	□ □
Car washing	□ □ □
Blocking moulding	-

Legend

□ = Occasional

□ □ = Regular

□ □ □ = Frequent

□ □ □ □ = Very Frequent

-                    =   Nil

Table 8: Anthropogenic Activities and their Impacts on the Aquatic Life

Ecosystem under study – Njaba River

Activity	**Impact**
Cassava fermentation	Introduces cyanide and organic
Farming /irrigation	Run off from farm manures and agrochemicals, introduction of nutrients
Solid waste dumps	Depletion of DO and microbe of dissolved oxygen and high biochemical oxygen demand
Excavation & quarrying	Introduction of suspended solids, sulphates & trace metal
Bathing and cloth washing	Introduction of orthophosphates
Food washing	Discharge of organic wastewater and solid Waste
Automobile service shops	Oil discharge, grease and hydrocarbon
Block industry	Suspended solids
Market	Commercial waste input

Table 9: Result of Physico-Chemical and Bacteriological Parameters of Njaba River.

Njaba River Results.

Parameters	**Upstream (A)**	**Mid stream(B)**	**Down stream©**	**Mean**
Odour	Odourless	Odourless	Odourless	-
Colour (Pt/Co)	11.00	17.00	12.00	13.3
Temperature (oc)	27.00	30.00	35.00	30.67
pH	5.42	5.37	5.32	5.37
Conductivity(us/cm)	390	450	420	420
TSS (mg/l)/TDS	15.00/342	22.5/390	21.0/380	19.5/371
Turbidity (ntu)	50	85	80	71.67
Nitrate (mg/l)	0.52	3.81	2.39	2.24
Total hardness(mg/$Coco_3$)	23.00	7.18	7.76	12.85
Phosphate (mg/l)	5.73	3.07	1.23	3.34
Sulphate (mg/l)	25.03	17.18	15.11	19.11
DO (mg/l)	9 .0	15.0	13.0	12.3
COD (mg/l)	5.0	8.0	7.0	6.67
Iron (mg/l)	0.90	2.01	2.14	1.68
BOD(mg/l)	11	40	32	27.6
Copper (mg/l)	1.55	3.79	2.32	2.61
Total Coliform Bacteria (efu/100ml)	15	80	60	51.6

Total viable bacteria (efu/100ml)	45	50	47	47.3

Table 10:

Comparative Analysis of Quality Parameters of the River with WHO standards.

Parameters	Njaba River	WHO drinking water standards (permissible limits)	Nigeria Institute of Standards NIS 554: 2007	FEPA Standard
Color	11	15	15	15
Ph	5.37	6.5 - 8.5	6.5 - 8.5	6.0 – 9.0
Nitrates (mg/l)	2.24	50	-	-
Turbidity	71.67	50	50	-
Total hardness mg/l	12.85	100	150	-
Sulphates (mg/l)	19.11	350	100	-
Phosphates (mg/l)	3.34	5.0	-	-
Temperature (^{o}c)	30.67	<35	-	27
Conductivity (us/cm)	420	250	-	200
TDS mg/l	371	500	500	450
TSS (mg/l)	19.5	5 - 10	-	>10
Total coliform bacteria	51.6	5 - 10	-	-
Copper (mg/l)	2.61	.30	1.0	

Iron (mg/l)	1.68	1.0	0.3	
COD (mg/l)	6.67	40	-	
BOD (mg/l)	27.6	10	10	40
DO (mg/l)	12.3	8 - 10	8 - 10	30

4.2 Analysis of the Result Obtained From Finding at the River

The result from Table 8 & 9, showed that most pollution –causing activities occur in Njaba River.

The high turbidity of the river could be as a result of run-offs from the nearby market and occasional dumping of waste by products into the river.

The high conductivity of Njaba River is as a result of the dissolved chloride of ions from the quarrying site. The same thing is applicable for the high Iron content of 1.68mg/l above WHO standard of 1.0mg/l.

4.3 Analysis of Result on Anthropogenic Activities and Impacts

From the Table 7, It was observed that human activities are the greatest causes of the reduction of river quality and its biodiversity. Different activities which go on around the river include cassava fermentation, food washing, bathing, defecation, cloth washing, animal washing, etc were found to adversely affect the river quality. These anthropogenic activities and their impacts are summarized below.

Farming and Irrigation

Fertilizers, pesticides, and herbicides are persistently used for agricultural activities within this area to improve crop yield. However, rain washes off copious quantities at this compound as runoff into the streams. This accounts for the presence of nitrates, phosphate and trace metals within the river. Nutrient enrichment results from this, thus promoting the excessive growth of algae and water weed. These activities contributed to the depletion in the level of the available dissolved oxygen.

Abattoir

The location of abattoir in the market closest to the river equally contributed to the to the pollution of Njaba River. The copious amount of blood, feaces and different animal's wastes such as intestines are processed, washed and or disposed off into the river. The butchers skin their animal by making a fire with used car tires and at the end; the soot is discharged into the water. These organic materials also combine to affect the river quality by depleting dissolved oxygen needed to degrade the wastes to stable end products. The fecal contamination from animals dung also result to incessant disease outbreak with the area.

Sewage Disposal

Open sewers carry storm runoff and sanitary waste into the river. The constituents of the sewage (phosphate, nitrates, organisms and putriscrible matter) degrade the water quality. Various pathogenic bacteria found in domestic sewage discharge can lead to serious illness and disease to man. Domestic sewage also comprises of alkryl benzene sulphate (ABS) used in detergents which is toxic and could result to fishery problems.

Bathing and Cloth Washing

Orthophosphates utilized for soap and detergent manufacture affects the river quality by decreasing productivity. A toxic constituent of detergent include alkyl/benzene sulphate (BS).

Food Washing

The direct utilization of the river for the washing of food items introduces tons of organic material into them. Organic wastes dramatically reduce the dissolved oxygen levels, increasing the biochemical oxygen demand.

Markets

Commercial activities introduce several tons of food remains, nylon paper, etc, causing depletion in oxygen and foul smell around the river environment.

4.4 Discussion on the Comparative Analysis of Njaba River

Facts from the analysis of variance show that there was a significant different at probability of level ($p<0.05$) between the parameters and river under review.

pH

This is the regulation of chemical and biological reactions in aquatic system and the toxicity of many chemical compounds is a function of this parameter. From WHO , Nigeria Industrial Standard and Nigeria Standard for drinking water (NSDWQ) Standard, permissible range of pH is 6.5 – 8.5 and when compared with result in Table 10, Njaba River is within limit at 6.5 – 8.5 respectively.

Conductivity

From Table 11 above, Njaba River was found to be high above the WHO and FEPA standards. This refers to a conductivity of 450 us/cm, which is above the standard of 200us/cm. This is related to the excavation and quarrying activities beside the river which introduce mineral salt and dissolved/dissociated ions like sodium, sulphates and chlorides into the river.

Total Suspended Solids

The concentration obtained from Table 11 shown that Njaba River is slightly above the WHO recommendation but within the FEPA standard of >10mg/L. The total suspended solid is important in the light transmitting properties of a river, consequently affecting photosynthetic organisms positively or conversely.

Total Dissolved Solids

Njaba River from Table 11 was found to be normal within both the WHO and FEPA standards of 500mg/l. However the value of 450mg/l of the Njaba River could be attributed to dissolve salt from the excavation and quarrying sites carried to the river with run off. This is in addition of the community market nearby, from where market products are brought to the river to be washed. The total dissolved solids affects conductivity largely and both are important in establishing polluted rivers due to affluent discharge and runoff water.

Colour

Visible colour is caused by dissolved and particulate substances present in water. Natural waters range from less than 5pt/co in very clear waters to 300pt in dark peaty water. From Table 11, Njaba River was found to have 11.00 pt/CO respectively conforming to WHO standard of 15pt/CO

Temperature

The temperature of surface water usually ranges within $0^{o}c$ – $30^{0}c$, although "hot spring may reach $40^{0}c$ or more (Chapman, 1992). In table 11 Njaba at $30.67^{0}c$ when compared with WHO standard. This high temperature is objectionable as it affects physical, chemical and biological process within the river especially in the solubility of dissolved gasses and depletion of dissolved oxygen due to increased metabolic rates.

Total Hardness

Njaba River is very soft. Its values were recorded at 12.85mg/l caco2 as compared with WHO standard of 100mg/l $caco_2$. The river presented slight hardness at 103.79mg/$Caco_2$ upstream. This was due to the presence of sulphates in the water.

Nitrates

The standard concentration of nitrates in surface water around 1.5mg/l levels in excess of 5mg/l. This indicates pollution by human or animal waste or fertilizer runoff. Njaba River was with the prescribed standard. It has a concentration of 2.24 mg/l which is attributed to intensive farming beside the river.

Phosphate: From table 11, Njaba River at 3.34 mg/l respectively was found to be normal as compared with WHO standard of 5.00 mg/l. This concentration is associated fertilizer from farmland runoff inputs to the river sulphate.

Concentration in natural water ranges between 2 and 80mg/l. The concentration of Njaba River at 19.1 respectively is within WHO standard which is 250mg/l.

Dissolved Oxygen

Dissolved Oxygen concentration in the result is within the WHO and FEPA recommendation. A value below 2mg/l may lead to death of most aquatic life. From table 11, Njaba River was found to be above standard at 12.3mg/l. This accounted for the considerably high fish production.

Biochemical Oxygen Demand

Unpopulated water has BOD values of 2mg/l or less while other receiving wastewater has values of 10mg/l or more. Comparing the value of the river with

WHO standard, Njaba river was found to be abnormal with high values of 27.6mg/l above the recommended WHO standard of 10mg/l. This could be attributed to petrochemical pollutants brought in by mechanic servicing the sand trucks. Again, the flagrant pouring of used oil and spilled diesel inside the river can as well contribute to this.

Chemical Oxygen Demand.

The concentration observed in natural waters range from 20mg/l or less. In comparison to WHO standard of 40mg/l, Njaba river as reported in Table 11, was founded to be absolutely normal at 6.92mg/l respectively.

Iron

The WHO standard for Iron (Fe) in drinking water is 1.0mg/l and from available result, in Table 11, Njaba River presented the high value of Iron at 1.68mg/l. This concentration is related to the iron bearing rocks dissolved from the excavation sites into the river from runoff

Copper

From table 11, Njaba River with value 2.61mg/l was above WHO standard of 0.3mg\l. The reason for this is because of sand excavation that is being carried out by the bank of the water. Trace chemicals are released and this, find their way into the river.

Total Viable Bacteria

WHO stipulates that no more than 5-10 organisms should be present in each 100mg/l of sample. However, Njaba River from Table 11, were clearly above 47 cfu respectively.

Total Coliform Bacteria

This is a very important indicator. It establishes the pathogenecity of a river. The Njaba River was not highly affected by faecal matter from results obtained. The concentration was found to be 51.6 cfu/100ml and this is attributed. This can be easily attributed to the sewage discharge into the river orchestrated by high density of population of people living around.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The findings from the research suggest that anthropogenic activities around the river, impacts on its quality. This occurs largely due to intensive agricultural activities which are predominant along the river banks.

High concentrations of nitrates, sulphate and phosphates were evident as seen from the results. The conductivity of the river on the other hands was high, largely due to free ion radicals of salts that dissolve in the water.

The problem is aggravated more because of the presence of erodible soils existing along the river banks.

Njaba River showed high susceptibility to pollution because of several tons of sundry wastes which is dumped along the river basin. These wastes caused a reduction in the amount of viable dissolved oxygen and consequently increased the biochemical oxygen.

The high coliform content of Njaba River is attributed to feacal contamination of the water and this led to high bacteriological activities.

From the above, it can be seen that the Njaba River is highly polluted and not fit to be consumed by the local populace without some form of water treatment.

5.2 Recommendations

To prevent further pollution of Njaba River and made it usable, the following recommendations are put forward.

(a) The abattoir and the market nearby contributed a lot of pollutants in the river. It is therefore recommended that that incinerator is built for the butchers to properly burn their wastes. Meat washing bays and bins should be provided in the abattoir to discourage the butchers from coming to the stream to watch their meat or dispose their waste.

(b) The indigenes of Nnenasa, Okwudor, Ekwe and umuaka communities should as much as possible, be discouraged from disposing palm oil wine feats into the river so as to reduce the large scale degeneration of the watershed.

(c) Sewage disposals should be properly done and not disposed off directly into the river without proper treatment procedures. Strict monitoring is therefore required and severe penalty recommended for any offender.

(d) The solid waste dumped along the river bank should be managed with proper methods such as sanitary landfill, composting, etc

(e) Government should enact laws which would protect water courses. River development authorities that are charged with the mandate of monitoring River basins, should extend their activities to smaller river courses like that of the Njaba River

(f) Farming activities especially those utilizing fertilizer should be limited to not less than 1 km from the river banks so as to prevent massive leaching and runoff bearing nutrients from getting into t he river.

(g) Water which is used for drinking, cooking and washing from the river should be treated before use.

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