ASSESSMENT OF WATER QUALITY IN IMO RIVER AT OYIGBO LOCAL GOVERNMENT AREA, RIVERS STATE

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CERTIFICATION

This is to certify that this work **"ASSESSMENT OF WATER QUALITY OF IMO RIVER AT OYIGBO LOCAL GOVERNMENT AREA RIVERS STATE."** was carried out by **FAVOUR, DORNUBARI NWIDU** with Registration Number **20105770229** in partial fulfillment of the requirements for the Award of Master of Technology (M.Tech.) degree in Environmental in the Department of Environmental Technology, School of Environmental Sciences, Federal University of Technology, Owerri (FUTO)

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DEDICATION

This project is dedicated to God Almighty for giving me the grace and strength to complete this work and also to my family and friends in church, school and work for their love and support in making this programe a huge success.

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ABSTRACT

The water quality of the Imo River in Oyigbo local government area was ascertained using standard methods in this research. The important physicochemical characteristics of the river were investigated during the wet season of 2013 at six sampling locations. *In situ* measurements were made for water temperature, salinity, turbidity, dissolved oxygen (DO), biological oxygen demand (BOD), etc using the HORIBA U-10 water quality checker. The total dissolved solids and total soluble solids etc were determined with HACH conductivity/TDS meter. Water samples were collected in replicates with 2 liters plastic containers and taken to the laboratory in iced coolers for analysis. The test for homogeneity in mean variance was used to determine spatial variation in the physicochemical variables. The eckman grab sampler was used to acquire sediments to test for the physicochemical variability of the sediments from the river. The physicochemical variability for the Imo river from the six sample locations indicated that Water temperature varied between (27.00- 28.00˚c), ph (6.3-6.6), turbidity (15-71 NTU), electrical conductivity (19.9- 82.0µs/cm), dissolved oxygen (4.8- 7.05mg/l), biological oxygen demand (2.10- 3.20 mg/l), total dissolved solids (19.9-30.30mg/l), total hydrocarbon (0.010-0.031mg/l), total soluble solids (3.6- 9.1mg/l), nitrates (0.13-0.43mg/l), phosphates (0.07-0.11mg/l), sulphates (0.99-7.00mg/l), and chlorides(0.01-0.08mg/l), on the other hand the physicochemical variability of the sediments from the six sample locations indicated that ph varied between (6.85-6.98),total hydrocarbon(0.22-4.84mg/kg), nitrates(0.22-0.71mg/kg), phosphates (0.41-1.10mg/kg), and sulphates(30.80-65.20mg/kg).While, the microbiological variability of the sediments indicated that total heterotrophic bacteria varied between(2.30-2.80x10^2), total heterotrophic fungi (5.0-6.3x10^2), hydrocarbon utilizing bacteria(1.40-1.95x10^2), and hydrocarbon utilizing fungi between(2.60-3.50x10^2). The results obtained for the physicochemical parameters and microbial variability agreed with the permissible limits set by both national and international bodies for drinking and domestic water and for the sustenance of aquatic life with few exceptions.

Keywords: Water quality, physicochemical, hydrocarbon, microbiological, and Heterotrophic.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Overview

Water quality assessment can be defined as the overall process of evaluation of the physical, chemical and biological status of water in relation to natural quality, human effects and intended uses, particularly uses which may affect human health and the health of the aquatic system itself, (Bartram and Ballance, 1996).
It includes the use of monitoring to define the condition of the water, to provide the basis for detecting trends and to provide the information enabling the establishment of cause-effect relationships. Important aspects of an assessment are the interpretation and reporting of the results of monitoring and the making of recommendations for future actions

According to Ibeh and Mbah (2007), the quality of any body of surface or ground water is a function of either or both natural influences and human activities. Without human influences, water quality would be determined by the weathering of bedrock minerals, by the atmospheric processes of evapotranspiration and the deposition of dust and salt by wind, by the natural leaching of organic matter and nutrients from soil, by hydrological factors that lead to runoff, and by biological processes within the aquatic environment that can alter the physical and chemical composition of water, (Akaishi *et al*., 2004). As a result, water in the natural environment contains many dissolved substances and non-dissolved particulate matter. Dissolved salts and minerals are necessary components of good quality water as they help maintain the health and vitality of the organisms that rely on this ecosystem service, (Stark *et al*., 2000).

Though, water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities, (Cambers &Ghina, 2005). Water abstraction for domestic use, agricultural production, mining, industrial production, power generation, and forestry practices can lead to deterioration in water quality and quantity that impact not only the aquatic ecosystem (i.e., the assemblage of organisms living and interacting together within an aquatic environment), but also the availability of safe water for human consumption, Agbozu and Emperor (2004). It is now generally accepted that aquatic environments cannot be perceived simply as holding tanks that supply water for human activities. Rather, these environments are complex matrices that require careful use to ensure sustainable ecosystem functioning well into the future.

Moreover, the management of aquatic environments requires an understanding of the important linkages between ecosystem properties and the way in which human activities can alter the interplay between the physical, chemical and biological processes that drive ecosystem functioning, (Agbozu & Izidor, 2004). Providing safe and secure water to people around the world, and promoting sustainable use of water resources are fundamental objectives of the Millennium Development Goals. The international community has recognized the important links between ecosystem and human health and well-being, particularly as human populations expand and place ever greater pressures on natural environments.

However, the ability to properly track progress toward minimizing impacts on natural environments and improving access of humans to safe water depends on the availability of data that document trends in both space and time. As such, ongoing monitoring of both water quality and quantity in surface and ground water resources is a necessary activity at all governing levels: local, national, and international.

Water quality and quantity are intimately linked although not often measured simultaneously, (Amadi *et al.*,2004). Water quantity is often measured by means of remote hydrological monitoring stations which record water level, discharge, and velocity. Monitoring of water quantity can be undertaken, to a certain degree, with a minimal amount of human intervention, once a monitoring station has been set up. In contrast, water quality is usually determined by analyzing samples of water collected by teams of personnel visiting monitoring stations at regular intervals. "The costs associated with monitoring the many parameters that influence water quality, when compared to those associated with monitoring only a few water quantity variables, usually means that water quality monitoring is not undertaken as frequently as water quantity monitoring. However, the results of water quality monitoring are vital to being able to track both spatial and temporal trends in surface and ground waters, (APHA 2005).

Water can also contain substances that are harmful to life; these include metals such as mercury, lead and cadmium, pesticides, organic toxins and radioactive contaminants. Water from natural sources almost always contains living organisms that are integral components of the biogeochemical cycles in aquatic ecosystems. However, some of these, particularly bacteria, protists, parasitic worms, fungi, and viruses, can be harmful to humans if present in water used for drinking, (Chindah *et al.,* 2004).

The availability of water and its physical, chemical, and biological composition affect the ability of aquatic environments to sustain healthy ecosystems: as water quality and quantity are eroded, organisms suffer and ecosystem services may be lost. Moreover, an abundant supply of clean, usable water is a basic requirement for many of the fundamental uses of water on which humans depend.

These include, but are not limited to:

- water used for human consumption and public water supply;
- water used in agriculture and aquaculture;
- water used in industry;
- water used for recreation; and
- water used for electrical power generation

The quality of water necessary for each human use varies, as do the criteria used to assess water quality. For example, the highest standards of purity are required for drinking water, whereas it is acceptable for water used in some industrial processes to be of less quality. The quality of water required to maintain ecosystem health is largely a function of natural background conditions. Some aquatic ecosystems are able to resist large changes in water quality without any detectable effects on ecosystem composition and function, whereas other ecosystems are sensitive to small changes in the physical and chemical makeup of a body of water and this can lead to degradation of ecosystem services and loss of biological diversity (Obunwo, 2003).

The degradation of physical and chemical water quality due to human influences is often gradual, and subtle adaptations of aquatic ecosystems to these changes may not always be readily detected until a dramatic shift in ecosystem condition occurs. For example, in many shallow European lakes, the gradual enrichment of the surface water with plant nutrients has resulted in shifts from systems that once were dominated by rooted aquatic plants to systems that are now dominated by algae suspended in the water column (Scheffer *et al*., 2001). Regular monitoring of the biological, physical, and chemical components of aquatic ecosystems can serve to detect extreme situations in which the ability of an ecosystem to return to its normal state is stretched beyond its limit.

Typically, water quality is determined by comparing the physical and chemical characteristics of a water sample with water quality guidelines or standards. Drinking water quality guidelines and standards are designed to enable the provision of clean and safe water for human consumption, thereby protecting human health. These are usually based on scientifically assessed acceptable levels of toxicity to either humans or aquatic organisms. Guidelines for the protection of aquatic life are more difficult to set, largely because aquatic ecosystems vary enormously in their composition both spatially and temporally, and because ecosystem boundaries rarely coincide with territorial ones (Nweke, 2000).

Therefore, there is a movement among the scientific and regulatory research community to identify natural background conditions for chemicals that are not toxic to humans or animals and to use these as guidelines for the protection of aquatic life (Robertson *et al*., 2006; Dodds & Oakes, 2004; Wickham *et al*., 2005). Other guidelines, such as those designed to ensure adequate quality for recreational, agricultural or industrial activities, set out limits for the physical, chemical, and biological composition of water needed to safely undertake different activities.

1.2. Statement of the Problems

According to Oguariri (1998), the development of rivers and water resources is essential for a wide range of human activities notably agriculture, food and energy production but we know that water can be put into best use when it is in a pure state. When the quality of water is impaired however, a lot of problems arise. Polluted water is a major cause of human disease, misery and death. According to Ukpak (2001), water borne pathogens that contribute to typhoid, cholera, amoebic infections, bacillary dysentery and diarrhea account for 80% of all diseases in developing countries and at least responsible for up to 90% of the 13 million child deaths each year.

The impairment of water quality can be caused by point or non-point sources (Smith, 2006).Water pollutants include sewage, nutrients, wastewater, chemical wastes, radioactive wastes, oil pollution, plastics, waste from animal feed lots, alien species, heat from factories, sediments and so on (Okereke, 2006).

According to Kanayo (2004), environmental degradation in the form of water quality impairment is essentially an economic problem, more so that it is a by-product of production and consumption activities. The resulting environmental ills he noted, pose extreme health hazards and loss of income for the growing number of people exposed to them e.g. methaemologlobinaemia is likely to be more acute in less developed countries where potable water is not readily available and there is inadequacy of fresh food (Dudley,1990). Another manifestation of water pollution is the presence of freshwater parasites, and bacteria such as *bilharzias* and *E-Coli*, (Uchegbu, 2000).

There are about 3 major industrial plants situated along the stretch of the middle course of the Imo River: an Afam electrical gas plant, a shell gas plant and an NNPC, Nigerian gas plant. and they could be possibly impacting negatively on the river: Research shows that The generation of electricity plays a large role in local, regional, national and international environmental issues, such as global warming, acid rain, ground-level ozone, air toxics, land use and water impacts. A variety of land and water impacts result from the various stages in fossil fuel cycles. Surface water quality is affected by the generation of electricity, causing increase of other dissolved constituents, and increased suspended solids.

Also, the extraction and usage of petroleum products and gas as energy sources the world over has led to a widespread pollution of the biosphere. About 6-10 million barrels of crude oil enter the aquatic environment yearly (Thorhang, 2002). The control of such pollution problems in the aquatic environment is very difficult because of the large number of input sources and their geographic dispersions. Contrary to popular views, evidence is accumulating to buttress the fact that petroleum hydrocarbon mixes with water and penetrates to the underlying sediments (Patin, 1999). The resultant effects of the above are a change in desirable portable water characteristics (Howgate, 1977). Impaired growth of marine organisms which depend basically on the quantity and quality of the primary production of phytoplankton, fish, crustaceans and molluscs acquire objectionable odour or flavour, thereby causing a reduction in their marketability and acceptance as food (Nwankwo & Irrechukwu, 1981).

The Imo River is one of the major coastal rivers in the Niger Delta of Nigeria that is significantly influenced by anthropogenic activities, resulting in possible pollution and deterioration of the water quality. There are a number of agricultural, oil and gas and textile based industries, markets etc discharging wastes and effluents into the imo river.

For the majority of the people in communities living along the banks and catchment area of Imo River, the major source of water for drinking and other beneficial uses, is the river. And so, it becomes necessary to examine the water quality in relation to acceptable limits of the general variables present/absent as specified by organizations concerned with standard guidelines, such as FEPA, WHO and EPA .However, in spite of the very hazardous nature of environmental pollutants on an aquatic environment, studies of these contaminants and pollutants in the Imo River are very scanty or nonexistent.

1.3. Aim and Objectives

This study was aimed at assessing, the physicochemical and microbiological regimes of the Imo River in Oyigbo Local Government of Rivers State.

The following objectives were applied to achieve this aim:

1. Determination of the physiochemical status of the surface water of the Imo River in Oyigbo L.G.A.
2. Determination of the physiochemical characteristics of the sediments of the Imo River in Oyigbo L.G.A.
3. Determination of the microbiological communities of the Imo River in Oyigbo L.G.A.

1.4. Scope and Delimitation

This study covered the stretch of the Imo River in Oyigbo Local Government area of Rivers State. It investigated the baseline physiochemistry (water temp, ph, turbidity, BOD etc) and microbiological (total heterotrophic bacteria and fungi, and hydrocarbonoclastic bacteria and fungi) status of the middle reaches of the river during the rainy season months of June, July and August, 2013.

1.5. Significance of Study

It is extremely necessary to know what the water quality of the surface water of our inland rivers, water ways and domestic channels is because these rivers are sometimes used by the local populace for drinking, washing of clothes, bathing and carrying out other domestic, agricultural and industrial activities. This research work:

- Provides statistically significant data which shows the current status of the water quality of the surface water of the Imo River in Oyigbo LGA.
- It provides an accurate scientifical reference point from which a further, broader and more in-depth research can be carried out.
- It also provides a reliable baseline data upon which future computations of the water quality as a result of increased industrialization and urbanization would be based.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1. Water Quality

Water quality is neither a static condition of a system, nor can it be defined by the measurement of only one parameter. Rather, it is variable in both time and space and requires routine monitoring to detect spatial patterns and changes over time. There is a range of chemical, physical, and biological components that affect water quality and hundreds of variables could be examined and measured. Some variables provide a general indication of water pollution, whereas others enable the direct tracking of pollution sources.

According to Montgomery(2006), Most of the water in the hydrosphere is in the salty oceans, and almost all the remainder is tied up in what leaves relatively little surface or subsurface water for partial fresh water sources Moreover, much of the water on the continents is not strictly fresh. Even rain water, long standard for “pure” water, contains dissolved chemicals of its kind, especially in industrialized areas with substantial pollution. Once precipitation reaches the ground, it reacts with soil, rock, and organic debris, dissolving still more chemicals naturally, aside from any pollution generated by human actions. Water quality thus must be a consideration when estimating water supplies.

2.2. Measures of water quality

According to Montgomery (2006), Water quality may be described in a variety of ways. A common means is to express the dilute substances, parts per billion (ppb). These units are analogous to weight percentages (which are really "parts per hundred) but are used for lower (more dilute) concentrations. For example, if water contains 1 weight percent salt, it contains one gram of salt per hundred grams of water, or one ton of salt per hundred tons of water, or whatever unit one wants to use. Likewise, if the water contains only 1 ppm salt, it contains one gram of salt per million grams of water (about 250gallons), and so on. For comparison, the most abundant dissolved constituents in sea water can be measured in parts per thousand (magnesium sulfate) or even percent (sodium chloride)

Another way to express overall water quality is in terms of total dissolved solids (TDS); the sum of the concentrations of all dissolved solid chemicals is in the water. How low a level of TDS is required or acceptable varies with the application. Standards might specify a maximum of 500 or 1000 ppm TDS for drinking water; 2000ppm TDS might be acceptable for watering livestock: industrial applications where water chemistry is important (in pharmaceuticals or textiles, for instance) might need water even purer than normal drinking water.

Yet describing water in terms of total content of dissolved solids does not present the whole picture: At least as important as the quantities of impurities present is what those impurities are. If the main dissolved component is calcite (calcium carbonate) from a limestone aquifer, the water may taste fine and be perfectly wholesome with well over 1000 ppm TDS in it. If iron or sulfur is the dissolved substance, even a few parts per million may be enough to make the water taste bad, though it may not be actually unhealthy. Many synthetic chemicals that have leaked into water through improper waste disposal are toxic even at concentrations of 1ppb or less.

According to Montgomery (2006), other parameters also may be relevant in describing water quality. One is ph, which is a measure of the acidity or alkalinity of the water. The ph of water is inversely related to acidity: the lower the ph, the more acid the water (water that is neither acid nor alkaline has a ph of 7) for health reasons, concentrations of certain bacteria may also be monitored in drinking water supplies.

A water quality concern that has only recently drawn close attention, is the presence, of naturally occurring radioactive elements that may present, a radiation hazard to the water consumer. Uranium, which can be found in most rocks, including those serving commonly as aquifers, decays through a series of steps. Several of the intermediate decay products pose special hazards. One- radium- behaves chemically much like calcium and therefore tends to be concentrated in the body in bones and teeth. Another radon- is a chemically inert gas but is radioactive itself and decays to other radioactive elements in turn. Radon leaking into indoor air from water supplies contributes to indoor air pollution. High concentrations of radium and/or radon in ground water may result from decay of uranium in the aquifer itself or, in the case of radon, from seepage out of adjacent uranium- rich aquitards, especially shales (Zaghloul & Elwan, 2011).

2.3. Physical and Chemical Parameters in Water Quality

2.3.1 temperature

According to (2001, Streamkeeper's Field Guide). Water Temperature is a controlling factor for aquatic life: it controls the rate of metabolic activities, reproductive activities and therefore, life cycles. If stream temperatures increase, decrease or fluctuate too widely, metabolic activities may speed up, slow down, malfunction, or stop altogether. There are many factors that can influence the stream temperature. Water temperatures can fluctuate seasonally, daily, and even hourly, especially in smaller sized streams. Spring discharges and overhanging canopy of stream vegetation provides shade and helps buffer the effects of temperature changes. Water temperature is also influenced by the quantity and velocity of stream flow. The sun has much less effect in warming the waters of streams with greater and swifter flows than of streams with smaller, slower flows.

According to McCaffrey (2011), Temperature affects the concentration of dissolved oxygen in a water body. Oxygen is more easily dissolved in cold water.

Temperature of a waterway is significant because it affects the amount of dissolved oxygen in the water. The amount of oxygen that will dissolve in water increases as temperature decreases. Water at O˚C will hold up to 14.6 mg of oxygen per litre, while at 30˚C it will hold only up to 7.6 mg/L.

Temperature also affects the rate of photosynthesis of plants, the metabolic rate of aquatic animals, rates of development, timing and success of reproduction, mobility, migration patterns and the sensitivity of organisms to toxins, parasites and disease. Life cycles of aquatic organisms are often related to changes in temperature. Temperature ranges for plants and animals can be affected by manmade structures such as dams and weirs and releases of water from them. The maximum daily temperature is usually several hours after noon and the minimum is around daybreak. Water temperature varies seasonally with air temperature, (Eze, 2005; Ogbuagu, 2013).

Aquatic organisms often have narrow temperature tolerances. Thus, although water bodies have the ability to buffer against atmospheric temperature extremes, even moderate changes in water temperatures can have serious impacts on aquatic life, including bacteria, algae, invertebrates and fish. Thermal pollution comes in the form of direct impacts, such as the discharge of industrial cooling water into aquatic receiving bodies, or indirectly through human activities such as the removal of shading stream bank vegetation or the construction of impoundments (Million, 2008).

2.3.2. dissolved oxygen

The amount of oxygen in water, to a degree, shows its overall health. That is, if oxygen levels are high, one can presume that pollution levels in the water are low. Conversely, if oxygen levels are low, one can presume there is a high oxygen demand and that the body of water is not of optimal health. Apart from indicating pollution levels, oxygen in water is required by aquatic fauna for survival. In conditions of no or low oxygen availability, fish and other organisms will die (McCaffrey,2011).

Oxygen enters water as a result of two processes:

1.) Diffusion - diffusion of oxygen into water is accelerated when the water turbulence is increased (moving through rapids and waterfalls) and when there is a strong wind blowing. Additionally, oxygen will diffuse into cold water at a higher rate than it will into warm water

2.) Photosynthesis - during daylight hours, aquatic plants use the sun’s energy to create energy they can use for growth. A by-product of this process is oxygen which is released into surrounding water.

The amount of any gas, including oxygen, dissolved in water is inversely proportional to the temperature of the water; as temperature increases, the amount of dissolved oxygen (gas) decreases, (Ogbuagu, 2013).

The concentration of dissolved oxygen in a stream is affected by many factors such as:

Temperature: Oxygen is more easily dissolved in cold water.

Flow: Oxygen concentrations vary with the volume and velocity of water flowing in a stream. Faster flowing white water areas tend to be more oxygen rich because more oxygen enters the water from the atmosphere in those areas than in slower, stagnant areas.

Aquatic Plants: The presence of aquatic plants in a stream affects the dissolved oxygen concentration. Green plants release oxygen into the water during photosynthesis. Photosynthesis occurs during the day when the sun is out and ceases at night. Thus in streams with significant populations of algae and other aquatic plants, the dissolved oxygen concentration may fluctuated daily, reaching its highest levels in the late afternoon. Because plants, like animals, also take in oxygen, dissolved oxygen levels may drop significantly by early morning.

Altitude: Oxygen in more easily dissolved into water at low altitudes that at high altitudes.

Dissolved or suspended solids: Oxygen is also more easily dissolved into water with low levels of dissolved or suspended solids.

Human Activities Affecting DO:

According to Million (2008), Removal of riparian vegetation may lower oxygen concentrations due to increased water temperature resulting from a lack of canopy shade and increased suspended solids resulting from erosion of bare soil. Typical urban human activities may lower oxygen concentrations. Runoff from impervious surfaces bearing salts, sediments and other pollutants increases the amount of suspended and dissolved solids in stream water. Organic wastes and other nutrient inputs from sewage and industrial discharges, septic tanks and agricultural and urban runoff can result in decreased oxygen levels. Nutrient input often leads to excessive algal growth. When the algae die, the organic matter is decomposed by bacteria. Bacterial decomposition consumes a great deal of oxygen.

Dams may pose an oxygen supply problem when they release waters from the bottom of their reservoirs into streams and rivers. Although the water on the bottom is cooler than the warm water on top, it may be low in oxygen if large amounts of organic matter has fallen to the bottom and has been decomposed by bacteria, Etc.

Usually streams with high dissolved oxygen concentrations (greater than 8 mg/L for Ozark streams) are considered healthy streams. They are able to support a greater diversity of aquatic organisms. They are typified by cold, clear water, with enough riffles to provide sufficient mixing of atmospheric oxygen into the water (WHO, 2004).

In streams that have been impacted by any of the above factors, summer is usually the most crucial time for dissolved oxygen levels because stream flows tend to lessen and water temperatures tend to increase (Toufeek & Korium, 2009).

According to Rajasooriyar (2003), DO levels less than 3 mg/L are stressful to most aquatic organisms. Most fish die at 1-2 mg/L. However, fish can move away from low DO areas. Water with low DO from 2 – 0.5 mg/L are considered hypoxic; waters with less than 0.5 mg/L are anoxic

2.3.3. ph and alkalinity

ph is a measure of the acidity or alkalinity of water. It is usually measured by using a colorimetric test - litmus paper changes color with increased acidity or alkalinity. The Alkalinity or the buffering capacity of a stream refers to how well it can neutralize acidic pollution and resist changes in ph. Alkalinity measures the amount of alkaline compounds in the water, such as carbonates, bicarbonates and hydroxides. These compounds are natural buffers that can remove excess hydrogen (H+) ions (Streamkeeper's Field Guide, 2011)

According to El Gammal and El Shazely (2008), Ph varies naturally within streams as a result of photosynthesis. There are a number of reasons that water may have extreme pH values:

1.) Acidic values

Geology and soils of the catchment affect ph. Acid soils (these are different from Acid Sulphate Soils) and rocks such as basalt, granite and sandstone contribute to lower pH in water. Acid sulphate soils are a major problem in estuarine areas. These soils form in anaerobic environments that are rich in sulphur, such as at the bottom of estuaries. If these soils are not disturbed and are left in anaerobic conditions, they do not pose any threat. However, when they are uncovered and oxidized, they release sulfuric acid into adjoining water ways. Runoff from bush land areas is slightly acidic. This is due to tannic acids (tannins), which are found naturally in leaves. Tannins are also responsible for giving water a tea-like colour.

2.) Alkaline values

Basic rocks such as limestone contribute to higher pH values. Runoff such as fertilizers and detergents cause increased alkalinity. Extreme values of pH can cause problems for aquatic fauna. For example, fish may develop skin irritations, ulcers and impaired gill functioning as a result of water that is too acidic. Death of most aquatic fauna may result from extremely acid or alkaline water. The pH scale ranges from 0 to 14:

Acidic: 0 to 6.9, Neutral: 7, Alkaline: 7.1 to 14

A ph range of 6.5 – 8 is optimal for freshwater. A range of 8 – 9 is optimal for estuarine and sea water

2.3.4. turbidity

Turbidity is a measure of the ability of light to pass through water, that is, a measure of the water's murkiness. Measuring murkiness gives an estimate of suspended solids in the water. Turbidity is measured in Nephelometric Turbidity Units (NTU's).

According to Zaky (2007), Turbidity may be due to organic and/or inorganic constituents. Organic particulates may harbor microorganisms. Thus, turbid conditions may increase the possibility for waterborne disease. Nonetheless, inorganic constituents have no notable health effects. The series of turbidity-induced changes that can occur in a water body may change the composition of an aquatic community. First, turbidity due to a large volume of suspended sediment will reduce light penetration, thereby suppressing photosynthetic activity of phytoplankton, algae, and macrophytes, especially those farther from the surface (Ezzat & Elkorashy, 2012). If turbidity is largely due to algae, light will not penetrate very far into the water, and primary production will be limited to the uppermost layers of water. Cyanobacteria (blue-green algae) are favored in this situation because they possess flotation mechanisms. Overall, excess turbidity leads to fewer photosynthetic organisms available to serve as food sources for many invertebrates. As a result, overall invertebrate numbers may also decline, which may then lead to a fish population decline.

If turbidity is largely due to organic particles, dissolved oxygen depletion may occur in the water body. The excess nutrients available will encourage microbial breakdown, a process that requires dissolved oxygen. In addition, excess nutrients may result in algal growth. Although photosynthetic by day, algae respire at night, using valuable dissolved oxygen.

Fish kills often result from extensive oxygen depletion.

2.3.5. Suspended solids

Suspended Solids usually enter the water as a result of soil erosion from disturbed land or can be traced to the inflow of effluent from sewage plants or industry. Suspended solids also occur naturally in the water from bank and channel erosion; however, this process has been accelerated by human use of waterways. Turbidity measurements also take into account algae and plankton present in the water, (Adefemi et al., 2007).

Pollutants such as nutrients and pesticides may bind with suspended solids and settle in bottom sediments where they may become concentrated. Suspended sediments can also smother aquatic plants as they settle out in low flows, and clog mouthparts and gills of fish and aquatic macro-invertebrates (Agbaire &Obi, 2009). High turbidity affects submerged plants by preventing sufficient light from reaching them for photosynthesis. High turbidity also has the capacity to significantly increase water temperature. Water temperature needs to remain fairly constant so aquatic fauna can survive. Though high turbidity is often a sign of poor water quality and land management, crystal clear water does not always guarantee healthy water. Extremely clear water can signify very acidic conditions or high levels of salinity (Muhammad et al., 2007).

Category	NTU’s
Excellent	≤10 NTU’s
Fair	15-30 NTU’s
Poor	> 30 NTU’s

2.3.6. Salinity and conductivity

According to Streamkeeper's Field Guide (2001), salinity is a measure of the dissolved salts in the water. Salinity is usually highest during periods of low flows and increases as water levels decrease. Salinity is measured as either TDS (Total Dissolved Solids), which measures the amount of dissolved salts in the water, or as EC (Electrical Conductivity), which is the property of a substance which enables it to serve as a channel or medium for electricity. Salty water conducts electricity more readily than purer water.

Conductivity is a measure of how well water can pass an electrical current. It is an indirect measure of the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron and aluminum. The presence of these substances increases the conductivity of a body of water. Organic substances like oil, alcohol, and sugar do not conduct electricity very well, and thus have a low conductivity in water. Inorganic dissolved solids are essential ingredients for aquatic life. They regulate the flow of water in and out of organisms' cells and are building blocks of the molecules necessary for life. A high concentration of dissolved solids, however, can cause water balance problems for aquatic organisms and decrease dissolved oxygen levels (Ubalua & Ezeronye, 2005).

Municipal, agricultural, and industrial discharges can contribute ions to receiving waters or can contain substances that are poor conductors (organic compounds) changing the conductivity of the receiving waters. Thus, specific conductance can also be used to detect pollution sources (Stoddard *et al*., 1999).

2.3.7. major ions

According to the UNEP GEMS (2006), the ionic composition of surface and ground waters is governed by exchanges with the underlying geology of the drainage basin and with atmospheric deposition. Human activities within the drainage basin also influence the ionic composition, by altering discharge regimes and transport of particulate matter across the landscape, and by changing the chemical composition of surface runoff and atmospheric deposition of solutes through wet and dry precipitation.

Global average concentrations of the four major cations (calcium, magnesium, sodium, and potassium) and the four major anions (bicarbonate, carbonate, sulphate, and chloride) in surface water tend to approach patterns in which calcium concentrations dominate the cations and bicarbonate and/or carbonate concentrations dominate the anions (Wetzel, 2001)

The ionic composition of surface waters is usually considered to be relatively stable and insensitive to biological processes occurring within a body of water. Magnesium, sodium and potassium concentrations tend not to be heavily influenced by metabolic activities of aquatic organisms, whereas calcium can exhibit marked seasonal and spatial dynamics as a result of biological activity. Similarly, chloride concentrations are not heavily influenced by biological activity, whereas sulphate and inorganic carbon (carbonate and bicarbonate) concentrations can be driven by production and respiration cycles of the aquatic biota (Wetzel, 2001). External forces such as climatic events that govern evaporation and discharge regimes and anthropogenic inputs can also drive patterns in ionic concentrations. Such forces are probably most responsible for long-term changes in the ionic composition of lakes and rivers.

2.3.8. nutrients

The three main plant nutrients are nitrogen, phosphorus and potassium. Of these, only phosphorus is tested by Waterwatch groups. Nutrient levels in Nigerian waters are naturally very low. However, due to human impacts these levels are often too high, resulting in algal blooms and excessive growth of water-plants including weed species such as *Eichhornia crassipes* (Water Hyacinth) and *Salvinia sp,* (Nyannayo, 2002).

The effects of consistently high levels of nutrient levels are: Water bodies choked with vegetation or algae - often weed species. Change in aquatic flora and fauna composition. This is often a change to a monoculture, that is a change to a system dominated by a single plant species; increased fluctuations of dissolved oxygen levels. This places stress on aquatic fauna and increase in total organic load, resulting in odours and reduced aesthetic quality, (Obasi et al., 2004).

2.3.9. phosphates

Phosphates are often the limiting nutrients for plant growth in most aquatic environments, in the Nigeria. Therefore, high phosphate levels could lead to the problems described above.

The main sources of phosphorus in local catchments are: Sediments from rocks and soil. Effluent from waste water treatment plants and in situ sewage disposal units. Detergents and fertilizers that have been washed down drains or that have run off from properties due to poor land management practices and storm water pollution. Decaying organic matter, (Uchegbu, 2002).

Category	**Total PO4 (mg/L)**
Low	< 0.06
Medium	0.06 – 0.15
High	> 0.15 – 0.45
Very High	> 0.45

2.3.10. Nitrogen

Nitrogen occurs in natural waters in various forms, including nitrate (NO_3), nitrate (NO_2), and ammonia (NH_3). Nitrate is the most common form tested.

Nitrogen as Ammonia

Ammonia (NH_3): It is one of the most important pollutants in the aquatic environment because of its relatively highly toxic nature and its ubiquity in surface water systems. It is discharged in large quantities in industrial, municipal and agricultural waste waters. In aqueous solutions, ammonia assumes two chemical forms: NH_4^+ - ionized (less/nontoxic) and NH_3 - unionized (toxic). The relative concentration of ionized and unionized ammonia, in a given ammonia solution are principally a function of pH, temperature and ionic strength of the aqueous solution (Fundamentals of Aquatic Toxicology, 1985).Total ammonia is the sum of the NH_3 and NH_4^+, (Fundamentals of Aquatic Toxicology, 1985).

Nitrogen as Nitrate

Nitrate (NO_3^-): Generally occurs in trace quantities in surface water. It is the essential nutrient for many photosynthetic autotrophs and has been identified as the growth limit nutrient. It is only found in small amounts in fresh domestic wastewater, but in effluent of nitrifying biological treatment plants, nitrate may be found in concentrations up to 30 mg nitrate as nitrogen/L (19th Edition, Standard Methods, 1995). Nitrate is a less serious environmental problem, it can be found in relatively high concentrations where it is relatively nontoxic to aquatic organisms. When nitrate concentrations become excessive, however, and other essential nutrient factors are present, eutrophication and associated algal blooms can be become a problem (Fundamentals of Aquatic Toxicology, 1985).

Nitrogen as Nitrite

Nitrite (NO_2^-): Nitrite is extremely toxic to aquatic life, however, is usually present only in trace amounts in most natural freshwater systems because it is rapidly oxidized to nitrate. In sewage treatment plants using nitrification process to convert ammonia to nitrate, the process may be impeded, causing discharge of nitrite at elevated concentrations into receiving waters.

The conversion process is affected by several factors, including pH, temperature and dissolved oxygen, number of nitrifying bacteria and presence of inhibiting compounds. Total ammonia in wastewater treatment systems consists of NH_3^- plus NH_4^+. If pH of the solution increases either naturally or by addition of a base, the concentration of unionized NH_3 increases. It impedes the conversion of nitrite to nitrate, causing nitrite to accumulate. When the pH decreases, as NH_4^+ and NO_2 are oxidized an increase in HNO_2 concentration occurs. Nitrous acid inhibits both nitrobacteria and nitrosomanas bacteria – this inhibition can result in an increase in nitrite. As ph increases the toxicity in terms of NO_2 as N decreases and the toxicity in terms of HNO_2 as N increases. (Fundamentals of Aquatic Toxicology, 1985).

Nitrogen as Total Kjeldahl

Organic nitrogen and ammonia can be determined together and have been referred to as "Kjeldahl nitrogen (TKN)", a term that reflects the technique used in their determination (19th Edition, Standard Methods, 1995).

Nitrogen, Organic

Organic Nitrogen: It is the byproduct of living organisms. It includes such natural materials as proteins and peptides, nucleic acids and urea, and numerous synthetic organic materials. Typical organic nitrogen concentrations vary from a few hundred micrograms per liter in some lakes to more than 20 mg/L in raw sewage (19th edition, Standard Methods, 1995).

Some systems are naturally eutrophic, whereas others have become eutrophic as a result of human activities (‘cultural eutrophication’) through factors such as runoff from agricultural lands and the discharge of municipal waste into rivers and lakes. Aquatic ecosystems can be classified into trophic state, which provides an indication of a system’s potential for biomass growth of primary producers. Trophic states are usually defined as oligotrophic (low productivity), mesotrophic (intermediate productivity), and eutrophic (high productivity). Ultraoligotrophic and hypereutrophic states represent opposite extremes in the trophic status classifications of aquatic environments. Although there are many methods for classifying systems into trophic state, a common approach examines concentrations of nutrients across many systems and separates systems according to their rank in the range of nutrient concentrations (Dodds *et al*., 1998).

2.3.11. metals

The effects of metals in water and wastewater range from beneficial through troublesome to dangerously toxic. Some metals are essential, others may adversely affect water consumers, wastewater treatment systems, and receiving waters. Some metals may be either beneficial or toxic, depending on concentration (19th Edition, Standard Methods, 1995). .

The primary mechanism for toxicity to organisms that live in the water column is by absorption to or uptake across the gills: this physiological process requires metal to be in a dissolved form. This is not to say that particulate metal is nontoxic, only that particulate metal appears to exhibit substantially less toxicity than does dissolved metal (U.S. EPA).

Dissolved: Those metals of an unacidified sample that pass through a 0.45 micrometer membrane filter and is thought to better represent the bioavailable fraction of metal in the water column than total recoverable metal (U.S. EPA, 1996).

Recoverable: Those metals that are not tightly bound and are biologically available to aquatic organisms

Total: Includes all metals, inorganically and organically bound, both dissolved and particulate. Will give a unrealistic high value of those metals that are biological available to aquatic organisms.

Not all metals are acutely toxic in small concentrations. The "heavy metals" include copper , iron , cadmium , zinc , mercury , and lead and are the most toxic to aquatic organisms. Some water quality characteristics which affect metal toxicity include temperature, pH, hardness, alkalinity, suspended solids, redox potential and dissolved organic carbon. Metals can bind to many organic and inorganic compounds which reduces the toxicity of the metal.

2.3.12. organic matter

Organic matter is important in the cycling of nutrients, carbon and energy between producers and consumers and back again in aquatic ecosystems. The decomposition of organic matter by bacteria and fungi in aquatic ecosystems, inefficient grazing by zooplankton and waste excretion by aquatic animals, release stored energy, carbon, and nutrients, thereby making these newly available to primary producers and bacteria for metabolism (UNEP GEMS, 2006). External subsidies of organic matter that enter aquatic ecosystems from a drainage basin through point sources such as effluent outfalls, or non-point sources such as runoff from agricultural areas, can enhance microbial respiration and invertebrate production of aquatic ecosystems.

Organic matter affects the biological availability of minerals and elements, and has important protective effects in many aquatic ecosystems, by influencing the degree of light penetration that can enter (Spaak & Bauchowitz , 2010).

2.3.13. organic carbon

Organic carbon refers to the myriad organic matter compounds in water. Dissolved organic carbon (DOC) is organic material from plants and animals that has been broken down to very small sizes, usually less than 0.45µm in diameter.

2.3.14. biological oxygen demand and chemical oxygen demand

BOD is a measure of the amount of oxygen removed from aquatic environments by aerobic micro-organisms for their metabolic requirements during the breakdown of organic matter, and systems with high BOD tend to have low dissolved oxygen concentrations. COD is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant, such as dichromate (Chapman, 1996).

COD is an indicator of organics in the water, usually used in conjunction with BOD. High organic inputs trigger deoxygenation. If excess organics are introduced to the system, there is potential for complete depletion of dissolved oxygen. Without oxygen, the entire aquatic community is threatened. The only organisms present will be air- breathing insects and anaerobic bacteria.

If all oxygen is depleted, aerobic decomposition ceases and further organic breakdown is accomplished anaerobically. Anaerobic microbes obtain energy from oxygen bound to other molecules such as sulphate compounds. Thus, anoxic conditions result in the mobilization of many otherwise insoluble compounds.

In areas of high organics there is frequently evidence of rapid sewage fungus colonization. Sewage fungus appears as slimy or fluffy cotton wool-like growths of micro-organisms which may include filamentous bacteria, fungi, and protozoa such as *Sphaerotilus natans, Leptomitus lacteus, and Carchesium polypinuym*, respectively. The various effects of the sewage fungus masses include silt and detritus entrapment, the smothering of aquatic macrophytes, and a decrease in water flow velocities. An accumulation of sediment allows a shift in the aquatic system structure as colonization by silt-loving organisms occur. In addition, masses of sewage fungus may break off and float away, causing localized areas of dissolved oxygen demand elsewhere in the water body.

Organic levels decrease with distance away from the source. In a standing water body such as a lake, currents are generally not powerful enough to transport large amounts of organics. In a moving water body, the saprotrophic organisms (organisms feeding on decaying organic matter) break down the organics during transportation away from the source. Hence, there is a decline in the oxygen demand and an increase of dissolved oxygen in the water. Community structure will gradually return to ambient with distance downstream from the source.

2.3.15. biological components

Organisms, populations, and communities composed of different species make up the biological diversity of aquatic ecosystems. From single-celled microbes such as viruses, bacteria, protists, and fungi, to multi-cellular organisms such as vascular plants, aquatic invertebrates, fish and wildfowl, the community of organisms that reside within and near aquatic ecosystems simultaneously plays a vital role in regulating biogeochemical fluxes in their surrounding environment and is influenced by these same biogeochemical fluxes. Aquatic organisms, often considered 'engineers' of aquatic ecosystems, not only react to physical and chemical changes in their environment, but also they can drive such changes and have important roles in cleansing and detoxifying their environment (Ostroumov, 2005). Losses of sensitive species may have feedback effects on other resident organisms that can lead to catastrophic shifts in the composition of aquatic communities and the functions they provide. As such, the overall diversity of biological communities enables many ecosystem processes to function normally and in a stable state. Loss of diversity may lead to declines in ecosystem function as well as shifts to alternate stable states (Ostroumov, 2005; Scheffer *et al*., 2001). A common example of a dramatic shift in ecosystem condition to an alternate stable state that has been attributed to water pollution is the shift from a clear-water, vascular plant dominated state to a turbid, phytoplankton-dominated state in many shallow lakes (Scheffer *et al*., 2001). The entire biological diversity of aquatic environments ensures that ecosystems can continue to function normally: shifts in species composition through species losses or biological invasions can lead to physical and chemical changes in the environment that may have detrimental effects on both the community of organisms residing within the ecosystem and on humans that rely upon the system for water supply and other activities. The diversity of aquatic ecosystems can also be influenced by physical and chemical changes in the environment.

There is considerable duplication of function in aquatic food webs, where several species and trophic levels may perform similar functions of self-purification of a body of water. For example, both bacteria and fungi have roles in the chemical breakdown of pollutants.

These biological components include: microbes, algae and aquatic vascular plants, invertebrates: zooplankton and benthic macro-invertebrates, fish.

2.3.16. organic contaminants

Organic contaminants are primarily human-produced chemicals that enter natural environments through pesticide use, industrial chemicals, and as by-products of degradation of other chemicals. Persistent Organic Pollutants (POPs) tend to persist in the environment and become widely distributed geographically, bioaccumulate through the food web, and pose the risk of causing severe adverse effects to human health and the environment. The Stockholm Convention on Persistent Organic Pollutants, which entered into force in 2004, is a global treaty to protect human health and the environment from POPs, in which signatory governments will take measures to eliminate or reduce the release of POPs into the environment. The POPs identified under the Stockholm Convention are listed in Table 1. Although by no means an exhaustive list of potential POPs entering the environment, the named compounds are often referred to as the ‘dirty dozen’: that is, those chemicals that pose the greatest known threat to the environment and human health. The effects of many other POPs are still being researched

Table 1

Twelve Persistent Organic Pollutants (POPs) scheduled to be phased out and eliminated under the Stockholm Convention.

Substance	**Class**
Aldrin	Pesticide
Chlordane	Pesticide
Dieldrin	Pesticide
Endrin	Pesticide
Heptachlor	Pesticide
Hexachlorobenzene	Pesticide / industrial chemical / by-product
Mirex	Pesticide
Toxaphene	Pesticide
Polychlorinated biphenyls (PCBs)	Industrial chemical / by-product
DDT	Pesticide
Dioxins	By-product
Furans	By-product

Other organic contaminants include: pesticides, polychlorinated biphenyls, oil and grease.

2.4. SUMMARY

Water quality can also be affected by other factors such as:

2.4.1. hydrological variables

The quantity of water contained within a system and its recharge rate affect the chemical and biological properties of all aquatic environments. Water levels and residence times in lakes, reservoirs and wetlands influence nutrient and ionic concentrations of the water and determine the physical extent over which biological production can occur. Changes in water levels tend to be most dramatic in reservoirs in which drawdown is a regular occurrence during dry seasons. Extended periods of drought in many areas can lead to reductions in water levels of all aquatic environments, and evaporative losses of water can lead to the concentration of mineral salts in systems, leading to the salinization of environments that would otherwise normally be considered to contain fresh water.

2.4.2. discharge (stream flow)

Although not technically a measure of water quality, discharge is an important parameter to monitor because of its direct influence on the chemical composition of a riverine environment and it's receiving waters.

Discharge is directly related to the amount of water moving from a watershed into a stream channel and can be defined as the volume of water that moves over a designated point in a stream over a fixed period of time. Discharge is affected by weather. Water withdrawals for uses such as irrigation, industry, or municipal extractions for household uses can seriously deplete the flow in a system. Dams used for electric power generation, particularly facilities designed to produce power during periods of peak need, often block the flow of a stream and release it in a surge (Smakhtin *et al*., 2003).

Stream velocity, which increases as the volume of water in a stream increases, determines the kinds of organisms and habitats that can be found in that stream. Some organisms prefer fast moving streams, whereas others prefer slow moving waters. Stream velocity affects the amount of silt and sediment carried by the stream. Sediment in slow-flowing streams will settle to the stream bottom, whereas sediment in fast-moving waters will remain suspended in the water column, eventually settling in lakes, reservoirs, or near shore marine environments, where they can be essential in the maintenance of deltas and biological productivity within these environments. Streams with higher water velocities, especially if they have a coarse substrate, will tend to have higher levels of dissolved oxygen than slow streams with smooth bottoms. Flow can also influence fluctuations of in-stream water temperature, as temperature is more heavily influenced by atmospheric conditions during periods of low flow.

Discharge influences the susceptibility of a stream to pollution. Large, swiftly flowing rivers can receive pollution discharges and, through dilution, be little affected. Small, slow-flowing streams have a reduced capacity to attenuate and degrade wastes. However, the popular notion that "the solution to pollution is dilution" is dangerous because it does not take into account effects on receiving waters or sediments where the accumulation of pollutants may have significant negative impacts.

CHAPTER THREE

3.0. MATERIALS AND METHOD

3.1. Study Area

Oyigbo Local Government was carved out of Khana/Oyigbo Local Government of Rivers State. The local government is made up of Asa and Ndoki people. Oyigbo is a town and Local Government Area of Rivers State, Nigeria. It is a satellite of Port Harcourt, lying a few kilometers to the northeast of the city. A brief history of Oyigbo local government area shows that it used to be a part of the old Imo state in the 70's. It was later merged to Rivers State in 1976 by the Nasir boundary Adjustment committee. The oyigbo Local Government was created in September 26,1991 from the Khana/Oyigbo Local Government Area during Gen. Ibrahim Badamasi Babangida administration. Sir Precious Oforji was elected Chairman of the Oyigbo LGA in 2008.The Local Government is currently headed by a Caretaker Committee Chairman in the person of Hon. Nnamdi Ihute as at the time of this research.Chief Sunday Elechi Oforji was the paramount ruler in Oyigbo until his death in July 2009 and the hereditary title was handed over to his son. His Royal Highness Chief Eze Mike Nwaji JP, who is the paramount ruler in Oyigbo, as at the time of this research.

The Imo River is located in southeastern Nigeria and flows 150 miles from its sources in Umuaku village in Isuochi Local Government Area, near Okigwe in Abia State. (Okonko *et al*.,) the spring start from the rock and gradually increases in volume as other rivers and streams flow into the main channel (Edema *et al*.,) relief map of Abia state

The Imo River flows through three (3) tributaries , the Aba River (in Abia State) the Otamiri River (in Imo state) and Oramirukwa River(in Imo state). The tributaries of the Imo river flow southward into its estuaries in Akwete, Obete, Kalaoko,Queenstown,Opobo South (all in Rivers State) and Ikot Abasi (in Akwa Ibom state) to the Atlantic Ocean (okonko *et al*.,1997). Its estuary is around 40km wide, and the river has an average discharge(volume rate of water flow) of 4000m^3/s with 26,000 hectares of wetland (laughren 1976).

It stretches across four (4) states abia, imo, rivers and akwa ibom states. Its coordinates are within latitude 4°28 ’14″N and longitutude 7°35’38 W .

It supplies water for the daily activities of the people who live along its banks and tributaries.

3.1.1 Climate and Vegetation

Oyigbo LGA features a tropical wet climate with lengthy and heavy rainy seasons and very short dry seasons. Only the months of November, December, January and February truly qualifies as dry season months in the city. The harmattan, which climatically influences many cities in West Africa, is less pronounced in Oyigbo LGA.

The LGA's heaviest precipitation occurs during September with an average of 370 mm of rain. December on average is the driest month of the year; with an average rainfall of 20 mm.(spdc, 2003)

Temperatures throughout the year in the LGA, is relatively constant, showing little variation throughout the course of the year. Average temperatures are typically between 25°C-28°C in the area, (SPDC, 2003).

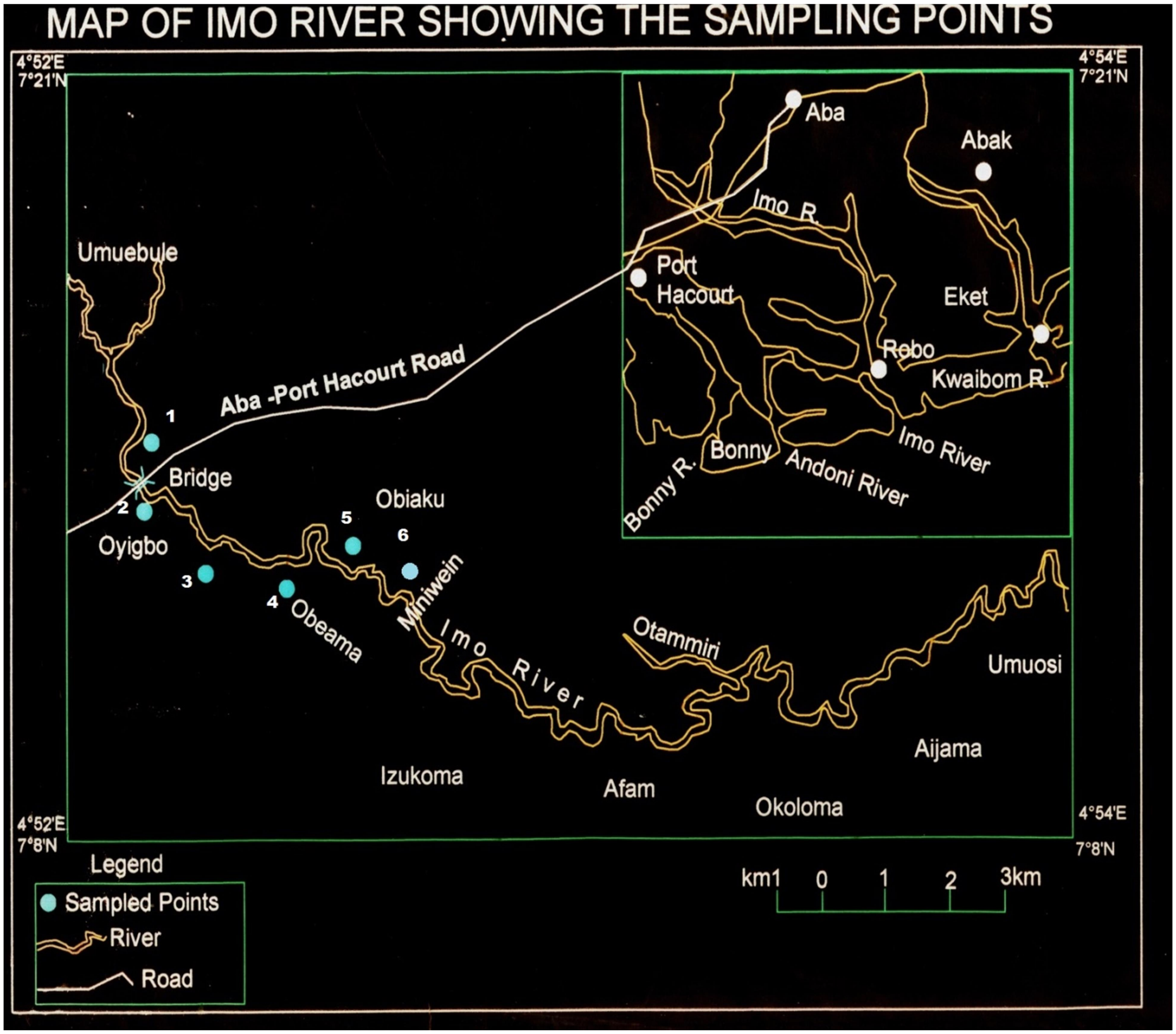
Relative humidity is usually at an average of 80percent in the rainy season and during the dry season at an average of 40 percent

The climate types as marked by high relative humidity are spread over the year from 8-10 months (March- November), and sometimes throughout the year for the rainy season. The dry season begins from either late November or early December to February.

The vegetation of the area is predominated by the typical tropical rainforest or riparian vegetation, along the river systems throughout the the region of the boundary of the Atlantic Ocean, the other vegetation type is the secondary bush which follows farming / fallowing. The first canopy consists of plants of 40meter and above while the middle canopy is between 15 and 40 meters high and the last, the mangrove shrubs which are about 15m high. Often mixed with woody climbers (lianas), epiphytes and ferns etc, there are thick forest growths with numerous plants of different kinds (e.g. palm trees, raffia palm and other economic, medicinal and food crops within the area of study).

Fig 1

MAP SHOWING THE IMO RIVER IN OYIGBO LGA AND THE SIX SAMPLING LOCATIONS



3.1.2 Population and Economic Activities

The total population of the area is put at approximately140, 243 people, with a growth rate of 3.27% and a total land area of about 1400km^2 (PMV, 2011). Oyigbo Local Government Area lies between latitude 4˚54 and 4˚46 N and between longitude 7˚15 and 7˚25 W. The economic activities for the people in the area are predominantly substance agriculture and small scale fishing. The people produce crops like yam, maize, cassava, plantain, cocoyam, okra and so on. Other economic activities gain expression in, palm wine tapping, hunting, and sand mining in this river etc.

With the advent and discovery of crude oil in this area, and coming of big oil companies, oil exploration is slowly becoming the main source of revenue of this people. Thus, there are 3 major Industries located around the stretch of the Imo River in Oyigbo LGA, which could be possibly impacting on it.

Namely :

i. **The Afam Power Station**; located approximately 30 km Northeast of Port Harcourt in the Niger Delta region of Nigeria. It lies between latitudes 4˚45'00"N and longitudes 7˚10'00"E. The power station is bounded in the north by Imo

River, east by Ayama village, south by Egberu village and in the west by Okoloma, the Local Government Headquarters. The power plant is located in Okoloma community. The project covers an area of approximately 157.20km^2 and is traversed by Imo River surrounded by the riparian swamp forest. There are eight communities within the project area. The area is characteristically low-lying, with relatively flat terrain and dendritic channels through which it is drained (SPDC, 2003). The swamp forests around the fringes of the Imo River experience seasonal flooding.

In March 2006, the Shell Petroleum Development Company of Nigeria Limited (SPDC) took over the management of the development and operation of Afam Power Station and most of its ancillary facilities for a period of approximately 25 years. Afam Power Station has five trains. The first train, Afam I, was installed in 1962; it had 4 turbines and was rated 56 MW. Since then, the power station has grown into a 20-turbine facility comprising Afam I-V. Train I is no longer operational. Afam II, III and IV, however, still have operational units with combined installed rating of 654 MW. However, at the time of this study, a high ranking official of the power station confirmed that the combined output of these three trains was less than 100 MW. This means that relative to the installed capacity of 710 MW for Afam I, II, III and IV, the current efficiency is 14.1 per cent. Train V, commissioned in 2001, has an installed capacity of 276 MW and consists of two functional Siemens V94.2 gas turbines. The electricity industry is a major contributor to some of the most significant environmental problems facing our society.

ii.) The Shell Okoloma Gas Plant: The Okoloma plant provides the gas for Afam VI power plant and equally support domestic gas supply network. It combines both the conventional and advanced Twister technology, the first of its kind in Africa for gas processing. Okoloma can process 240 million cubic feet of gas each day and is being supplied from six gas wells drilled for the project. From here, the plant supplies gas both to the Afam VI power plant and the Nigerian Gas Company, which manages the domestic gas network and supplies industrial users around the country.

iii.) The Nigerian Gas Plant Plc; operates a series of gas plant systems in Oyigbo LGA namely Obigbo North- Afam system which caters for PHCN power station at Afam, the Alakiri to Onne Gas pipeline system, for supply of gas to National Fertilizer Company (NAFCON) for fertilizer production: the Alakiri- Afam –Ikot Abasi system for gas supply to the Aluminium Smelting Plant (ALSCON).

3.2 Sources of Data

The data used in this research were obtained from both primary and secondary sources

3.2.1. Primary Data

The primary data are the set of data collected from the study area through sampling, and include those derived from observations made during sampling and laboratory.

3.2.2 Secondary Data

Secondary data includes all published materials used in this study. These are information and data from text books, monographs, lecture books, journals, periodicals, internet and literatures from other peoples work.

3.3 Sampling Design

Replicate sampling was made on six different days at six different sampling locations between 07:00-11:00am in August, 2013. The study comprised field sampling and laboratory analyses.

3.4 Sampling Locations

Six sampling locations were established; with 5 located downstream at highest points marine transportation and fishing activities and the sixth located upstream away from areas of intense activities and to serve as a control all along the stretch of the imo river in Oyigbo local government area. The six sampling locations were located 200m from each other.

3.5. Field Sampling

3.5.1. *In situ* measurements

In situ measurements for surface water temperature, turbidity, electrical conductivity, pH and dissolved oxygen were determined with the use of HANNAH HI 9828 V1.4 PH/0RP/EC/DO Meter. Total dissolved solids (TDS) and resistivity were determined electrometrically *in situ.* The meter was calibrated with the standard HI 9828-25 calibration solution. The desired physicochemical parameter was read off the LCD of the meter.(table 3.1)

3.5.2. Collection of water samples for laboratory analysis of physicochemical characteristics

Water samples were collected in 2 litres plastic bottles that had been severally rinsed with the channel water from the six sampling locations. Samples were then transported to the laboratory in iced coolers to maintain their integrity. However, water Samples for the measurement of the 5-days biological oxygen demand

(BOD), were collected in 250ml brown bottles while submerged in water. Water samples for trace metals concentration were collected in plastic containers and fixed with conc. HNO_3 in the ratio of 2:500. Water samples for the other physicochemical parameters (turbidity, sulphate, nitrate, phosphate and total suspended solids) were collected with 500ml sterile plastic containers. Water samples were taken to the laboratory as soon as possible in an iced-cooler to maintain their integrity.

3.6 Laboratory analyses

3.6.1. Determination of Nitrate (NO_3^-)

The cadmium reduction method as adapted from APHA (1998) was employed in the determination of nitrate levels of the water samples. A cadmium based reagent pillow was added into 25ml of the water sample in a cuvette and shaken for 1 minute and allowed to stand for another 5 minutes for complete reaction to occur. The absorbance and concentration in mg/l was read at 500nm wavelength using HACH DR 2010 UV-visible spectrophotometer.

3.6.2. Determination of Sulphate (SO_4^{2-})

The barium chloride (Turbidometric) method (APHA, 1998) was adopted. The barium chloride based powdered reagent pillow was added into 25ml of water sample. The mixture was properly mixed and allowed to stand for 5 minutes for reaction to occur. The absorbance and concentration in mg/l was read at 450nm wavelength using HACH DR 2010 UV-visible spectrophotometer.

3.6.3. Determination of Phosphate (PO_4^{2-})

The ascorbic acid method, according to APHA (1998) was adopted for the determination of phosphate level of the river water. Ascorbic acid based reagent powdered pillow was added into 25ml of the water sample in a cuvette. The sample was allowed to stand for 2 minutes for reaction to occur. The absorbance and concentration in mg/l was read at 890nm wavelength using HACH DR 2010 UV-visible spectrophotometer.

3.6.4 Determination of total suspended solids (TDS)

An aliquot of the sample was filtered through a weighed glass-fibre filter paper, and the filter paper was oven-dried at 105ºC for 3 hours according to ASTM D1888-78 method. The weight of the filter paper was measured with a Mettler H78AR analytical balance. The difference in weight was taken as the TSS in mg/l.

3.6.5. Determination of trace metals

The heavy metals content of the river water was determined with the use of a Varian Spectra AA 600 Atomic Absorption Spectrometer, as adopted from APHA (1998).

3.6.6. Biological oxygen demand (BOD)

BOD was determined after 5 days incubation period at 20 ± 1 °C with same HANNAH HI 9828 V1.4 PH/0RP/EC/DO Meter.

Calculation

$$\mathbf{BOD_5\ (mg/l) = \frac{D_1 - D_2}{P}}$$

Where D_1 is dissolved oxygen of the dilution sample 15 minutes after preparation

D_2 is dissolved oxygen of the diluted sample after incubation period of 5 days, and

P, decimal fraction of sample used

3.6.7. Determination of Chloride ions (Cl^-)

In the determination of the chloride ions content of water samples, the Argentometric method (APHA, 1998) was employed.

3.6.8 Reagents

a. Potassium chromate (K_2CrO_4) indicator solution

Five grams of K_2CrO_4 was added to 10ml distilled water in a 50ml beaker. Drops of 0.014N $AgNO_3$ solution were added until a definite red precipitation was formed. The precipitate was allowed to stand for 12 hours, after which it was filtered and diluted to 10ml with distilled water.

b. 0.0141N standard silver nitrate solution ($AgNO_3$)

This was prepared by dissolving 0.2395g $AgNO_3$ in 100ml-distilled water.

c. 0.0141N standard sodium chloride solution (NaCl)

This was prepared by dissolving 82.4mg of NaCl (dried at 140°C) in 100ml-distilled water.

Procedure

The pH of 60ml of the sample was first determined to be less than 7 and then adjusted to about 10 by adding drops of 1N NaOH solution. One millilitre of K_2CrO_4 indicator solution was added to 25ml of sample. This was followed with titration with $AgNO_3$ solution to a pinkish-yellow end point. For the standardization of the $AgNO_3$ solution, 25ml of distilled water containing the reagent (reagent blank) was also titrated with the $AgNO_3$ solution.

Calculation

$$\text{Mg Cl/l} = (A\text{-}B) \times N \times 35{,}450/\text{Ml sample}$$

Where **A** is ml titration for sample,

B is ml titration for blank,

N is normality of $AgNO_3$

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

3.6.9. Determination of total petroleum hydrocarbons (THC)

The water samples were extracted by pouring 20ml carbon tetrachloride in seperatory funnel and shaking the mixture vigorously for 5 minutes with intermittent release of air. This was then allowed to stand as to enable the extracts settle to the bottom of the funnel. The volume of the water was measured with a measuring cylinder and the value recorded. Extract was analyzed in an infrared spectrophotometer. Cuvette measuring 1cm x 1cm was filled with the extract and corked. The extract was treated with silica gel and scanned between 3000cm^{-1} and 2700 cm^{-1} wave numbers while placed in the sample compartment of the FTIR.

3.7. Microbiological Analyses

Water samples were collected in replicates with sterile Nickson Water Sampler at each of the sampling locations monthly from the pelagial and deeper columns and composited. Total heterotrophic bacteria (THB) were enumerated with nutrient agar (NA) (Oxoid) while total heterotrophic fungi (THF) were enumerated with potato dextrose agar (PDA). The modified mineral salt agar (MS) was used to isolate the hydrocarbon utilizing fungi (HUF) while the unmodified MS agar was used to isolate the hydrocarbon utilizing bacteria (HUB) applying the vapour phase transfer method of Thijsse and van der Linden (1961) as modified by Okpokwasili and Amanchukwu (1988). Standard method as provided by the Bergey's Manual of Determinative Bacteriology (1993) and Mills *et al*. (1978) were used.

CHAPTER FOUR

4.0 RESULTS, ANALYSES AND DISCUSSION

After sample collection and laboratory tests were carried out the following results were obtained on various parameters on the water quality of the Imo River.

Table 4.1. Physiochemical Variability Of Imo River In Oyigbo L.G.A

Parameters	Sampling locations					
	1	2	3	4	5	6
Water temp(˚c)	28.0	28.0	28.0	27.5	28.0	27.8
	27.5	27.0	27.5	27.2	28.0	28.0
PH	6.3	6.4	6.4	6.4	6.5	6.3
	6.5	6.5	6.5	6.5	6.6	6.6
Turbidity(NTU)	30	55	40	38	71	67
	33	19	66	20	37	15
DO(mg/l)	5.60	5.20	5.00	5.00	4.80	5.00
	7.00	7.05	7.00	7.00	6.80	6.80
BOD_5(mg/l)	2.10	2.20	2.40	2.20	2.10	2.50
	3.00	3.20	3.00	2.40	3.10	3.00
TSS(mg/l)	4.0	4.5	5.0	4.8	4.5	3.6
	8.5	8.1	9.0	8.0	9.1	8.7
TDS(mg/l)	19.9	22.5	20.8	21.5	22.1	21.0
	27.2	28.9	30.3	27.5	27.5	27.0
THC(mg/l)	0.010	0.021	0.026	0.030	0.020	0.020
	N.D	0.020	0.019	0.019	0.020	0.031
Conductivity(µs /cm)	20.5	21.1	24.0	4.1	19.9	21.5
	50.0	98.8	72.1	58.5	70.5	82.0
	0.41	0.39	0.41	0.33	0.43	0.19
NO_3^-(mg/l)	0.21	0.17	0.13	0.37	0.29	0.31
	0.07	0.07	0.08	0.09	0.09	0.10
PO_4^{2-}(mg/l)	0.10	0.12	0.11	0.11	0.15	0.10
	1.00	1.00	1.10	0.99	1.21	1.11
SO_4^{2-}(mg/l)	7.00	4.21	3.95	6.11	5.14	5.20
	0.01	0.02	0.02	0.03	0.02	0.01
Cl^- (mg/l)	0.08	0.07	0.05	0.04	0.01	0.03

HORIBA U-10 Water quality checker

Table 4.2 Physiochemical Variability Of Sediments Of The Imo River In Oyigbo L.G.A

	Sampling locations					
Eckman grab	**1**	**2**	**3**	**4**	**5**	**6**
PH	**6.98** **6.91**	**6.98** **6.97**	**6.85** **6.94**	**6.98** **6.95**	**6.97** **6.98**	**6.96** **6.91**
THC(mg/kg)	**0.83** **1.04**	**1.22** **0.22**	**3.11** **2.51**	**2.22** **3.21**	**4.51** **1.91**	**4.82** **4.84**
NO_3^-(mg/kg)	**0.51** **0.22**	**0.32** **0.41**	**0.51** **0.53**	**0.62** **0.64**	**0.32** **0.41**	**0.43** **0.71**
SO_4^{2-}(mg/kg)	**50.21** **39.00**	**50.80** **60.30**	**30.80** **55.50**	**48.50** **43.20**	**40.41** **65.20**	**33.50** **38.50**
PO_4^{2-}(mg/kg)	**0.51** **0.70**	**0.53** **0.60**	**0.41** **1.10**	**1.02** **0.52**	**0.71** **0.73**	**0.81** **1.10**

Table 4.3 Microbiological Variability Of Imo River In Oyigbo L.G.A

Cfu/ml	1	2	3	4	5	6
THB($x10^2$)	2.30 2.33	2.31 2.30	2.50 2.40	2.70 2.70	2.72 2.70	2.80 2.80
THF($x10^1$)	5.0 5.0	5.1 5.0	6.0 6.2	6.1 6.3	5.5 5.4	7.5 7.4
HUB($x10^1$)	1.60 1.65	1.20 1.22	1.40 1.40	1.80 1.78	1.72 1.70	1.95 1.92
HUF($x10^1$)	2.70 2.60	2.75 2.70	3.00 3.30	3.30 3.30	3.40 3.20	3.50 3.40

ABBREV- FULL MEANING
THB- total heterotrophic bacteria **THF-** total heterotrophic fungi **THC**- total hydrocarbon **TDS**- total dissolved solids **HUB-** hydrocarbon utilizing bacteria **HUF-** hydrocarbon utilizing fungi **NTU-** Nephelometric Turbidity Unit **DO-** dissolved oygen **TSS-** Total soluble solids **BOD-** biological oxygen demand

4.1. Variation in Physicochemical Parameters of the surface water

Table 4.1. Shows the values of the physicochemical characteristics of the Imo River in Oyigbo L.G.A, during the study period. Both narrow and wide variations were observed in the parameters measured. Conductivity, turbidity, total dissolved solids as well as sulphates showed wide variations, while other parameters showed narrow variations. Temperature ranged between (27.00- 28.00) ˚C, ph between (6.3-6.6), turbidity between (15-71) NTU, nitrates between (0.13-0.43) mg/l, phosphates (0.07-0.11) mg/l,(Table 4.1) . Conductivity ranged between 19.9- 82.0 µs/cm, DO between 4.8- 7.05mg/l, BOD between 2.10- 3.20 mg/l, TDS between 19.9-30.30mg/l, THC between 0.010-0.031mg/l, TSS between 3.6- 9.1mg/l, sulphates between 0.99-7.00mg/l, and chlorides between 0.01-0.08mg/l(table 4.1) .

Graphical representation of result analysis showing spatial variation of some parameters

Fig 4.4 – 4.7

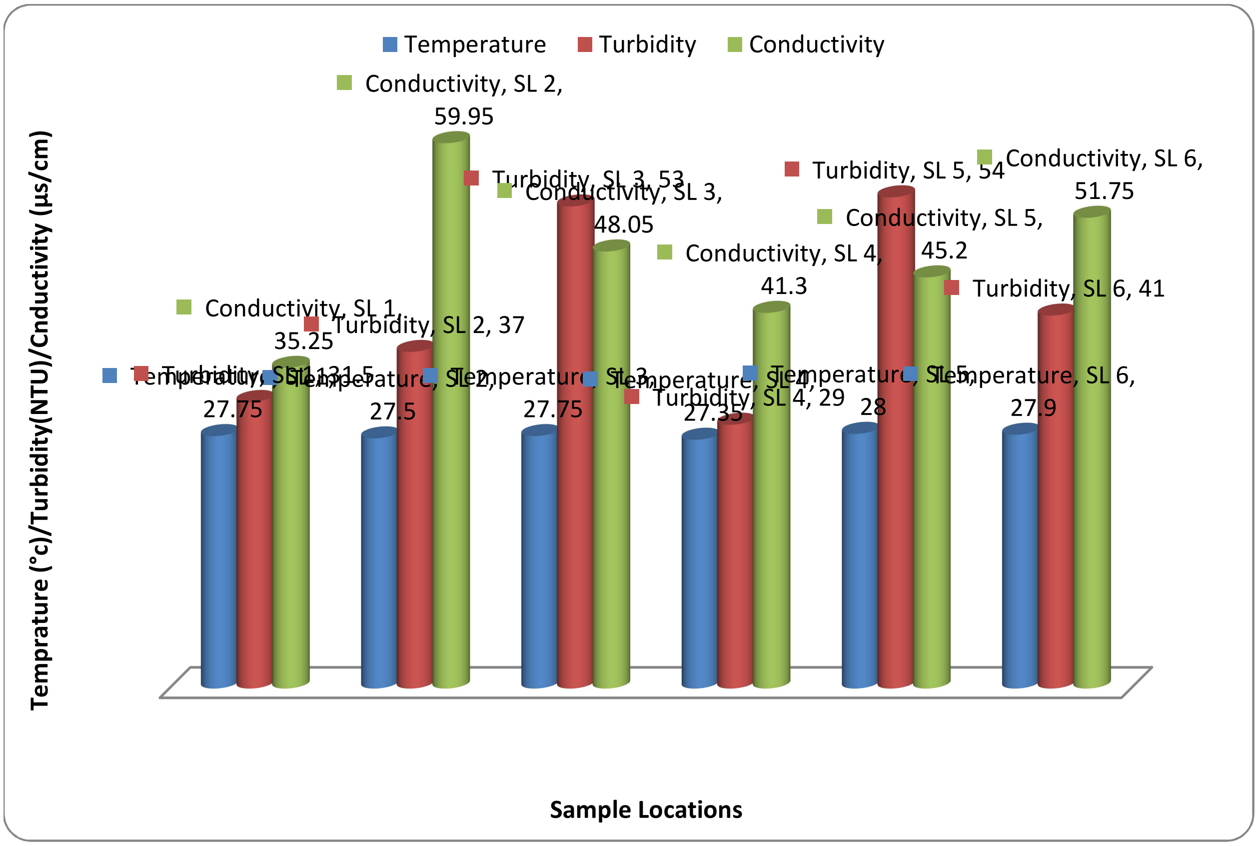


Fig. 4.4. Spatial variations in water temperature, turbidity and electrical conductivity of Imo river in Oyigbo L.G.A

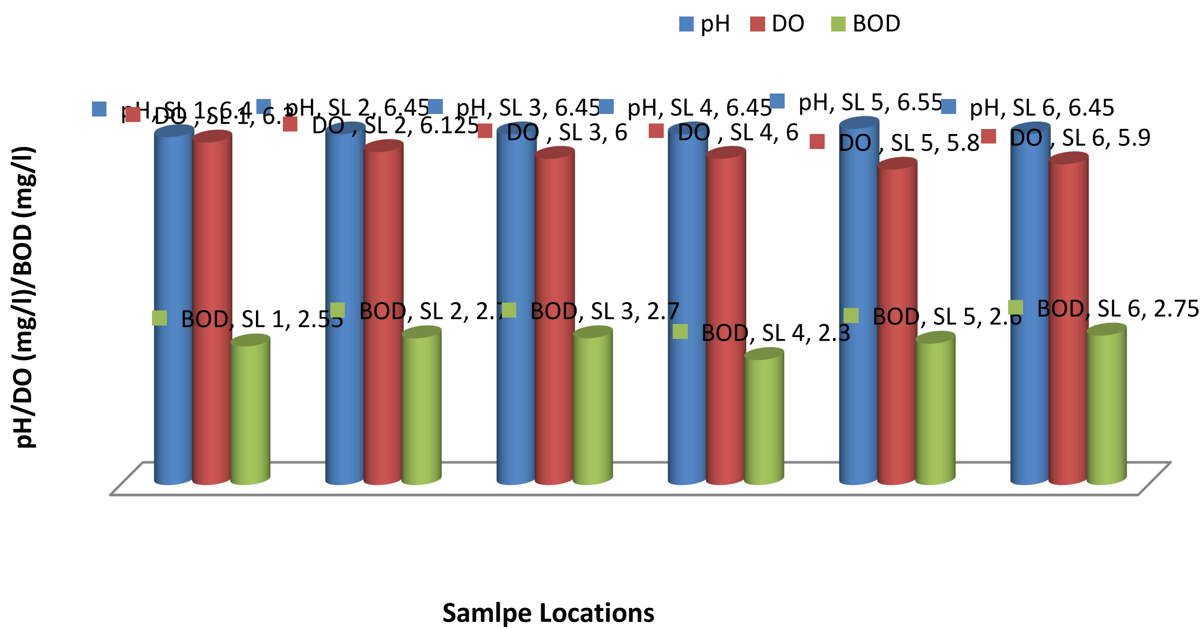


Fig . 4.5. Spartial variation in pH, dissolved oxygen and biolobical oxygen demand of Imo river in Oyigbo L.G.A

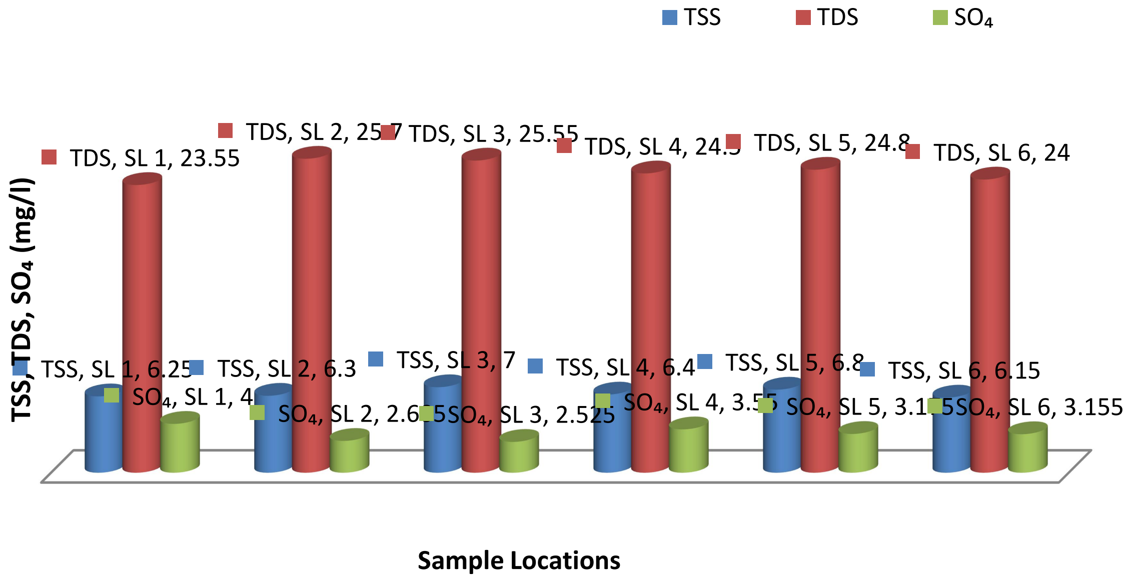


fig. 4.3 Spartial variations in total suspended and ddissolved solids, and sulphate ion concerntrations of Imo river in Oyigbo L.G.A

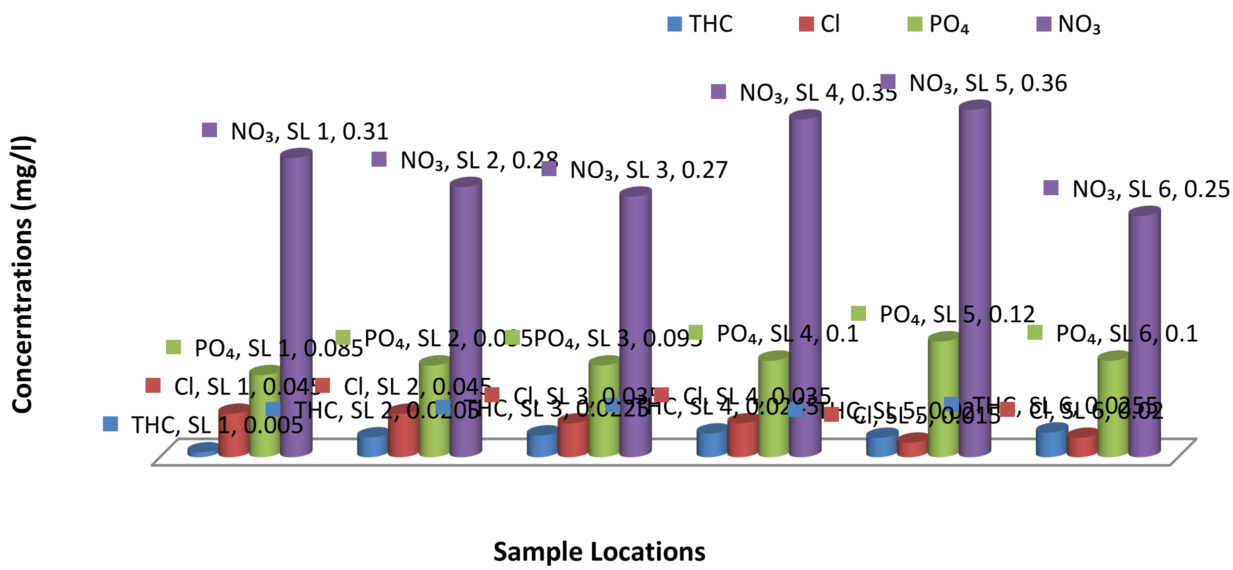


Fig. 4.4. Spartial variations in toatl petoleum hydrocarbons, chloride, phosphate and nitrate ion contents of Imo river in Oyigbo L.G.A

4.2. Variations in physiochemical parameters of sediments

Table 4.2., Shows values of the physiochemical characteristics of the sediments of the Imo River in Oyigbo L.G.A, during the study period. Total hydrocarbon and sulphates showed wide variations while ph, nitrates, and phosphates showed narrow variations. pH ranged between 6.85-6.98, total hydrocarbon between 0.22-4.84mg/kg, nitrates between 0.22-0.71mg/kg, phosphates between 0.41-1.10mg/kg, and sulphates between 30.80-65.20mg/kg.

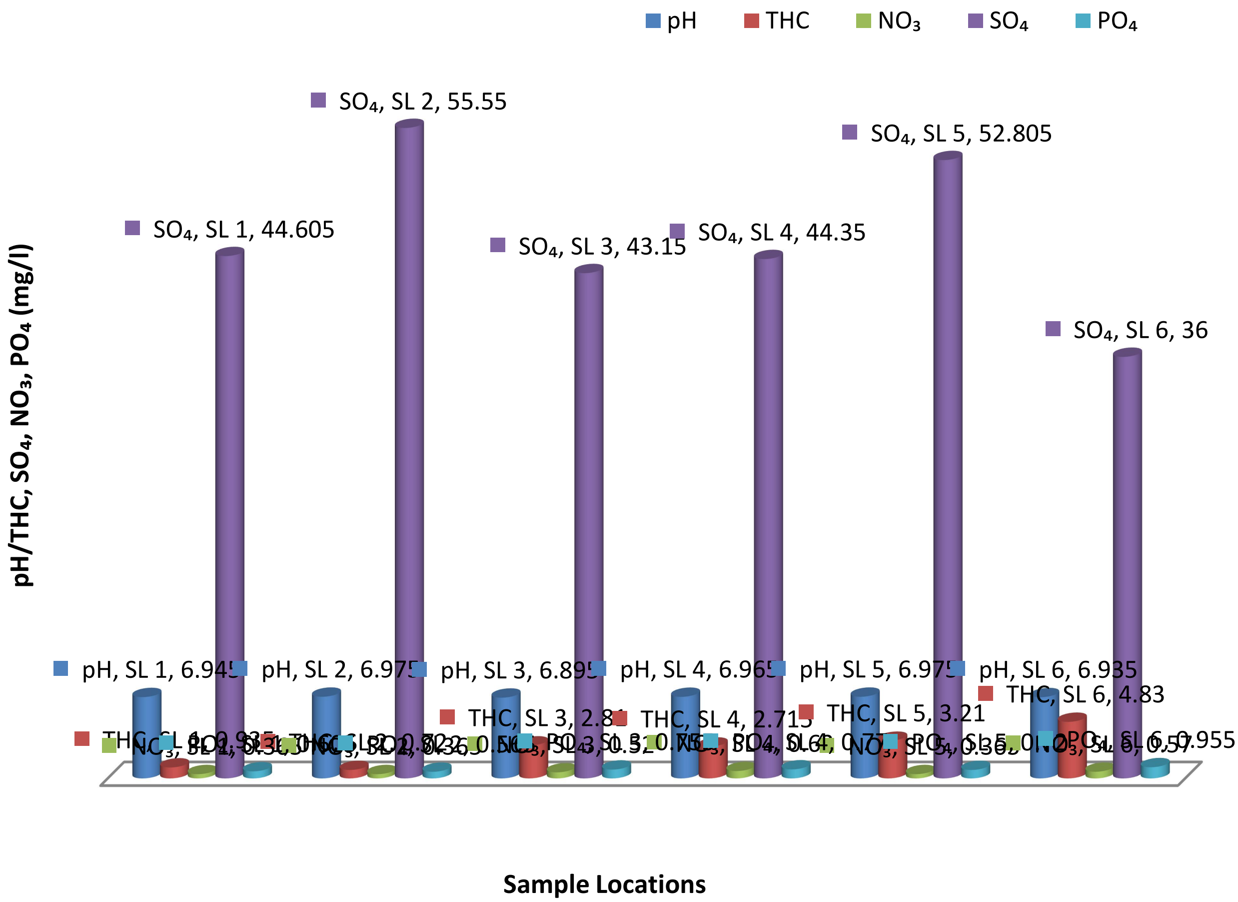


Fig.4.5. Spatial variations in pH, total petroleum hydrocarbons, sulphate, nitrate and phosphate in sediments of Imo river in Oyigbo L.G.A

4.4. Variation in microbiological parameters

Table 4.3., shows the values of the microbiological characteristics of the Imo River in Oyigbo L.G.A., during the study period. Microbiological variability of the six sample locations within the study period was relatively uniform with narrow variations. Total heterotrophic bacteria ranged between 2.30-2.80x10^2, total heterotrophic fungi between 5.0-6.3x10^2, hydrocarbon utilizing bacteria between 1.40-1.95x10^2, and hydrocarbon utilizing fungi between 2.60-3.50x10^2.

Most of the physiochemical parameters measured were within the federal ministry of environments permissible limits for aquatic life(appendix 2) and within WHO and NESREA/UNEP limits for water quality for domestic use (appendix 3).

However , turbidity values were above regulatory limits of 1- 5NTU, although there is no health impact that results from this increament.

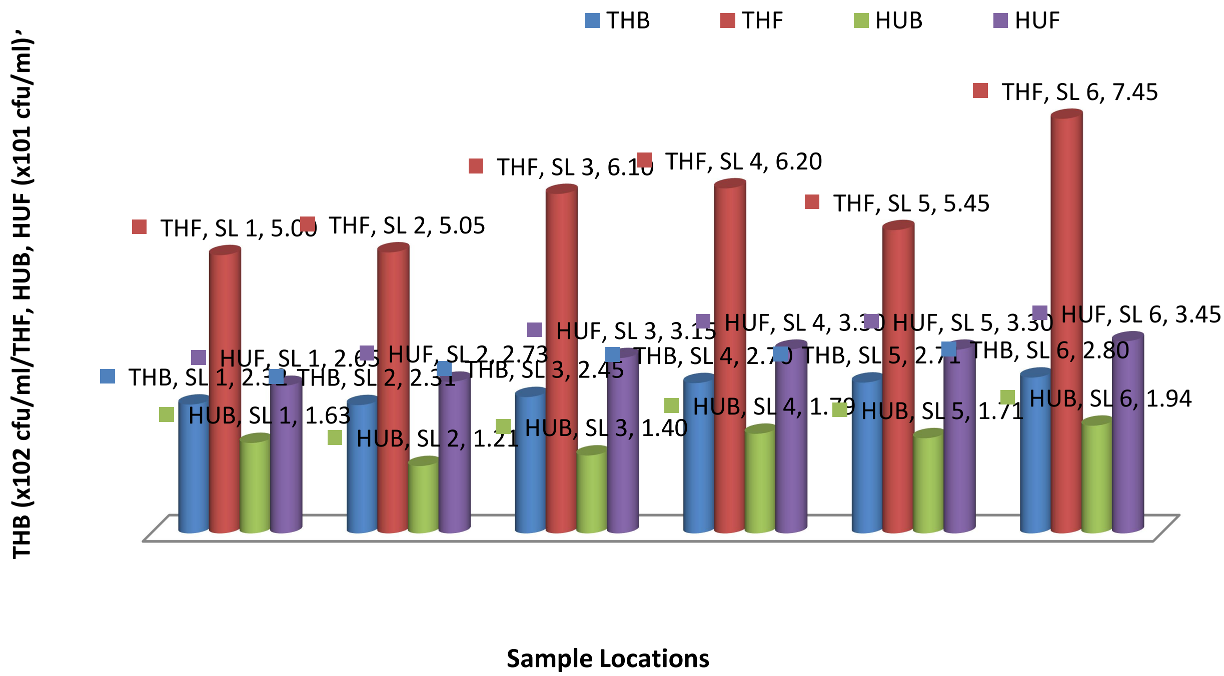


Fig. 4.6. Spatial variation in total heterophic bacteria and fungi, and hydrocarbon utilizing bacteria and fungi of Imo river in Oyigbo L.G.A

4.5. Discussion

The results of the Physiochemical variability of the Imo River in table 4.1. the objective for drinking water is pH between 6.5 and 8.5(Mckean and Nagbal,1991) the analysis of the results showed pH in the Imo River in Oyigbo L.G.A was generally near neutral, with average values ranging from 6.3-6.6 for the surface water.((table 4.1). all pH values were well within the drinking water and aquatic life guidelines set by the Federal Ministry Of Environment(FMOE) and Standard Organization Of Nigeria(SON), suggesting that pH is not presently a concern with the Imo River in Oyigbo L.G.A.

For the protection of aquatic life, the allowable change in temperature is +/-1°C from naturally occurring levels. The narrow variation in temperature of +/-0.5 recorded in this study is suitable for aquatic organisms. Since, they have narrow temperature tolerance, even as the temperature range is similar to many other waters of the Niger delta area (NADECO, 1980; SPDC, 1998). Temperature is considered in drinking water for aesthetic reasons. The WHO guideline is 15°C and temperatures above this level are considered to be too warm to be aesthetically pleasing (Oliver and Fidler, 2001).

The temperature range from the six samples were well below maximum limits for the support of aquatic life forms in the Imo river, although temperature exceeded the aesthetic drinking water guideline (a maximum of 15°C) by a considerable margin, there is no health impact that could result from this.

For though turbidity was not specified by the Federal Ministry Of Environment (FMOE) for aquatic life, comparatively high values in this study could impair aquatic productivity of resident biotypes. Elevated turbidity levels can decrease the efficiency of disinfection, allowing coli forms to enter the water system. As well, there are aesthetic concerns with cloudy water, and particulate matter can clog water filters and leave a film on plumbing fixtures.

As presented in table 4.1.The turbidity levels of 15 to 67 observed and recorded in the Imo River in Oyigbo L.G.A, were significantly higher than the (NG.SON) maximum levels permitted for drinking water, although there were no negative health impacts associated with this increase.

The guideline for drinking water that does not receive treatment to remove turbidity is an induced turbidity over background of 1 NTU when background is not more than 5 NTU and a maximum change from background of 5 NTU (during turbid flow periods) (Caux *et al*., 1997). In general, it is considered that turbidity values greater than 2 NTU will compromise disinfection efficiency (VIHA pers. comm., 2006).

It should be noted that turbidity values above 2 NTU are considered likely to affect disinfection in a chlorine-only system. An alternative to the average objective of 2 NTU would be to treat the raw water prior to chlorination to remove some of the turbidity and increase chlorine efficiency.

As presented in table 4.1. SO_4^{2-} varied from 1.0 to 7.0. The wide variation recorded for SO_4^{2-} is attributed to increased inputs from catchment lands, through runoffs and flooding. Okpokwasili and Olisa (1991) and Odokuma and Okpokwasili (1992) reported that concentrations of sulphate in water bodies could also be contributed by the use of sulphate containing detergents by humans in catchment areas

As presented in table 4.1. NO_3^- ranged from 0.13to 0.43. PO_4^{2-} varied from 0.07 t0 0.15. The concentrations of nitrogen (nitrite- NO_3^-) and phosphorus (PO_4^{2-}) are important parameters, since they tend to be the limiting nutrients in biological systems. Productivity is therefore directly proportional to the availability of these parameters. Nitrogen is usually the limiting nutrient in terrestrial systems, while phosphorus tends to be the limiting factor in freshwater aquatic systems.

The guideline for the maximum concentration for nitrite is a maximum of 1 mg/L as nitrogen. When both nitrate and nitrite are present, their combined concentration must not exceed 10 mg /L as N. For the protection of freshwater aquatic life, the nitrate guidelines are a maximum concentration of 31.3 mg/L and an average concentration of 3 mg/L. Nitrite concentrations are dependent on chloride; in low chloride waters (i.e., less than 2 mg/L) the maximum concentration of nitrite is 0.06 mg/L and the average concentration is 0.02 mg/L. Allowable concentrations of nitrite increase with ambient concentrations of chloride (Meays, 2009).

There are no Federal Ministry of Environment (FMOE) guidelines for phosphorous in streams. However, the low NO_3^- and PO_4^{2-} loadings in this study preclude possible eutrophication in the channel. This is because nitrogen and phosphorus are considered to be the primary drivers of eutrophication of aquatic ecosystems (kiely, 1998), where increased nutrient concentrations lead to increased primary productivity (Ogbuagu and Ayoade, 2011).

As presented in table 4.1. The DO levels recorded in this study ranged from 5.0 to 7.05 and where well within limits set by WHO. According to Rajasooriyar (2003), DO levels less than 3 mg/L are stressful to most aquatic organisms. Most fish die at 1-2 mg/L. However, fish can move away from low DO areas. Water with low DO from 2 – 0.5 mg/L are considered hypoxic; waters with less than 0.5 mg/L are anoxic.

BOD (and COD) is a common measure of water quality that reflects the degree of organic matter pollution of a water body (UNEP GEMS, 2006). As presented in table 4.1 the B.O.D of this study ranged from 2.1 to 3.2 and did not indicate pollution of the channel during the study.

The results of the microbial variability of the Imo River is presented in table 4.3 THB ranged from 2.30 to 2.80.THF ranged from 5.0 t0 6.3. HUB ranged from 1.20 to 1.95, HUF ranged from 2.70 to 3.50). Colony counts of THB, THF HUB and HUF's in the Imo River where high. The microbiological content of marine and fresh waters will reflect the quantity and quality of inputs from many sources, including sewage, effluents, birds, animals and industrial and agricultural discharges(anon, 1996). Colony counts of THB,THF , HUB and HUF’s can be used to access the general microbiological content of water. Counts of THB,THF, HUB and HUF’s are useful in evaluating treatment effectiveness. THB, THF, HUB and HUF’s are not an index of faecal pollution or health risk but can provide basic information on source water quality (Clark, 1968).

The relationship between illness and contact with or ingestion of water that contains microorganisms has been investigated several times, and various guidelines involving indicator organisms bathing densities have been reported. Although plausible associations between recreational exposure and minor diseases have been reported, it is difficult to correlate these illnesses to the microbiological quality of water.

CHAPTER FIVE

5.0 SUMMARY AND CONCLUSION

5.1. summary

According to Adakole *et al*. (2003), the quality of any water body is governed by its physiochemical factors. The monitoring of these factors therefore is vital for both long and short term environment management (Wood, 1995). The distribution and productivity levels of organisms are largely determined by physicochemical factors in aquatic systems (Adakole *et al*., 1998). Consequent upon this Spaak and Bauchrowitz (2010) asserts that anthropogenic environmental changes affect natural biodiversity. Accordingly, several authors have investigated the direct effect of interactions of many frequently measured physicochemical variables on biotic residents of aquatic ecosystems (Jonnalagadda and Mhere, 2001; Kemdirim, 1993; Wood, 1995)

The water quality of the Imo River in Oyigbo local government area was ascertained using standard methods in this research. The important physicochemical characteristics of the river were investigated during the wet season of 2013 at six sampling locations. *In situ* measurements were made for water temperature, salinity, turbidity, dissolved oxygen (DO), biological oxygen demand (BOD), etc using the HORIBA U-10 water quality checker. The total dissolved solids and total soluble solids e.t.c were determined with HACH conductivity/TDS meter. Water samples were collected in replicates with 2 liters plastic containers and taken to the laboratory in iced coolers for analysis. The test for homogeneity in mean variance was used to determine spatial variation in the physicochemical variables. The eckman grab sampler was used to acquire sediments to test for the physicochemical variability of the sediments from the river. The physicochemical variability for the Imo river from the six sample locations indicated that Water temperature varied between (27.00- 28.00 °c), ph (6.3-6.6), turbidity (15-71 NTU), electrical conductivity (19.9- 82.0µs/cm), dissolved oxygen (4.8- 7.05mg/l), biological oxygen demand (2.10- 3.20 mg/l), total dissolved solids (19.9-30.30mg/l), total hydrocarbon (0.010-0.031mg/l), total soluble solids (3.6- 9.1mg/l), nitrates (0.13-0.43mg/l), phosphates (0.07-0.11mg/l), sulphates (0.99-7.00mg/l), and chlorides(0.01-0.08mg/l), on the other hand the physicochemical variability of the sediments from the six sample locations indicated that ph varied between (6.85-6.98),total hydrocarbon(0.22-4.84mg/kg), nitrates(0.22-0.71mg/kg), phosphates (0.41-1.10mg/kg), and sulphates(30.80-65.20mg/kg).While, the microbiological variability of the sediments indicated that total heterotrophic bacteria varied between(2.30-2.80x10^2), total heterotrophic fungi (5.0-6.3x10^2), hydrocarbon utilizing bacteria(1.40-1.95x10^2), and hydrocarbon utilizing fungi between(2.60-3.50x10^2). The results obtained for the physicochemical parameters and microbial variability agreed with the permissible limits set by both national and international bodies for drinking and domestic water and for the sustenance of aquatic life with few exceptions.

These exceptions are : the high turbidity, the low NO_3^- and PO_4^{2-}, high colony counts of THB,THF,HUB and HUF's.

5.2. Conclusion

The assessment of the Imo River in Oyigbo L.G.A of rivers state revealed wide variations in nitrites, phosphates, turbidity, colony counts THB, THF,HUB and HUF's during the sampling period. However narrow variations were observed in temperature, pH, nitrates, BOD and phosphates. The levels of several of these parameters were simila5 to those recorded for other inland waters of the Niger-Delta area of Nigeria.

Other than turbidity the other physiochemical variables fell within recommended limits for aquatic life by the Federal Ministry of Environment. The microbiological content of the Imo River in Oyigbo L.G.A of Rivers State revealed that adequate treatment and purification should be carried out on the water before consumptive measures are put to it. Failure to do so could easily result in such severe health implications like a break out of several endemic/epidemic gastrointestinal and water borne diseases like Diarrhea, Dysentery, Schistosomiasis, Otitis Externa, Typhoid Fever, Ascariasis, Cholera. Etc.

5.3 Recommendations

Sequel to the research finding in the current study, the following recommendations were made:

1. The state environmental protection agencies (sepa) Should develop practical standards and regulations for the protection of water ways.

2. SEPA should mount regular surveillance to prevent further pollution of the channel

3. Current approaches by the pollution and control department of the Federal Ministry of Environment,(FMOE) aimed at reducing significant pollution should be maintained.

4. Further studies should include detection and enumeration of faecal coli forms and other pathogenic microorganisms and ways of remediating and reducing pollutions within this river.

5. Basic personal and environmental hygiene should be made known to the people to safeguard their health as well as the environmental resources.

6. The companies operating in close proximity to this river should ensure adequate treatment of effluents discharge and waste dumps with the best available technique (BAT) to permissible limits before discharging.

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