CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The importance of River Niger in the daily life of the people living along the bank of the river through which the river flows and its health implications make it imperative that thorough quality examination be conducted on the water. It is possible that floods and other anthropogenic activities might have introduced many substances into the water body that may be harmful to the people and the aquatic life.

The economic, health and physical well being of the people are tied to the river which is the major source of their daily supply of water for drinking and household chores. The river serves as source of their livelihood as most of the people depend heavily on the water for fishing both for commercial and subsistence purposes. The river is also used for irrigation farming for vegetables and other crops mostly for commercial purposes. The river also serves as their means of transportation. The people and the farm produce are transported using boats and ferries across the river to the markets.

Drinking water is the basic need for the development of human civilization. Over many centuries people lived on the banks of rivers, streams and other water courses. They drank, washed and moved from place to place on these waters. Only during the last 200 years we have seen rapid developments in water treatment. Developments were more rapid during 20th century, due to rapid developments in the quality and quantity requirements and due to increase in population per capita needs and industrial development (Rao, 2006).

Infectious diseases are transmitted by microbes for which water acts as a carrier. The normal carriers of infectious diseases are:

1. Water used for drinking, bathing, washing vegetables and fruits.
2. Food stuffs in which microbes develop
3. By direct or indirect contact of infected with healthy ones.
4. By insect in which water plays a vital role (Rao, 2006).

The lack of safe drinking water and adequate sanitation measure lead to a number of diseases such as cholera, dysentery, salmonellosis and typhoid, and every year millions of lives are claimed in developing countries. Diarrhoea is the major cause of the death of more than two million people per year worldwide, mostly children under the age of five. It is a symptom of infection or the result of a combination of a variety of enteric pathogens (Anon, 2000).

Water borne pathogens infest around 250 million people each year resulting in 10 to 20 million deaths worldwide. In South Africa alone more than 7 million people (approximately 17% of the population) do not have access to potable water supply and nearly 21 million (54% of the population) lack basic sanitation (Dwaf, 1996). This highlights the potential of infection due to water borne pathogens.

The evaluation of water supplies for coliform bacteria is important in determining the sanitary quality of drinking water. High level of coliform count indicates a contaminated source, inadequate treatment or post treatment deficiencies (Matthew *et al.*, 1984). Many developing regions suffer from either chronic shortage of freshwater or the readily accessible water resources are heavily polluted (Lehloesa and Muyiwa, 2000). Microbiological health risks remain associated with many aspect of water use including drinking water in developing countries (Horne and Bennison, 1987). It has been reported that drinking water supplies have a long history of association with a wide spectrum of microbial infection. Therefore, the primary goal of water quality management from a health perspective is to ensure that consumers are not exposed to doses of pathogens that are likely to cause disease. Protection of water sources and treatment of water supplies have greatly reduced the incidence of these diseases in developing countries (Sues, 1982).

One of the difficulties in evaluating the impact of drinking water supply on health is the lack of local demographic statistics, particularly in rural communities. Therefore, it is important to know the incidence of diseases occurring in rural areas due to polluted water. This will provide an opportunity to compare the incidence of water-borne disease between the communities that have drinking water and those that do not.

Detection and enumeration of indicator organisms is the basic microbiological technique used in water quality monitoring (APHA and AWWA,1984). The coliform group of bacteria can be defined as the principal indicators of purity of water for domestic, industrial and other uses.

Along the River Niger over 80% of the population in Nigeria rely on surface water as the main source of water (Madu *et al*., 2008). This relatively high percentage of the population that is without proper water supply service indicates that many of the people still utilize untreated surface water for domestic purpose. Most of these people are poor and rely on state intervention for improved water supply.

In less industrialized areas, pollution from human settlements lacking appropriate sanitary infrastructure, partially treated or untreated waste water, leachates from refuse dumps and from land use activities such as agriculture are the major pollution sources of the surface water

(Sodhi,2005). Microbiological and the physical water quality indicators are therefore, the major parameters to be monitored in the rivers, dams or boreholes of catchments (Dwaf, 1996).

Heavy metals enter human bodies through food, drinking water and air. Heavy metals can find its way into a surface water source through industrial and consumer waste or even from acidic rain breaking down soils and releasing heavy metals into the streams, dams, lake and rivers (Sundaray *et al*., 2006). The concentrations of the inorganic constituents of underground water are primarily dependent on the elemental availability in the soil and rocks through which the ground water percolates (Freeze and Cherry, 1979).

A wide variety of metals in various forms can be found in water, some concentration occur naturally (background level), their presence being influenced by the soil or rock mineralogy while others can be introduced through man's activity (Onianwa *et al.,2001).*

Many heavy metals (such as Fe, Mn, Cu, Cd, and Pb) occur in nature in ore deposit (Laws, 1981., Ezegbo, 1989). As trace elements some heavy metals (e.g copper, selenium and zinc) are essential to maintain the metabolic process of the body. However at higher concentration they can lead to poisoning. Heavy metals are dangerous because they tend to bioaccumulate, causing some health effect like cancers, bone defects; (Osteomalacia and Osteoporosis) in human and aquatic animals. They accumulate in fishes or other aquatic animals thus adding to the danger of eating fish that may have been exposed to high level of heavy metals in water (Venugopal *et al.*, 2009).

Heavy metals are already present in the environment, all man needs to do is to modify their concentration and the ways in which they spread. The trends to reduce use of heavy metals should be encouraged. However two points deserved special attention, recycling and disposal.

Eliminating the use of heavy metals is often extremely expensive and the outcome uncertain. The spreading of sludge on land; this issue goes far beyond the single question of heavy metals.

Technique of “slurrry spray” and the recurrent food crisis demonstrate considerable reticence on the part of farmers. There is no simple conclusion as regards the transfer of heavy metal into plants (Adeyeye, 1996)

Very low concentration of most metal are required for living organism in the environment, but in excess concentration heavy metals can be harmful; the potential adverse impact of heavy metals are diverse pollution of aquatic system by heavy metals, inhibit primary production, nitrogen fixation, the mineralization of carbon, nitrogen, phosphorus, alter decomposition and enzymes synthesis (Forstner & William, 1983; Rahman *et a*l.,2012).

Apart from the sources or origin of heavy metals, the physico- chemical properties of water also affect the concentration of heavy metal in soils. Organic matter and pH are the most important parameters controlling the accumulation and availability of heavy metals in soil environments. It is then necessary to evaluate the relationship among these parameters and heavy metals accumulation in soil (Nyamangara & Mzezewa, 1999).

The origin of sediment heavy metals can be divided into point and non-point sources of pollution. Point sources of pollution come from specific identifiable sources such as pipe. Non-point sources includes municipals sewage treatment plants, overflow from combined sanitary and storm sewers, storm water facilities and waste discharge from industry. Point sources includes storm water, run off from hazardous water, run off from hazardous and solid wastes, run off from crop land, livestock pens, mining and manufacturing operations and storm sites and atmonspheric depositon (USEPA,1996).

Chronic low-level intakes of heavy metals have damaging effects on human beings and other animals, because metals such as lead, mercury, cadmium and copper cause serious environmental hazards and are known to be exceptionally toxic (Tucker *et al*., 2003)

Recent studies have shown for instance that human activities have created ecological pressure on the natural habitat of fish and other marine organism overtime. There is an upsurge of interest in water pollution as a result of this deleterious effect (Olowu *et al*., 2009). Furthermore, factors such as high population growth accompanied by intensive urbanization, increase in industrial activities and higher exploitation of natural resources including cultivatable land have caused pollution increase. There had been a steady increase in discharge that reaches the aquatic environment from industries (Atta *et al*., 1997). In addition to direct depletion of oxygen, the deposition of large quantities of organic materials in the water produces inorganic nutrients such as ammonia, nitrate, and phosphorus. These enrich the water considerably and give rise to dense algae growth or bloom which can cause the wide daily fluctuation in dissolved oxygen content of water bodies. This increased productivity caused by excessive organic loads can cause a decline in water quality.

Sediments are normally the final pathway of both natural and anthropogenic components produced or derived to the environment. Sediment quality is a good indication of pollution in the water column, where it tends to concentrate the heavy metals and other organic pollutant (Saheed and Shaker, 2008).

Sediments have been known to be the major repository of heavy metals in aquatic system. Bioaccumulation and magnification is capable of leading to toxic level of these metals in fish even when the exposure is low (Olowu *et al.*, 2009) .The presence of metal pollutant in fresh water is known to disturb the delicate balance of the aquatic eco-system. Fishes are notorious for their ability to concentrate heavy metals in their muscles and since they play important roles in human nutrition, they need to be carefully screened to ensure the unnecessary high level of some toxic trace metals are not being transferred to man through fish consumption (Ademisi and Yusuf, 2007).

Over the last few decades there has been growing interest in determining heavy metal levels in the marine environment and attention was drawn to the measurement of contamination levels in public food supplied, particularly fish (Khaled, 2004). Although heavy metal is a closely defined term (Dwaf, 1996), it is widely recognized and usually applied to the wide spread contaminant of terrestrial and fresh water ecosystems. Some examples of heavy metals include lead, zinc, cadmium, copper, manganese, mercury and arsenic e.t.c. many of these heavy metals are toxic to organism at low concentrations (Alloway and Ayers, 1990, Akoto *et al.*,2008).

The concentration of metal in bio-available form is not necessarily proportional to the total concentration of the metal. The concentration of the various elements in water may be increased beyond their natural level due to the agricultural, domestic and industrial effluents. These substances are described as contaminants when discharged to the environment (Madu *et al*., 2008). In water, insoluble heavy metals may be bound to small slit particles. Metals and other contaminants in suspension or solution do simply flow down the stream, they form complexes with other compounds settle to the bottom and ingested by plants and animals or adsorbed to sediments. Consequently, aquatic organisms may acquire heavy metals in body directly from water via gills or food chain mechanisms (Collision and Shrimp, 2002).

Aquatic animals (including fish) bio-accumulate heavy metals in considerable amount in the tissue over a long time and the dependence of the populace in this area as source of protein makes it imperative to assess the level of heavy metals in the aquatic ecosystem in view of the health implications that cut across the food strata. Heavy metals contamination in river is one of the major quality issues in many fast growing cities because maintenance of water quality and sanitation infrastructure did not increase along with population and urbanization growth, especially for the developing countries (Sundaray *et al*., 2008; Amadi *et al*., 2010). Heavy metals are non-degradable and accumulate in the body system, causing damages to the internal organs (Lee *et al*., 2007; Lohani *et al.*, 2008). They enter into river water from mining areas through various ways such as mine discharge, run off chemicals, weathering rocks and soils, wet and dry fall out of atmosphere particulate matter (Macklin *et al*., 2003; Bird *et al.*, 2003; Kraft *et al*., 2003; Kraft *et al.*, 2006; Venogopal *et al*., 2009) or from industrial areas via discharge of untreated industrial effluent in the river (Singh *et al*., 2008). Rivers in urban areas have also been associated with water quality problems because of the practice of discharging of untreated domestic and small scale wastes into the water bodies which lead to the increase in the level of metals concentration in river water (Rim- Rikeh *et al*., 2006; Juang *et al*., 2009; Venugopal *et al*., 2009). However rivers play a major role in assimilation or transporting municipal and industrial waste- water and run off from agricultural and mining land (Singh *et al*., 2008).

Environmental issues in recent years have dominated and generated more lively discussions than any other scientific topic. This may be due to the sudden realization of the damaging effect of man's activities to the environment. These activities of men have resulted in acid rain, ozone layer depletion, deforestation, dessertation, erosion, global warming, solid waste, toxic chemicals which are detrimental to the environment (Ademoroti, 1996).

1.2 Statement of the Problem

From the best of my knowledge, no systematic study has been conducted on the River within the period and the areas mentioned in this work to evaluate its suitability for agro-domestic purposes. River Niger is transboundary water, which many people in Kogi state depend on for their livelihood such as fishing, irrigation purposes, washing and doing household chores. Along the course of the Niger River particularly areas like Idah, Itobe, Shintaku and Lokoja, there were high rate of anthropogenic activities such as washing of clothes and other materials, dumping of wastes, farming activites that could generate wastes, fishing, passing of faeces at the River bank and a host of others. There is no doubt, many pollutants must have been introduced into the River, including heavy metals.The public health significance of the river can not be over emphasized. In the area studied, many of the people living in the settlements along the bank of the River Niger have no access to portable water, and therefore, depend heavily on the river for domestic purpose, fishing, irrigation farming and transportation.Hence the river has to be monitored for pollution to ascertain its suitability for agricultural and domestic purposes.

1.3 Aim and Objectives

The aim of the research is to evaluate the suitability of the River Niger water for agricultural and domestic purposes from Idah to Kotonkarfe in Kogi State, with a view to ascertaining possible risk effects of using the water.

The objectives of this study are to:

i. determine the physicochemical characteritics of the water,
ii. determine the concentration of heavy metals in water, sediments and some fishes,
iii. determine some microbiological pollution level of the river.

iv. compare the results with international standards, to ascertain the suitability of the water for Agro-Domestic purposes and to ascertain if the aquatic fishes are safe for consumption using risk equations.

1.4 Significance of Study

The public health significance of water quality cannot be over emphasized because many infectious diseases are transmitted by water through the faecal- oral route; disease contracted through water kills about 5million children annually and made 1/6th of the world population sick (WHO, 2011). In Nigeria, many of the settlements along River Niger do not have access to portable water and therefore depend heavily on the River Niger for agricultural and domestic purposes (fishing, irrigation farming) and transportation. No extensive and systematic study has been conducted on the river within the area mentioned in this work to ascertain its suitability for agricultural and domestic purposes. The research is expected to do the following:

Provision of data to assess the quality of the river and its suitability for agricultural and domestic purposes, that could be used in solving some health problems with regard to the river and the people living within its enviroment.

Availability of data that could be used as guidance by government in formulating sustainable policies with regard to the river and its environment.

1.5 Scope of Study

The study covered River Niger from Idah to Kotonkarfe in Kogi state, Nigeria, the sampling period covered 8months, 4 months of wet season (June – September, 2014) and 4 months of dry season (March – October, 2014), it involved the collection of 40 samples of water and 40 samples of sediments on daily basis. A total of 640 samples of water and sediments were obtained. It also involved the collection of 5 samples of Catfish and Tilapia from 3 designated points along the River (Idah, Itobe and Lokoja). The scope also covered the measurement of the physico-chemical and microbial properties of the 320 samples of water. The following 9 heavy metals were measured on water, sediments and fish samples (Cr, Pb, CO, Ni, Fe, Zn, Cu, Cd). A total of 670 samples were analysed.

1.6 Study Area

This section discusses the area where the study was conducted. In doing this, the following were diecussed.

Nigeria is the final downstream country through which the River Niger flows and contains 28.3 percent (424,500 square kilometers) of the basin area. The River Niger extends across 20 of the 36 states of Nigeria and comprises two main rivers, the Niger and the Benue and 20 tributaries of Nigeria's major rivers; more than half are from the Niger River Basin. Their combine length accounts almost 60 percent of the total length of all important rivers in Nigeria. Almost 60 percent of Nigeria's population or about 67.6 million inhabitants live in the Basin (Edime *et al.*, 2011). These Nigerians comprises 80 percent of the population of the entire basin. Given Nigeria size and location, its agricultural production, both rainfed and irrigated is substantial. The study area is located in a region of high rainfall with an increase in numbers of the tributaries in the lower River Niger which flow south emptying into the Niger Delta. The study area is generally warm or hot although the high mountains along the Coast experienced extreme temperature. Inger *et al*, (2005).

The River Niger is one of the principal rivers in West Africa, extending about 4,180km. Its drainage basin is 2117700km^2 in area. The Niger originated somewhere in the high land of Guinea not far from the Atlantic coast (https://en.m.wikipedia.com). The River Niger enters the Atlantic Ocean a distance of 1700km from its source. The river traffic contributed to the development of timber as well as oil palm and rubber plantations in Nigeria. (https://en.m.wikipedia.org).

The study area extends from Idah through Lokoja to Kotonkarfe all in Kogi State. The study area lies between longitude $7^0\ 5'\ 4''$ N to longitude $7^0\ 55'\ 31'''$ N and latitude $6^0\ 43'\ 55''$ E to $6^0\ 45'\ 2''$E.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition of Water

The Oxford Advanced Learner dictionary (2005) defines water as a liquid without colour, smell or taste that fall as rain, in lakes, and seas and is used for drinking, washing etc. Water is a universal solvent which consist of hydrogen and oxygen atoms. Chemically it could be defined as a chemical substance with two atoms of hydrogen and one atom of oxygen in each of its molecule hence molecular formular is H_2O. It is formed by the direct reaction of hydrogen with oxygen (Duward *et al.,* 1994).

2.2 Pollution and its Origin

Pollution is the introduction by man into the environment of substances or energy liable to cause hazard to human health, harm to the living resources and ecological systems, damage to structures or amenity or interference with legitimate uses of the environment. Pollution had always been misused for contamination which can be defined as the presence of elevated concentrations of a substance in the air, water, soil or any other such thing not necessary resulting in a deleterious effect (Glenn and Toole, 1997). Pollution is a human problem because it is a relatively recent development in the planet's history; before the 19^{th} century industrial revolution, people lived more in harmony with their immediate environment. As industrialization has spread around the globe, so the problem of pollution has spread around with it. When earth population was smaller, no one believed pollution would ever present a serious problem. It was far too big to be polluted. Today, with over 8 billion people on planet, it has become apparent that there are limits. Pollution is one of the sign that human have exceeded these limits (Manjare *et al*., 2010).

According to the environmental campaign organization, pollution from toxic chemicals threatens life on the planet. Every ocean and continent, from the tropics to the once pristine polar region is contaminated and in West Africa almost every 14 hours a child die of contaminated water (WHO, 2011).

Industrialization and technological advancement development processes have led to introduction of hazardous chemicals into the environment (water, air, sea, rivers, lakes atmosphere, land/soil). These chemicals includes the following; environmental pollutants, heavy metals, agrochemicals, herbicides, pesticides, halogenated polycyclic hydrocarbons, food addictives and other allied contaminants and sewage wastes . The combined effect of population affluence and technology are the factors responsible for pollution and other types of environmental degradation. Pollution arose as a result of technological development. Over 60,000 chemicals are in common use while up to 500 new ones are introduced to the commercial market annually. Similarly, the production and use of industrial chemicals and increased agricultural practice have lead to deleterious effect on water affecting man generally and specifically (Maduka, 2005; Saheed and Shaker, 2008).

Nigeria like every other nation, desires industrial development. It is an acceptable fact that industrial development brings good economy and higher standard of living.What we have always forgotten to think about is that this development will in respect to Newton’s law, in physics that to every action there is equal and opposite reaction, make us desire a balance between the existence of man and the ecosystems. It has become very clear particularly to the industrialized nations, that there is a big price to pay for industrialization (Clair *et al*., 2003).

Today we talk about ozone layer depletion, disease, epidemics, sustainable development, global climate changes, afforestation, shore line erosion etc. and we have come to this vocabularies on the ecosystem. We are now bathling to strike a balance and protect our God given environment and are therefore talking of sustainable development (Danida, 1998).

The developing countries to which Nigeria belongs must count themselves lucky they did not develop that fast. These countries however have to learn from the mistakes of the developed countries and increase their awareness on environment issues. In Nigeria today the problem of waste management. Energy conservation, desert encroachment, deforestation, coastal erosion, clean drinking water and health hazards are enormous, both in the urban and rural areas. Nigeria has however started on the right footing, through the establishment of Federal Environment Protection Agency (FEPA). The decree establishing FEPA provides for the establishment of State Environmental Protection Agencies (SEPAS). Unfortunately only a few states have implemented this section of the decree.

Environmental pollution comes principally from urban, rural and industrial wastes. Urban and rural waste consists mainly of domestic and agricultural wastes (garbage's from houses, animals, and human wastes, while industrial wastes come from process wastes including effluents and emissions) (Egereonu *et al*., 2012).

Prominent among such industries are paints, pharmaceutical, textiles, battery, food, chemicals, petroleum and petrochemical industries. However, since air and water pollution know no boundaries, there is today a global effort toward prevention and control of pollution. Environmentalists therefore refer to the world as a global village (Ogbuagu *et al.*, 1998).

2. 3 Water Pollution and Quality

Like air, water is also essential for the existence of all kinds of life on the earth. But as a result of activities of human beings and animals, air and water are adversely affected and many unwanted and harmful substances enter into our atmosphere; in other words, air and water get polluted. This process of pollution has been continuously taking place since the existence of life but now it has assumed dangerous proportions due to population explosion and rapid growth of industries. The pollutants present in the air and industrial areas also ultimately contaminate water of rivers, lakes, springs etc. through rains. Previously, it was thought that rivers had the capacity to purify their water. This is true to some extent but when huge quantities of domestic and industrial wastes are dumped into rivers, they are no longer capable of self purification (Obasi and Balogun, 2001).

Unpolluted natural water contains some organic as well as inorganic matter to such a small extent that it does not affect human health. The cause of water pollution is the discharge of domestic and industrial wastes into different sources of water such as rivers, lakes etc. If this waste is discharged on land surface, it percolates down the earth surface and contaminates ground water. The disposal of industrial waste is one of the most important causes of water pollution. There are various industries such as those related to dairy products, distillers, fruit and vegetable products, tanneries, textiles, pulp and paper, drugs, organic chemicals, explosives, pesticides, fertilizer, steel mills, oil refineries, thermal power plants etc. These industries produce a variety of pollutants such as ammonia, organic matter of different kinds, collodidal material, suspended solids, acidic and basic substances, mineral oils, variety of inorganic substances, some toxic material and heat which are discharged into receiving waters. Some water pollutants are highly toxic. Hence, water pollution is responsible for a large variety of diseases. Polluted water affects irrigated lands and leads to decline in fisheries. Due to rapid industrialization, the availability of water is becoming increasingly difficult. People have now become aware of the hazards of water pollution and steps are being taken to minimize it. The waste water that flows from factories is analyzed and subjected to suitable treatment before it is allowed to be discharge into receiving waters such as a river or a lake so that it does not cause pollution (Verma, 2012).

Water quality is the physical, chemical and Biological characteristics of water. The primary basis for such characterization is parameters which relates to drinking water, safety of human contact and for health of ecosystems. The vast majority of surface water on the planet is neither potable nor toxic. This remains true even if sea water in the ocean (which is too salty to drink) isn't counted. Another general perception of water quality is that of a simple property that tells weather water is polluted or not. In fact, water quality is a very complex subject, in part because water is a complex medium intrinsically tied to the ecology (Verma, 2012).

2.4 Bioavailability and Bioaccumulation of Heavy Metals

Bioaccumulation means an increase in the concentration of a chemical or substance in biological organism overtime compared to it concentration in the environment (DPR, 2002). Thus understanding the process of bioaccumulation is very important in protecting human beings and other organisms from the adverse effects of chemical exposure and has become a critical consideration in the regulation of chemicals.

Bioavailability and bioaccumulation of contaminants in an aquatic environment is mainly dependent on the partitioning behaviour or binding strength of the contaminant to sediment (Bryan & Langstone, 1992; Li *et al*., 2000; Fan *et al.*, 2002). Dissolved or weakly adsorbed contaminants are more bioavailable to aquatic biota compared to more structurally complex mineral bound contaminants which may only become bioavailable upon ingestion with food. (Calmano *et al*., 1993). For example metals in the aquatic phase are the most bioavailable compared to particulate complex or chelated forms (Forstner, 1989). Fish accumulate toxic chemicals such as heavy metals directly from water and diet and contaminant residues may ultimately reach concentration hundreds or thousands of times above food level (Labonne, 2001; Rahman *et al*., 2012).

Heavy metals are normal constituents of marine environment that occur as a result of pollution principally due to the discharge of untreated wastes into rivers by many industries. Bioaccumulation of heavy metals in tissues of marine organism has been identified as an indirect measure of the abundance and availability of metals in the marine environment (Kucu, 2006). For this reason, monitoring fish tissue contamination serves an important function as an early warming indicator of sediment contamination or related water quality problems (Mansour & Sidky, 2002; Barak & Mason, 1990) and enables us to take appropriate action to protect public health and the environment.

Multiple factors including season, physical and chemical properties of metal accumulation in different fish tissues have also indicated that fish are to accumulate and retain heavy metals from their environment depending upon exposure, concentration and duration as well as salinity, temperature, hardness and metabolism of the animals (Romeo, 1999; Karthikeyan, 2007; Adeyeye, 1996) also showed that the concentration of metals was a function of fish species as it accumulate more in some fish species than others.

Fish has been the most popular choice as test organisms because they are presumably the best understood organisms in aquatic environment (Buikema, 1982; Ezigbo, 2012) and also due to their importance to man as a protein source.

2.5 Protection of Sediments Quality

Protecting sediment quality is an important part of restoring and monitoring the biological integrity of our nation's water as well as protecting aquatic life, wild life and human health.

Sediment is an integral component of aquatic ecosystem providing habitat, feeding, spawning and rearing areas for many aquatic organisms. Sediment also serves as reservoir for pollutants and therefore a potential source of pollutant to the water column, organisms and ultimately human consumers of those organisms. Contaminated sediment can cause lethal and sub-lethal effect in benthic and other sediment associated organisms (USEPA, 2000).

Also natural and human disturbances can release pollutants to the overlying water, where pelagic (water column) organism can be exposed. Sediment pollutants can reduce or eliminate species of recreational, commercial or ecological importance either through direct effects or by affecting the food supply which the sustainable population requires.

The extent and severity of sediment contamination in U.S has been documented in national sediment inventory (NSI). The evaluation of sediment contamination data indicates that thousands of locations have been affected throughout USA. (USEPA, 2000).

2.6 Physico-chemical and Microbial Assessment of water

Ajiwe *et al.,* (2008) analysed the physical, chemical and biological properties of Borehole water in Fegge area, Onisha in Anambra State. Eight samples of borehole water from different areas of

Fegge in Onitsha were analysed bacteriologically and phisco-chemically. The results obtained were compared with the World Health Organisation (WHO) standards and the international standard limits of drinking water supply. From the results obtained some of the borehole waters were polluted. The work further recommended that the environment of the borehole water should be clean, the wells and boreholes should be elevated. The borehole water should be aerated and chlorinated.

Inachalo and River Niger were studied by Edimeh *et al*.,2011.Water samples were collected from river Inachalo and River Niger in Idah metropolitan and analysed for some physico- chemical parameters including heavy metals (As, Co, Cr, Cu, Fe, Se, and Zn.) using AAS for 3-consecutive months (Jan.-March,2010). The results indicated that the rivers were polluted for all the physico-chemical parameters analysed. And all the metals analysed for except Zn were above the acceptable standard for drinking water set by WHO (2011).

Idodo, (2013) determined the physio-chemical properties of Areba River. The physical parameters such as temperature, conductivity, pH, turbidity, colour, total dissolved solids, total suspended solids, dissolved oxygen, BOD, COD, carbonate, bicarbonate, total hardness, nitrate, nitrate, ammonium, phosphate, sulphate, chloride, sodium, potassium, calcium, and magnesium were analysed for using various standard methods and the results compared with WHO limits for drinking water. Seasonally, water temperature, total dissolved solids, BOD, COD, NO_4^-–N, nitrite, $NH4^+$-N, phosphate, sulphate and magnesium were higher during the dry season while other parameters were higher during the rainy season.

Victor and Ataguba, (2013) evaluated the physicochemical and microbial water quality as well as abundance fish fauna in lokoja metropolis, Kogi State Nigeria. Results obtained revealed that water quality deteriorated and fluctuated significantly. The microbial analysis result of water from flowing river was moderate in total coliform, it was also found that in residential areas copliform levels was critical.

Ogbuagu *et al.*, (2008) analysed the physico-chemical characteristics of Agulu lake in the Easter Nigerian during the rainy and dry seasons in which the concentration of Cd, Na, Cu, Fe, Co, Zn, Ni, K, Pb, Mg & Cr, were determined. The results obtained were compared with the WHO standard values; Iron, Chromium and lead were found to be above permissible levels. The presence of weeds on the surface of the lakes was seen as a sign of eutrophication. Overall, the results obtained call for caution in the use of the water for drinking and domestic purpose by the Local populace.

Afiukwa (2011) investigated the level of nitrate and phosphates in the public water supplies in part of Ebonyi State, Nigeria.He studied the nitrate and phosphate levels in drinking water supplies in nine Local Government areas of Ebonyi State. Fifty water samples were analysed for NO^-_3 and PO_4^{3-} concentration using standard methods. The results showed that the seasonal variation of these ions are not significant, $P > 0.05$. The nitrate levels are within the WHO guideline limits.

Orakwue *et al* (2011) carried out the physico-chemical analysis and bacteriological assay of 3 rural water resources in Unubi, Nnewi South Local Government Area of Anambra State. The portability and quality of the rural water supply to the community were evaluated. Water samples were collected from each of the boreholes located in different villages in the community for analysis using various standard methods. The parameters analysed were: pH, Conductivity TS; TDS, SS, Total hardness, alkalinity, Chloride, Sulphate, nitrite,nitrate, K, Ca, Mg, Fe, Zn, Cu, Pb, Cd, residual chlorides, vinyl-cloride and *E – coli, coliform.* From the results it was observed that *E- coli* was present in two of the boreholes. All the parameters determined were within or slightly above WHO safe limit for portable water in most of the samples. The presence of *coliform* and *E-coli* in two of the samples impair the quality of water resources in these areas. Treatment by the addition of lime, sedimentation, filtration and boilng was recommended to make the water safe for drinking and other uses.

Physico – Chemical Parameters of surface water samples collected from various site in and aruond Akot City were determined by Murhekar, (2011). The parameters determined are: temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), Turbidity, dissolved oxygen (DO), Total alkalinity (TA), Total hardnes (TH), Calcium ion (Ca^{2+}) ,Magnesium ion (mg^{2+}), Sodium ion (Na^{+}), Potassium ion (K^{+}), Chloride (Cl^{-}), Floride (F^{-}), Nitrate (NO_3^{-}), Sulphate (SO_4^{2-}), and Phosphate(PO_4^{3-}). The results were compared with standards prescribed by WHO, (2011) and ISI (10500-91). It was found that the water samples collected from various site in and around Akot City was contaminated. All sampling site showed Physico – Chemical parameters above the water quality standards and the quality of water are very bad and was unfit for drinking purpose.

Manjare and Muley, (2010) carried out analysis of water quality using physico – chemical parameters of Tamdalge Tank in Kolhapur district, Maharashtra, Monthly changes in Physical and Chemical parameters such as water temperature, transparency, turbidity, total dissolve solids, pH, Dissolved Oxygen, free Carbon dioxide, total hardness , Chlorides, alkalinity, phosphate and nitrates were for a period of one year. The results showed that the tank is non – polluted and can be used for domestic, irrigation and pisciculture.

Raji V. *et al.*, (2012) investigated the physical, chemical and microbial analysis of different River waters in Western Tamil Nadu, India between January – March (2012). The Comparative results showed slight variations between water qualities of the river:

Physico – Chemical Analysis were carried out on water samples from Ogun river collected from Lafenwa (a densely populated area) and Akin – Olugbade (a sparsely populated area) in Abeokuta Ogun State of Nigeria by Osunkiyesi, (2012). The results obtained showed that parameters like alkalinity, PH, acidity, chloride, magnesium and calcium were in the normal range and chromium, lead, nickel, zinc and cadmium content were below detection limit. Parameters such as nitrite, total solid, total suspended solid and total dissolved solid, manganese, sodium, potassium, iron and copper were found to be out of desirable levels. On the overall it was found to be unsafe for some human activities except properly treated and screened.

2.7 Risk Assessment of Water

Liu *et al*., (2012) Reported non carcinogenic risk induced by heavy metals in the sources of drinking water treatment plants located along Huaihe River in Jiangsu province, China. Eight metals in water from 30 treatment plant were determined. Non-Carcinogenic risks induced by the metals were assessed using the methods recommended by USEPA. The induced non-carcinogenic risk showed temporal and spatial variations. This study reveals that the metals in tap water induced negligible public health risks for Local residents.

Naveedullah, *et al.*, (2014) investigated the spatio-temporal variationsand human health risk of selected heavy metals in surface water of siling reservoir watershed in Zhejiang provinces, China. The metals investigated were Zn, Cu, Mn, Fe, Cr, Cd and Pb. During summer Mn, Fe and Cd concentrations were higher in the water sampleswhile the concentration of Zn, Fe and Pb were higher in winter. The health risk assessment revealed that hazard quotient (HQ) and hazard index (HI) values were within accepted limit, indicating non-carcinogenic risk, via ingestion pathway to the recipients.

Rasheed (2001) determined the transgfer factors for Cu, Cr, Co, Fe, Mn, Sr, and Zn from water, sediment, and plant in *Tilapia nilotica* fish in Basser lake in Egypt. The results indicated that only transger factors from water for all metals were greater than one, which means that fish accumulated metals from water.

A study on the heavy metals levels and it risk assessment in some edible fishes from Bangshi River, Bangladash was carried out by Rahman, *et al.*, (2012). The concentrations of eight heavy metals namely; Pb, Ni, Cr, Cu, Zn, Cd, Mn and as in the muscles of ten species of fish collected from Bangshi River were measured in two different seasons. Apart from Pb, the concentrations of the studied metals were below the safe limit stipulated by international authoritiesfor *Carico Soborna.* Zn was the most accumulated metal while Cd was the least accumulated metal in the studied fish muscles.Significant positive correlation between the heavy metals concentration in fish muscles were observed in both seasons while ANOVA nalysis revealed that there was significant variation in heavy metal concentrations in different fish species in Bangshi River. The health risk assessment indicated that there was no possible health risk to consumers due to intake of studied fishes under the consumption rate of 21g fish per day.

The concentration of heavy metals (Cu, Cd, Zn, Pb and Ni) was determined in the liver, gills and muscles of tilapia fish *(Oreochromis niloticus)* from Langat River and Engineering Lake in Bangi, Malaysia. This analysis was conducted by Taweel, *et al.,* (2013) using inductively coupled plasma mass-spectrometry (ICP-MS) after appropriate digestion. There were differences in the concentration of the studied heavy metals between different organs and between sites. In the liver samples, Cu>Zn>Ni>Pb>Cd and in the gills and muscles Zn>Ni>Cu>Pb>Cd. Levels of Cu, Cd, Zn and Pb in the liver of fish from engineering lake were higher than thosefrom Langat River.

The health risk associated with Cu, Cd, Zn, Pb and Ni was assessed based on the target hazard quotient (THQ).in Langat River, the risk from Cu was minimal compared to other studied elements and the concentrations of Pb and Ni were found to pose the greatest risk. The health risk analysis of the heavy metals measured in the fish muscle samples indicated that the fish is safe and there were no possible risk pertaining the tilapia fish consumption.

Amirah, *et al.*, (2013) evaluated the human health risk induced by Cu, Pb and Cd through the consumption of fish at selected river in Kuartan, Pahang. The concentration of the trace metal was determined using ICP-MS and the average concentration of Cu, Pb and Cd in three locations are 0.0205µg/g, 0.0145µg/g and 0.004µg/g respectively. The human risk assessment was estimated using target hazard quotient (THQ) and the result revealed that the THQ of all the metals studied (Cu, Pb and Cd) were less than unity signifying that daily exposure to fish at this level may not cause any adverse effect during a person's lifetime.

Ecological risk assessment of heavy metals in sediment and human health risk assessment of heavy metals in fish in the middle and lower reaches of the Yantze river basin was conducted by Yi, (2011). The concentrations of the heavy metals (Cr, Cd, Hg, Cu, Zn, Pb and As) in water, sediment and fish were determined using inductively coupled-plasma atomic emission spectroscopy (ICP-AES). Potential ecological risk analysis of heavy metal concentration in the sediment indicates that six sites in the middle reach, half of the sites in the lower reach and twosites in lakes posed moderate or considerable ecological risk. Health risk analysis of individual heavy metal in fish indicated safe level for the general pollution for the fishermen but, in combination, there was a possible risk in terms of total target hazard quotient. Correlation analysis and PCA revealed that heavy metals (Hg, Cd, Cr, Cu and Zn) were derived from metal processing, electroplanting industries, industrial wastewater and domestic sewage. Significant positive correlation between total nitrogen (TN) and as was observed.

Mansouri, *et al.,* (2013) quantified the concentrations of Cr, Cd and Pb in fish muscle tissues and estimated the hazard indices dueto the consumption of fish caught in the Anzali wetland in Tehran using methods recommended by USEPA. The concentrations of Pb in *Cyprinus Carpo* and *Esoxlucius* species were higher than the WHO limit. The hazard index value indicated no adverse health effect from the consumption of these fish species, although no adverse health effect from the consumption of these fish species, although bioaccumulation andbiomagnification of these heavy metals in human may occur.

Ra, *et al.,* (2013) studied the spatial distribution of heavy metal contamination and its ecological risk assessment in sediments from the Korean Coast. Surface sediments from 12 coastal zones of Korea (total 200 sediment samples) along the west, south and east coast of Korea were analyzed for heavy metal using inductively coupled plasma/mass spectrometer hyphenated system (ICO-MS). Mean concentrations in mg/kg were Cr (58.3), Co (10.2), Ni (24.3), Cu (36.25), Zn (122), As (9.1), Cd (0.25), Pb (35), Hg (0.046). Sediments sampled from industrialized areas like Shihwa, Masan, Gwangyang, Ulsan were contaminated with Cu, Zn, Cd and Hg. Significant positive correlations among metals were observed at P(<0.01). The results indicated that metal contamination sources may have been due to anthropogenic inputs from surrounding environments especially national industrial complexes made up of iron, steel, electronics and petrochemical.

The results of metal assessment indices revealed that Korean coast sediments were moderately contaminated with the measured metals. The metal enrichment levels decreased according to the order Cu>Hg>Cd>Zn>As>Pb>Co>Cr>Ni. The values for Cu, As and Zn when compared with sediment quality guideline indicated that 40% of the sediment samples exceed TEL values and may likely result in potential adverse effect on sediment-dwelling organisms.

2.8 Level of Heavy Metals in Water, Sediments and Fishes

The status of heavy metal pollution of the River Niger within the vicinity of the Ajaokuta Iron and steel industrial complex was determined by Omanayi *et al.,* (2011). The concentration of the metals (Cr, Pb, Fe, Co, Mn, V, Zn, Cu, Ni and Cd) were determined in water, fish , soil and plant using AAS . The results showed that the concentration of these heavy metals were higher in the plant sample (*Eichhornia crassipes*) than in other samples analysed.The heavy metals concentration in the plant sample was in the order Fe >Mn >Zn >Cu >Ni >Cr >Co. while the other metals were not detected . Heavy metals concentrations in the other samples were found to be low and mostly at undetectable levels.

Wangboje and Ikuabe., (2015) worked on the heavy metal content in fish and water from Agenebode area of river Niger the concentration of Pb, Cu, Cd, and Zn in fish and water were determined by AAS technique.the results showed that Zn in water was the highest across the sampled months with peak in the month of April compared to other metals.

Ebong, *et al.,* (2004) investigated the seasonal variation of heavy metal concentration in Qua Iboe river estuary, Nigeria. Concentration of five metals namely Pb, Cd, Ni, Fe & Cu were determined in the water samples from the above estuary and its adjoining creeks. The mean concentrations of the metals were higher in the wet season than the dry season and the mean concentration of Pb and Ni were above WHO acceptable limit.

Udosen, *et al.,* (2007) researched on the trends in heavy metals and total hydrocarbon burdens in stubb's creek, a tributary of Qua – Ibo river estuary, Nigeria. Surface water samples and intertidal sediments were collected monthly between May and November, 2003 from Creek and the level of some metals (Zn, Ni, Co, V, Fe, Pb) were determined using unicam 939/959 Atomic Absortion Spectrophotometer. High level of Iron was recorded in water and sediments from downstream, mid-stream and upstream location.

Otitoju and Otitoju, (2013) reported different level of trace metals in water, sediments & periwinkle from oil producing communities of Oron, Abaloma and Itu. They attributed the observed values to trace metal pollution of terrestrial and aquatic environments as a result of increased urbanization and crude oil exploration. Oil drilling operations requires Chemicals such as drilling fluids which contains various trace elements which may present a potential pollution source.

The heavy metal pollution status of water and fish in Qua – Ibo river estuary was investigated by Oze *et al*., (2005). The mean values of the metal were Ni (0.2lmg/l), Cr (0.53mg/l), Cd (0.0mg/l), Mn (0.14mg/l) and Pb (0.3mg/l). Based on WHO safety standard, the result indicated that the water was polluted with respect to all the metals analysed for except Mn and Zn. The result for the bioaccumulation of the metals in fish was as follows: Ni (0.9g/g), Cr (not detectable), Cd (0.38mg/g), Mn (12.85mg/g) and Pb (25.88mg/g). When the result for bioaccumulation was compared with WHO standard, the Fish was polluted with respect to all the metals except Zn and

Cr which were not detected. Since Cd, Mn, Pb, Zn anb Ni are known to be neurotoxins they can be passed to humans through the food chains. This may predispose water and fish consumers around Qua – Ibo terminal (QTT) community to possible neurotoxicity.

The level of heavy metals in kidney, heart, grills and liver of silver cat fish *(Chrysicthy nigrodigitants)* from Ifiayong and Ibaka beaches were analyzed using by Akpanyung, *et al.*, (2014). The result shows that the levels of Zn and Cu were significantly higher than the maximum tolerable levels at both locations.

The bioaccumulation of some heavy metals in tilapia fish relevant to their concentration in water and sediment of Wadi Hanifah, Saudi Arabia was determined using Shimadzu atomic absorption spectrophotometer by Abdel-Barki, *et al.,* (2011). The concentrations of the heavy metals in water were within the international permissible limit. The result indicates that fish accumulated all metals in it tissues from water. Heavy metals under study in the edible parts of tilapia were within the safety permissibe level for human use.

The trace metal distribution in fish tissues, bottom sediments and water from Okumeshi River in Delta State, Nigeria was studied by Ekeanyanwu, *et al.,* (2010). Atomic absorption spectrophotomer was used to quantitatively analyse for the presence of Pb, Ni, Cr, Mn and Cd in bottom sediments, tilapia, catfish and water samples. The highest concentration of 0.62mg/kg was found in the muscle of tilapia while the lowest concentration of 0.04mg/kg was recorded in tilapia bone. In most fish samples, the cadmium concentration was above the maximum tolerable values stipulated by international regulatory authorities.

Pourang, *et al.,* (2005) determined the concentration of trace elements in fish, surficial sediments and water from the Northern part of Persian Gulf. Inductively coupled plasma-mass spectrometer was used to determine the concentrations of Cd, Pb, Ni and V in the above samples. There was no signiticant difference among the sampling site in terms of Cd and Pb levels in the sediment. The highest concentration of Ni and V in sediments was found in the southern coast of the study area. The concentration of all the metals except vanadium was higher than the global baseline values.

The determination of heavy metals in fish tissues, water and sediment from Epe and Badagry lagoons, Lagos-Nigeria was reported by Olowu, *et al.,* (2010). The samples were analyzed quantitatively for the presence of ZN, Ni, Fe using Perking Elmer atomic absorption spectrophotometer.

The highest concentration was recorded for ZN in the head of cat fish while the lowest concentration was recorded for Zn in tilapia head. All the trace metals investigated were within the permissible level set by World Health Organization (WHO 2011).

Ozturk, *et al.,* (2009) analyzed heavy metal levels in water, sediment and fish samples *(Cyprinus carpo)* from Avsar dam lake in Turkey using inductively coupled plasma spectroscopy (ICP-AES). The result showed that the average values of Fe in water samples were higher than the stipulated values for fresh water. The analysis of heavy metals in sediments indicated that among the six heavy metals tested; Fe was maximally accumulated, followed by Ni, Cu, Cr, Pb and CD. The decrease in the level of trace metals in *Cyprimus carpio* muscle, stomachand intestine followed the trend in the gill and heart Fe>Cu>Pb>M>Cd; and liver: Fe>Cu>Ni>Pb>Cd>Cr. In the fish samples the concentration of Cd, Cr, Ni and Pb wereabove the regulatory limit set by international agencies.

The seasonal variation of heavy metal concentration in sediment samples around major tributatries in Ibeno coastal area, Niger Delta, Nigeria was studied by Nwadinigwe, *et al.*, (2014). The concentrations of Mn, Ni, Pb and Zn in the dry season were above that of the wet season. The concentrations of all the metals were higher in the examined sites than the control but belowWHO standard. The concentration of iron was abundant in both seasons while the pH of the sediment was slightly acidic and below WHO and the department of petroleum resources (DPR) standard.

Ayenimo *et al* (2005) studied the level of heavy metal pollution in Warri River, Nigeria. The total levels of Fe, Cu, Ba, Pb, Cd, Cr, Ni and Co were determined using flame atomic absorption spectrophotometer at upstream, effluent zone and downstream of the River. In each location, Fe, Cu and Pb were found to be the most abundant metals in the river. The metal distribution pattern of the river indicates that the source of pollution may be land-based, due to industries located adjacent to the river. Correlation analysis of the metal pairs suggested that some of them were strongly interrelated; this indicates common source.

Moore, *et al.,* (2009) assessed the heavy metal contamination of water and surface sediment of Maharlu saline lake in southwest Iran. The total concentrations of As, Cr, Cu, Co, Cd, Pb, Zn, Ni, Fe and Mn were determined in surface sediment and water of the lake using inductivelycoupled plasma. As and Cr were not detected in the water sample. When compated with consensus sediment quality guidelines, the results revealed a high degree of contamination due to Ni and Pb and possible threat to the aquatic ecosystem.

Studies on the contamination of sediments from River-Orogodu in Delta State, Nigeria by heavy metals was undertaken by Issa, *et al.*, (2011). Sediment samples were collected for four months and analysed for heavy metal (Cd, Mn, Fe, Cu, Ni, Pb, Zn) using atomic absorption spectrophotometer. Some physiochemical characteristics such as organic matter, pH and conductivity which can influence the interaction and dynamics of netaks within the sediment matrix were also determined. The result of the analysis indicates signficiant difference ($P<0.05$) in pH, organic matter, Mn, Zn, and Cr levels for the four months. The concentration of most heavy metals was low but the iron content was above the background value and department of petroleum resources (DPR) standard for soil sediment which indicates significant contamination.

Obasohan, (2008) studied the levels of heavy metals in the sediment of Ibiekuma stream Ekpoma, Edo State – Nigeria. The concentration of the metals (Fe, Cd, Cr, Cu, Mn, Ni, P, V and Zn) were determined using a Varian atomic absorption spectrophotometer (Spectra AA-10). The metal levels except Cd were below the mean values for continental crust and unpolluted African Inland Water sediments and indicated that metal contamination in the stream might not pose immediate threats to the oeganisms and people that utilize the stream for drinking and other domestic functions.

A study on the levels of heavy metals in waterand sediments of Subarnarekha River was investigated by Manoj, *et al.*, (2012). Water and sediments collected from six locations were analysed for Fe, Zn, Cu, Pb, Ni, Cd, Mn and Cr with atomic absorption spectrophotometer (AAS). Contamination factor, contamination degree, pollution load index (PLI) and geoaccumulation indices were used to assess the degree of accumulation of heavy metals in sediment. All the sampling sites recorded PLI values between 0-1, and geoaccumulation index values for the metals at all the sample sites were less than zero. Also, close relationships for the metals at all the sampling sites were less than zero. Also, a close relationship was established between organic carbon and metal content on the sediments from the rivers. The results indicated that the water and bed sediments were not polluted and ecologically suitable and sustainable. Lack of anthropogenic influence was primarily found to be responsible for the unpolluted nature of water and sediments.

The seasonal variation of heavy metal concentration in sediment samples around major tributaries in Ibeno Coastal area, Niger Delta, Nigeria was studied by Nwadinigwe *et al.,* (2014). The concentrations of Mn, Ni, Pb and Zn in the dry season were above that of the wet season. The concentrations of all the metals were higher in the examined sites than the control but below WHO standard. The concentration of Iron was abundant in both seasons while the pH of sediment was slightly acidic and below WHO and the department of Petroleum resources standard.

The concentrations of Cd, Cu, Co, Fe, Zn, Mn, Pb and Ni were determined by Anmar *et al*., (1992) in water and sediment of river Tigris at the samana impoundment during high (April) and low (July) river discharge months in 1988. The result showed that the recorded concentrations in water were either significantly lower or within the Iraqi water standards and the average clean river water of the world. The concentrations of most of the examined elements in the surficial sediments (except for Mn and Fe during April) were lower than those in the suspended.

Ezigbo, (2012) studied the concentrations of the the heavy metals; Arsenic, Lead, chromium and mercury in four selected fresh water fish species sold in Onitsha market. Samples of fishes were collected from Onitsha market over a period of 3 days. Results obtained indicated that the fish species were contaminated and the contamination of the fish species by the heavy metals in fish samples were generally below the WHO and FAO maximum permissive limits, (mg/kg) of

Arsemic (0.5), Lead (0.2), Chromium (0.5), mercury (<0.05) and hence pose no consumption risk.

The concentration of seven heavy metals (Cd, Cr, Cu, Fe, Pb, Mn and Zn) were studied for twelve consecutive months in Rivers Benue using Atomic Absorption Spectrophotometer (AAS) techniques by Eneji and Sha' Ato, (2012). The result showed that the concentration of most heavy metals were higher during the dry season (Cr, Cu, Fe, Pb and Mn) probably due to the concentration of those metals in the river (reduced volume of water). Cd levels reduced by a factor of 2) in the dry season, while Zn level increased throughout the cycle. The general order of the metals through out the season was found to be Fe> Cr> Pb> Mn> Zn> Cu> Cd.

Hector, *et al.*, (2014) studied the heavy metal concentration of warri river using water and crab samples and analysed for heavy metals concentration using Atomic Absoption Spectrophotometer (AAS). The result obtained showed that the concentration of zinc and Cd were far below WHO recommendation limit in the crab and water samples while concentrations of Cd, Cr, Co, Hg, As, Fe and Pb in all the samples studied were in excess of the WHO recommended limit for safe water and aquatic foods. These results confirmed that warri river was highly polluted.

The heavy metal pollution of effluents from three (3) food industries in Nnewi/Ogidi areas of Anambra State was assessed by Nwosu, *et al.*, (2014). The effluent from three food processing industries within Nnewi and Ogidi were sampled for a period of 8 month; 4 months rainy season and 4 months dry season. The results showed that the total mean level of all the heavy metals determined were generally above the allowable limit. The values obtained showed that the concentrations of the heavy metals in the effluent sample were higher in the dry season than in the rainy season. Pollution index showed significant degree of pollution by heavy metals.

Gadzala-Kopcious *et al.,* (2004) noted that the emission of harmful substances has negative effects on the natural environment, human health and agricultural production efficiency.according to him, toxic chemical substances introduced into environment may be transported by air, water and living organisms and may accumulates in food chain .

It was pointed out by Alloway and Ayres (1995) that the toxic effect of the pollutants at the initial stage is usually impossible to notice but may manifest after many years.

According to NCSU (2006), trace metals has many sources from which they can flow into the water bodies, these includes:

i. Natural sources: Trace metals which are found in the earth geological structures can enter water through leaching and rock weathering.

ii. Industrial sources: Industrial processes that discharge waste water into water bodies lead to water pollution by tracxe metals, these metals may settle to the bottom of the river.

iii. Agricultural sources: Agricultural activities such as fertilizer application pesticide spraying and irrigation which often contains heavy metals can contribute to water pollution.

iv. Domestic waste water: Trace metals can be found in domestic formulations where the found their ways in to domestic waste water and eventually pollute water bodies.

Okoye, *et al.,* (1991) reported heavy metals concentration in Lagos lagoon and attributed it to urban and industrial wastes resources.

Ibok *et al.,* (1991) carried out an analysis to determine the levels of heavy metals in water and fish from fish in Ikot Ekpene and reported that the samples were contaminated by metals as a result of municipal and industrial wastes.

Davies *et a.,l* (2006) studied the accumulation of three heavy metals (Cr, Cd and Pb) in periwinkle, water and sediments collected from four station along Elechi creek course in River State and reported that the sediments contains high level of heavy metals than the water and periwinkle.

Udosen and Benson (2006) carried out analysis on the Spatio-temporal distribution of heavy metals in sediments and surface water inStubbsCreek Nigeria and found out that the average metal concentration values of Fe, Ni and Pb in the water were high and they attributed it to anthropogenic activities.

Kakulu and Osibanjo, (1992) higher concentration of Cd, Pb, Ni and Zn in water collected from Warri and Calabar River.

In a study carried out by Olabanji and Oluyemi, (2014) to determine the concentration of five selected heavy metals in water and tissuesof two fish species from opa reservoir in Obafemi Awolowo University, Ile-Ife with a view to assess its pollution level , it was reported that Opa reservoir was heavy metal polluted.

A study on the heavy metal levels and the risk assessment in some edible fishes from Bangshi River, Bengladesh was carried out by Rahman *et al* (2012). The concentrations of eight heavy metals namely; Pb, Ni, Cr, Cu, Zn, Cd, Mn and As in the musles of ten species of fish collection from Bangshi River were measured in two different seasons. Apart from Pb, the concentrations of the studied metals were below the safe limit stipulated by International Authorities for Carico

Soborna. Zn was the most accumulated metal while Cd was the least accumulated metals in the studied fish muscles.

2.9 Water Quality and Pollution

Christopher and Olatunji (2018) carried out the assessment and classification of Ogbese River using quality index (QI) tool. The results obtained indicated that most of the parameter was within maximium permissible limit of World Health Organisation, Food and Agriculture Organisation (FAO) and Nigeria Standards for Drinking Water Quality (NSDWQ) with the exception of total dissolved solids, turbidity, electrical conductivity and total coliform in both seasons. Lead, Zinc and Iron were not detected in dry season, while their traces were recorded in wet season. The water quality indices indicated considerable degrees of pollution with classification numbers of 46.61 and 44.91 for dry and wet seasons respectively.

Adeaga *et al.* (2013) worked on the quality of surface water upstreams of Niger Delta. The study focused on major ions and trace elements concentration and provides an update of trace metals and arsenic concentration in water of Niger Basin and of the region of Lagos, Nigeria for standardization and comparison with WHO maximum allowable concentrations in drinking water and mean annual European Quality Standards (EQS). The water quality assessment reflects the fact that the water resource from the Niger and Benue River Basins ismooderately contaminated upstream of their confluence (Lokoja) with the exception of Pb. Downstream of their confluence, particularly around the Lagos region, drinking water exceeds the WHO quality water for Mn, and to a lesser extent, Al. the arsenic concentrations are lower than the drinking water quality standards and are safe for consumption and irrigations upstream of the Niger Delta.

Akwanwa *et al*. (2011) worked on the ground water quality around open waste dump sites Ifejika and Obosi in Anambra State Nigeria. The ground water quality was investigated using experimental method. Two dump sites were studied with a total of four Leachate samples collected from each dump site. Similarly twelve ground water samples were collected from the vicinities of the dump sites during the rainy season. The physical, chemical and bacteriological parameters of the leachate of the ground water samples were analysed using experimental method. The survey method was used to sample the opinions of people on the effect of the waste dumps on the ground water. The heavy metals were determined using AAS and the student t – test was used to analyse the data generated. The physical, chemical and bacteriological content of the leachates shows marked deviations from the acceptable standard in treated waste water discharge in Nigeria. The chloride, sulphate, Nitrite, Iron, total *coliform* and *E-coli* in both areas also shows deviatons above the acceptable standard in drinking water quality in Nigeria. The high level of *coliform* and *E-coli* showed faecal contamination and human pathogenic bacteria in the ground water of the area. The heavy metals both in the leachate and the ground water samples were within the acceptable standard. The study recommends that ground water in the area be treated before use and the wastes dumped be closed or managed in an environmental friendly way.

The pollution status of Ughoton stream water as a result of crude oil spillage in Ughoton stream in the Niger Delta was investigated by Uzoekwe and Achudume (2011). The surface water samples were collected at various distance 50m, 280m, 500m and 500m downstream from an oil well.The concentration of potential toxic elements such as Fe, Mn, Zn, Cu, Cr, Cd, Ni, Pb were below the threshold levels associated with toxicological effect and regulatory limits. The pollution status of the stream was further confirmed by its oil firm coated environment.

Adekunle, *et al.* (2007) co- studied the quality of ground water in a typical rural settlement in Southwest, Nigeria. The results showed that all the parameters were detected up to 200m from pollution source and most of them increases in concentration during the rainy season over the dry periods, pointing to infiltrations from storms water. *Coliform* population, Pb, NO_3^- and Cd in most cases exceed the WHO recommended thresholds for portable water. Effect of distance from pollution sources was more pronounced on fecal and and total *Coliform* Counts, which decrease with increasing distance from waste dump. The qualities of the well water sample were therefore not suitable for human consumption.

2.10 Pollution Indices of River

Uwah et al (2013) evaluated the heavy metals pollutions status of sediments in Qua Iboe River Estuary. Enrichment factor, geoaccumulation index and contamination factor were used to assess sediment pollution. The result revealed that the sediment was enriched with Cd, Zn, Cu and Pb. The geoaccumulation index result indicated that the sediments are strongly polluted with Cd, extremely polluted with Ni, moderately contaminated with Cr, Cu, Pb.

Rasheed, (2001) determined the transfer factors for Cu, Cr, Co, Fe, Mn, Sr, and Zn from water, sediments and plant in *Tilapia nilotica* fish in Nasser Lake in Egypt. The result indicated that only transfer factor from water for all metals were greater than one which means that Fish accumulated metals from water.

The pollution index of Ndibe Rivers in Afikpo, Ebobyi State; Nigeria and ground water in five villages in Ndibe river Catchment area as well as the Langlier Saturation index (LST) of the ground water were investigated by the Egereonu *et al.* (2012)

The result were compared with the WHO standard and Ndibe river was found to have an overall pollution index of 1.0 which is a critical value while the ground water in the catchment erea was found to have negative LSI hence corrosive. There was no zinc pollutant in both the river and the ground water. The Arsenic level of the ground water was found to be higher than the WHO standard of 0.03mg/l which the iron level of the river was higher than the WHO permissible level of 0.3mg/l.

Akagha, *et al.*, (2016) investigated the pollution state of Aba River along its course using pollution index. The result obtained of the physico – Chemical parameters revealed a mean pollution index indices that exceeded WHO set critical value of 1.0 for surface waters. Analysis was also conducted for some heavy metals on the Aba River for the period of June 2014 through to March 2015 and the results revealed that the present of Cu was greatly significant at the Abatoir station in the month of August and September of the year 2014. With a mean value of 4.482mg/l, the result comfirmed that Aba River was highly polluted due to industrial discharges and other human activities along its course.

In the literature surveyed so far, many works have been done on the physico-chemical and the microbial content of the River Niger, for example, Edimeh *et al* (2011), Victor and Ataguba, (2013) worked on the River at Idah and Lokoja respectively. Others also worked on the heavy metal concentrations of the Niger water, for example, Wanaboje and Ikuabe, (2015). The risks and water quality assessment was done by others, for example, Adeaga et al, (2013). Some of the works were done on surface streams which has tributary to the river Niger. However, none of the works seen addressed the suitability of the Niger River for Agricultural and Domestic purposes. As the river is, basically, used for irrigation farming and other domestic purposes by those living at the bank of the river.

CHAPTER THREE

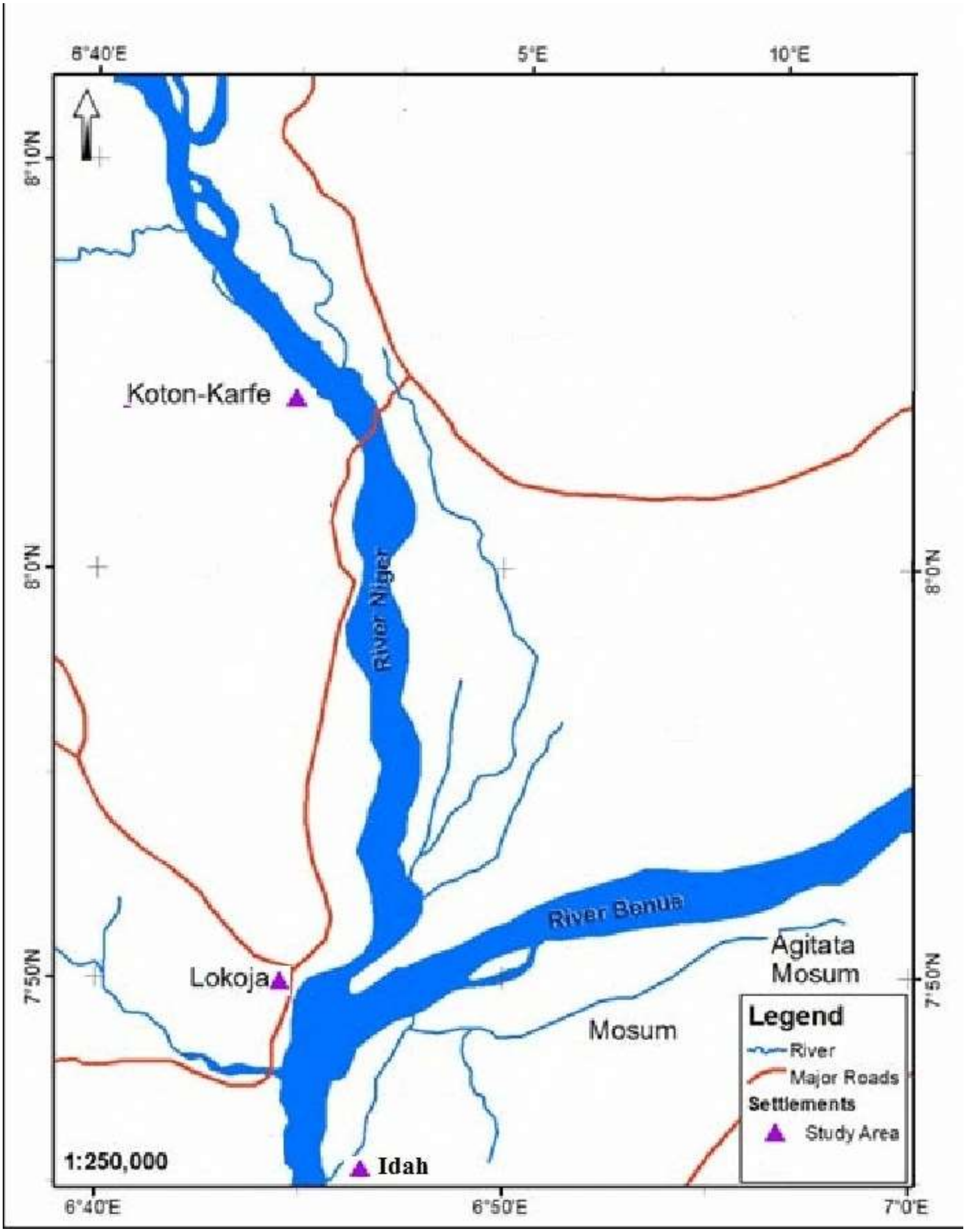
MATERIALS AND METHODS

This section discusses the method of analysis and the materials used for the work.

3.1 Sampling and Sample Treatment

In this study, sampling was done monthly between March, 2014 and October 2014. Sampling was conducted from 40 sampling points designated along the river course from Idah to Kotonkarfe, within an interval of 2km apart.

Five samples per sampling site were homogenized to form a composite sample. Coordinates of the sampling points were recorded using global positioning system (GPS).



The Map of Study Area

The River Niger features two main bridges within the study area. One is at the cross between the Eastern and the Central senatorial district in Kogi State at Itobe while the other is located at Kotonkarfe on the way to FCT. Abuja.

The river serves as source of water for domestic uses, fishery, recreational activities, sand mining and agricultural irrigation programs for more than five million people settled along the river. Some major portion of the river includes; Idah, Ajaokota, Itobe, Shintaku, Lokoja and Kotonkarfe. The section under study cut across; Idah, OFU, Ajaokuta, Lokoja and Kotonkarfe local government's areas of Kogi State.

Idah covers total area of 36km^2 with the total population of 79,815 (2006 census). While Lokoja covers area of 3180km^2 and a population of 195, 261 (2006 census). The major occupation of the people is fishing and irrigation farming, few of them engaged in commercial activities.

The Niger loses itself into the complex delta system in Africa and supplies life to remote villages and town through which it passes. (Figure 2.1)

3.1.2 Water Sampling and Preservation

The sample bottles used were washed with metal free non-ionic detergent solution and finally rinsed several times with distilled water. The pre-cleaned poly- ethene sample bottles were immersed 10cm below the water surface and 0.5liter of water was taken at each sampling location. The surface water samples were collected from the selected locations with a 500ml sterilized polyethylene bottle. The samples from five points per sampling site were homogenized to form a composite sample. Samples were acidified with 10% HNO_3, placed in an ice bath and brought to the laboratory. The samples were filtered using whatman No.1 filter paper and stored at 4^0C in a refrigerator until time for trace metal analysis (Bassey, 2015). The water samples for physico-chemical analysis were collected into acid cleaned polyethene bottles packed and transported in ice-box to the laboratory. They were stored in the refrigerator prior to analysis. The water sample for micro biological analysis was obtained against the water current and stored in well sterilized amber bottles.

3.1.3 Sediment Sampling and Preservation

Grab sediments were collected from the river for 8 months (March 2014 to October 2014). In the study area, five grab samples were collected at each sampling location and were combined together in a stainless steel bowl to form a composite sample. The samples were transported back to the laboratory in a cooler with crushed ice.

In the laboratory the sediment samples were air dried for one week, after drying visible remains of organism and debris were removed. The dried samples were crushed or ground into fine particles using pestle and mortal and sieved through a 2mm sieve (mesh) to remove unground matters and separate the coarse fractions from the fine fractions.

3.1.4 Fish Sampling Preservation and Treatment

Five samples of Tillapia (*Oreochromis niloticus)* and five samples, of catfish (*Clarias gariepinus*) each were obtained from three selected sampling sites viz: Idah, Itobe and Lokoja where anthropogenic activities were high. The lengths of the fishes were between 15 and 18 cm and weight, between 50 and 75g. The fish samples were obtained by some fishermen using fishing nets and local traps.

The fish samples were washed with deionized water and collected into pre-cleaned polyethene bags and were immediately transferred into a thermo-insulated flask filled with ice-blocks and taken to the Zoology laboratory of Kogi State University, Anyigba for identification and was indentified by Dr. A.A. Akinolu of the department. The fish samples were then immediately preserved in a deep freezer at -18^{0}C to avoid deterioration.

The frozen samples were washed with distilled water after removing the scales. The sample was oven dried to a constant weight at 80^{0}C in an acid wash petridish. After cooling in a desiccator, the samples were ground using a mortar and pestle to powdery form and sieved through 1mm mesh. The homogenized powdered samples were stored in an air tight pre-cleaned dry plastic bottles for further analysis.

3.1.5 Materials and Equipment

Whatman filter paper No.1&42

Electric hotplate

Volumetric flasks

Buck scientific, 210 VGP Atomic Absorption Spectrophotometer.

Jenway P.F7 flame photometer.

Sieve

Beakers

Fume cupboard

Hach colourimeter – model Dr 890

Jen way model 470 portable conductivity and total dissolved solid meter.

Pipette S and Bureltes.

Bar magnet and PH electrodes

Magnetic stirrer

pH meter

Water proof wegtech PH scan 3 + double Junction mdel

Thermo Evolution 600 UV/visble spectrophotometer computer based automated model.

Conical flasks.

Shewood scientific limited flane photometer model 410.

250ml Erlen Meyer flask.

3.1.6 Reagents

Analar nitic acid solution

50% HCl solution

De – ionized water

Concentrated HNO_3 solotion

Hach customised reagents

Sodium trioxocabornate (iv) solution

Buffer solutions

$K_2Cr_2O_4$ solution

EDTA

Sodium hydroxide (NaOH) solution

Murixide indicator

Calgamite indicator.

All reagents used were of analytical grade and obtained from Franny Chemical company, Ikeja Lagos.

3.2 Digestion of Samples for Trace Metal Analysis

3.2.1 Digestion of Water for Metal Analysis

About 100mL of the water sample was filtered using a whatman filter paper No1. The filtrate was acidified with 10mL Analar nitric acid and 10ml of 50% HCl solution. It was evaporated to near dryness on an electric hot plate. After cooling, the solution was quantitatively transferred to a 100mL volumetric flask and made up to the mark with de-ionized water and the metals determined by using Buck scientific, 210 VGP Atomic Absorption Spectrophotometer and Jenway P.F 7 flame photometer was used to determine K, Na and Ca.

3.2.2 Digestion of Sediment for Metal Analysis

The dried ground and sieved sample of the sediment (1g) was weighed into a 100mL beaker. The digestion of the metal was done using mixed acid method. A mixture of concentration $HClO_4$ and HNO_3 (20 mL) was added at a ratio of 4:1 to the sample and covered with a watch glass. The mixture was placed on a hot plate under a fume cupboard and heated to near dryness. This was allowed to cool before leaching the residue with 5mL of 20% (v/v) HNO_3. The solution was filtered using an acid washed filter paper (Whatman No.42) and the filtrate was made up to $20cm^3$ with distilled water. A blank was prepared similarly with the omission of the sample. Buck scientific, 210 VG.P. Atomic Absorption spectrophotometer was used to determine the heavy metals. While Jenway p.f.7 flame photometer was used for K, Ca, & Na.

3.2.3 Digestion of Fish for Trace Metal Analysis

The digestion of the sample was performed as described by Sodhi, (2005). The digestion was performed by using 0.5g homogenized powdered sample placed in a Teflon beaker and digested with 100mL mixture of concentrated perchloric acid (70%) and concentrated nitric acid (65%) on a hot plate. The digestion process lasted for 5 hrs. In a fume chamber and a clear solution was obtained. After complete digestion, the residue was dissolved and diluted with 0.2% V/V nitric acid to 20mL. The digested solution was filtered and Buck scientific Atomic Absorption spectrophotometer model 210 VGP and Jenway P.F.7 photometer was used for the determination of metals.

3.3 Determination of Colour, Chemical Oxygen Demand, Turbidity and Fluoride by Colorimetric Method.

These parameters were determined using Hach Colorimeter model DR890, a semi automated colorimeter with 95 Hach programmes permanently stored in memory. A programme usually includes programmed calibration curves; each curve is the result of an extensive calibration performed under ideal condition and is normally adequate for most testing.

Hach colorimeter (operation): The colorimeter was turned on. The programme number to be used was selected and as needed reaction timer was started. The instrument was set at zero using samples blank. The procedures for each parameter as depicted by the manufacturer were adopted for the assay of the sought analytes using special Hach customized reagents. The prepared sample was then placed into the sample cell holder. The read mark on the instrument was then pressed to obtain reading in concentration.

3.4 Determination of Conductivity, Total Dissolved Solids and Temperature by Conductivity/Total Dissolved Solids Meters.

JENWAY Model 470 portable conductivity/total dissolved solids meter, a general purpose hand held meter offering direct calibration on standard solutions was used for the determination of conductivity, total dissolved solids and temperature in all the samples in-situ. The custom liquid crystal display simultaneous showed temperature, compensated conductivity or total dissolved solids (TDS) and temperature. The meter was calibrated according to manufacturer's instruction each day prior to use with a 0.0100M standard solution of potassium chloride (equivalent to conductivity of 1413µS/cm at 25^{o}C). After calibration measurement was carried out by immersing the cell in the samples, allowing the reading to stabilise before recording the result. The mode button was then pressed down for 3 seconds to change the display to TDS and temperature measurement and results recorded accordingly.

3.5 Determination of Total Alkalinity by Potentiometric Titration

3.5.1 Standardization

Two replicates of 10.0 mL of 0.05M Na_2CO_3 were pipetted into 100mL beakers. Each of the standards was titrated potentiometrically to pH 4.5 end-point using 0.02 M HCl. The procedure above was repeated using 100mL deionised water as blank transferred into 250mL beaker. The molarity of the acid was calculated as:

$$\text{Molarity} = A \times B/106 \times C \qquad (3.1)$$

Where A = g Na_2CO_3 weighed into the 500 mL flask

B = mL Na_2CO_3 solution taken for titration and

C = mL acid used

106 = molar mass of Na_2CO_3 weighed into

500mL volumetric flask for preparation of 0.05 M (APHA AND AWWA, 1984)

100mL of unfiltered sample was transferred into 250mL beaker. A bar magnet and a pH electrode were inserted and the magnetic stirrer was switched on (care was taken so that the bar magnet does not touch the electrode). The initial pH, sample volume and sample temperature were recorded. The sample was titrated to pH of 4.5 using pH meter. The volume of the titrant (0.02M HCl) consumed was recorded. The same procedure was repeated for all the samples.

Calculation:

Total alkalinity, $mgCaCO_3/L$ = (A-B) x M x 100,000/mL sample (3.2)

Where A = mL sample standard acid used for sample

B = mL standard acid used for blank

M = Molarity of the acid used (APHA AND AWWA, 1984)

3.5.2 Determination of pH Using pH-Meter

The pH of the samples was determined on site using portable waterproof Wagtech pHScan3+ double junction model. Before the commencement of work on each day the instrument was calibrated with buffers 4.01, 7.00 and 10.01 starting with buffer 7.00. The pH meter was switched on by pressing on/off button on the unit and then the cap of the electrode was removed. Water sample was then collected in plastic cup according to prescribed method and the electrode dipped 2 to 3 cm into the tested water sample. It was stirred once and the reading was allowed to stabilize before the reading was taken. This procedure was repeated for all the samples.

3.5.3 Determination of Ammonia, Nitrate, Nitrite, Sulphate, Phosphate, Hexavalent By UV/Visble Spectrophotometry

Thermo Evolution 600 UV/Visible Spectrophotometer computer based automated model was used for the analysis of the above parameters in all the samples. The instrument was switched on and allowed to initialize fully for a warm up time of about 2 hours. The quant mode single wavelength was selected followed by appropriated wavelength of the analyte of interest (wavelengths for ammonia = 410 nm; nitrate = 543 nm; nitrite = 543 nm; sulphate = 420 nm; phosphate = 800 nm; chromium (VI) = 540 nm, manganese = 525 nm). Standard curve for each parameter was a calibration performed at 0.999, correlation coefficient under ideal condition internally in the laboratory and stored in the system memory subject to review every three months or when it fails reliability test performed before each analysis. Samples were then prepared according to standard methods for analysis for water and wastewater (APHA, 1987). Duplicate and quality control samples were analysed in every batch of 10 samples to ensure that the results were within controls.

3.5.4 Determination of Chloride by Argentometric Method.

100 ml of sample was measured into 250 mL conical flask. Samples whose pH were not in the range of 7 to 10 were adjusted to this range prior to titration using pH meter with a non chloride type electrode. 1ml of K_2CrO_4 was added to the sample as indicator and then titrated with standard 0.0141$AgNO_3$ as titrant to a pinkish yellow end point. The same procedure was followed for all the samples. A blank titration was done using distilled water by adopting the same procedure above (APHA, 1998)

Calculation:

$$Cl^- \text{ (mg/L)} = \frac{\text{(A-B) x M x 34500/m of sample used}}{\text{mL of sample used}} \qquad (3.3)$$

Where A = volume of titrant used for the sample

B = volume of titrant used for the blank

M = molarity of the titrant used

3.5.5 Determination of the Heavy Metals by Atomic Absorption Spectrophotometry.

Cadmium, copper, lead and zinc in the samples were analysed by the use of Thermo Electron Corporation S Series Model of flame Atomic Absorption Spectrophotometer (AAS), which has a deuterium arc background correction with hollow cathode lamps light source. The software as specified automatically performed several Quality Control (QC) checks. The software was set up to accept mid range standard as the QC sample and check the recovery initially every 10 samples and at the end of the run. Each sample was automatically spiked and the recovery compared with 80-120 % limits. The digested samples were analysed in accordance with the manufacturer's procedures by using the appropriate cathode lamp of discrete wavelength for each analyte and the concentration obtained directly from the instrument system read out device.

3.5.6 Determination of Sodium, Potassium and Calcium by Flame Emission Spectrophotometry

Sodium and potassium in all the samples were analysed using Shewood Scientific Limited Flame Photometer Model 410. The fuel supply of the instrument at the source was turned on and the appropriate filter selector was set to the required position. The nebulizer inlet tube was inserted into a beaker containing 100 mL of diluent and allowed 30 minutes for the operating temperature to stabilize. This was to ensure a stable burner temperature when solutions were aspirated. During the warm up period a set of calibration solutions of 0.0, 2.0, 4.0, 6.0, 8.0 and 10.0 ppm were prepared for sodium and potassium. While aspirating the diluent, the blank control on the instrument was adjusted so that the display reads 0.0. The highest concentration of standard (in this case) 10 ppm was aspirated while 20 seconds allowance was given for a stable reading before the coarse and fine controls were adjusted for instrument to read 100. The standard solution was removed and waited for 10 seconds, and then a blank solution of diluent was aspirated for 20 seconds before adjusting the blank control for 0.0 reading. The blank was removed and waited for another 10 seconds before the highest standard was re-aspirated again. This was repeated until the blank reading was 0.0 (within ±0.2) and the calibration reading was within ±1%. Without touching the fine and coarse controls each of the remaining standards were aspirated for 20 seconds (starting with the lowest concentration to avoid carry over) again allowing 10 seconds between measurements. The value of each standard from the instrument response was noted and the results plotted against concentration on linear excel graph. Each of the samples was then aspirated for 20 seconds and the concentration of the unknown samples estimated from the caliberation curve (APHA, 1998).

3.6 Determination of Calcium Hardness by Titrimetry

3.6.1 Standardization

5.0mL of the standard calcium solution was transferred to a 250 mL Erlenmeyer flask. 45ml of deionised water was added with graduated cylinder. Sufficient amount of the 1M NaOH solution was added to adjust the pH to between 12 to 13. This was followed by addition of 0.1 to 0.2 g of murixide indicator. The content was titrated with 0.01M EDTA titrant until colour changed from red to blue. 5.2mL of the titrant was consumed and mg$CaCO_3$ equivalent to 1.00 mL EDTA was calculated.

Two 50 mL deionised water blanks were set up and same procedure for reagents addition and titration as described above for standard was followed. Average of 0.2mL of the titrant was consumed in the blank titration. 50mL of the sample was measured into a 250mL Erlenmeyer flask. The pH was adjusted to 12 to 13 by adding a sufficient volume of 1M NaOH solution. This was followed by addition of 0.1 to 0.2 g murixide indicator. The content was titrated slowly with the addition of 0.01M EDTA titrant until the colour changed from red to blue (APHA and AWWA, 1984).

Calculation:

Calcium hardness as $CaCO_3$ mg/L = (A-B) x D x1000/ml sample (3.4)

Where A = mL of titrant used for the sample

B = mL of titrant used for blank

C = mL of titrant used for standard

D = mg$CaCO_3$/L equivalent to

1.00ml EDTA titrant

= 5mg $CaCO_3$ std/(C-B) ≈ 1

3.6.2 Determination of Total Hardness byTitrimetry

50mL of water sample was transferred into 250mL Erlenmeyer flask by graduated cylinder. The pH was adjusted to about 10 by adding a sufficient volume of buffer. 2 drops of calgamite indicator was added and titrated slowly with 0.01M EDTA solution with continuous stirring until colour changed from red wine to sky blue. This procedure was repeated for all the samples. (APHA and AWWA, 1984).

Calculation:

$$\text{Total hardness as } CaCO_3 mg/L = (A-B) \times D \times 1000/mL \text{ sample} \qquad (3.5)$$

Where

A = mL of titrant used for the sample

B = mL of titrant used for the blank

D = mg$CaCO_3$ equivalent to 1.00mL EDTA titrant

Magnesium hardness, calcium ion and magnesium ion in all the samples were estimated by calculation.

3.6.3 Computation of Pollution Index of River Niger

The pollution index of River Niger was determined using pollution quality of water as developed by Horton, (1965). This uses multiple items of water qualities expressed as Ci's and prermissible levels of the respective items expressed as Li's. The relative value of Ci'/Li; is the expression of pollution index. In this expression I is the number of the Ith item of the water quality and j is the number of the jth water used. Each value of (Ci/Lij) shows the relative pollution contributed by single item A value of 1.0 is the critical value for each (Ci/Lij). Values grater than 1.0 indicates that the water requires some special treatment before use for specific purpose.

Pollution index was given by

$$Pij = \sqrt{\frac{(Max.\ Ci/Lij)^2 - 1\ (Mean\ Ci/Lij)^2}{2}} \qquad (3.6)$$

3.6.4 Estimation of Dietary Intake

The estimated daily intake (EDI) of Cd, Cu, Zn, Ni, Pub, Co, Mn, Cr and Fe through edible parts of fish species (Catfish and Tillapia) was calculated using the following equation:

$$\frac{MI_F \text{ X } CM_F}{BW} = \text{EDI (mg/kg – BW/day)} \qquad 3.7$$

MI_F = Mass of fish ingested per day

CM_F= Concentration of Metal in Fish

BW = Body Weight (60kg for Adult)

The per capita consumption of fish and shell fish in Nigeria for human food is average 9.0kg which is aequivalent to 24.7g per day. (WHO, 2011)

3.6.5 Target Hazard Quotient (THQ)

The target hazard quotioent (THQ) was calculated by the formulation established by the United State Environmental Protection Agency (USEPA, 2000).

$$\text{THQ} = 10^{-3} \text{ x } \frac{\text{EF X ED X MI X CM}}{\text{ORD x BW x AT}} \qquad (3.8)$$

Where EF = Exposure frequeny (365 days/year; E is the exposure duration (51.86 years WHO, 2011)) which corresponded to average life expectancy of a Nigeria; AT = Averaging exposure time for non-carcinogens (365 days/year x ED). The oral reference dose (ORD) is an estimate of daily exposure to human population) that is likely to be without an appreciable risk of deterious effect during life time. 10.3 is the unit conversion factor. The oral reference Does (ORD) (mg/kg/day) used were, Cd (0.001), Cu (0.04), Zn (0.3), Ni (0.02), Pb (1.5), and Fe (0.7), Co (0.06), Mn (0.14), Cr (1.50) (USEPA, 2000).

3.6.6 Hazard Index (HI)

The hazard index from the consumption of catfish and tilapia obtained from River Niger was given by the equation below (WHO, 2011)

$$HI = \sum THQi \qquad (3.9)$$

where I is the distinct heavy metals tested

HI= Hazard index

THQ= Tardet Hazard Quotient

3.6.7 Metal Pollution Index Computation

Meta pollution index (MPI) is a method of rating that shows the composite influence of individual parameters on overall quality of water (Tamasi and Cimi, 2004). The rating is a value between 0 and 1. The higher the concentration of metal copared to its maximum allowable concentration the worse the quality of the water (Amadi, 2011). MPI represents the sum of the ratio between the analysed parameter and their conresponding national standard value (Tamasi and Cini, 2004).

$$MPI = \sum_{i=1}^{n} \left[\frac{Ci}{MAC} \right] \qquad (3.10)$$

Ci = mean concentration

MAC = Maximum Allowable concentration

CHAPTER FOUR

RESULTS AND DISCUSSIONS

This chapter discusses the results obtained in this study/work..

The mean physico-chemical and microbial results of Niger River (Dry and Wet Seasons) are shown in Table 4.1 to 4.5

Table 4.1: Dry Season Mean Value of Physiochemical (mg/L) and Microbial Parameters of River Niger

Parameter	March	April	May	October
pH	7.55±0.62	7.60±0.72	7.54±0.16	7.83±0.22
TEMP. (^{0}C)	31.7±0.53	31.4±0.59	31.5±0.51	31.5±0.56
COLOUR(Pt-Co)	206±10.8	279±37.7	237±11.5	820±46.0
COND.µS/CM	78.1±22.3	77.6±21.1	77.5±19.8	59.3±16.3
TDS	47.5±11.9	48.6±10.2	48.4±10.9	40.2±11.0
TSS	79.9±28.3	78.5±41.3	81.2±38.2	287±18.2
TS (mg/l)	125±29.9	124±40.6	126±40.9	328±17.7
TURB.(NTU)	29.7±15.6	29.5±16.7	32.4±16.5	248±126
Na	49.2±15.9	52.2±21.9	46.8±15.8	3.19±0.34
K	3.48±1.3	2.85±1.07	2.82±1.07	1.99±0.33
Ca^{2+}	4.80±1.74	4.31±2.17	4.54±1.48	4.62±2.45
Mg^{2+}	19.1±9.33	20.7±11.9	20.2±8.10	2.14±1.10
T.hardness	111±24.0	97.7±4.65	85.7±5.30	22.5±4.99
CaH (as mg /L $CaCO_3$)	13.7±12.4	11.2±6.55	13.5±6.25	12.6±3.70
MgH (as mg/L $CaCO_3$)	97.0±27.6	85.0±5.06	79.9±4.42	9.95±3.94
T Alkalinity (as mg/l $CaCO_3$)	25.8±8.86	25.7±8.15	28.0±15.3	26.0±10.8
Cl^-	17.0±5.62	20.4±7.09	19.4±7.16	6.95±3.86
F^-	0.95±0.61	0.84±0.63	1.24±0.11	0.40±0.032
NO^-_3 (mg/L as NO_3)	4.37±18.1	2.85±11.4	3.75±11.1	3.65±0.80
NO_2(mg/L as NO_3)	0.05±0.005	0.06±0.01	0.16±0.004	0.08±0.003
NH_3	1.50±0.54	0.88±0.24	0.91±0.55	1.17±0.92
SO_4^2-	24.7±10.6	21.9±8.67	21.6±8.13	8.29±4.53
PO_4^3-	2.33±5.47	2.11±3.55	1.87±2.88	0.35±1.12
TOC	3.79±1.48	2.5±1.54	4.35±2.10	5.40±2.50
BOD	5.02±1.05	3.82±1.34	3.99±1.76	1.41±3.19
COD	6.57±6.20	3.03±5.26	11.2±4.40	13.9±10.2
DO	12.57±6.20	5.44±2.01	5.57±1.69	8.67±10.7
T. coliform cfu, 100mL	111±19.5	135±24.8	180±21.1	246±24.9
E.coli cfu/100mL	30.8±5.05	26.7±5.47	121±10.4	168±17.7

Table 4.2: Wet Season Mean Value of Physicochemical (mg/L) and Microbial Parameters of River Niger

Parameter	June	July	August	September	WHO, 2008
Ph	7.4±1.16	7.58±0.27	7.77±0.23	7.80±0.19	6.5 – 8.5
TEMP. (^{0}C)	31.6±0.55	31.2±0.44	31.4±0.55	31.5±0.56	30
COLOUR(Pt-Co)	262±12.2	799±42.4	939±79.1	795±40.7	1,400
COND.µS/CM	73±22.8	62.5±13.9	62.3±13.5	761.7±14.2	1,200
TDS	47.3±13.8	40.9±8.21	40.1±8.62	36.7±13.5	<30
TSS	84.1±41.9	273±16.3	276±16.5	273±17.3	500
TS	134±43.8	283±14.1	315±15.8	317±16.8	5.0
TURB.(NTU)	360.5±16.9	215±12.1	234±11.7	253±15.8	200
Na	41.1±1.66	3.35±1.38	3.09±1.47	3.23±1.30	<20
K	2.65±0.86	2.45±0.32	2.34±0.29	2.27±0.28	75
Ca^{2+}	5.70±6.50	5.25±1.44	5.35±1.67	5.12±1.80	<100
Mg^{2+}	15.3±9.34	3.20±1.47	4.80±1.31	2.37±1.26	500
T.hardness	72.6±4.64	24.5±4.79	24.1±4.85	23.2±5.11	-
CaH (as mg /L $CaCO_3$)	13.9±5.80	13.8±3.78	13.8±3.75	13.0±3.78	-
MgH (as mg /L$CaCO_3$)	58.7±4.05	10.7±4.74	10.3±4.66	10.2±4.24	100
T Alkalinity (as mg/L $CaCO_3$)	25.1±8.77	26.7±11.7	26.0±6.39	25.6±6.17	250
Cl^-	18.2±7.28	10.2±8.33	9.22±7.71	8.79±7.65	-
F^-	1.16±2.97	0.39±1.50	0.62±1.74	0.42±1.35	50
NO^-_3 (mg/L as NO_3)	3.81±1.08	2.39±1.51	2.37±1.29	2.14±1.29	0.2
NO_2 (mg/L as NO_3)	0.14±0.45	0.03±0.08	0.10±0.38	0.09±0.34	-
NH_3	0.90±0.30	1.14±0.51	1.33±0.34	1.43±0.12	500
SO_4^2-	19.3±7.51	7.53±5.56	9.08±4.82	8.50±4.60	6.5
PO_4^3-	2.00±2.55	0.53±1.63	0.75±1.90	0.42±1.19	-
TOC	4.47±1.87	5.64±2.41	5.53±2.42	5.42±2.59	-
BOD	3.41±1.02	1.62±3.42	1.60±3.37	1.57±3.22	-
COD	11.6±4.58	18.0±13.4	17.8±14.0	15.4±12.6	5.0
DO	5.78±1.64	7.43±1.04	7.29±1.14	6.93±1.90	10
T. coliform cfu/ 100mL	156±99.8	317±44.3	324±43.1	280±24.7	0
E.coli cfu/100mL	109±64.2	251±4.11	228±39.8	180±19.3	0

4.1 Physico-chemical and Microbial Parameters

Tables 4.1 and 4.2 present the results of dry season and the wet season mean values of the physico-chemical and microbial analysis of River Niger.

pH is a term used universally to express the intensity of the acid or alkaline condition of a solution.The ranges of the mean pH values for the Wet and Dry seasons are; 7.40 – 7.80 and 7.54 – 7.83 respectively. The pH values were within the allowable limit for the surface water (WHO, 2011). The water of River Niger was not acidic as acid water tends to be corrosive particularly if the pH is below 6 while alkaline water with pH above 8.5 may tends to have a bitter or taste like that of soda (SON, 2007).

Generally the pH increased from March to October, where the highest pH of 7.83 was obtained. This may be due to anthropogenic activities within the river bank like washing, dumping of wastes and excreta which may deplete the dissolve oxygen and pH-alteration. It was also observed that the average pH of the dry season was higher than that of the Wet season. This may be due to the washing of different acidic substances into the river body during the 2012 flood.

The fluctuation in optimum pH-ranges may lead to an increase or decrease in the toxicity of poisons in water bodies (Ali, 1991). The pH obtained in the River Niger was within the ranges suitable for aquatic life (Chapman, 1996). Based on these guidelines the pH of the River would not adversely affect its use for agricultural, domestic and recreational purposes.

Temperature is an important biologically significant factor, which plays an important role in the metabolic activities of the organism. The mean value ranges of the temperature for the Wet and Dry seasons are 31.2 – 31.6 and 31.4 – 31.7^{0}C respectively. Temperature is an important parameter for aquatic environment; it is governed by physical, chemical and biochemical properties (Osunkiyesi, 2012). The temperature is slightly above allowable limit for surface water (WHO, 2011). This may be due to the dissipation of heat by engine boats and other anthropogenic activities and activities of microbes on organic substances in water. The highest value of 31.7 was obtained in dry season.

The colour observed appeared cloudy having mean values whose ranges are; 262 – 939 (Pt-Co) and 206 – 820 (Pt-Co) for wet and dry seasons respectively. This indicated that there are particle suspension that gave the apparent colour to the analysed samples. The wet season values tend to be higher than the dry season because floods might have leached some particles into the water body. The high value of the colour corroborates the high value of the total solids and the turbidity. The organic matter present in water may impart considerable colour to the water. Such organic matter might have been leached from the soil or from the decaying vegetation by rain storms.

Conductivity is a measure of the water ability to convey electric current. It signifies the amount of total dissolved salts present in water (Sudhir and Amarjeet, 1999). It is also an index of the total ionic content and therefore indicates freshness or otherwise of the water body. Conductivity results ranged between 62.3- 762 µS/cm. In wet season and 59.3 - 78.1µS/cm, in dry season. These results indicated that the conductivity is higher in wet season than in dry season, which meant that the amount of dissolved salts in wet seasons was more than dry season due to the leaching of substance into water body by the floods. It has been reported (Edimeh *et al,* 2011) that waters with conductivity values below 1000µS/cm are fresh while those with values above 40,000 µS/cm indicate marine nature of the water and those between these two limits are brackish waters.. The observed values for both wet and dry seasons were however within the allowable limit of 1,400 µS/cm prescribed by WHO, (2011).

The total dissolved solids indicate the salinity behaviour of surface water. Water containing more than 500mg/L of TDS is not considered desirable for drinking water supplies, but in unavoidable cases, 1,500mg/L is allowed. (Shrinivasa and Venkateswaraw, 2000). The average total dissolved solid obtained for wet season ranged from 36.7 to 47.3 (mg/L) and 40.2mg/L to 48.6mg/L in dry season. The TDS for dry season was observed to be higher than that obtained in the wet season perhaps due to reduction in volume of water. The values however are still within the allowable limit of surface water of 1,200mg/L (WHO, 2011). The high concentration of TDS suggests high anthropogenic activities in the water samples (UNESCO/WHO/UNEP, 2001). TDS and TSS are common tests of polluted waters. The average total suspended solids ranged from 84.1 to 276mg/L in wet season while that of Dry season ranged from 78.5 to 28.7mg/L. These values are high and far above the maximum allowable limit of 30mg/L (WHO, 2011). These may be as result of dumping of wastes along the river bank. High total suspended solids endangered aquatic environment of fish and other organisms.

Turbidity in most water is due to colloidal and extremely fine dispersions. The average turbidity of the river in wet season range from 36.5 NTU to 253 NTU while that of the dry season ranged from 29.5 to 248 NTU. The highest value was obtained in dry season which might be due to human activities, decrease in the water level and presence of suspended particulate matter leached into the water body by the 2012- flood. Mean while, the least value 29.NTU was obtained in April which may be as a result of high volume of water in the river due to the flood. The turbidity values in both seasons out weighed the maximum allowable limit prescribed by the (WHO, 2011) which may be as a result of suspended particles leached in to the river by floods.

The average sodium concentration for wet season ranged from 3.09mg/L to 41.1mg/L while the dry season value ranged from 3.19 to 52.2mg/L. The highest value of 52.2mg/L was obtained in

April (Dry season) which may be due to reduction in he volume of the river or salt water. Intrusion into the river areas, infiltration of the river contaminated by road salts, irrigation and precipitation leaching through soil high in sodium (Osunkiyesi, 2012). Sodium concentration above 20mg/L in surface water does not agree with the WHO standard (WHO, 2011). The least average of 3.09mg/L was obtained in August which may be as a result of high volume of water level due to the influence of floods.

The major source of potassium in natural fresh water is weathering of rocks but the quantities increased in polluted water due to disposal of waste water (Trivedy and Goel, 1986) the average potassium (K^{+}) concentration for wet season ranged from 2.27mg/L to 2.65mg/L and that for dry seasons ranged from 1.99mg/L to 3.48mg/L. The highest value was obtained in March (Dry season) which may be as a result of anthropogenic activities around the river bank, like dumping of wastes and waste water from the industries. Both the dry season and wet season value were above the WHO standard of 2mg/L except for the 1.99mgL obtained in October.

Calcium is directly related to hardness the average calcium (Ca^{2+}) concentration (mg/L) ranged for wet and dry season respectively are; 5.12 – 5.70 and 4.31 - 4.80mg/ L. The higher calcium content of river in wet season may be because of entry of calcium by leaching process of the rock into the water body by the floods. The highest average (5.70mg/L) was obtained in June when the flood was at it height , while the least average of 4.31mg/L was obtained in April. The seasonal values obtained were all below the WHO standard. (WHO, 2011).

Magnesium (Mg^{2+}) is also directly related to hardness. The highest magnesium average was found to be 20.7mg/L and was obtained in April (Dry season) while the least average of magnesium was found to be 2.14mg/L and was obtained in October. The values for the dry season were found to be higher than the values for the wet season. Which may be due to reduce in volume of the river. In general the values are within the WHO maximum allowable limit of 50mg/L.

Total hardness (TH) in mg/L is the property of water which prevents the lather formation with soap and increases the boiling points of water. (Trivedy and Goel, 1986). Hardness of water mainly is a function of the amount of calcium or the magnesium salts or both present in the water body. The hardness value ranged from 23.2mg/L to 72.6mg/L for the wet season and 22.5mg/L to 111mg/L for the dry season respectively. It was observed that the highest mean value (111mg/L) was found in March and this could be due to anthropogenic activities such as washing and dumping off refuse. The values for both seasons are within the WHO prescribed limit of 500mg/L. The total hardness that was higher during dry season than wet season can be attributed to decrease in water volume and increase of rate of evaporation of water (Hujare, 2008).

Total alkalinity of water is its ability to neutralize a strong acid and it is usually due to the present of bicarbonate, carbonate and hydroxide compound of calcium, sodium and potassium. Total alkalinity mean values for the wet season ranged from 25.1mg/L to 26.7mg/L for the wet season and 25.7mg/L to 28.0mg/L for the dry season. The maximum value of 28.0mg/L was recorded for the month of May (dry season) and minimum value of 25.1mg/L was recorded for month of June (wet season). It was reported that alkalinity value was maximum in dry season and minimum in wet season due to high photosynthesis rate which implies that there was increase in bicarbonates in water (Manjare *et al*; 2010). The total alkalinity for both wet and dry season in the river was found to be less than the value prescribed by the (WHO, 2011).

The chloride concentration is an indication of pollution by sewage. (Murhekar, 2011). In the present work the range of chloride for the wet and dry seasons were found to be 8.79 – 18.2mg/L and 6.95 – 20.4mg/L respectively. The highest average value of chloride was recorded in months of April (dry season), (Table 4.1). The highest value obtained in the dry season may be due to reduction in the volume of water and high rate of evaporation, it could also be attributed to the activities of man such as dumping of waste water and sewage on the body of the river. However the values recorded for both wet and dry season are below the maximum allowable limit recommended by the WHO value of 250mg/L.

Portable source of high fluoride in surface waters seems to be that during weathering and circulation of water in rocks and soils, fluorine are leached out and dissolved in surface water. Excess intake of fluoride through drinking water causes fluorosis on human being. The mean value for fluoride for wet season was found to be within the range of 0.39 to 1.16mg/L (Table 4.3), while that for dry season ranged between 0.40 to 1.24mg/L (Table 4.1). The values for the dry season was observed to be higher, may be due to reduction in volume of river, high rate of evaporation and other human activities.

Surface water contains nitrate due to leaching of nitrate with the percolating water. Surface water can also be contaminated by sewage and other wastes rich in nitrates (Murhekar, 2011) nitrate content in the study area varied in the range 2.14 to 3.81mg/L for wet season and 2.85 to 4.37mg/L in the dry. The dry season was found to be higher than the wet seasons, with the highest value of 4.37mg/L obtained in the month of March. This may be due to reduce volume of water. Most of the nitrate found in water are as a result of biological action going on in it. (Okieimen *et al*; 2012). Under the right condition, a lot of the organic nitrogen is decomposed into ammonia which then oxidized the ammonia to nitrites and finaly to nitrate by bacteria. Thus nitrates are very often the most predominant nitrogen compound in any water body (OKieimen *et al*; 2012). Nitrate ion in water is undesirable because it can cause menthaemoglobinaemia or blue baby syndrome in which blood looses it ability to carry sufficient oxygen in infants less than 6 months old (Egereonu and Nwachukwu, 2005). In this work the nitrate content is within the (WHO, 2011) permissible limit. The nitrite varied from 0.05 to 0.16mg/L in dry season and 0.03 to 0.14mg/L in wet season. The highest value was obtained in May (dry season) while the lowest was obtained in July may be due to high river volume. In all, the values obtained are less than the WHO standard of 0.2mg/L. These results indicated no nitrate and nitrite pollution in the samples analysed. The relatively high nitrate levels for some samples might be as a result of localize of infiltration of sewage into the surface water. The high nitrate concentration may be as a result of seepage of unsafely disposed volume of low, medium and high level waste effluents (Ogbuagu *et al*., 1998). In samples where low concentration of nitrate was found, it may be due to low level of domestic waste generation, judicious use of fetilizers in farm practices and absorption of nitrates from the soil by plants (Mbanigo *et al*; 1999). The ammonia concentration varied from 0.88 to 1.5mg/L in dry season and 0.90 to 1.43mg/L in wet season. The highest value (1.5mg/L) obtained in dry season may be due to reduction in volume of the river and may be leached into the river as a result of flood. High concentrating of NH_3 may denote the presence of putrifying bacteria due to the total solid present in the water body. The low value of nitrate and ammonia nitrogen in this water sanples are within permissible limits (UNESCO/WHO/UNEP, 2001), implying that the river Niger contaminated water samples are unlikely to be source of cyanosis and asphyxia in infants under 3 months (SON, 2007).

Sulphate occurs naturally in water as a result of leaching from gypsum and other common minerals (Shrinivasa *et al;* 2000). Dishcarage of industrial wastes and domestic sewage tends too increase its concentration (Muhekar, 2011). The sulphate concentration ranged from 7.53 to 19.3mg/L in wet season and 8.29 to 24.7mg/L in dry season. The values tend to be higher in dry season than wet season. Although, they were found to be within the prescribed limit of 500mg/L.

The phosphate in mg/L may occur in surface water as a result of domestic sewage, detergent and agricultural effluents with fertilizers. The phosphate concentration in the study area ranged between 0.35 to 2.33mg/L in dry season and 0.42 to 2.00mg/L in wet season. The highest value of 2.33mg/L was obtained in March (dry season) which may be due to anthropogenic activities and reduced volume of the river.

The total organic carbon average values ranged from 4.47mg/L to 5.64mg/L in wet season and 2.5 to 5.4mg/L in dry season. The highest average (5.64mg/L) was obtained in July, (wet season), this may be attributed to influx of organic matter into the river through floods and anthropogenic activities. High organic matter however may affect biogeochemical processes, nutrient cycling, chemical transport and interactions. Human and animal wastes as well as effluents from industries processing plants or animal products contain a mixture of complex organic substances such as carbohydrates, protein and fats as their major pollution load (Danida, 1998). Some of the organic matter is oxidized to carbondioxide and used for the synthesis of new microbial cells. In due course these organisms will die and become food for other decomposers. Eventually virtually all the organic carbon will be oxidized (Lamn, 1985).

Dissolved oxygen is important parameter in water quality assessment and reflects the physical and biological processes prevailing in the water. The DO mean values obtained ranged from 5.78 to 7.43mg/L in wet season while 5.44 to 12.6mg/L was obtained for dry season. The dissolved oxygen indicaes the degree of pollution in water body. The value for the dry season average was higher than obtained for the wet season which may be due to waste discharged and washed into the river body by the flood which is above the WHO limit of 10mg/L.

Chemical oxygen demand (COD) is the measure of the total quality of oxygen required to oxidize all organic materials into carbondioxide and water. The COD value ranged from 3.03 to 13.9mg/L in dry season and 11.6 to 18.0mg/L for wet season. It was observed that the wet season value was higher than the dry season value and this could be as a result of wastes discharge and washed into the river body by the floods high in organic mater and nutrient in water samples which probably leads to increased in microbial activities that used up the available oxygen .

The average BOD values obtained for both seasons (wet and dry season) were low. It ranged from 1.62 to 3.41mg/L in wet season and 1.41 to 5.02mg/L in dry season. The low values could be ascribed to waste discharges high in organic matter and nutrient in water samples and could also be as a result of increased microbial activities (Patnaik, 2005). The total coliform average values ranged 111 to 246cfu in dry season and 156 to 324cfu in wet season. The wet season value seems to be greater than the dry season value because excreta closed to the water body might have been washed into the river during the rain storm. The *E. Coli* also ranged from 109 to 228cfu in wet season and 30.8 to 168cfu in dry season. The presence of these organisms in the river indicated that the river was heavily polluted of fecal origin. For good water quality, this group of organisms should be absent (WHO, 2011)

TABLE 4.3: Anova of the Dry Season Mean Value of Physico-chemical Parameter of River

	Sum of Squares	Df	Mean Square	F	Sig
Between Groups	13148.639	3	4382.880	.846	.472
Within Groups	580375.379	112	5181.923		
Total	**593524.018**	**115**			

4.2 ANOVA of the Dry and Wet Season Mean Value of Physico-chemical and microbial Parameters of the River Niger.

The ANOVA shown in the Table 4.3 above indicated that the degree of variation of dry season mean concentration of the physico-chemical and microbial parameters was significant. Since P is greater than 0.05.

Table 4.4 Anova of the Wet Season Mean Value of Physico-Chemical and Microbial Parameters of River Niger

	Sum of Squares	Df	Mean Square
Between Groups	40623.185	3	13541.062
Within Group	2794932.743	112	24954.757
Total	**2835555.927**	**115**	

Similarly the degrees of variation of the wet season mean values of the physico-chemical and microbial parameters were found to be significant (Table 4.4).

Table 4.5: Correlations of the wet and dry season physico-chemical and microbial analysis

		WET SEASON MEAN VALUE OF PHYSIC-OCHEMICAL PARAMETER OF RIVER NIGER	DRY SEASON MEAN VALUE OF PHYSICO-CHEMICAL - PARAMETER OF RIVER NIGER
RAINING SEASON MEAN VALUE OF PHYSICOCHEMICAL PARAMETER OF R. NIGER(2014)	Pearson Correlation	1	.830**
	Sig. (2-tailed)		.000
	N	29	29
DRY SEASON MEAN VALUE OF PHYSICOCHEMICAL PARAMETER OF R. NIGER(2014)	Pearson Correlation	.830**	1
	Sig. (2-tailed)	.000	
	N	29	29

Correlation is significant at the 0.01 level (2-tailed).

Table 4.5 showed the correlation analysis of the physico-Chemcial and microbial parameter. This indicated that there is a strong positive relationship between the dry and wet season mean concentration of the physico-chemical and microbial parameters of River Niger.

The Pollution Index of Physico- Chemical Parameters of River Niger are shown in Tables 4.6 and 4.7.

Table4.6: Pollution Index of Water Samples from River Niger (Dry Season)

Parameter	Max Ci Quality	Permissible level WHO Li	Ci/Lij
pH	7.8	8.5	0.921
TDS	48.6	1000	0.049
T. Hardness	111	500	0.222
T. alkalinity	28.0	400	0.070
Sulphate	24.7	500	0.049
Chloride	20.4	250	0.082
Temperature	31.7	30	1.06
Color	820	1,400	0.59
Conductivity	78.1	1,200	0.07
TSS	287	500	0.57
TS	327	500	0.65
Turbidity	248	200	1.24
Na	52.2	200	0.26
K	3.48	75	0.05
Ca^{2+}	4.80	100	0.05
Mg^{2+}	20.7	500	0.04
MgH	58.7	100	0.59
CaH	13.7	50	0.27
Flouride	1.24	50	0.02
Nitrates	4.37	10	0.44
NH_3	1.50	500	0.003
Phosphate	2.33	250	0.36
TOC	5.4	10	0.54
BOD	5.02	6.0	0.84
COD	13.9	10	1.40
DO	12.6	10	1.26
Total ∑(Ci/Lij)			11.696
Mean (Ci/Lij)/n			0.450

Using equation (3.6) Pollution Index for Dry Season (P_{ij}) = 8.28

4.7: Pollution Index of Water Samples from River Niger (Wet Season)

Parameter	Max Ci Quality	Permissible level WHO Li	Ci/Lij
pH	7.8	8.5	0.92
TDS	47.3	10,000	0.05
T. Hardness	72.6	500	0.15
T. alkalinity	26.7	50.0	0.53
Sulphate	19.3	250	0.08
Chloride	18.2	250	0.07
Temperature	31.6	30	1.05
Color	939	1,400	0.67
Conductivity	762	1,200	0.64
TSS	276	500	0.55
TS	317	500	0.63
Turbidity	365	200	1.83
Na	41.1	200	0.21
K	2.65	75	0.04
Ca^{2+}	5.7	100	0.06
Mg^{2+}	15.3	500	0.03
MgH	58.7	50.0	1.17
Flouride	1.16	1.50	0.77
Nitrates	3.81	10.0	0.38
NH_3	1.43	500	0.002
Phosphate	19.3	250	0.08
TOC	5.64	10	0.56
BOD	3.41	6.0	0.57
COD	18.0	10.0	1.8
DO	7.43	10	0.74
CaH	13.9	50	0.28
Total ∑(Ci/Lij)			12.69
Mean (Ci/Lij)/n			0.488

Using equation (3.6) Pollution Index for Wet Season (P_{ij}) = 8.98

4.3: **Pollution Index of the River**.

The result of the pollution index from Tables 4.6 nand 4.7 for both wet and dry seasons were; 8.98 and 8.28 respectivley. These results showed that they were well above 1.0 which are regarded as critical values. The River was therefore regarded as crtically polluted and cannot be used for specific purposes without certain treatments.

The cumulative average concerntration of metals in Niger River for wet and dry season are dipicted in Tables 4.8 and 4.9 and Table 4.10 and 4.11 outlined the cumulated anova.

Table 4.8: Cumulative Dry Season Concentration of Metals (mg/L) in Water Samples of River Niger

MONTHS	METALS								
	Cr	**Mn**	**Pb**	**Co**	**Ni**	**Fe**	**Zn**	**Cu**	**Cd**
March	ND	0.23±0.15	0.05±0.05	0.01±0.01	ND	0.22±0.11	0.09±0.08	0.01±0.10	ND
April	ND	0.07±0.08	0.04±0.04	ND	ND	0.18±0.09	0.07±0.01	0.01±0.01	ND
May	ND	0.15±0.07	0.03±0.05	ND	ND	0.18±0.11	0.05±0.03	0.01±0.02	ND
Oct.	0.01±0.01	0.25±0.6	0.01±0.01	0.02±0.01	0.01±0.01	0.14±0.08	0.02±0.01	0.02±0.01	0.01±0.00
WHO	7.00	0.4	0.01	0.410	0.04	5.60	3.0	3.50	0.003

ND = NOT DETECTED

Table 4.9: Cumulative Wet Season Concentrations of Metal in Water of River Niger (mg/L)

MONTH	METALS								
	Cr	**Mn**	**Pb**	**Co**	**Ni**	**Fe**	**Zn**	**Cu**	**Cd**
June	ND	0.21±0.08	0.02±0.04	ND	ND	0.11±0.07	0.03±0.02	0.01±0.03	ND
July	0.01±0.01	0.15±0.06	ND	0.01±0.01	ND	0.09±0.08	0.01±0.01	0.01±0.03	ND
August	0.01±0.01	0.26±0.20	0.01±0.01	0.01±0.1	ND	0.13±0.08	0.02±0.01	0.02±0.02	ND
Sept.	0.01±0.02	0.26±0.14	0.01±0.01	0.01±0.01	0.01±0.01	0.14±0.14	0.02±0.02	0.02±0.03	ND
WHO	7.00	0.4	0.01	0.41	0.04	5.60	3.0	3.50	0.003

ND = NOT DETECTED

4.4 Heavy Metals Concentration in Water of River Niger

Table 4.8 and 4.9 showed the cumulative dry and wet seasons concentration of heavy metals from River Niger. Chromium was not detected for the month of March to May, but the least value of 0.01mg/L was recorded in the month of October which was far below the WHO limit. The highest average value for manganese (0.25mg/L) was recorded in the month of October perhaps due to reduction in volume of river. The concentration of the metals obtained during dry season were all below the WHO recommended limits except Cd which had the concentration of 0.01mg/L in October against the 0.003mg/L recommended by the WHO. The values in the dry seasons decreased according to the following trend: Fe > Mn> Zn > Pb > Cu > Cr > Cd > Ni while the trend for the wet season was Mn > Fe > Zn > Cu > Pb > Cr > Co > Ni > Cd. The values recorded for the wet season were significantly higher than the values recorded for the dry season. Perhaps due to influx of substances into the river during rain storm.

Table 4.10: Anova of the Cumulative Dry Season Concentrations of Metals in Water of River Niger.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.171	8	.021	20.922	.000
Within Groups	.028	27	.001		
Total	**.199**	**35**			

Table 4.11 Anova of the Cumulative Wet Season Concentrations Of Metals In Water Of Niger River

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.181	8	.023	58.767	.000
Within Groups	.010	27	.000		
Total	**.191**	**35**			

There was significant degree of variation of cumulative wet season concentration of metals as ($P < 0.01$), Table 4.10). Similarly there was significant degree of variation of cumulative dry season concentration of the metal of River Niger ($P < 0.01$) (Table 4.11). The concentrations of the metals in water for both dry and wet season were however within the WHO recommended limits.

The metal pollution index of River Niger for both dry and wet season are shown in Table 4.12 and 4.13 respectively.

Table 4.12 Metal Pollution Index of Water Samples from River Niger (Dry Season)

Metal	Mean Concentration Ci (mg/L)	Allowable limit (mg/L) WHO (2011)	MPI
Cr	0.003	0.05	0.060
Mn	0.175	0.4	0.438
Pb	0.003	0.01	3.30
Co	0.008	-	-
Ni	0.003	0.02	1.65
Fe	0.180	1.0	0.180
Zn	0.058	3.0	0.019
Cu	0.013	2.0	0.007
Cd	0.003	0.01	0.3
∑MPI			5.954

Table 4.13: Metal Pollution Index of Water samples from River Niger (Wet Season)

Metal	Mean Concentration Ci (mg/L)	Allowable limit (mg/L) WHO (2011)	MPI
Cr	0.008	0.05	0.160
Mn	0.22	0.4	0.55
Pb	0.01	0.01	1.00
Co	0.008	-	-
Ni	0.003	0.02	0.150
Fe	0.118	1.0	0.118
Zn	0.02	3.0	0.007
Cu	0.015	2.0	0.008
Cd	-	0.01	0.3
∑MPI			1.993

The metal pollution index of the river as indicated in Tables 4.12 and 4.13 showed that the river has accumulated metals beyond the critical value of 1.0 and hence cannot be used for specific purposes without any special treatment.

The metal pollution index of the wet season (1.993) as shown in Table 4.13 was found to be much lower than that of the dry season (5.954) which may be due to the reduction in volume of the river after the flood. Though both dry and wet season values were above the critical value of 1.0.

The cumulative concentration of heavy metals in Sediment for Wet and Dry Seasons are shown in Tables 4.14 and 4.15 respectively. There ANOVA and Bichart results are depicted in Tables 4.16, 4.17 respectively.

Table 4.14: Cumulative Wet Season Concentrations of Metal in Sediments of Water samples from River Niger

MONTH	METALS(mg/kg)								
	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
June	0.26±0.16	54.2±43.8	2.44±2.01	1.70±1.60	0.27±0.13	14.9±11.6	0.89±1.10	0.94±0.81	ND
July	0.22±0.13	47.0±50.5	2.19±1.88	1.32±1.15	0.20±0.10	15.1±15.0	0.71±0.99	0.81±0.68	ND
August	0.35±0.69	86.4±11.2	4.05±2.87	2.49±1.98	0.81±1.26	15.8±12.5	0.67±0.94	0.57±0.92	ND
Sept.	0.74±0.68	79.3±81.3	5.00±3.13	2.62±1.88	0.84±0.57	17.1±12.6	0.92±1.08	1.12±0.91	ND
WHO	7.00	0.4	0.01	0.410	0.04	5.60	3.0	3.50	0.003

BDL = BELOW DETECTION LIMIT

Table 4.15: Cumulative Dry Season Concentration of Metals in Sediments of River Niger

MONTH	METALS (mg/kg)								
	Cr	**Mn**	**Pb**	**Co**	**Ni**	**Fe**	**Zn**	**Cu**	**Cd**
March	0.26±0.16	58.1±48.0	3.05±2.35	1.81±1.51	0.25±0.25	16.1±11.5	1.05±1.29	1.13±0.95	0.02±0.01
April	0.17±0.15	50.7±43.3	2.55±2.08	1.54±1.38	0.17±0.19	15.0±11.1	0.83±1.14	0.87±0.78	0.16±0.01
May	0.11±0.16	51.4±45.1	1.80±2.10	1.28±1.27	0.09±0.13	13.6±10.6	0.57±0.97	0.72±0.72	0.00±0.00
Oct.	1.10±0.80	81.4±81.0	5.62±3.21	3.14±2.09	1.17±0.61	17.6±13.0	1.20±1.18	1.57±0.84	0.01±0.01
WHO	7.00	0.4	0.01	0.410	0.04	5.60	3.0	3.50	0.003

4.16: Anova of the Cumulative Wet Season Concentration of Metals in Sediments Samples of River Niger (March-Oct. 2014)

	Sum of Squares	df	Mean Square	F	Significance
Between Groups	15227.594	8	1903.449	46.649	.000
Within Groups	1101.703	27	40.804		
Total	**16329.297**	**35**			

4.17 Anova of the Cumulative Dry Season Concentration of Metals In Sediments Samples of the River Niger

	Sum of Squares	df	Mean Square	F	Significance
Between Groups	12494.318	8	1561.790	65.630	.000
Within Groups	642.514	27	23.797		
Total	**13136.833**	**35**			

4.5: Heavy Metals Concentration in Sediment of River Niger.

Sediments act as a sink for different elements (Thomas 1977). Therefore their metal concentrations may reflect the degree of pollution in the area (Edgren, 1978).

The cumulative wet and dry season concentration of heavy metals in sediments samples of the River Niger is shown in Tables 4.14 and 4.15 respectively. Higher values in sediments especially for manganese and iron probably reflect the character of the soil in the region. Further more, these may be as a result of the influx from Ajaokuta iron and steel company situated around the study area. The cumulative wet and dry season concentrations of metals in sediment of River Niger indicated that Mn, Pb, Co, Ni and Fe were found to be far above the recommended limit for WHO. Cd was not detected in wet season but over shoots the WHO limit in dry season, may be due to local/ urban pollution. Only Cr, Zn and Cu were found to be within the WHO recommended limits.

It was also observed that, the highest value of 86.4 mg/kg was obtained for manganese in the wet season which could be attributed to leaching of metal from rocks and Ajaokuta iron and steel company environmnent into the water body and settled in the sediment. The ANOVA indicated that there was a significant variation in both the wet and dry seasons cumulative mean value of the metals in sediment of River Niger as the P value < 0.05.

The interrelationship between heavy metals in surfacial sediments and water are pesented as correlations in Appendix XXVII Tables, 1 to 4. From the Tables, p values were all less than 0.01 which implies strong positive relationship between the dry and wet season concentration of heavy metals in water and sediments. These were confirmed by their respective scatter plots as seen in Appendix XXII, Figs. 1 – 4. The scatter plots when traced cannot give linear plots, which implies that the increased in heavy metals in water leads to increase in heavy metals in sediments, which may be due to high rate of sedimentation taking place in suspended matter. Also the dry and wet season concentration of heavy metal in water and sediment correlated, positively as their P values is less than 0.01. This perhaps may be as a result of reduction in volume of water. The high number of significant correlations may indicate that concentrations are controlled by heavy metal abundances in the rocks and soil of Ajaokuta iron and steel company catchment area. This is in line with known character of River Benue (Eneji and Sha'ato, 2012). The negative significant correlation of Cd with most metals, analysed Appendix XXIV, Table 1– 9 could indicate the competition between cations in the sediments (Wood, 1984).

The concentration of Cr, Mn, Pb, Co, Ni Fe, Zn and Cu for the wet season ranged as follows (mg/kg) 0.22 – 074, 470.86.4, 2.19 – 5.0, 1.32 – 2 .62, 0.20 – 0.84, 14.9 – 17.1, 0.67 – 0.92, 0.57 – 1.12 respectivley. While Cd was below detection limit, manganese had the highest concentration of 86.4mg/kg in August while the least concentration 0.2mg/kg was recorded for Ni in the month of July.

The range of the heavy metal in sediment during dry season (mg/kg) were: 0.11 – 0.26, 50.7 – 81.4, 1.8 – 5.62, 1.28 – 3.14, 0.09 – 1.17, 13.6 – 17.6, 0.57 – 1.2, 0.72 – 1.57 and 0.00 – 0.16 for Cr, Mn, Pb, Co, Ni, Fe, Zn, Cu and Cd respectively. It was observed that while the Cd was below detection limit in the result obtained during wet season, the highest average value of 0.16mg/kg was recorded in month of April, this may be due to reduction in volume of water and the catchment area. The concentration of manganese was highest in October as presented in figure 4.4, while the least value of Mn was obtained in April. Co, Ni, Zn and Cu had the lowest concentration in the dry season. Cd was almost not detected, as depicted by Figure 4.4.

The concerntrations of Heavy Metals in Fish Samples from Lokoja Area of River Niger are shown in Tables 4.18 and 4.19

Table 4.18: Heavy Metals Concentration in Tilapia (*Oreochromis nilticus*) from Lokoja Area of River Niger

Heavy Metal	1 mg/kg	2 mg/kg	3 mg/kg	4 Mg/kg	5 mg/kg	Mean value ±S.D (mg/kg)	WHO 2008
Fe	1.44	1.74	1.74	3.21	2.52	2.13±0.72	100
Ni	BDL	BDL	BDL	BDL	BDL	BDL	0.6
Zn	0.44	0.48	0.43	0.37	0.42	0.43±0.04	75
Cu	0.05	0.02	0.05	0.02	0.05	0.04±0.02	3.5
Cr	0.02	BDL	0.01	0.01	BDL	0.01±0.01	0.15
Mn	0.37	0.45	0.35	0.40	0.36	0.39±0.04	0.5
Co	0.01	BDL	0.01	0.01	0.01	0.01±0.00	0.41
Cd	0.01	BDL	BDL	BDL	BDL	0.002±0.004	2.0
Pb	0.01	BDL	BDL	BDL	BDL	0.002±0.004	0.2

BDL = Below Detection Limit

Table 4.19: Result of Heavy Metals Analyses in catfish (*clarias gariepinus*) from Lokoja Area of River Niger

Heavy Metal Document	1 mg/kg	2 mg/kg	3 mg/kg	4 mg/kg	5 mg/kg	Mean value ±S.D (mg/kg)	WHO 2008
Fe	1.23	1.61	0.51	0.56	0.88	0.96±0.47	100
Ni	BDL	BDL	BDL	BDL	BDL	-	0.6
Zn	0.28	0.36	0.14	0.29	0.19	0.25±0.09	75
Cu	0.04	0.06	0.02	0.01	0.02	0.03±0.02	3.5
Cr	0.01	0.03	0.01	BDL	0.01	0.01±0.01	0.15
Mn	0.03	0.08	0.03	0.08	0.03	0.05±0.03	0.5
Co	0.01	0.02	0.01	BDL	0.01	0.01±0.007	0.41
Cd	BDL	BDL	BDL	BDL	BDL	BDL	2.0
Pb	BDL	BDL	BDL	BDL	BDL	BDL	0.2

BDL = Below Detection Limit

4.6: Results of Heavy Metals in Fish Sample (Lokoja area of the River)

Table 4.18 and 4.19 Indicated the results of heavy metal analyses in Tilapia (*oreochromis Niloticus)*and Catfish (*clarias gariepinus*) respectively obtained from Lokoja Area of the River Niger. All the fishes obtained from the River Niger were contaminated with the heavy metals analysed for except Cd and Pb that were not detected in Catfish while Tillapia was found to accumulate these metals. The concentration of the heavy metals in Tilapia was observed to be higher than concentration of metals obtained in Catfish. The mean concentration of Fe (0.958) mg/kg was found to be the highest in Catfish. Co and Cr have the least concentration of 0.1mg/kg in Catfish. Co in Tilapia was found to have accumulated the highest concentration of 8.0mg/kg. It was noted that all the metals analysed in Catfish are within the recommended limit of WHO while Ni (2mg/kg), Mn (0.39mg/kg), Co (8.0mg/kg).And Pb (2.0mg/kg) exceeded the limit set by WHO.

These contaminants may be traced to entry into the water of industrial effluents from steel industries around the catchment of the study area (Rasheed, 2001). The correlation analysis done for the concentration of heavy metals in Tillapia from Lokoja and the concentration of heavy metals in catfish from Lokoja indicated strong positive correlation at p. value < 0.01.Also the concentration of heavy metals in Tilapia and catfish from Itobe indicated strong positive correlation . Similarly the concentration of heavy metals in catfish and tilapia from Itobe have strong positive correlation,the concentration of heavy metals in tilapia and catfish from Idah are also positively correlated. The concentration of catfish from lokoja and Idah and the concentration of tilapia from Itobe and Idah are positively correlated, finally the concentration of hevy metals in catfish from itobe and Idah were also positively correlated (Appendix XXIII, Tables 1-9).

The result of Heavy Metal concentrations in Fish Samples from Itobe Area are shown in Tables 4.20 and 4.21 respectively

Table 4.20: Heavy Metals Concentration in Tilapia (*Oreochromis Niloticus*) from Itobe Area of River Niger

Heavy Metal	1 mg/kg	2 mg/kg	3 mg/kg	4 mg/kg	5 mg/kg	Mean value ±S.D (mg/kg)	WHO 2008(mg/kg)
Fe	5.65	2.10	1.33	1.29	1.04	2.28±1.92	100
Ni	0.01	BDL	0.1	0.01	BDL	0.02±0.04	0.60
Zn	0.35	0.25	0.13	0.17	0.08	0.19±0.11	75
Cu	0.02	0.02	0.40	0.01	0.02	0.09±0.17	3.5
Cr	0.01	0.01	0.01	0.01	0.02	0.01±0.004	0.15
Mn	0.31	0.14	0.01	0.06	0.3	0.16±0.14	0.5
Co	0.01	0.01	0.02	0.01	BDL	0.01±0.007	0.41
Cd	BDL	BDL	BDL	BDL	BDL	BDL	2.0
Pb	BDL	BDL	BDL	BDL	BDL	BDL	0.2

BDL = Below Detection Limit

Table 4.21: Heavy Metals Concentration in Catfish (*clarias gariepinus*) from Itobe Area of River Niger.

Heavy Metal	1 mg/kg	2 mg/kg	3 mg/kg	4 mg/kg	5 mg/kg	Mean value ±S.D (mg/kg)	WHO (mg/kg)
Fe	5.56	3.14	3.59	4.61	7.28	4.84±1.66	100
Ni	BDL	BDL	BDL	BDL	BDL	-	0.60
Zn	0.14	0.08	0.11	0.19	0.46	0.20±0.15	75
Cu	0.02	BDL	0.01	0.02	0.03	0.02±0.01	3.5
Cr	0.01	0.01	0.01	0.01	0.01	0.01±0.00	0.15
Mn	0.41	0.20	0.24	0.32	0.75	0.38±0.22	0.5
Co	0.01	BDL	0.01	0.01	BDL	0.01±0.00	0.41
Cd	BDL	BDL	BDL	BDL	BDL	-	2.0
Pb	BDL	BDL	BDL	BDL	BDL	-	0.2

BDL = Below Detection Limit

4.7: Results of Heavy Metals in Fish Sample (Itobe area of the river)

The results of heavy metals content in two species of fish samples: Tillapia (*Oreochromis niloticus)* and Catfish (*Clarias Gariepinus*) obtained from River Niger at Itobe in Kogi State are presented in table 4.20 and 4.21 respectively. The mean concentration of the heavy metals in Tilapia ranged from 0.01 mg/kg to 2.28mg/kg and that for catfish ranged from 0.01mg/kg to 4.84mg/kg. The highest concentration was obtained for iron (4.84mg/kg) in catfish. Also Fe ranked the highest accumulated in Tilapia (2.28mg/kg). Cd and Pb were not detected in the two speciesof fish at Itobe area of the River Niger(Tables 4.20 and 4.21), which may be attributed to less anthropogenic activities.

The mean value of Fe in tilapia is 2.28mg/kg which is the highest concentration obtained. This is less than the maximum permissible level of 100mg/kg set by the WHO. It was observed that all the metals accumulated by Tilapia at Itobe area were within the WHO limits. In table 4.21, the concentration of Fe in catfish (4.84mg/kg) was higher than that of Tilapia but also within the limit stipulated by WHO. It was also observed that the concentration of other metals were within the stipulated limit by WHO.

The correlation of the heavy metals in tilapia and catfish from Itobe indicates a positive linear relationship between the heavy metal concentration in tilapia and the heavy metals concentrated in catfish obtained in the same region of itobe. (Appendix XXIII, Table 1-9). The concentration of heavy metals in tilapia from Itobe also revealed that there is a strong positive linear correlation within the concentrations of these metals obtained in Itobe and Lokoja. As the concentration of the metals in tilapia from Lokoja increased that of Itobe also increased. Similary, the concentration of heavy metals in catfish from Lokoja also correlated positively with the concentration of heavy metals in catfish from Itobe (Appendix XXIII, Table 9.0). Therefore the concentration does not depend on the location nor the species of fish samples.The concentration may be as a result of the catchment area of study,the geology of the study area,the effect of the 2012-flood that might have leached some metals into the river to settle to the sediment.

The Concentrations of Heavy Metals in Fish from Idah Area are outlined in Tables 4.22 and 4.23

Table 4.22: Heavy Metals Concentrationin (Catfish) (Clarias Garieping) in) from Idah Area of RiverNiger.

Heavy Metal	1 mg/kg	2 mg/kg	3 mg/kg	4 mg/kg	5 mg/kg	Mean value ±S.D (mg/kg)	WHO (mg/kg)
Fe	2.54	2.58	3.49	7.90	1.87	3.68±2.43	100
Ni	BDL	BDL	BDL	BDL	BDL	-	0.6
Zn	1.08	0.38	1.28	2.39	0.22	1.07±0.86	75
Cu	0.12	0.06	0.21	0.29	0.05	0.15±0.101	3.5
Cr	0.05	0.04	0.08	0.01	0.02	0.04±0.03	0.15
Mn	0.15	0.15	0.35	0.55	0.08	0.26±0.19	0.5
Co	0.01	0.02	BDL	BDL	0.01	0.01±0.00	0.41
Cd	BDL	BDL	BDL	BDL	BDL	-	2.0
Pb	BDL	BDL	BDL	BDL	BDL	-	0.2

BDL = Below Detection Limit

Table 4.23: Heavy Metals Concentrations in *orechromis nilotus* (Tilapia) in (mg/kg)from Idah Area of River Niger

Heavy Metals	1 mg/kg	2 mg/kg	3 mg/kg	4 mg/kg	5 mg/kg	Mean value ±S.D (mg/kg)	WHO (mg/kg)
Fe	5.23	4.26	6.25	5.49	4.48	5.14±0.800	100
Ni	BDL	BDL	BDL	BDL	BDL	-	0.6
Zn	0.40	0.24	0.37	0.95	0.28	0.a44±0.290	75
Cu	0.03	0.03	0.03	0.12	BDL	0.04±0.004	3.0
Cr	0.01	0.03	0.01	0.09	0.01	0.02±0.002	0.15
Mn	0.94	0.62	0.95	0.72	0.62	0.77±0.160	0.5
Co	0.01	0.01	BDL	0.03	BDL	0.01±0.001	0.41
Cd	BDL	BDL	BDL	0.01	BDL	-	2.0
Pb	BDL	BDL	BDL	BDL	BDL	-	0.2

BDL = Below Detection Limit

4.8 Result of Heavy Metal in the Fish Samples (Idah Area of the River)

The heavy metal concentgration in catfish and tilapia from Idah area of the River Niger are displayed in Table 4.22 and 4.23. The mean concentration of the heavy metals ranged from 0.01mg/kg to 3.68mg/kg in catfish, and 0.01mg/kg to 5.14mg/kg in tilapia, it was observed that iron has the highest mean concentration in both species of fish (catfish-3.68mg/kg and tilapia-5.4mg/kg). However the concentration of Fe in tilapia was higher. The least detected metal concentration in catfish was obtained in Co (0.01mg/kg). It is also worthy to note that Cd and Pb metals were not detected in Idah area of River Niger. Therefore all the metals analysed for in the two species of fish from Idah area of the River Niger were within the WHO stipulated limits except manganese that was above the limit which may be attributed to anthropogenic activities,low effectof industries and the effect of the 2012 flood that result to high volume of water.

The correlation analysis obtained from the concentration of heavy metals in tilapia and catfish from Idah indicates that there is strong positive linear correlation between the two concentrations as p value < 0.01. (Appendix XXVIII, Table 1). Also the correlation between the heavy metals in tilapia from Lokoja and Idah (Appendix XXVIII, Table1 2) shows a positive linear correlation too. The correlation between the concentration of heavy metals in the catfish from Idah and Lokoja indicates positive linear relationship between the concentration of the metals (Appendix XXVIII, Table 3). The concentration of heavy metals in tilapia and catfish from Itobe and Idah area of the River Niger were also correlated and the results shows that there are positive linear correlations between the concentrations of the metals in two species of the fish obtained from Idah and Itobe. (Appendix XXVIII, Table 4 and 5) .the flood increase the volume of the river therefore enhancing even distribution of the metals in the area studied hence the positive correlation seen in the two species of fishes being studied.

The Average Concentration Of Heavy Metals In Water ,Sediments And Fish Samples From The 3 Locations (Idah,Itobe And Lokoja) And Their Multipple Correlations Are Shown In Table 4.24 And 4.25 Respectively.

Table 4.24. Average concentration of heavy metals in water, sediment and fish samples from Idah, Itobe, and Lokoja Area of River Niger.

	SAMPLE FROM IDAH AREA			SAMPLE FROM ITOBE AREA			SAMPLE FROM LOKOJA AREA		
METALS	WATER	SEDIMENT	FISH	WATER	SEDIMENT	FISH	WATER	SEDIMENT	FISH
Cr	0.005	0.39	0.03	0.01	0.40	0.01	0.01	0.40	0.01
Mn	0.23	29.0	0.52	0.19	30.2	0.27	0.22	35.7	0.22
Pb	0.03	4.54	---	0.02	3.91	---	0.02	2.80	0.001
Co	0.01	1.50	0.01	0.01	2.07	0.01	0.72	2.27	0.01
Ni	0.01	0.42	---	0.02	0.40	0.01	0.22	0.61	---
Fe	0.1	12.60	4.41	0.16	16.7	3.56	0.19	17.1	1.55
Zn	0.05	0.74	0.76	0.05	1.07	0.2	0.06	0.79	0.34
Cu	0.02	0.98	0.1	0.14	1.36	0.06	0.02	0.69	0.04
Cd	0.01	0.005	---	0.00	0.005	---	0.00	0.005	0.001

From Table 4.24, it was observed that the concentrations of the metals in sediment was higher than their concentrations in water samples. Manganese in sediment was found to be the most accumulated metals with the highest concentration of 35.7 mg/kg obtained in Lokoja Area of the

River Niger which may be due to presence of industries and the effect of the flood around the area. It was also observed that the fish accumulated less concentration of metals than was found in the sediments which may be due to the 2012-Flood which made the volume of the River to rise. There was high level of iron/ Manganese in the samples obtained from these areas of study which may be due to the presence of iron and steel company around the study area and the 2012 flood might have leached the metals from these industries into the river body. Similar work done by Otitoju and Otitoju (2013), reported that having metals from pollutted source is capable of contaminating the terrestrial and acquatic environment.

Iron with the concentration of 3.56mg/kg from Itobe area was found to be the highest accumulated may be due to the closeness to Ajaokuta Iron and steel company. In all, iron was the highest accumulated metal in the area studied which may be due to the presence of iron and steel company in the area studied.

Table 4.25 showed the multiple correlations of the heavy metal concentrations in Idah, Itobe and Lokoja area of the River Niger. It was observed that the heavy metals from Idah area correlated positively with the heavy metal in sediment from Idah, Itobe and Lokoja areas respectively. Similarly, the heavy metals concentration in water from Idah area are also significantly correlated with the metals in water from Itobe and Lokoja areas.

Heavy metals from sediment from Idah area are significantly correlated with those in water from Idah and Itobe area ($P < 0.191$ and $P < 0.774$). Similarly, heavy metals in sediment from Idah area positively correlated with the metals in sediment from Itobe and Lokoja area ($P < 0.993$ and $P < 0.996$). Heavy metals concentration in fish from Idah area are positively correlated with the metal in fish from Itobe and Lokoja area ($P < 0.993$ and $P < 0.999$) of River Niger. The concentration of heavy metals in water from Itobe area was seen to correlate positively with the heavy metals in water from Idah, heavy metals in sediment from Itobe and Lokoja areas.

Significant correlation between metal pairs indicates that there is a linear relationship between them (Demirak *etal*., 2006) and also provide clue about the chemical association between trace metals in a particular area (Harikuma and Jisha, 2010). In this study, significant correlatation among Cr, Mn, Pb, Co, Ni, Fe, Zn, Cu and Cd may be due to their similarity in chemical structure, valency and their ability to replace this others in their Ores or reaction sides (Manahan, 2000).

The Risk Assessment of Heavy Metals in Fish from Idah, Itobe and Lokoja Areas of River Niger are outlined in Tables 4.26 – 4.27

Table 4.25: Estimated Daily Intake of Metals (mg/kg-BW/day) through the Consumption of Catfish and Tillapia from Idah Area of River Niger

Metals	Tillapia	Catfish
Fe	2.117	1.514
Ni	-	-
Zn	0.181	0.440
Cu	0.016	0.062
Cr	0.008	0.016
Mn	0.317	0.107
Co	0.004	0.003
Cd	-	-
Pb	-	-

4.9 Estimated Daily Dietary Intake

Table 4.26 showed the values of the estimated daily dietary intake of the metals through the consumption of tilapia and catfish from Idah area of the River Niger. The intake of iron was found to be highest in the tilapia (2.12mg/kg-BW/Day). This value is greater than unity, which implies that it is not safe for consumption. Similarly, daily intake of Fe has the highest value in catfish. Zinc in tilapia and catfish have the next higher values of 0.181 and 0.440mg/kg-BW/day. Co has the least EDI of 0.004mg/kg BW/day.this collaborate with the work done by Hector, Ajiwe and Okonkwo (2014), it was reported that the concentration of Zinc and Cobalt were far below the WHO recommended limit for safe water and aquatic foods. Oze *et al* .,2005 woked on the water and fish in the Qua-Iboe river estuary reported that when the results for the bioaccumulation of metals in fish was compared with the WHO standard the fish was polluted with respect to all the metals except Zn and Cr which were not detected, in the contrary in this work Cd and Pb were not detected.

The EDI of metal in tilapia and catfish obtained in Lokoja area is shown in Table 4.27 The results revealed a range of 0.0008 to 0.878mg/kg-BW/day and 0.004 to 0.396mg/kg-BW/day in tilapia and catfish respectively. Again Fe was found to have the highest value of 0.878 and 0.396mg/kg-BW/day, which implies that the daily intake of Fe is the highest in the area being investigated perhaps due to the prevailing local industries around the catchment area. The cumulative daily dietary intake of these metals in this area is greater than 1.0 which implies that it is above the safe limit for human consumption.

EDI of metals through the consumption of tilapia and catfish in Itobe area of River Niger was displayed in Table 4.28. Like the rest area Fe was found to have the highest value of 0.939 and 1.994 mg/kg-BW/day. These results revealed that iron is the most accumulated through the consumption of tilapia and catfish from these areas. Again, the daily cumulated dietary intake of this metal is above unity, hence not very safe as it may accumulate to toxic level in man.

Table 4.26: Estimated Daily Intake of Metals (mg/kg-BW/day) through the Consumption of Catfish and Tillapia from Lokoja Area of River Niger.

Metals	Tillapia	Catfish
Fe	0.878	0.396
Ni	-	-
Zn	0.177	0.103
Cu	0.016	0.012
Cr	0.004	0.004
Mn	0.161	0.21
Co	0.004	0.004
Cd	0.0008	-
Pb	0.0008	-

The estimated daily intake of the metal from Lokoja area of the River Niger as indicated in table 4.27, showed that Tillapia has the highest daily intake of Iron of 0.878mg/kg – BW/day and the least metal taken daily were Cadmuim and Lead with estimated daily intake of 0.0008mg/kg- BW/day. Similarly, Iron in catfish has the highest value of 0.396mg/kg- BW/day, meanwhile, Cd and Pb were absent in catfish.

Table4.27: Estimation of Daily Intake of Metals (mg/kg-BW/day) through the Consumption of Catfish and Tillapia in Itobe Area of River Niger.

Metals	Tillapia	Catfish
Fe	0.939	1.994
Ni	0.008	0.0008
Zn	0.078	0.082
Cu	0.038	0.008
Cr	0.004	0.004
Mn	0.066	0.157
Co	0.004	0.002
Cd	-	-
Pb	-	-

The Estimation of daily intake of Iron (0.939 mg/kg- BW/day and 1.994mg/kg – BW/day) ranked highest in both species of fish consumed in Itobe area of the River Niger. Cd and Pb were conspicuously absent in the two species of fish consumed in the area. Hence, from the values obtained Fe was the most accumulated in these two species of fish studied.

The Hazard Associated with eating of Fish from Idah, Lokoja and Itobe Areas of River Niger are shown in Table 4.29 to 4.31

Table4.28: THQ and HI from consumption of catfish and tillapia from Idah Area of River Niger.

Metals	Tillapia	Catfish
Fe	0.417	0.300
Ni	-	-
Zn	0.083	0.209
Cu	0.057	0.213
Cr	0.001	0.0025
Mn	0.312	0.106
Co	0.009	0.016
Cd	-	-
Pb	-	-
HI	0.879	0.853

The Hazard Associated with eating of Fish from Idah, Lokoja and Itobe Areas of River Niger are shown in Tables 4.30 to 4.31

Table 4.29: THQ and HI from consumption of catfish and tillapia from Lokoja Area of River Niger.

Metals	Tillapia	Catfish
Fe	0.173	0.078
Ni	-	-
Zn	0.081	0.047
Cu	0.057	0.043
Cr	0.003	0.003
Mn	0.158	0.020
Co	0.009	0.009
Cd	0.114	-
Pb	0.000	-
HI	0.592	0.155

Table 4.30: THQ and HI from consumption of catfish and tillapia from Itobe Area of River Niger.

Metals	Tillapia	Catfish
Fe	0.185	0.393
Ni	0.057	0.006
Zn	0.036	0.038
Cu	0.128	0.028
Cr	0.004	0.0003
Mn	0.065	0.154
Co	0.009	0.006
Cd	-	-
Pb	-	-
HI	0.4484	0.625

4.10 Hazard Quotient and Hazard Index

Hazard quotient is the risk to a human receptor from being exposed to a chemical through diet. Tables (4.29 – 4.31) showed the total hazard quotient and hazard index from the consumption of catfish and tilapia obtained from the Idah Itobe and Lokoja areas of the River Niger. The result revealed that the hazard index of the tilapia from Lokoja, Itobe and Idah are found to be 0.52, 0.448 and 0.879 respectively. The hazard index of catfish from Lokoja, Itobe and Idah are: 0.155, 0.65 and 0.853 respectively. The result revealed that the HI for the Idah area is the highest for two species of fish studied. The hazard indices are all below 1.0 which is referred to as the critical value. The Hazard index fo the Idah area was found to be closed to unity which is the critical value, and thus fishes from that area are more hazardous to health interm of consumption (Table 4.29). The hazard index of Itobe and lokoja area are relatively lower , which mean that fihes from those areas are save for consumption , but may how ever accumulate to toxic level with time.(Tables 4.30 and 4.31)

The diet path way account for 95 – 99% dominant exposure route of all the metals to local residents foreach metal analysed, the average risk value of all the samples did not exceed their permissible level. The total hazard quotient for fish from Idah Area of the River decreased in the following order

Catfish: Fe>Cu>Zn>Mn>Cr>Co and for tilapia: Fe>Mn>Zn>Cu>Co>Cr. The total hazard quotient value obtained in Idah area were all less than one (Table 4.29), hence posed no serious health hazard for the two specie of fish analysedin Idah area of the River. The hazard index for Tilapia is 0.879 and for catfish is 0.853. The HI here, were closed to 1.0 which is the threshold value. These species of fish may not pose a problem as a result of a lower hazard index.

In Table 4.30, the THQ and HI from the consumption of tilapia and catfish from Lokoja area of River Niger. The order of decrease of THQ of the pollutant in tilapia (from Lokoja) is Fe>Mn>Cd>Zn>Cu>Co>Cr>Pb while the order of decrease for catfish is: Fe>Zn>Cu>Mn>Co>Cr>Cd> and Ni. Here the obtained HI values were much lower (0.592 and 0.155) for tilapia and catfish respectively. Hence, the consumers of these species of fish in this area may be exposed to less hazard as compared to species from Idah area.

The Target Hazard Quotient and Hazard Index for the consumption of the two species of fish (catfish and tilapia) from Itobe area is shown in Table 4.31. The THQ for metal pollution in tilapia in decrease order is: Fe>Cu>Mn>Ni>Zn>Co>Cr and for Catfish the decrease order is: Fe> Mn>Zn>Cu>Ni and Co>Cr. The HI value for Tilapia and Catfish are 0.448 are 0.625 respectively. The prevailent of Fe in these species 0f fish may be attributed to local industries that engaged in iron minning in this area and the nature of the catchment area. The heavy metals in these species of fish may not pose a problem as a result of the low HI values. Therefore local residents could eat these species of fish from these areas. The contribution of individual THQ values to the HI showed that Fe contributed the largest percentage in the 3 areas of the River Niger studied. This was in agreement with the result obtained by Omanayi *et al.*, (2011*)* while working on River Niger around Ajaokuta vicinity.

CHAPTER FIVE

Conclusion and Recommendation

5.1 Conclusion

The main objectives of this research were to determine the nature and level of pollutants, to determine the concentration of physico-chemical pollutant and concentrationof the heavy metals in water sediment and some fishes. Equally, one of the study objectives was tocompare the results obtained with the international standards, to ascertain the suitability of the water for agricultural and domestic uses.

The results of thephysico-chemical paramerters showed that: pHwas within the allowable WHO limit for surface water, and was within the range suitable for aquatic life. And will not affect it use for domestic and recreational purpose. The temperature was slightly above allowable limit for surface water. The colour obtained appeared cloudy which is an indication of suspended particles leached from soil or organic matter.

There was high value of conductivities inwet season than in the dry season which may be attributed to substance leached by rain water into the River. The values obtained for both season (Wet and Dry) were within the allowable WHO limit.

The total dissolved solids for both seasons were within the WHO recommended value while the Total suspended values far exceeded the maximum allowable WHO limit. The turbidity values out-weighed the maximum limit prescribed by WHO. The average sodium concentration obtained for dry season is the highest and far above WHO limits.

Similarly, potassium values for both seasons were above the maximum allowable WHO limit. Calcium values obtained were all below the WHO standard for surface water. The value of magnesium in general is within theWHO allowable limit of 50mg/L

The total hardness was found to be higher in dry season than in wet season, but were within theallowable limit set by WHO. The maximum value of Total alkalinity was obtained in dry season. But the values for both seasons were within the WHO presecribed limit. The highest average value of Chloride was obtained in dry season. But the values obtained in both season were below the WHO values of 250mg/L. The results obtained showed no nitrate and nitrite pollution in the water samples analysed. The concentration of ammonia and sulphate in the water samples were found to be within WHO prescribed limit. The phosphate concentration was higher in dry season than in wet season.

The highest average value of total organic compound obtained in wet season may be duetothe influx of organic matter into the river by rain. The concentration of DO and COD were higher in dry season than in wet season while BOD had lower value in both seasons. The River was heavily polluted of fecal origin judging from the high value of the total *coliform* and *E. Coli* obtained in the water smaples for both seasons. The pollution index oftheriver gives a result that indicates critical value of approximately 1.0.

The water of River Niger was found tobe contaminated with all theheavy metals analysed for (Fe, Ni, Zn, Cu, Cr, Mn, Co, Cd and Pb). The wet season values were significantly higher than the dry season except for Cadmium.

The metals had accumulated above critical value of 1.0 as indicated by the MPI. The MPI of the wet season was found to be much lower than that of the dry season. Iron alone accumulated above the critical value of 1.0.

The cumulative wet season concentration of metals in sediments of River Niger indicated that; Mn, Pb, Co, Ni and Fe concentration were far above theWHO recommended limit Cd was notdetected in wet season but overshoot the WHO limits in dry season. There was strong positive linear correlation in metals concentration in water and sediments. Increased concentration of metals in sediment also lead to increased concentration of metals in water.

All the fish samples obtained from all the 3 areas of River Niger assessed were all contaminated with the heavy metals analysed for except cadmium and lead that were not detected in catfish while tilapia was found to accumulate these metals from Lokoja area. Here, Ni, Mn, Co and Pb exceeded the limit set by WHO. The concentrations of the metals in the two species of fish were accumulated close to the critical value of 1.0 in Idah area of River Niger while Itobe and Lokoja are relatively lower.

Iron was found to be the most accumulated through the consumption of tilapia and catfish from these areas sampled. The hazard indices obtained were below 1.0 which is the critical value hence the fish specie obtained from this area may pose no significant health risks to the consumers.

5.2 Recommendation

The following recommendations are made as a result of the present study:

1. Due to the importance of the River Niger to the inhabitant along its course, periodic physico-chemical analysis should be carried out to ascertain its uses for agro-domestic purposes.

2. The level of the metals concentrations in the river should also be determined using fish and other bio-indicator for the determination.

3. Public awareness fora should be organized from time to time by the state environmental protection agency to educate the populace especially those living on the River Bank and the town through which the River transverses on the ill effect of indiscriminate dumping of wastes at non-designated areas.

4. Industries located close to the River course should treat their wastes effectively before dumping in the river body.

5. Farmers should be assisted in fertilizers and agro-chemical applications by agricultural extension officers of the ministry of agriculture to avoid high incidence of chemical contaminant on surface water.

6. Indiscriminate disposal of wastes of fecal origin should be legislated and discouraged to avoid disease ransmission through water.

7. Human health risk assessment of heavy metals should be extended to the numerous dietary products that are consumed daily over a life time in order to translate the level of concern arising from the environment into potential risks to human health, modifying

factors that may enhance or prohibit the body's ability to cope with metal exposure should also be taken into consideation.

5.3 Contribution to knowledge

Based on the findings from this study, the contribution to knowledge is that baseline data has been provided since no work has been done within the period and in the area where this research was carried out.

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APPENDICES

Appendix I: Summary of the statistical package used

Output Created		02-FEB-2017 20:50:11
Comments		
Input	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	36
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax		ONEWAY CONCENTRATIONS BY METALS /STATISTICS DESCRIPTIVES HOMOGENEITY /PLOT MEANS /MISSING ANALYSIS /POSTHOC=LSD ALPHA(0.05).
Resources	Processor Time	00:00:01.56
	Elapsed Time	00:00:02.18

APPENDIX II

DESCRIPTIVE STATISTIC OF THE WET SEASON MEAN VALUE OF PHYSICOCHEMICAL AND MICROBIAL PARAMETER OF RIVER NIGER

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
JUNE	29	43.0714	59.44629	11.03890	20.4592	65.6835	.17	262.00
JULY	29	84.9831	171.38566	31.82552	19.7915	150.1747	.07	799.00
AUGUST	29	89.5293	192.18523	35.68790	16.4260	162.6327	.10	939.00
SEPTEMBER	29	83.4172	173.13855	32.15102	17.5589	149.2756	.09	825.00
TOTAL	116	75.2503	157.02550	14.57945	46.3712	104.1293	.07	939.00

APPENDIX III:

Test of Homogeneity of Variances

Test for the Wet Season Mean value of physicchemical and Microbial Parameter of River Niger

Levene Statistics	df1	df2	Sig.
2.8423112	.041		

POST HOC TESTS FOR THE WET SEASON MEAN VALUE OF PHYSICOCHEMICALPARAMETER OF RIVER NIGER

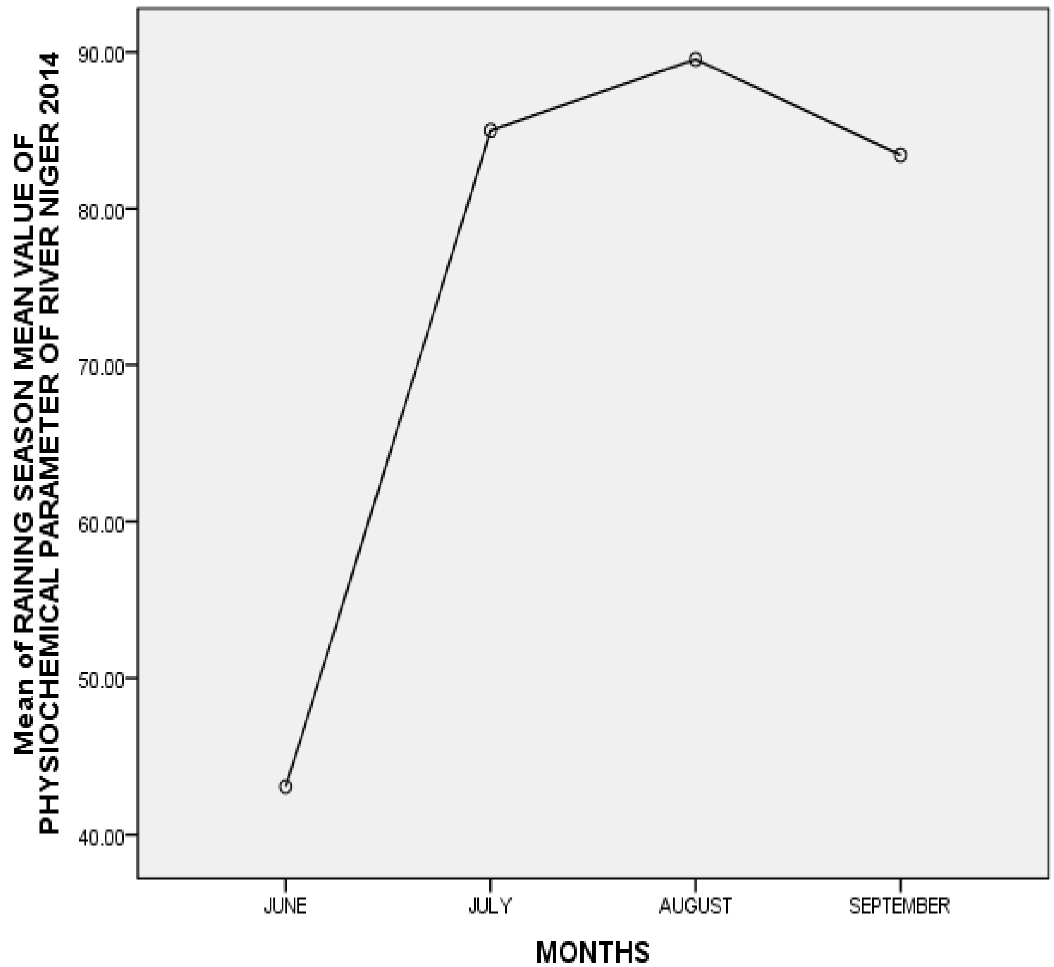
Multiple Comparisons

Depenent Variable: Wet Season Mean Value of Physicochemical Parameter of River Niger 2014

(1) MONTHS	(J) MONTHS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
JUNE	JULY	-41.91172	41.48515	.315	-124.1092	40.2858
	AUGUST	-46.45793	41.48515	.265	-128.6554	35.7396
	SEPTEMBER	-40.34586	41.48515	.333	-122.5434	41.8516
JULY	JUNE	-41.91172	41.48515	.315	-40.2858	124.1092
	AUGUST	-454621	41.48515	.913	-86.7437	77.6513
	SEPTEMBER	1.56586	41.48515	.970	-80.6316	83.7634
AUGUST	JUNE	46.45793	41.48515	.265	-35.7396	128.6554
	JULY	-4.54621	41.48515	.913	-77.6513	86.7437
	SEPTEMBER	-6.11207	41.48515	.883	-76.0854	88.3096
SEPTEMBER	JUNE	40.34586	41.48515	.333	-41.8516	122.5434
	JULY	-1.56586	41.48515	.970	-83.7634	80.6316
	AUGUST	-6.11207	41.48515	.883	-88.3096	76.0854

APPENDIX IV:

Means Plots of Wet Season Mean Value of Physicochemical Parameter of River Niger



APPENDIX V

Descriptive Statistic of the Dry Season Mean Value of Physicochemical Parameter of River Niger 2014

					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
MARCH	29	37.4966	52.93691	9.83014	17.3604	57.6327	.00	240.00
APRIL	29	28.0090	43.83588	8.14012	11.3347	44.6832	.00	188.00
MAY	29	34.3593	47.47034	8.81502	16.3026	52.4161	.05	198.00
OCTOBER	29	56.57411	17.26192	21.77499	11.9701	101.1782	.01	445.00
TOTAL	116	39.1097	71.8406	56.67024	25.8973	52.3222	.00	445.00

APPENDIX VI

Test of Homogeneity of Variances and post hoc. Test of Dry Season Mean Value of Physicochemical and Microbial Parameters of River Niger

Dry Season Mean Value of Physicochemical Parameter of River Niger

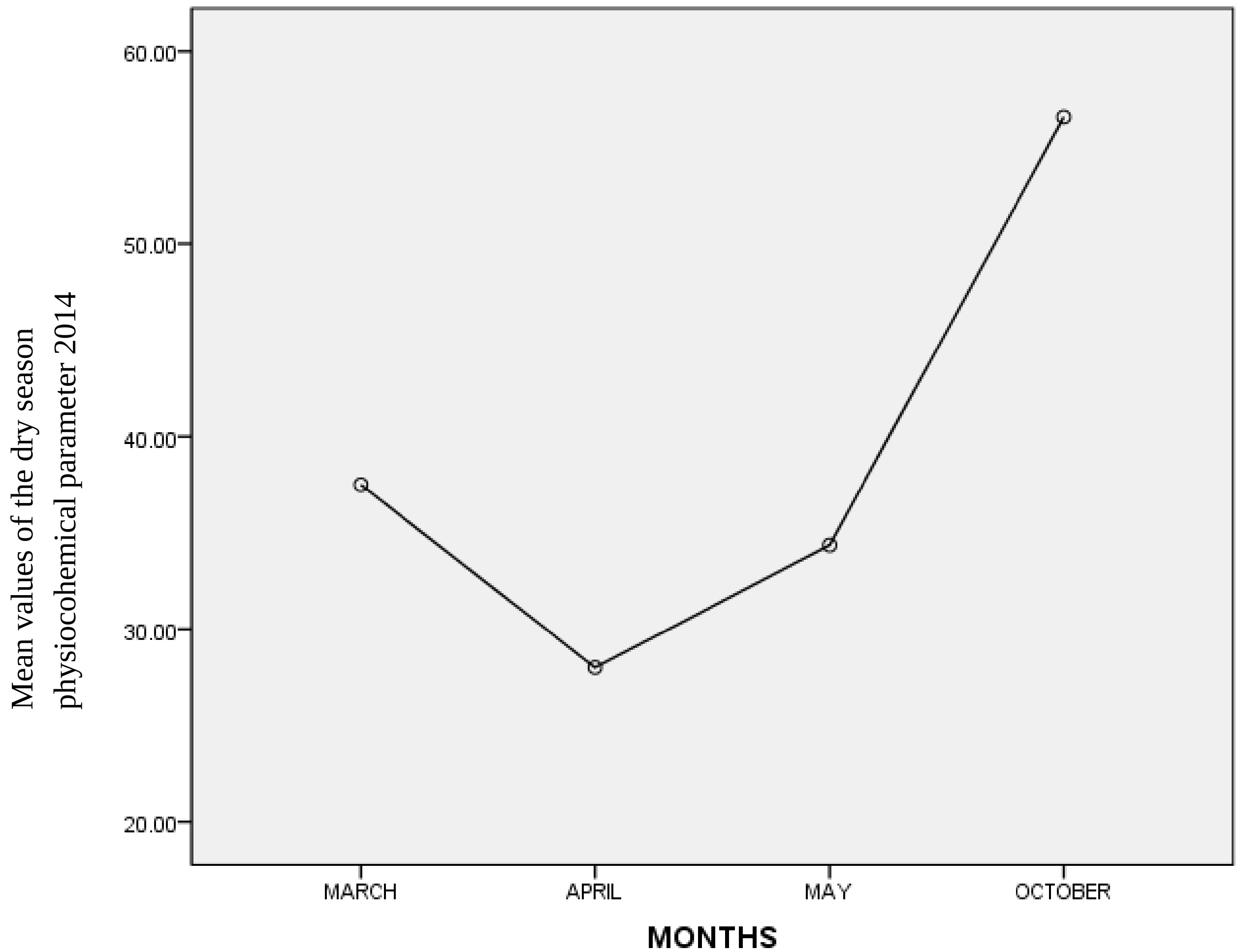
Levene Statistics	df1	df2	Sig.
7.283	8	27	.000

Dependent Variable

(2) MONTHS	(J) MONTHS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
MARCH	APRIL	9.48759	18.90434	.617	-27.9689	46.9441
	MAY	3.13724	18.90434	.868	-34.3193	40.5938
	OCTOBER	-19.07759	18.90434	.315	-56.5341	18.3789
APRIL	MARCH	-9.48759	18.90434	.617	-46.9441	27.9689
	MAY	-6.35034	18.90434	.738	-43.8069	31.1062
	OCTOBER	-28.56517	18.90434	.134	-66.0217	8.8914
MAY	MARCH	-3.13724	18.90434	.868	-40.5938	34.3193
	APRIL	-6.35034	18.90434	.738	-31.1062	43.8069
	OCTOBER	-22.21483	18.90434	.242	-59.6714	15.2417
OCTOBER	MARCH	19.07759	18.90434	.315	-18.3789	56.5341
	APRIL	28.56517	18.90434	.134	-8.8914	66.0217
	MAY	22.21483	18.90434	.242	- 15.2417	59.6714

APPENDIX VII:

Mean Plots for The Dry Season Mean Value of physicohemical and Microbial Paratmeters of River Niger



APPENDIX VIII:

Descriptive Statistic of Cumulative Wet Season Concentrations of Metals in Water of River Niger

					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Cr	4	.0075	.00500	.00250	-.0005	.0155	.00	.01
Mn	4	.2200	.05228	.02614	.1368	.3032	.15	.26
Pb	4	.0100	.00816	.00408	-.0030	.0230	.00	.02
Co	4	.0075	.00500	.00250	-.0005	.0155	.00	.01
Ni	4	.0025	.00500	.00250	-.0055	.0105	.00	.01
Fe	4	.1175	.02217	.01109	.0822	.1528	.09	.14
Zn	4	.0200	.00816	.00408	.0070	.0330	01	.03
Cu	4	.0150	.00577	.00289	.0058	.0242	.01	.02
Cd	4	.0000	.00000	.00000	.0000	.0000	.00	.00
Total	36	.0444	.07397	.01233	.0194	.0695	.00	.26

APPENDIX IX:

Test of Homogeneity of Variances and Post Hoe

Test for

Cumulative Wet Season Concentrations of Metals in Water of River Niger

Levene Statistics	df1	df2	Sig.
7.283	8	27	.000

Dependent Variable: Cumulative Wet Season Concentrations Of Metals In Water 0f R. Niger

	(J) METAL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Cr	Mn	-.21250*	.0138	.000	-.2410	-.1840
	Pb	-.00250	.0138	.858	-.0310	.0260
	C0	.00000	.0138	1.000	-.0285	.0285
	Ni	.00500	.0138	.721	-.0235	.0335
	Fe	-.11000*	.0138	.000	-.1385	-.0815
	Zn	-.01250	.0138	.376	-.0410	.0160
	Cu	-.00750	.0138	.593	-.0360	.0210
	Cd	.00750	.0138	.593	-.0210	.0360
Mn	Cr	.21250*	.0138	.000	.1840	.2410
	Pb	.21000*	.0138	.000	.1815	.2385
	C0	.21250*	.0138	.000	.1840	.2410
	Ni	.21750*	.0138	.000	.1890	.2460
	Fe	.10250*	.0138	.000	.0740	.1310
	Zn	.20000*	.0138	.000	.1715	.2285
	Cu	.20500*	.0138	.000	.1765	.2335
	Cd	.22000*	.0138	.000	.1915	.2485

Pb	Cr	.00250	.01388	.858	-.0260	.0310
	Mn	-.21000*	.01388	.000	-.2385	-.1815
	C0	.00250	.01388	.858	-.0260	.0310
	Ni	.00750	.01388	.593	-.0210	.0360
	Fe	-.10750*	.01388	.000	-.1360	-.0790
	Zn	-.01000	.01388	.477	-.0385	.0185
	Cu	-.00500	.01388	.721	-.0335	.0235
	Cd	.01000	.01388	.477	-.0185	.0385
Co	Cr	.00000	.01388	1.000	-.0285	.0285
	Mn	-.21250*	.01388	.000	-.2410	-.1840
	Pb	-.00250	.01388	.858	-.0310	.0260
	Ni	.00500	.01388	.721	-.0235	.0335
	Fe	-.11000*	.01388	.000	-.1385	-.0815
	Zn	-.01250	.01388	.376	-.0410	.0160
	Cu	-.00750	.01388	.593	-.0360	.0210
	Cd	.00750	.01388	.593	-.0210	.0360
Ni	Cr	-.00500	.01388	.721	-.0335	.0235
	Mn	-.21750*	.01388	.000	-.2460	-.1890
	Pb	-.00750	.01388	.593	-.0360	.0210
	C0	-.00500	.01388	.721	-.0335	.0235
	Fe	-.11500*	.01388	.000	-.1435	-.0865
	Zn	-.01750	.01388	.218	-.0460	.0110
	Cu	-.01250	.01388	.376	-.0410	.0160
	Cd	.00250	.01388	.858	-.0260	.0310

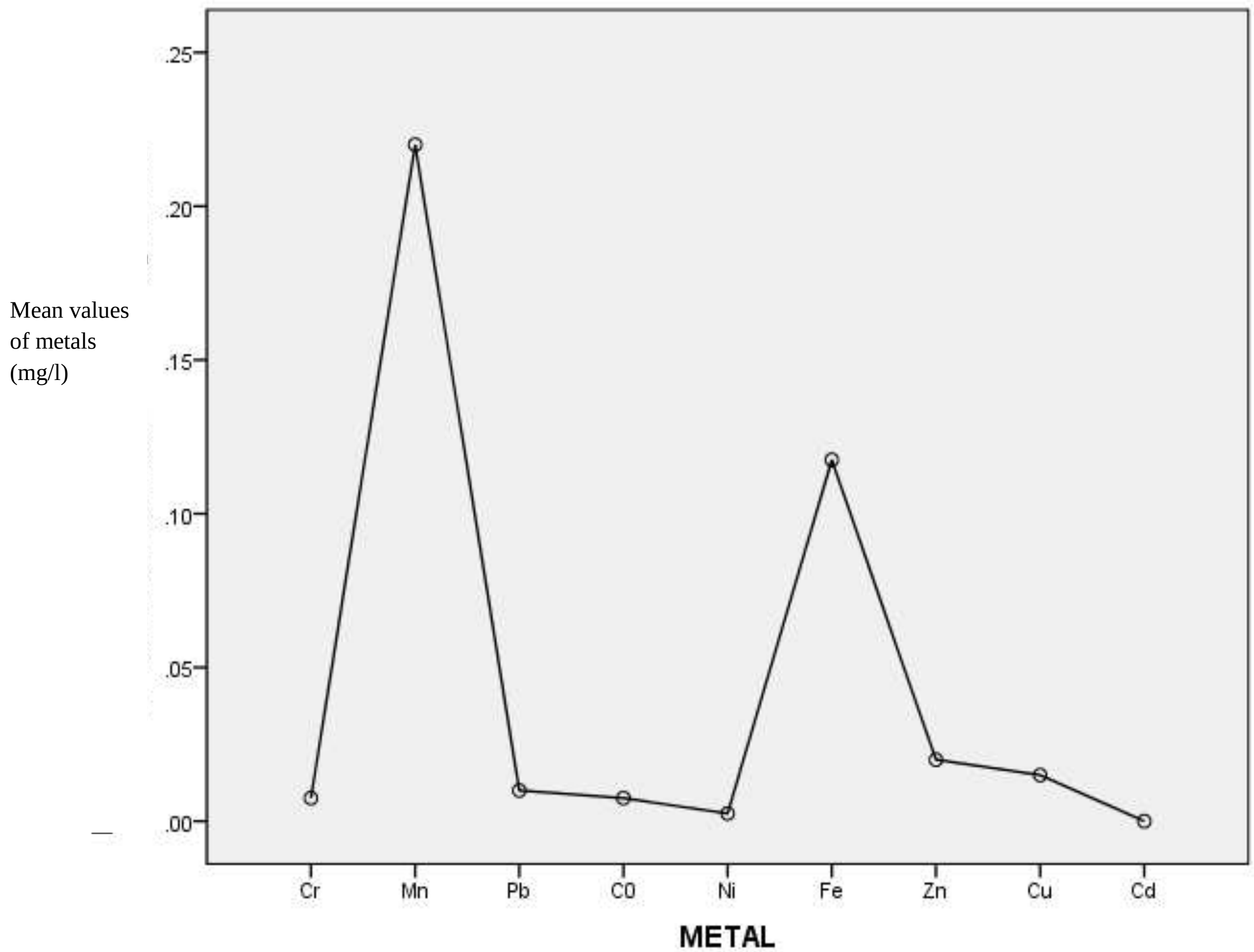
Fe	Cr	.11000*	.01388	.000	.0815	.1385
	Mn	-.10250*	.01388	.000	-.1310	-.0740
	Pb	.10750*	.01388	.000	.0790	.1360
	C0	.11000*	.01388	.000	.0815	.1385
	Ni	.11500*	.01388	.000	.0865	.1435
	Zn	.09750*	.01388	.000	.0690	.1260
	Cu	.10250*	.01388	.000	.0740	.1310
	Cd	.11750*	.01388	.000	.0890	.1460
Zn	Cr	.01250	.01388	.376	-.0160	.0410
	Mn	-.20000*	.01388	.000	-.2285	-.1715
	Pb	.01000	.01388	.477	-.0185	.0385
	C0	.01250	.01388	.376	-.0160	.0410
	Ni	.01750	.01388	.218	-.0110	.0460
	Fe	-.09750*	.01388	.000	-.1260	-.0690
	Cu	.00500	.01388	.721	-.0235	.0335
	Cd	.02000	.01388	.161	-.0085	.0485

Cu	Cr	.00750	.01388	.593	-.0210	.0360
	Mn	-.20500*	.01388	.000	-.2335	-.1765
	Pb	.00500	.01388	.721	-.0235	.0335
	C0	.00750	.01388	.593	-.0210	.0360
	Ni	.01250	.01388	.376	-.0160	.0410
	Fe	-.10250*	.01388	.000	-.1310	-.0740
	Zn	-.00500	.01388	.721	-.0335	.0235
	Cd	.01500	.01388	.289	-.0135	.0435
Cd	Cr	-.00750	.01388	.593	-.0360	.0210
	Mn	-.22000*	.01388	.000	-.2485	-.1915
	Pb	-.01000	.01388	.477	-.0385	.0185
	C0	-.00750	.01388	.593	-.0360	.0210
	Ni	-.00250	.01388	.858	-.0310	.0260
	Fe	-.11750*	.01388	.000	-.1460	-.0890
	Zn	-.02000	.01388	.161	-.0485	.0085
	Cu	-.01500	.01388	.289	-.0435	.0135

The mean difference is significant at the 0.05 level.

APPENDIX X:

The Mean Plots of the Cumulative Wet Season Concentrations of Metals in Water



APPENDIX XI:
Descriptive Statistic of Cumulative Dry Season Concentrations of Metals in Water of River Niger

					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Cr	4	.0025	.00500	.00250	-.0055	.0105	.00	.01
Mn	4	.1750	.08226	.04113	.0441	.3059	.07	.25
Pb	4	.0325	.01708	.00854	.0053	.0597	.01	.05
Co	4	.0075	.00957	.00479	-.0077	.0227	.00	.02
Ni	4	.0025	.00500	.00250	-.0055	.0105	.00	.01
Fe	4	.1800	.03266	.01633	.1280	.2320	.14	.22
Zn	4	.0575	.02986	.01493	.0100	.1050	.02	.09
Cu	4	.0125	.00500	.00250	.0045	.0205	.01	.02
Cd	4	.0025	.00500	.00250	-.0055	.0105	.00	.01
Total	36	.0525	.07538	.01256	.0270	.0780	.00	.25

APPENDIX XII:

Test of Homogeneity of Variances

Cumulative Dry Season Concentrations of Metals in Water of River Niger

Levene Statistics	df1	df2	Sig.
7.283	8	27	.000

Post Hoc Tests For The Cumulative Dry Season Concentration Of Metals In Water of River Niger (Multiple Comparisons)

Dependent Variable:Cumulative Dry Season Concentration of Metals in Sediments of River Niger

(I) METALS	(J) METALS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cr	Mn	-.17250*	.02262	.000	-.2189	-.1261
	Pb	-.03000	.02262	.196	-.0764	.0164
	Co	-.00500	.02262	.827	-.0514	.0414
	Ni	.00000	.02262	1.000	-.0464	.0464
	Fe	-.17750*	.02262	.000	-.2239	-.1311
	Zn	-.05500*	.02262	.022	-.1014	-.0086
	Cu	-.01000	.02262	.662	-.0564	.0364
	Cd	.00000	.02262	1.000	-.0464	.0464
Mn	Cr	.17250*	.02262	.000	.1261	.2189
	Pb	.14250*	.02262	.000	.0961	.1889
	Co	.16750*	.02262	.000	.1211	.2139
	Ni	.17250*	.02262	.000	.1261	.2189
	Fe	-.00500	.02262	.827	-.0514	.0414
	Zn	.11750*	.02262	.000	.0711	.1639
	Cu	.16250*	.02262	.000	.1161	.2089
	Cd	.17250*	.02262	.000	.1261	.2189

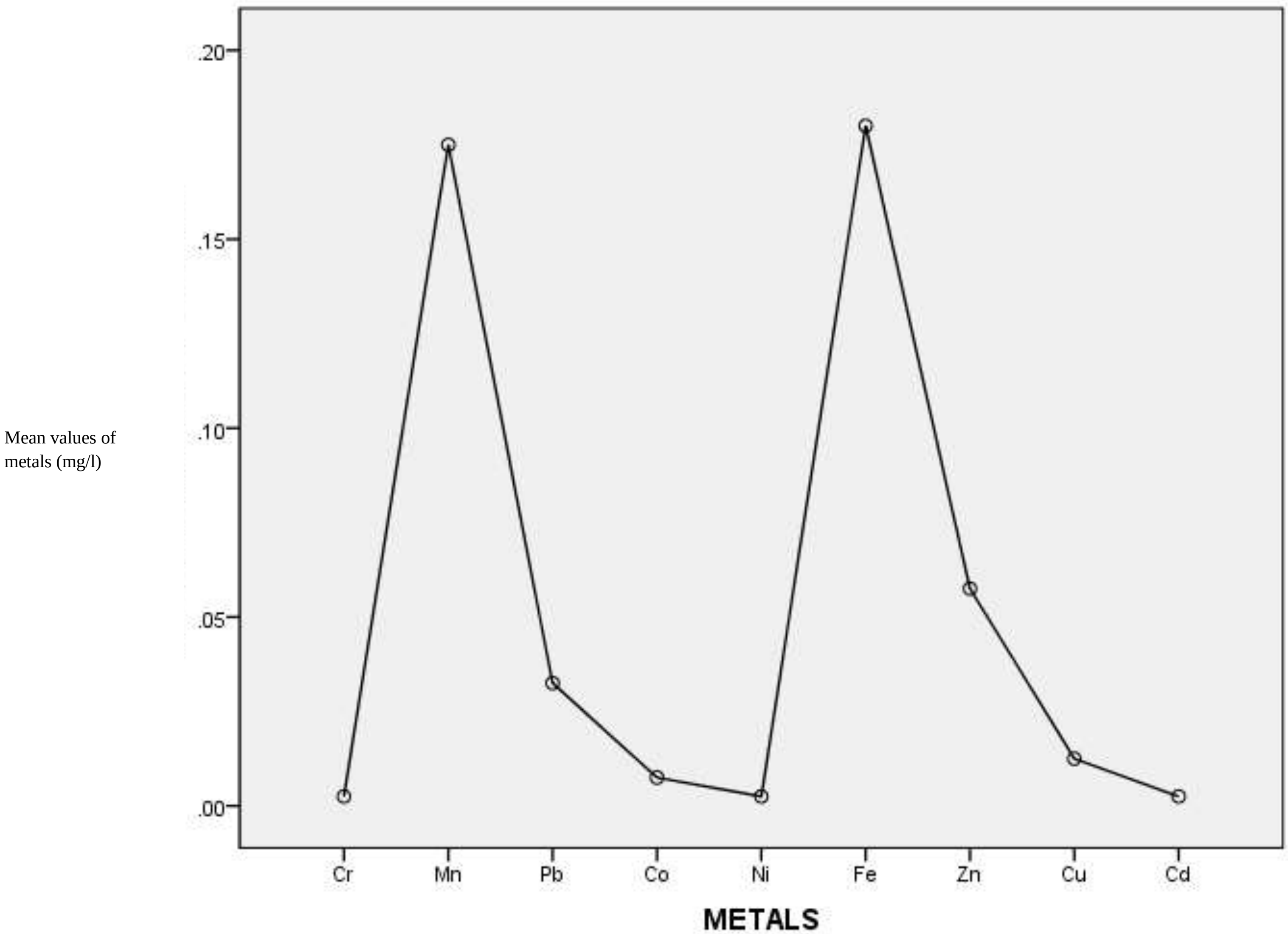
Pb	Cr	.03000	.02262	.196	-.0164	.0764
	Mn	-.14250*	.02262	.000	-.1889	-.0961
	Co	.02500	.02262	.279	-.0214	.0714
	Ni	.03000	.02262	.196	-.0164	.0764
	Fe	-.14750*	.02262	.000	-.1939	-.1011
	Zn	-.02500	.02262	.279	-.0714	.0214
	Cu	.02000	.02262	.384	-.0264	.0664
	Cd	.03000	.02262	.196	-.0164	.0764
Co	Cr	.00500	.02262	.827	-.0414	.0514
	Mn	-.16750*	.02262	.000	-.2139	-.1211
	Pb	-.02500	.02262	.279	-.0714	.0214
	Ni	.00500	.02262	.827	-.0414	.0514
	Fe	-.17250*	.02262	.000	-.2189	-.1261
	Zn	-.05000*	.02262	.036	-.0964	-.0036
	Cu	-.00500	.02262	.827	-.0514	.0414
	Cd	.00500	.02262	.827	-.0414	.0514
Ni	Cr	.00000	.02262	1.000	-.0464	.0464
	Mn	-.17250*	.02262	.000	-.2189	-.1261
	Pb	-.03000	.02262	.196	-.0764	.0164
	Co	-.00500	.02262	.827	-.0514	.0414
	Fe	-.17750*	.02262	.000	-.2239	-.1311
	Zn	-.05500*	.02262	.022	-.1014	-.0086
	Cu	-.01000	.02262	.662	-.0564	.0364
	Cd	.00000	.02262	1.000	-.0464	.0464
Fe	Cr	.17750*	.02262	.000	.1311	.2239
	Mn	.00500	.02262	.827	-.0414	.0514
	Pb	.14750*	.02262	.000	.1011	.1939
	Co	.17250*	.02262	.000	.1261	.2189
	Ni	.17750*	.02262	.000	.1311	.2239
	Zn	.12250*	.02262	.000	.0761	.1689
	Cu	.16750*	.02262	.000	.1211	.2139
	Cd	.17750*	.02262	.000	.1311	.2239
Zn	Cr	.05500*	.02262	.022	.0086	.1014
	Mn	-.11750*	.02262	.000	-.1639	-.0711
	Pb	.02500	.02262	.279	-.0214	.0714
	Co	.05000*	.02262	.036	.0036	.0964
	Ni	.05500*	.02262	.022	.0086	.1014
	Fe	-.12250*	.02262	.000	-.1689	-.0761
	Cu	.04500	.02262	.057	-.0014	.0914
	Cd	.05500*	.02262	.022	.0086	.1014

Cu	Cr	.01000	.02262	.662	-.0364	.0564
	Mn	-.16250*	.02262	.000	-.2089	-.1161
	Pb	-.02000	.02262	.384	-.0664	.0264
	Co	.00500	.02262	.827	-.0414	.0514
	Ni	.01000	.02262	.662	-.0364	.0564
	Fe	-.16750*	.02262	.000	-.2139	-.1211
	Zn	-.04500	.02262	.057	-.0914	.0014
	Cd	.01000	.02262	.662	-.0364	.0564
Cd	Cr	.00000	.02262	1.000	-.0464	.0464
	Mn	-.17250*	.02262	.000	-.2189	-.1261
	Pb	-.03000	.02262	.196	-.0764	.0164
	Co	-.00500	.02262	.827	-.0514	.0414
	Ni	.00000	.02262	1.000	-.0464	.0464
	Fe	-.17750*	.02262	.000	-.2239	-.1311
	Zn	-.05500*	.02262	.022	-.1014	-.0086
	Cu	-.01000	.02262	.662	-.0564	.0364

The mean difference is significant at the 0.05 level.

APPENDIX XIII

The Mean Plots of the Cumulative Dry Season Concentrations of Metals in Water



APPENDIX XIV

Descriptive Statistic of Cumulative Wet Season Concentrations of Metals in Sediment of River Niger

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Cr	4	.3925	.23796	.11898	.0139	.7711	.22	.74
Mn	4	66.7250	19.07168	9.53584	36.3777	97.0723	47.00	86.40
Pb	4	3.4200	1.33749	.66874	1.2918	5.5482	2.19	5.00
Co	4	2.0325	.62521	.31261	1.0376	3.0274	1.32	2.62
Ni	4	.5300	.34205	.17103	-.0143	1.0743	.20	.84
Fe	4	15.6750	1.04043	.52022	14.0194	17.3306	14.90	17.10
Zn	4	.7975	.12580	.06290	.5973	.9977	.67	.92
Cu	4	.8600	.23137	.11569	.4918	1.2282	.57	1.12
Cd	4	.0000	.00000	.00000	.0000	.0000	.00	.00
Total	36	10.0481	21.59980	3.59997	2.7397	17.3564	.00	86.40

APPENDIX XV

Test of Homogeneity of Variances

Cumulative Wet Season Concentrations of Metals in Sediment of River Niger

Levene Statistics	df1	df2	Sig.
56.685	8	27	.000

Post Hoc Tests for the Cumulative Wet Season Concentration of Metals Sediment of River Niger

(Multiple Comparisons)

Dependent Variable: Cumulative Wet Season Concentration Of Metals In Sediments Of River Niger

(I) METALS	(J) METALS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Cr	Mn	-66.33250*	4.51685	.000	-75.6003	-57.0647
	Pb	-3.02750	4.51685	.508	-12.2953	6.2403
	Co	-1.64000	4.51685	.719	-10.9078	7.6278
	Ni	-.13750	4.51685	.976	-9.4053	9.1303
	Fe	-15.28250*	4.51685	.002	-24.5503	-6.0147
	Zn	-.40500	4.51685	.929	-9.6728	8.8628
	Cu	-.46750	4.51685	.918	-9.7353	8.8003
	Cd	.39250	4.51685	.931	-8.8753	9.6603
Mn	Cr	66.33250*	4.51685	.000	57.0647	75.6003
	Pb	63.30500*	4.51685	.000	54.0372	72.5728
	Co	64.69250*	4.51685	.000	55.4247	73.9603
	Ni	66.19500*	4.51685	.000	56.9272	75.4628
	Fe	51.05000*	4.51685	.000	41.7822	60.3178
	Zn	65.92750*	4.51685	.000	56.6597	75.1953
	Cu	65.86500*	4.51685	.000	56.5972	75.1328
	Cd	66.72500*	4.51685	.000	57.4572	75.9928
Pb	Cr	3.02750	4.51685	.508	-6.2403	12.2953
	Mn	-63.30500*	4.51685	.000	-72.5728	-54.0372
	Co	1.38750	4.51685	.761	-7.8803	10.6553
	Ni	2.89000	4.51685	.528	-6.3778	12.1578
	Fe	-12.25500*	4.51685	.011	-21.5228	-2.9872
	Zn	2.62250	4.51685	.566	-6.6453	11.8903
	Cu	2.56000	4.51685	.576	-6.7078	11.8278
	Cd	3.42000	4.51685	.456	-5.8478	12.6878

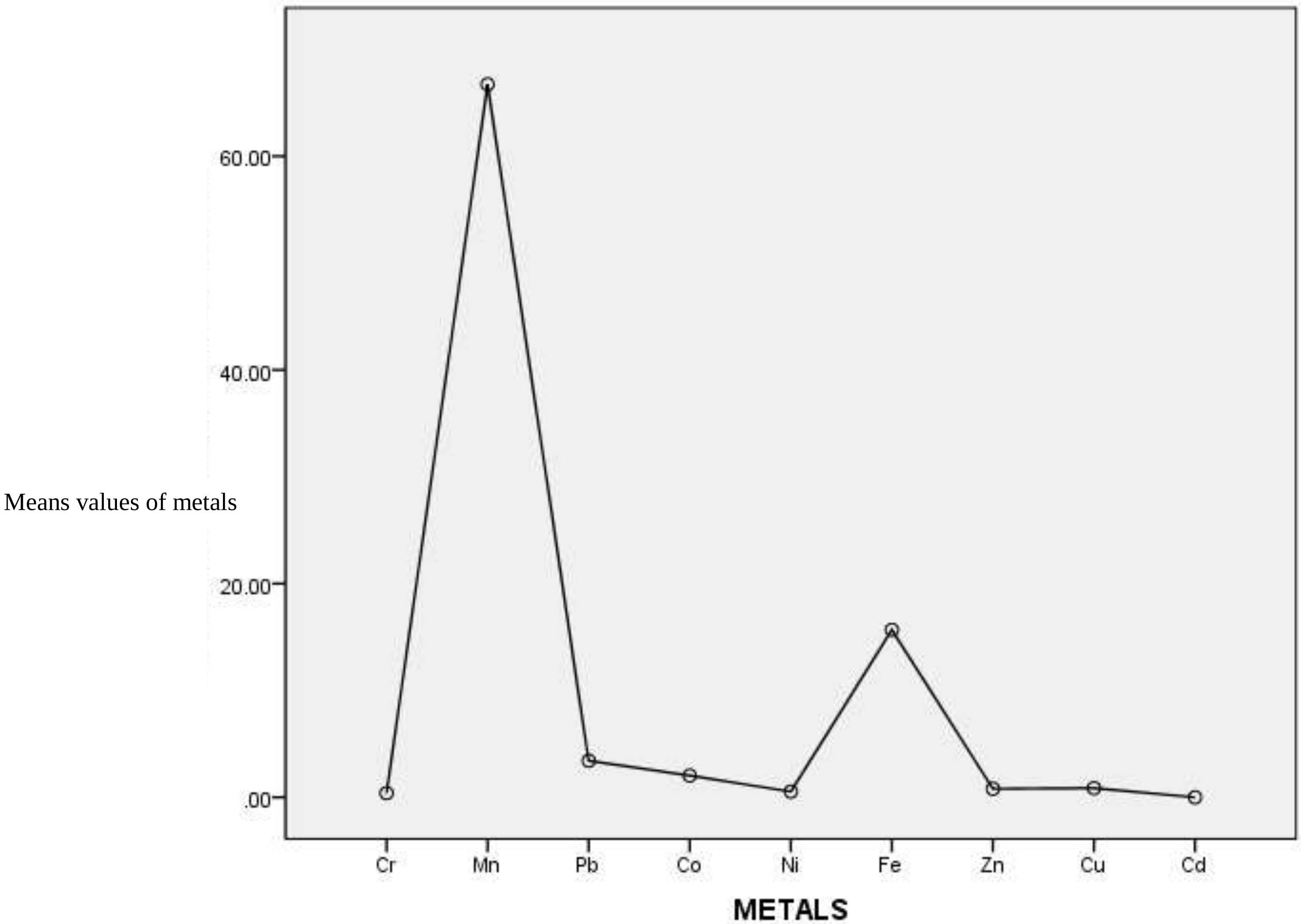
Co	Cr	1.64000	4.51685	.719	-7.6278	10.9078
	Mn	-64.69250*	4.51685	.000	-73.9603	-55.4247
	Pb	-1.38750	4.51685	.761	-10.6553	7.8803
	Ni	1.50250	4.51685	.742	-7.7653	10.7703
	Fe	-13.64250*	4.51685	.005	-22.9103	-4.3747
	Zn	1.23500	4.51685	.787	-8.0328	10.5028
	Cu	1.17250	4.51685	.797	-8.0953	10.4403
	Cd	2.03250	4.51685	.656	-7.2353	11.3003
Ni	Cr	.13750	4.51685	.976	-9.1303	9.4053
	Mn	-66.19500*	4.51685	.000	-75.4628	-56.9272
	Pb	-2.89000	4.51685	.528	-12.1578	6.3778
	Co	-1.50250	4.51685	.742	-10.7703	7.7653
	Fe	-15.14500*	4.51685	.002	-24.4128	-5.8772
	Zn	-.26750	4.51685	.953	-9.5353	9.0003
	Cu	-.33000	4.51685	.942	-9.5978	8.9378
	Cd	.53000	4.51685	.907	-8.7378	9.7978
Fe	Cr	15.28250*	4.51685	.002	6.0147	24.5503
	Mn	-51.05000*	4.51685	.000	-60.3178	-41.7822
	Pb	12.25500*	4.51685	.011	2.9872	21.5228
	Co	13.64250*	4.51685	.005	4.3747	22.9103
	Ni	15.14500*	4.51685	.002	5.8772	24.4128
	Zn	14.87750*	4.51685	.003	5.6097	24.1453
	Cu	14.81500*	4.51685	.003	5.5472	24.0828
	Cd	15.67500*	4.51685	.002	6.4072	24.9428
Zn	Cr	.40500	4.51685	.929	-8.8628	9.6728
	Mn	-65.92750*	4.51685	.000	-75.1953	-56.6597
	Pb	-2.62250	4.51685	.566	-11.8903	6.6453
	Co	-1.23500	4.51685	.787	-10.5028	8.0328
	Ni	.26750	4.51685	.953	-9.0003	9.5353
	Fe	-14.87750*	4.51685	.003	-24.1453	-5.6097
	Cu	-.06250	4.51685	.989	-9.3303	9.2053
	Cd	.79750	4.51685	.861	-8.4703	10.0653
Cu	Cr	.46750	4.51685	.918	-8.8003	9.7353
	Mn	-65.86500*	4.51685	.000	-75.1328	-56.5972
	Pb	-2.56000	4.51685	.576	-11.8278	6.7078
	Co	-1.17250	4.51685	.797	-10.4403	8.0953
	Ni	.33000	4.51685	.942	-8.9378	9.5978
	Fe	-14.81500*	4.51685	.003	-24.0828	-5.5472
	Zn	.06250	4.51685	.989	-9.2053	9.3303
	Cd	.86000	4.51685	.850	-8.4078	10.1278

Cd	Cr	-.39250	4.51685	.931	-9.6603	8.8753
	Mn	-66.72500*	4.51685	.000	-75.9928	-57.4572
	Pb	-3.42000	4.51685	.456	-12.6878	5.8478
	Co	-2.03250	4.51685	.656	-11.3003	7.2353
	Ni	-.53000	4.51685	.907	-9.7978	8.7378
	Fe	-15.67500*	4.51685	.002	-24.9428	-6.4072
	Zn	-.79750	4.51685	.861	-10.0653	8.4703
	Cu	-.86000	4.51685	.850	-10.1278	8.4078

The mean difference is significant at the 0.05 level.

APPENDIX XVI

Means plots of the Wet Season Concentration of Metal in Sediments of River Niger



APPENDIX XVII

Descriptive Statistic Of Cumulative Dry Season Concentrations of Metals In Sediment of River Niger

					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Cr	4	.4100	.46411	.23206	-.3285	1.1485	.11	1.10
Mn	4	60.4000	14.39190	7.19595	37.4993	83.3007	50.70	81.40
Pb	4	3.1900	1.67398	.83699	.5263	5.8537	1.80	5.62
Co	4	1.9425	.82714	.41357	.6263	3.2587	1.28	3.14
Ni	4	.4200	.50425	.25212	-.3824	1.2224	.09	1.17
Fe	4	15.5750	1.69386	.84693	12.8797	18.2703	13.60	17.60
Zn	4	.9125	.27427	.13714	.4761	1.3489	.57	1.20
Cu	4	1.0725	.37241	.18621	.4799	1.6651	.72	1.57
Cd	4	.0475	.07544	.03772	-.0725	.1675	.00	.16
Total	36	9.3300	19.37364	3.22894	2.7749	15.8851	.00	81.40

APPENDIX XVIII

Test of Homogeneity of Variances

Cumulative Dry Season Concentration of Metals in Sediments of River Niger

Levene Statistics	df1	df2	Sig.
6.497	8	27	.000

Post Hoc Tests for Cumulative Dry Season Concentration of Metals in Sediment of River Niger

Multiple Comparisons

Dependent Variable: Cumulative Dry Season Concentration of Mentals in Sediments of River Niger

(I) METALS	(J) METALS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cr	Mn	-59.99000*	3.44941	.000	-67.0676	-52.9124
	Pb	-2.78000	3.44941	.427	-9.8576	4.2976
	Co	-1.53250	3.44941	.660	-8.6101	5.5451
	Ni	-.01000	3.44941	.998	-7.0876	7.0676
	Fe	-15.16500*	3.44941	.000	-22.2426	-8.0874
	Zn	-.50250	3.44941	.885	-7.5801	6.5751
	Cu	-.66250	3.44941	.849	-7.7401	6.4151
	Cd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mn	Cr	59.99000*	3.44941	.000	52.9124	67.0676
	Pb	57.21000*	3.44941	.000	50.1324	64.2876
	Co	58.45750*	3.44941	.000	51.3799	65.5351
	Ni	59.98000*	3.44941	.000	52.9024	67.0576
	Fe	44.82500*	3.44941	.000	37.7474	51.9026
	Zn	59.48750*	3.44941	.000	52.4099	66.5651
	Cu	59.32750*	3.44941	.000	52.2499	66.4051
	Cd	60.35250	3.44941	.000	53.2749	67.4301
Pb	Cr	2.78000	3.44941	.427	-4.2976	9.8576
	Mn	-57.21000*	3.44941	.000	-64.2876	-50.1324
	Co	1.24750	3.44941	.720	-5.8301	8.3251
	Ni	2.77000	3.44941	.429	-4.3076	9.8476
	Fe	-12.38500*	3.44941	.001	-19.4626	-5.3074
	Zn	2.27750	3.44941	.515	-4.8001	9.3551
	Cu	2.11750	3.44941	.544	-4.9601	9.1951
	Cd	3.14250	3.44941	.370	-3.9351	10.2201
Cu	Cr	1.53250	3.44941	.660	-5.5451	8.6101
	Mn	-58.45750*	3.44941	.000	-65.5351	-51.3799
	Pb	-1.24750	3.44941	.720	-8.3251	5.8301
	Ni	1.52250	3.44941	.662	-5.5551	8.6001
	Fe	-13.63250*	3.44941	.001	-20.7101	-6.5549
	Zn	1.03000	3.44941	.768	-6.0476	8.1076
	Cu	.87000	3.44941	.803	-6.2076	7.9476

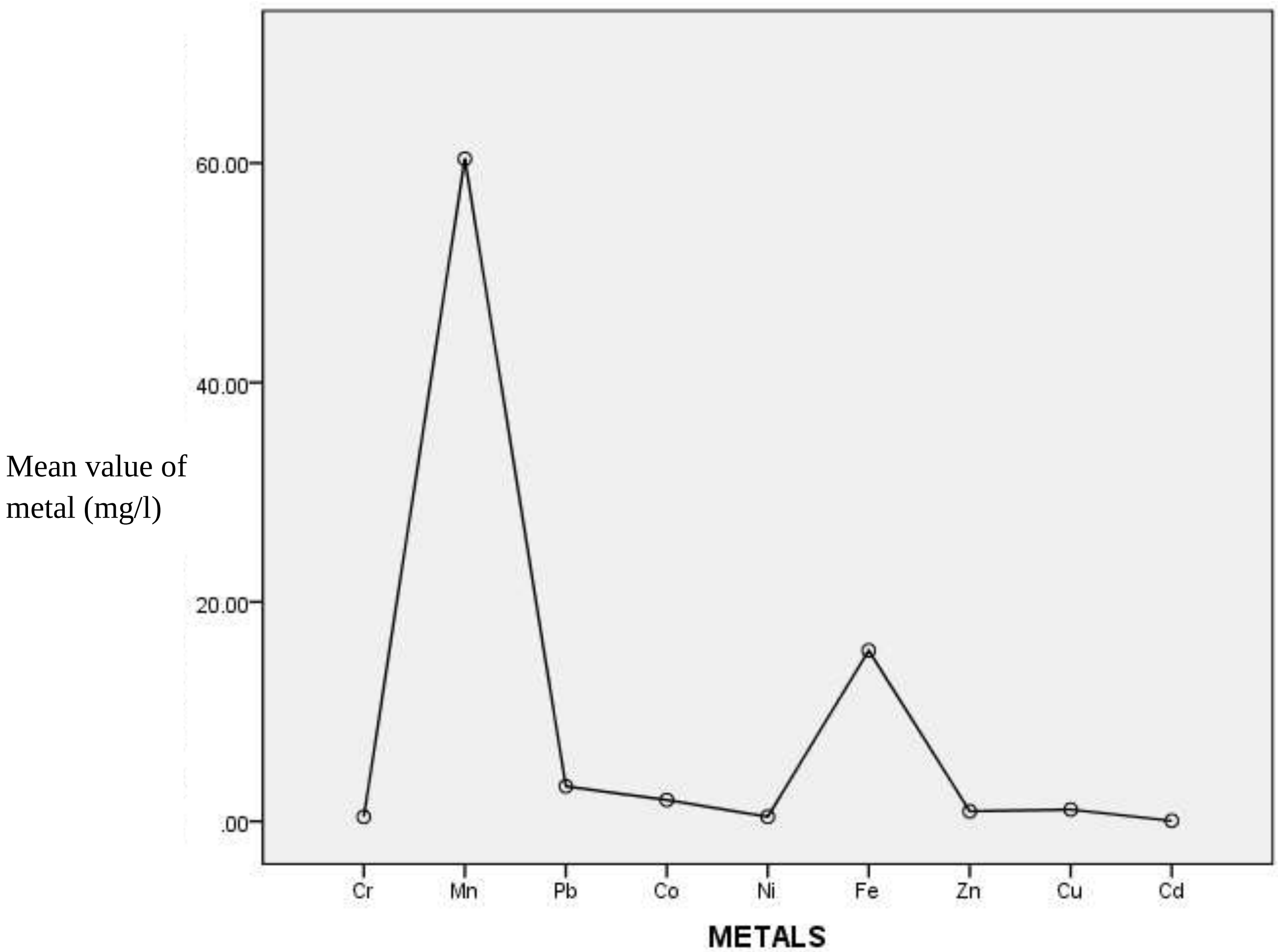
	Cd	1.89500	3.44941	.587	-5.1826	8.9726
Ni	Cr	.01000	3.44941	.998	-7.0676	7.0876
	Mn	-59.98000*	3.44941	.000	-67.0576	-52.9024
	Pb	-2.77000	3.44941	.429	-9.8476	4.3076
	Co	-1.52250	3.44941	.662	-8.6001	5.5551
	Fe	-15.15500*	3.44941	.000	-22.2326	-8.0774
	Zn	-.49250	3.44941	.888	-7.5701	6.5851
	Cu	-.65250	3.44941	.851	-7.7301	6.4251
	Cd	.37250	3.44941	.915	-6.7051	7.4501
Fe	Cr	15.16500*	3.44941	.000	8.0874	22.2426
	Mn	-44.82500*	3.44941	.000	-51.9026	-37.7474
	Pb	12.38500*	3.44941	.001	5.3074	19.4626
	Co	13.63250*	3.44941	.001	6.5549	20.7101
	Ni	15.15500*	3.44941	.000	8.0774	22.2326
	Zn	14.66250*	3.44941	.000	7.5849	21.7401
	Cu	14.50250*	3.44941	.000	7.4249	21.5801
	Cd	15.52750*	3.44941	.000	8.4499	22.6051

Zn	Cr	.50250	3.44941	.885	-6.5751	7.5801
	Mn	-59.48750*	3.44941	.000	-66.5651	-52.4099
	Pb	-2.27750	3.44941	.515	-9.3551	4.8001
	Co	-1.03000	3.44941	.768	-8.1076	6.0476
	Ni	.49250	3.44941	.888	-6.5851	7.5701
	Fe	-14.66250*	3.44941	.000	-21.7401	-7.5849
	Cu	-.16000	3.44941	.963	-7.2376	6.9176
	Cd	.86500	3.44941	.804	-6.2126	7.9426
Cu	Cr	.66250	3.44941	.849	-6.4151	7.7401
	Mn	-59.32750*	3.44941	.000	-66.4051	-52.2499
	Pb	-2.11750	3.44941	.544	-9.1951	4.9601
	Co	-.87000	3.44941	.803	-7.9476	6.2076
	Ni	.65250	3.44941	.851	-6.4251	7.7301
	Fe	-14.50250*	3.44941	.000	-21.5801	-7.4249
	Zn	.16000	3.44941	.963	-6.9176	7.2376
	Cd	1.02500	3.44941	.769	-6.0526	8.1026
Cd	Cr	-.36250	3.44941	.917	-7.4401	6.7151
	Mn	-60.35250*	3.44941	.000	-67.4301	-53.2749
	Pb	-3.14250	3.44941	.370	-10.2201	3.9351
	Co	-1.89500	3.44941	.587	-8.9726	5.1826
	Ni	-.37250	3.44941	.915	-7.4501	6.7051
	Fe	-15.52750*	3.44941	.000	-22.6051	-8.4499
	Zn	-.86500	3.44941	.804	-7.9426	6.2126
	Cu	-1.02500	3.44941	.769	-8.1026	6.0526

The mean difference is significant at the 0.05 level.

APPENDIX XIX

Means Plots of the Dry Season Concentration of Metal in Sediment of River Niger



APPENDIX XX (TABLE 1 -56)

TABLE 1: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 5'47" N, 6^0 43' 55" E

PARAMETER	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
pH	5.90	4.50	7.80	7.60	7.50	7.80	7.70	7.80
TEMP. (^{0}C)	31.0	32.0	32.0	32.0	31	31.0	32.0	31
COLOUR(Pt-Co)	160	168	166	200	442	450	480	488
COND.μS/CM	95.5	97.8	97.8	40.2	58.2	60.0	65.0	18.0
TDS (mg/l)	60	57.7	67	70	34.9	40.0	80.0	82.0
TSS (mg/l)	100	92.3	95	100	453	446	420	416
TS (mg/l)	160	150	162	170	488	490	500	498
TURB.(NTU)	22.4	23.4	22.8	30.0	29.5	300	325	430
Na (mg/l)	60.	75.0	70.8	10.4	3.00	3.01	3.20	3.30
K (mg/l)	5.0	2.10	2.50	2.40	2.20	2.10	2.20	1.80
Ca^{2+}(mg/l)	BDL	BDL	1.20	3.00	4.01	4.00	3.80	3.40
Mg^{2+}(mg/l)	40.0	52.7	50.5	10.60	4.39	4.20	4.60	4.50
`T.hardness (mg/l)	100	216	220	30.0	28.0	27.0	25.0	25.0
CaH (as mg /l $CaCO_3$)	BDL	BDL	BDL	10.0	10.0	9.40	9.60	9.20
MgH (as mg /l $CaCO_3$)	100	216	220	20.0	18.0	17.6	15.4	15.8
T Alkalinity (as mg/l $CaCO_3$)	41.0	37.5	35.4	26.0	24.2	24.3	24.0	23.8
Cl^- (mg/l)	13.0	12.0	10.0	5.48	4.76	4.70	4.50	4.20
F^- (mg/l)	0.56	BDL	BDL	0.01	0.02	0.03	0.02	0.04
NO^-_3 (mg/l as NO_3)	BDL	BDL	BDL	1.20	2.70	2.40	2.50	2.45
NO_2 (mg/l as NO_3)	0.04	0.08	0.10	0.09	0.01	0.03	0.02	0.03
NH_3 (mg/l)	0.05	0.45	0.50	0.52	0.94	1.00	0.98	1.00
SO_4^{2}-(mg/l)	14.0	15.1	15.0	14.80	7.91	7.80	7.84	7.90
PO_4^{3}- (mg/l)	1.49	1.47	1.38	1.40	0.30	0.28	0.29	0.31
TOC (mg/l)	BDL	BDL	1.20	4.20	8.10	10.0	9.80	10.0
BOD (mg/l)	5.60	4.80	4.20	4.10	0.50	0.60	1.00	0.98
COD (mg/l)	12.0	BDL	10.10	12.0	15.0	17.0	17.4	17.5
DO (mg/l)	5.0	4.0	4.0	5.40	7.00	7.40	7.30	7.40
T. coliform cfu, 100ml	180	150	160	180	520	450	500	480
E.coli cfu/100ml.	170	150	100	200	520	200	300	420

TABLE 2: Physico- chemical And Microbial Analyses Results in Water (2014)Location ,7^0 5' 54" N,6^0 43' 47" E

PARAMETERS	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
Ph	6.0	4.7	7.5	8.10	7.2	7.6	7.8	7.7
TEMP. (^{0}C)	32	31	31	32.0	32	31	31	31
COLOUR(Pt-Co)	157	165	170	420	1375	1250	980	870
COND.µS/CM	86.4	85.2	85.0	86.0	57.8	40.8	40.9	50.8
TDS (mg/l)	48.2	51.0	60	112	34.7	60.0	61.2	61.0
TSS (mg/l)	60.0	15.0	40	88	293	300	320	300
TS (mg/l)	108	66.0	100	200	328	360	361	361
TURB.(NTU)	34.3	21.4	25.0	24.5	21.5	20.5	18.9	19.0
Na (mg/l)	50.0	60.0	64.0	30.5	3.10	2.50	2.55	2.60
K (mg/l)	5.40	2.40	2.20	2.00	2.10	2.20	2.30	2.31
Ca^{2+}(mg/l)	BDL	BDL	1.00	1.20	5.61	4.60	4.40	5.10
Mg^{2+}(mg/l)	28.2	32.2	30.0	10.2	3.42	3.40	4.20	4.10
T.hardness (mg/l)	141	132	120	47.0	28.0	30.0	28.0	28.0
CaH (as mg /l $CaCO_3$)	10.0	BDL	30.0	20.0	14.0	18.0	19.0	18.8
MgH (as mg /l $CaCO_3$)	131	132	90.0	27.0	14.0	12.0	10.0	10.0
T Alkalinity (as mg/l $CaCO_3$)	30.0	22.5	24.40	23.4	23.1	23.2	22.2	23.0
Cl^- (mg/l)	12.0	12.1	10.5	9.00	9.52	8.50	8.40	8.60
F^- (mg/l)	BDL	BDL	BDL	0.40	0.59	0.60	0.45	0.50
NO^-_3 (mg/l as NO_3)	BDL	BDL	0.10	2.21	4.50	4.70	4.50	4.60
NO_2 (mg/l as NO_3)	0.05	0.09	0.08	0.65	0.01	0.02	0.01	0.04
NH_3 (mg/l)	0.23	0.22	0.40	0.40	0.70	0.60	0.68	0.64
SO_4^2-(mg/l)	25.0	21.1	20.5	10.5	7.48	7.20	0.25	0.23
PO_4^3- (mg/l)	1.09	1.38	1.10	1.16	0.34	0.20	0.25	0.23
TOC (mg/l)	2.20	7.20	7.40	7.45	8.50	8.40	8.30	8.10
BOD (mg/l)	4.40	4.20	4.10	3.80	0.50	0.60	0.65	0.70
COD (mg/l)	11.0	BDL	12.0	15.0	39.0	40.0	4.20	4.10
DO (mg/l)	4.80	8.20	7.10	7.20	7.40	7.46	7.50	7.60
T. coliform cfu, 100ml	0.00	0.00	200	200	100	150	200	150
E.coli cfu/100ml.	0.00	0.00	100	200	100	100	100	150

TABLE3: Physico-Chemical And Microbial Analyses Results in Water (2014) Location: 7^0 6' 10'' N, 6^0 43' 42'' E

PARAMETERS:	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PH	7.40	6.80	7.50	7.60	7.9	8.0	7.8	7.7
TEMP. (^{0}C)	32.0	32.0	31.0	32.0	31.0	31.0	31	31.0
COLOUR(Pt-Co)	320	312	325	330	455	460	465	470
COND.µS/CM	82.0	89.6	90.5	92.0	57.6	45.2	46.0	46.8
TDS (mg/l)	58.2	53.9	44.5	45.2	34.6	40.8	38.2	37.0
TSS (mg/l)	16.8	72.1	75.5	76.1	293	289.2	295.8	303
TS (mg/l)	75.0	126	120	121.3	328	330	334	340
TURB.(NTU)	21.4	29.8	30.0	31.20	30.9	40.8	42.0	41.9
Na (mg/l)	61.0	64.0	65.0	65.4	3.10	3.00	3.10	3.00
K (mg/l)	2.30	2.40	2.48	2.50	2.10	2.00	2.10	2.20
Ca^{2+}(mg/l)	3.60	4.81	4.90	5.20	4.81	4.40	4.30	4.32
Mg^{2+}(mg/l)	27.0	28.3	28.2	27.20	4.81	3.60	3.50	3.40
`T.hardness (mg/l)	123	128	127	120	26.0	26.8	25.8	25.7
CaH (as mg /l $CaCO_3$)	BDL	12.0	14.0	15	12.0	12.8	13.0	14.5
MgH (as mg /l $CaCO_3$)	123	116	113	105	14.0	14.0	12.8	11.2
T Alkalinity (as mg/l $CaCO_3$)	23.5	15.0	20.5	19.4	20.1	19.20	18.80	8.70
Cl^- (mg/l)	15.0	12.0	12.7	11.0	4.76	4.50	4.54	4.50
F^- (mg/l)	BDL	BDL	0.01	0.02	0.05	0.06	0.07	0.06
NO^-_3 (mg/l as NO_3)	68	70.4	71.0	70.0	BDL	70.0	70.0	70.2
NO_2 (mg/l as NO_3)	0.08	0.12	0.14	0.15	0.01	0.10	0.11	0.12
NH_3 (mg/l)	0.34	0.39	0.40	0.52	0.91	0.98	0.97	0.98
SO_4^2-(mg/l)	27.0	26.0	26.5	26.8	0.08	0.06	0.07	0.05
PO_4^3- (mg/l)	1.29	0.38	0.92	0.96	0.25	0.20	0.21	0.23
TOC (mg/l)	4.60	2.40	2.80	3.00	4.20	4.80	4.85	4.95
BOD (mg/l)	4.50	4.50	4.80	3.20	1.00	1.40	1.50	1.55
COD (mg/l)	10.0	BDL	10.2	15.4	40.0	41.2	41.0	42.0.
DO (mg/l)	7.8	8.1	9.20	9.60	7.20	7.10	7.23	7.40
T. coliform cfu, 100ml	0.00	0.00	100	100	520	500	400	500
E.coli cfu/100ml.	0.00	0.00	150	100	460	400	400	200

TABLE 4: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 6' 20'' N, 6^0 43' 18'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PARAMETERS:								
P^H	7.50	5.90	7.80	7.60	8.00	8.50	8.20	8.40
TEMP. (^{0}C)	31.0	30.0	31.0	32.0	32.0	31.0	31.0	31.0
COLOUR(Pt-Co)	200	210	250	300	1250	980	890	900
COND.µS/CM	88.3	84.6	82.8	70.8	67.9	60.8	50.0	49.8
TDS (mg/l)	50.0	50.8	48.2	45.4	40.8	39.4	40.0	38.5
TSS (mg/l)	5.80	3.20	8.20	8.11	743	75.1	810	949.5
TS (mg/l)	56.0	45.0	56.4	53.1	78.4	790	850	988
TURB.(NTU)	20.3	25.4	25.8	26.2	32.5	40.8	50.6	60.4
Na (mg/l)	50.8	63.0	60.4	60.2	3.50	3.10	3.20	2.80
K (mg/l)	3.50	2.70	3.00	2.80	2.50	2.10	2.20	2.00
Ca^{2+}(mg/l)	4.00	BDL	4.10	3.60	6.41	10.0	11.20	13.0
Mg^{2+}(mg/l)	25.0	40.9	50.0	48.8	3.42	5.0	4.00	4.20
T.hardness (mg/l)	133	168	169.8	100	30.0	35.0	31.40	28.8
CaH (as mg /l $CaCO_3$)	12.0	BDL	13.0	15.0	16.0	17.0	14.0	15.0
MgH (as mg /l $CaCO_3$)	113	168	156.8	85.0	14.0	18.0	17.40	13.8
T Alkalinity (as mg/l $CaCO_3$)	30.0	30.0	28.2	28.4	27.3	26.4	26.2	25.0
Cl^- (mg/l)	13.0	15.0	14.0	13.8	9.85	8.20	7.50	7.30
F^- (mg/l)	BDL	0.87	0.49	0.50	0.12	0.08	0.06	0.06
NO^-_3 (mg/l as NO_3)	6.00	5.70	5.80	4.80	3.30	3.20	2.50	2.40
NO_2 (mg/l as NO_3)	0.12	0.12	0.20	0.10	0.01	BDL	BDL	0.01
NH_3 (mg/l)	0.43	0.22	0.20	0.18	0.74	0.80	0.96	0.10
SO_4^{2-}(mg/l)	29.1	26.3	26.1	25.8	6.60	6.30	5.50	5.00
PO_4^{3-} (mg/l)	2.10	0.83	0.81	0.78	0.28	0.22	0.18	0.15
TOC (mg/l)	4.20	4.80	4.78	4.78	4.80	4.86	4.90	5.00
BOD (mg/l)	2.40	4.50	4.80	3.80	0.90	0.80	0.75	0.50
COD (mg/l)	BDL	BDL	9.80	8.70	45.0	48.0	4.96	5.00
DO (mg/l)	8.40	4.70	4.50	4.60	7.50	8.60	8.80	9.64
T. coliform cfu, 100ml	300	600	500	400	380	368	480	500
E.coli cfu/100ml.	0.00	0.00	100	200	340	300	200	300

TABLE5: Physico-Chemical and microbial analyses results in Water (2014) Location: 7^0 6’ 51’’N, 6^0 43’ 54’’ E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PARAMETERS:								
pH	7.80	6.90	7.40	7.20	7.8	8.20	8.20	8.00
TEMP. (^{0}C)	30.0	32.0	31.0	32.0	32	32.0	32.0	32.0
COLOUR(Pt-Co)	130	231	240	243	549	560	570	600
COND.µS/CM	90.3	82.5	80.1	79.2	68.0	64.5	63.2	62.0
TDS (mg/l)	75.0	49.7	48.5	43.0	40.8	40.2	38.8	36.4
TSS (mg/l)	110	106	91.5	92.0	311	320	335	345
TS (mg/l)	185	156	140	135	352	360	374	381
TURB.(NTU)	24.4	34.1	34.8	35.0	326	345	350	420
Na (mg/l)	52.40	52.8	53.4	40.6	3.50	2.80	2.43	2.20
K (mg/l)	3.10	3.80	3.70	3.65	2.60	2.40	2.10	1.80
Ca^{2+}(mg/l)	4.40	4.20	4.20	4.10	4.10	3.80	3.20	2.60
Mg^{2+}(mg/l)	20.0	30.0	20.8	8.40	4.39	3.80	3.58	3.20
T.hardness (mg/l)	134	168	765	150	28.0	25.0	20.0	19.4
CaH (as mg /l $CaCO_3$)	11.0	BDL	8.00	9.80	10.0	9.40	8.60	8.20
MgH (as mg /l $CaCO_3$)	123	168	157	140	18.0	15.6	11.4	11.20
T Alkalinity (as mg/l $CaCO_3$)	30.0	22.5	24.1	23.4	29.4	28.6	26.2	24.4
Cl^- (mg/l)	12.0	15.0	16.4	16.20	14.3	13.7	12.5	12.4
F^- (mg/l)	0.87	1.02	0.10	0.14	0.19	0.16	0.14	0.14
NO^-_3 (mg/l as NO_3)	8.00	3.00	3.10	2.80	2.40	230	2.10	2.00
NO_2 (mg/l as NO_3)	0.21	0.17	0.18	0.16	BDL	0.06	0.02	0.01
NH_3 (mg/l)	0.56	2.36	2.40	2.10	0.81	0.06	0.02	0.01
SO_4^2-(mg/l)	32.3	27.0	26.0	24.8	11.1	10.8	9.40	8.60
PO_4^3- (mg/l)	2.24	1.47	1.30	1.60	0.32	0.42	0.20	0.10
TOC (mg/l)	2.10	4.80	4.20	4.80	5.90	4.60	4.40	4.20
BOD (mg/l)	5.20	6.60	6.80	6.40	2.50	2.30	2.10	1.80
COD (mg/l)	BDL	BDL	2.20	3.50	41.0	40.8	36.2	20.6
DO (mg/l)	5.60	5.70	5.90	6.80	7.30	7.60	7.80	7.90
T. coliform cfu, 100ml	50.0	30.0	100	230	230	220	400	250
E.coli cfu/100ml.	50.0	40.0	200	200	180	500	300	100

TABLE 6: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 7'49" N, 6^0 44'43" E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PARAMETERS:								
pH	7.90	5.20	8.00	7.60	6.80	7.80	7.60	7.70
TEMP. (^{0}C)	32.0	32.0	31.0	32.0	31.0	31.0		
COLOUR(Pt-Co)	141	111	220	230	500	510	520	50.0
COND.µS/CM	78.0	89.7	90.7	98.0	63.9	59.2	54.6	50.0
TDS (mg/l)	36.4	53.8	66	49.6	38.4	36.8	35.6	42.4
TSS (mg/l)	35.7	48.2	60.0	78.4	230	233	240	235
TS (mg/l)	72.0	102	126	128	268	270	276	278
TURB.(NTU)	32.1	22.9	23.4	25	34.5	350	360	367
Na (mg/l)	50.8	72.0	73.4	68.4	3.30	3.20	2.86	2..50
K (mg/l)	4.20	3.00	3.40	3.00	2.50	2.40	2.1	1.86
Ca^{2+}(mg/l)	4.20	BDL	3.80	3.40	641	6.52	6.20	5.80
Mg^{2+}(mg/l)	25.0	38.10	40.6	20.4	22.4	2.20	1.80	1.64
T.hardness (mg/l)	122	156	160	167	26.0	24.0	22.0	20.0
CaH (as mg /l $CaCO_3$)	14.0	BDL	2.00	7.00	16.0	14.2	13.6	12.2
MgH (as mg /l $CaCO_3$)	108	156	158	160	10.0	9.80	8.40	7.80
T Alkalinity (as mg/l $CaCO_3$)	34.0	30.0	28.0	28.6	27.3	26.0	26.5	25.0
Cl^- (mg/l)	11.0	18.0	18.6	18.7	4.76	3.24	3.18	3.20
F^- (mg/l)	0.72	BDL	0.60	0.50	0.10	0.09	0.07	0.08
NO^-_3 (mg/l as NO_3)	BDL	750	7.30	7.20	1.30	1.20	1.15	1.10
NO_2 (mg/l as NO_3)	0.11	0.13	0.14	0.12	BDL	0.08	0.06	0.05
NH_3 (mg/l)	0.27	0.40	0.50	0.68	0.75	0.68	0.54	0.48
SO_4^{2}-(mg/l)	34.5	22.0	21.0	20.8	15.4	14.8	13.4	12.6
PO_4^{3}- (mg/l)	2.43	2.48	2.45	2.47	0.29	0.24	0.21	0.20
TOC (mg/l)	2.20	2.40	2.54	2.68	2.50	2.48	2.40	2.38
BOD (mg/l)	6.80	3.15	3.20	3.20	0.80	0.70	0.50	0.40
COD (mg/l)	BDL	BDL	5.0	4.80	40.0	38.0	35.0	28.0
DO (mg/l)	6.80	3.70	3.80	4.50	7.40	8.40	9.20	10.5
T. coliform cfu, 100ml	0.00	0.00	100	200	160	200	400	150
E.coli cfu/100ml.	0.00	0.00	50.0	100	0.00	150	300	200

TABLE 7: Physico-Chemicaland Microbial Analyses Resultsin Water (2014) Location: 7^{O} 24’ 53’’ N, 6^{O} 42’ 49’’ E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PARAMETERS:								
pH	7.90	7.40	7.50	7.50	7.60	7.80	7.80	7.70
TEMP. (^{0}C)	32.0	31.0	31.0	31.0	32.0	32.0	32.0	32.0
COLOUR(Pt-Co)	163	123	130	145	1170	1080	1100	1120
COND.µS/CM	96.0	83.1	80.6	70.4	67.0	64.8	60.4	50.8
TDS (mg/l)	35.1	50.1	49.0	48.2	40.2	30.80	30.4	29.2
TSS (mg/l)	68.0	21.9	29.0	42.2	260	289	310	360
TS (mg/l)	103	72.0	78.0	90.4	300	320	340	389
TURB.(NTU)	31.4	20.4	20.2	19.60	345	348	350	360
Na (mg/l)	50.0	63.0	65.0	60.9	3.30	3.10	3.00	2.89
K (mg/l)	5.00	2.70	2.50	2.50	2.40	2.20	1.85	1.76
Ca^{2+}(mg/l)	4.10	6.41	6.30	5.30	5.61	5.40	4.80	4.20
Mg^{2+}(mg/l)	28.0	25.4	24.60	20.4	3.42	3.20	3.10	2.60
T.hardness (mg/l)	120	120	100	50.0	28.0	25.0	24.0	22.0
CaH (as mg /l $CaCO_3$)	13.0	16.0	15.6	14.0	14.0	13.2	12.8	12.2
MgH (as mg /l $CaCO_3$)	107	104	84.4	36.0	14.0	11.8	11.2	9.80
T Alkalinity (as mg/l $CaCO_3$)	23.5	22.5	21.8	26.0	27.3	26.8	25.0	24.0
Cl^- (mg/l)	20.0	12.0	12.0	10.8	9.52	8.40	8.10	7.80
F^- (mg/l)	0.76	0.42	0.40	0.39	0.24	0.21	0.19	0.16
NO^-_3 (mg/l as NO_3)	3.00	BDL	2.10	2.16	2.00	1.80	1.87	1.69
NO_2 (mg/l as NO_3)	0.13	0.13	0.12	0.10	BDL	0.08	0.06	0.02
NH_3 (mg/l)	0.17	0.36	0.48	0.58	1.11	1.25	1.38	1.40
SO_4^{2}-(mg/l)	22.4	27.0	26.6	24.8	8.70	7.80	7.20	6.40
PO_4^{3}- (mg/l)	3.40	2.57	2.52	2.40	0.28	0.28	0.19	0.16
TOC (mg/l)	2.20	2.40	2.20	2.00	2.10	2.10	1.80	1.40
BOD (mg/l)	7.20	4.20	4.10	3.40	0.60	0.40	0.40	0.40
COD (mg/l)	BDL	13.0	12.0	14.0	18.0	20.0	22.0	24.0
DO (mg/l)	10.0	5.70	5.80	5.90	7.30	7.80	7.40	7.20
T. coliform cfu, 100ml	0.00	0.00	100	150	320	400	420	150
E.coli cfu/100ml.	0.00	0.00	50	50	160	100	200	100

TABLE 8: Physic-Chemical and Microbial Analyses Results in Water (2014) Location; 7^0 25' 36'' N, 6^0 43' 32'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMENTERS								
pH	8.00	7.40	7.50	7.80	7.70	7.60	7.90	8.00
TEMP. (^{0}C)	31.0	32.0	32.0	32.0	31.0	31.0	31.0	31.0
COLOUR(Pt-Co)	118	201	225	230	549	556	567	580
COND.µS/CM	88.0	81.0	90.6	89.5	57.7	40.8	40.5	30.6
TDS (mg/l)	43.2	48.5	49.3	45.6	34.6	34.2	32.8	31.4
TSS (mg/l)	67.5	168	191	199.	237	242	247	257
TS (mg/l)	111	216	240	245	272	276	280	288
TURB.(NTU)	32.5	25.3	26.4	28.0	292	298	299	320
Na (mg/l)	51.0	54.0	48.0	45.0	2.90	2.20	1.80	1.74
K (mg/l)	4.8.0	2.70	2.40	2.30	2.10	1.80	1.75	1.65
Ca^{2+}(mg/l)	3.80	BDL	3.00	2.70	4.01	4.80	4.20	3.87
Mg^{2+}(mg/l)	25.0	32.2	28.5	18.5	3.42	3.20	2.81	2.65
T.hardness (mg/l)	144	132	120	118	24.0	23.8	23.2	22.8
CaH (as mg /l $CaCO_3$)	17.0	BDL	10.0	18.0	10.0	11.0	12.0	12.0
MgH (as mg /l $CaCO_3$)	127	132	11.0	100	14.0	12.8	11.2	10.8
T Alkalinity (as mg/l $CaCO_3$)	35.5	37.5	36.6	34.0	23.1	22.8	20.8	20.7
Cl^- (mg/l)	21.0	18.0	16.8	14.5	4.76	4.20	4.00	3.80
F^- (mg/l)	0.34	0.72	0.24	0.21	0.12	010	0.09	0.06
NO^-_3 (mg/l as NO_3)	0.60	BDL	0.50	0.40	2.40	2.10	2.00	1.86
NO_2 (mg/l as NO_3)	0.10	0.15	0.13	0.10	0.01	0.01	0.02	0.01
NH_3 (mg/l)	0.19	1.20	1.10	0.98	0.68	0.58	0.43	0.38
SO_4^2-(mg/l)	34.5	34.2	30.8	22.4	11.6	10.3	9.50	8.60
PO_4^3- (mg/l)	3.26	1.10	1.28	1.40	0.30	0.28	0.18	0.12
TOC (mg/l)	4.50	2.40	2.20	2.30	2.40	2.50	2.80	3.20
BOD (mg/l)	6.40	4.65	4.20	4.12	0.80	0.70	0.60	0.20
COD (mg/l)	11.0	13.0	15.0	19.0	2.00	2.10	2.20	2.40
DO (mg/l)	12.5	2.60	2.80	2.90	7.00	8.00	6.00	5.00
T. coliform cfu, 100ml	0.00	0.00	100	150	380	480	360	400
E.coli cfu/100ml.	0.00	0.00	50.0	50.0	380	300	160	200

TABLE 9: Physico-Chemical and Microblal Analyses Results in Warer (2014)Location ,7^0 25'44" N,6^0 42' 56" E

PARAMETERS	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
pH	7.60	6.90	7.50	7.40	7.20	8.00	7.90	7.80
TEMP. (^{0}C)	32.0	31.0	32.0	32.0	32.0	32.0	32.0	31.0
COLOUR(Pt-Co)	200	183	191	200	1413	1430	1450	1458
COND.µS/CM	45.0	77.1	79.8	90.6	59.2	55.4	50.7	48.5
TDS (mg/l)	50.3	46.4	45.6	43.3	35.5	33.2	31.5	30.5
TSS (mg/l)	70.8	55.6	54.4	54.7	349	346	329	309.5
TS (mg/l)	121	102	100	98.0	384	379	360	340
TURB.(NTU)	32.4	22.5	28.0	50.8	367	370	382	390
Na (mg/l)	50.0	54.0	51.0	49.8	3.00	2.80	2.65	1.89
K (mg/l)	3.5	3.00	3.20	2.80	2.20	2.16	2.11	2.00
Ca^{2+}(mg/l)	3.40	BDL	3.10	3.20	3.21	3.80	2.61	2.54
Mg^{2+}(mg/l)	30.2	32.2	30.1	10.8	3.42	3.33	3.21	3.14
T.hardness (mg/l)	140	132	135	11.0	22.0	20.8	18.2	17.4
CaH (as mg /l $CaCO_3$)	14.0	BDL	10.7	9.8	8.00	7.8	7.4	7.00
MgH (as mg /l $CaCO_3$)	126	132	124	100	14.0	13.0	11.0	10.4
T Alkalinity (as mg/l $CaCO_3$)	37.5	17.50	16.0	15.0	25.2	23.4	21.8	20.1
Cl^- (mg/l)	15.0	18.0	17.8	16.4	4.76	4.50	4.48	4.10
F^- (mg/l)	BDL	1.53	1.40	1.20	BDL	6.80	0.40	0.20
NO^-_3 (mg/l as NO_3)	BDL	0.60	0.16	0.58	4.60	3.80	2.69	2.48
NO_2 (mg/l as NO_3)	0.18	0.13	0.12	0.10	0.01	0.02	0.01	BDL
NH_3 (mg/l)	0.20	0.47	0.58	0.78	4.58	4.60	4.78	4.75
SO_4^2-(mg/l)	23.4	31.9	32.8	33.0	6.98	0.97	0.99	1.00
PO_4^3- (mg/l)	3.21	0.92	0.97	2.30	6.79	6.86	6.92	7.10
TOC (mg/l)	4.50	7.20	8.40	8.60	10.28	10.3	12.4	12.9
BOD (mg/l)	4.60	5.10	5.04	3.20	0.70	0.78	0.79	BDL
COD (mg/l)	13.0	11.0	12.0	14.8	41.0	45.0	45.4	45.7
DO (mg/l)	11.6	4.00	5.00	6.00	7.30	7.40	7.80	8.00
T. coliform cfu, 100ml	50.0	50.0	100	100	160	150	220	200
E.coli cfu/100ml.	0.00	0.00	50.0	100	100	100	110	100

TA**BLE 10:** Physico-Chemical and Microblal Analyses Results in Water (2014)Location ,7^0 29’ 21” N,6^0 41’ 9” E

PARAMETERS	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
pH	7.50	7.00	7.40	7.80	7.80	8.00	7.90	8.00
TEMP. (^{0}C)	32.0	31.0	31.0	31.0	31.0	32.0	32.0	32.0
COLOUR(Pt-Co)	230	54.0	56.0	57.0	1175	1178	1180	1182
COND.µS/CM	83.7	33.1	82.0	81.7	54.4	34.0	33.7	32.8
TDS (mg/l)	44.3	49.8	48.8	47.80	34.4	34.0	33.7	32.8
TSS (mg/l)	75.4	4.20	10.2	12.6	214	215	224	237
TS (mg/l)	120	54.0	59.0	60.4	248	249	258	270
TURB.(NTU)	25.7	20.9	22.0	24.0	314	320	321	330
Na (mg/l)	58.5	60.0	62.0	64.0	2.90	2.40	2.30	2.10
K (mg/l)	3.00	3.30	3.50	2.62	2.00	2.00	1.84	1.70
Ca^{2+}(mg/l)	4.20	4.81	4.80	4.80	4.81	4.60	4.40	3.80
Mg^{2+}(mg/l)	4.50	40.9	40.8	40.6	1.95	1.34	1.22	1.10
T.hardness (mg/l)	146	180	198	200	20.0	25.8	19.6	19.4
CaH (as mg /l $CaCO_3$)	12.0	12.0	11.0	11.0	12.0	9.20	7.20	6.80
MgH (as mg /l $CaCO_3$)	134	168	88.0	89.0	8.00	16.6	12.4	12.6
T Alkalinity (as mg/l $CaCO_3$)	33.5	15.0	16.4	16.8	30.5	29.8	29.2	78.8
Cl^- (mg/l)	14.0	17.0	20.6	19.5	19.52	9.40	9.38	9.18
F^- (mg/l)	BDL	0.54	0.55	0.62	BDL	0.32	0.24	0.22
NO^-_3 (mg/l as NO_3)	BDL	BDL	4.50	4.10	3.50	3.40	3.39	3.10
NO_2 (mg/l as NO_3)	0.16	0.11	0.10	0.12	0.11	0.90	0,88	0,84
NH_3 (mg/l)	0.48	0.18	0.75	0.30	0.74	0.53	0.32	0.20
SO_4^{2}-(mg/l)	20.6	31.0	30.2	32.8	7.49	7.40	7.38	7.20
PO_4^{3}- (mg/l)	3.21	3.11	7.09	2.00	0.30	0.28	0.24	0.21
TOC (mg/l)	2.40	BDL	2.50	2.60	9.80	9.90	9.98	10.3
BOD (mg/l)	5.40	1.50	1.70	2.50	0.70	0.70	0.68	0.66
COD (mg/l)	14.0	11.0-	12.4	14.7	43.0	43.8	44.0	44.5
DO (mg/l)	13.5	4.3	5.80	6.80	7.30	7.40	7.70	7.90
T. coliform cfu, 100ml	0.00	0.00	50.0	100	360	50.0	300	3.40
E.coli cfu/100ml.	0.00	0.00	50.0	80.0	320	200	150	220

TABLE 11: Physico-Chemical and Microblal Analyses Results in Water (2014)Location ,7^0 31'36" N,6^0 40' 57" E

PARAMETERS	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
pH	8.50	7.40	7.50	7.60	7.50	8.10	7.80	7.90
TEMP. (^{0}C)	32.0	31.0	31.0	31.0	31.0	32.0	32.0	32.0
COLOUR(Pt-Co)	111	168	170	190	159	5120	540	560
COND.μS/CM	89.3	96.89	97.0	98.0	76.3	75.2	74.2	72.0
TDS (mg/l)	45.8	58.3	60.2	61.4	45.8	45.3	44.5	43.9
TSS (mg/l)	87.3	73.7	70.5	60.5	98.2	100	101	103
TS (mg/l)	133	131	131	122	144	145	46	147
TURB.(NTU)	30.5	22.5	25.6	30.0	169	170	178	179
Na (mg/l)	80.10	84.0	60.7	58.2	3.60	3.20	2.86	2.50
K (mg/l)	2.80	3.00	3.20	3.10	2.70	2.65	2.40	2.50
Ca^{2+}(mg/l)	4.20	4.81	6.20	6.00	7.20	7.00	6.86	6.40
Mg^{2+}(mg/l)	36.5	35.1	34.5	32.0	2.93	2.60	2.50	2.20
T.hardness (mg/l)	107	156	158	140	30.0	28.4	28.2	27.9
CaH (as mg /l $CaCO_3$)	12.0	12.0	10.0	9.80	18.0	17.6	16.2	15.5
MgH (as mg /l $CaCO_3$)	95.0	144	148	130	12.0	11.0	12.0	12.4
T Alkalinity (as mg/l $CaCO_3$)	36.5	300	31.8	31.4	30.5	32.0	33.6	34.0
Cl^- (mg/l)	12.0	15.0	16.4	16.2	9.52	8.60	8.20	7.90
F^- (mg/l)	0.69	BDL	BDL	0.50	0.03	0.03	0.02	0.01
NO^-_3 (mg/l as NO_3)	BDL	BDL	1.00	1.02	2.00	2.10	1.80	1.86
NO_2 (mg/l as NO_3)	0.14	0.15	0.18	0.17	0.02	0.01	BDL	0.01
NH_3 (mg/l)	0.45	1.16	1.20	1.25	0.26	0.24	0.22	0.22
SO_4^2-(mg/l)	31.5	10.2	9.80	8.60	5.16	5.12	5.10	5.00
PO_4^3- (mg/l)	1.12	3.15	3.14	3.12	0.10	0.08	0.05	0,04
TOC (mg/l)	4.80	4.80	5.0	5.14	7.80	7.60	7.50	7.20
BOD (mg/l)	5.10	3.90	3.70	3.20	1.10	1.10	0.98	0.50
COD (mg/l)	11.0	14.0	16.0	18.9	39.0	38.4	39.8	40.4
DO (mg/l)	12.5	4.1	3.80	3.60	7.60	7.20	7.30	7.10
T. coliform cfu, 100ml	50.0	50.0	150	250	420	400	430	450
E.coli cfu/100ml.	0.00	0.00	100	230	420	300	360	410

TABLE 12: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 34’ 21’’, 6^0 38’ 26’’ E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PARAMETERS:								
pH	7.60	7.30	7.40	7.50	7.70	7.80	7.60	8.00
TEMP. (^{0}C)	32.0	30.0	31.0	31.0	31.0	31.0	32.0	32.0
COLOUR(Pt-Co)	131	2490	250	300	1310	1320	1340	1350
COND.µS/CM	74.4	87.0	88.0	88.5	37.0	34.8	34.2	33.7
TDS (mg/l)	56.3	52.0	50.8	48.2	34.2	33.8	33.2	32.6
TSS (mg/l)	67.4	86.0	90.2	102	338	340	345	348
TS (mg/l)	124	138	141	1509	372	374	378	381
TURB.(NTU)	32.5	35.4	35.8	36.1	338	401	413	420
Na (mg/l)	56.40	57.0	50.4	48.0	2.90	2.71	2.60	21.1
K (mg/l)	3.00	2.70	2.60	2.50	2.20	2.09	1.80	1.48
Ca^{2+}(mg/l)	5.00	4.81	4.60	4.40	4.01	3.80	3.25	3.10
Mg^{2+}(mg/l)	25.0	23.4	22.3	21.8	2.93	2.60	2.20	2.10
T.hardness (mg/l)	104	108	106	102	22.0	20.8	19.2	18.6
CaH (as mg /l $CaCO_3$)	15.0	12.0	11.0	8.40	10.0	9.20	9.00	8.80
MgH (as mg /l $CaCO_3$)	89.0	96.0	95.0	93.6	12.0	11.60	10.2	9.80
T Alkalinity (as mg/l $CaCO_3$)	21.5	30.0	28.0	27.0	23.1	22.7	21.4	20.6
Cl^- (mg/l)	11.0	18.0	17.3	17.0	4.76	4.50	3.68	3.20
F^- (mg/l)	0.80	0.78	0.80	0.79	0.10	0.08	0.05	0.03
NO^-_3 (mg/l as NO_3)	BDL	18.0	2.70	2.75	7.80	1.75	1.50	1.48
NO_2 (mg/l as NO_3)	0.16	0.03	0.03	0.02	0.02	0.01	BDL	0.01
NH_3 (mg/l)	0.44	2.80	1.40	1.20	0.77	0.78	0.80	0.82
SO_4^{2}-(mg/l)	34.4	0.03	11.80	11.4	16.0	14.20	13.10	10.20
PO_4^{3}- (mg/l)	0.98	13.1	1.27	1.28	0.32	0.30	0.28	0.25
TOC (mg/l)	4.80	2.40	2.48	4.50	7.50	7.60	7.35	7.10
BOD (mg/l)	6.45	5.10	5.00	4.70	0.90	0.80	0.60	0.20
COD (mg/l)	12.0	4.00	3.80	3.60	38.0	37.8	36.6	35.1
DO (mg/l)	12.6	3.80	4.80	5.50	7.80	7.90	8.00	8.10
T. coliform cfu, 100ml	0.00	0.00	100	150	140	200	150	100
E.coli cfu/100ml.	0.00	0.00	50.0	50.0	120	100	200	100

TABLE 13: Physico-Chemicaland Microblal Analyses Results in Water (2014) Location ,7^0 36'52" N,6^0 43'47" E

PARAMETERS	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
pH	7.70	7.10	7.40	7.60	7.40	7.80	7.60	7.50
TEMP. (^{0}C)	31.0	31.0	31.0	31.0	31.0	32.0	32.0	32.0
COLOUR(Pt-Co)	129	177	178	200	550	555	560	580
COND.µS/CM	79.5	91.8	93.0	94.6	57.9	58.0	57.0	56.8
TDS (mg/l)	43.6	55.1	53.2	50.8	34.7	33.2	31.8	31.6
TSS (mg/l)	60.3	58.9	71.8	79.8	281	287	294	298
TS (mg/l)	124	114	125	130	316	320	326	330
TURB.(NTU)	24.6	31.9	40.8	45.6	311	316	320	334
Na (mg/l)	65.0	66.0	40.5	40.1	3.00	2.40	2.10	1.80
K (mg/l)	2.40	2.70	2.50	2.40	2.20	2.10	1.86	1.46
Ca^{2+}(mg/l)	4.70	4.81	4.42	4.20	4.01	3.86	3.60	3.50
Mg^{2+}(mg/l)	24.0	23.4	23.20	22.6	4.88	4.53	4.20	3.80
T.hardness (mg/l)	93.0	108	109	118	30.0	30.0	29.4	28.8
CaH (as mg /l $CaCO_3$)	17.0	12.0	14.7	25.2	10.0	10.2	9.80	10.5
MgH (as mg /l $CaCO_3$)	76.0	96.0	94.3	92.8	20.0	19.8	19.6	18.3
T Alkalinity (as mg/l $CaCO_3$)	24.5	15.0	17.0	18.4	23.1	22.7	22.4	22.2
Cl^- (mg/l)	12.0	15.0	9.10	8.60	7.62	7.80	7.58	7.20
F^- (mg/l)	0.65	10.3	9.40	9.20	BDL	3.10	2.80	2.71
NO^-_3 (mg/l as NO_3)	1.50	2.70	2.80	2.86	3.10	2.98	2.70	2.50
NO_2 (mg/l as NO_3)	BDL	0.10	0.09	0.07	BDL	0.04	0.03	0.01
NH_3 (mg/l)	0.65	0.58	0.63	0.65	0.45	0.50	0.56	0.65
$SO_4{}^2$-(mg/l)	38.6	16.3	16.1	15.8	15.7	15.4	15.2	14.9
$PO_4{}^3$- (mg/l)	1.10	2.45	2.30	2.10	0.33	0.31	0.28	0.25
TOC (mg/l)	4.10	BDL	4.80	4.90	7.20	7.30	7.10	6.58
BOD (mg/l)	2.40	4.20	4.00	3.20	0.60	0.54	0.48	0.35
COD (mg/l)	15.0	15.0	14.4	12.6	8.00	7.60	7.40	7.10
DO (mg/l)	10.5	4.5	5.00	6.80	7.40	7.80	8.20	8.60
T. coliform cfu, 100ml	100	100	100	150	1100	1000	200	100
E.coli cfu/100ml.	0.00	0.00	50.0	50.0	780	480	100	100

TABLE 14:Physico-Chemical and Microblal Analyses Results in Water (2014) Location ,7^0 38' 3" N,6^0 40' 56" E

PARAMETERS	MARCH	APRIL	MAY	JULY	JULY	AUGUST	SEPTEMBER	OCTOBER
pH	7.80	7.10	7.60	7.50	7.40	750	7.60	7.40
TEMP. (^{0}C)	32.0	31.0	31.0	31.0	31.0	32.0	32.0	32.0
COLOUR(Pt-Co)	48.0	84.0	101	103	550	560	548	580
COND.μS/CM	66.8	86.4	70.5	60.4	57.8	54.6	54.3	53.7
TDS (mg/l)	48.2	51.6	48.3	47.5	34.7	33.6	33.4	32.8
TSS (mg/l)	67.4	86.4	90.8	101	345	34/8	356	358
TS (mg/l)	116	136	139	149	380	382	389	391
TURB.(NTU)	34.3	24.1	25.0	26.9	330	333	338	341
Na (mg/l)	50.0	60.0	40.0	40.0	2.90	1.86	13.8	1.63
K (mg/l)	3.80	2.70	2.90	2.85	2.10	1.76	1.80	1.50
Ca^{2+}(mg/l)	9.70	8.02	7.60	7.52	5.61	4.85	4.60	4.20
Mg^{2+}(mg/l)	25.0	21.5	20.6	19.2	4.88	4.60	4.20	4.10
T.hardness (mg/l)	83.0	108	100	98.0	34.0	30.4	30.0	28.2
CaH (as mg /l $CaCO_3$)	16.0	20.0	29.6	29.0	14.0	12.4	13.4	12.4
MgH (as mg /l $CaCO_3$)	67.0	88.0	70.4	68.9	20.0	18.0	16.6	15.8
T Alkalinity (as mg/l $CaCO_3$)	30.5	37.5	37.4	37.0	37.8	36.6	35.5	34.3
Cl^- (mg/l)	10.0	15.0	10.8	10.2	3.81	3.50	3.10	2.90
F^- (mg/l)	0.68	0.96	0.85	0.76	BDL	BDL	0.02	0.01
NO^-_3 (mg/l as NO_3)	1.80	BDL	BDL	3.70	3.50	3.20	3.00	2.92
NO_2 (mg/l as NO_3)	BDL	0.05	0.04	0.01	BDL	BDL	0.01	BDL
NH_3 (mg/l)	BDL	0.36	0.78	0.90	BDL	1.00	1.20	1.50
SO_4^{2}-(mg/l)	34.4	15.9	18.40	18.10	17.1	14.3	12.7	11.3
PO_4^{3}- (mg/l)	1.32	1.74	1.63	1.78	0.28	0.24	0.10	0.10
TOC (mg/l)	6.40	BDL	6.80	6.91	6.80	7.20	7.42	8.50
BOD (mg/l)	4.80	4.80	4.30	4.10	1.00	2.90	3.70	3.80
COD (mg/l)	12.0	8.00	10.2	9.80	7.00	5.32	6.40	6.80
DO (mg/l)	15.0	4.60	4.80	5.00	7.70	8.20	8.40	8.70
T. coliform cfu, 100ml	0.00	0.00	150	100	320	250	200	100
E.coli cfu/100ml.	0.00	0.00	100	50.0	260	100	50.0	50.0

TABLE 15: Physico-Chemical and Microbial Analyses Resultsin Water (2014) Location: 7^0 41' 57" N, 6^0 44' 8'' E

PARAMETERS	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
pH	7.9	7.6	7.8	7.4	7.50	8.10	8.00	7.80
TEMP. (^{0}C)	31.0	31.0	31.0	31.0	31	32.0	32.0	32.0
COLOUR(Pt-Co)	480	420	400	450	375	1380	1378	1385
COND.µS/CM	79.4	94.0	90.1	70.8	57.6	48.2	47.2	47.8
TDS (mg/l)	45.6	57.0	49.6	48.2	34.6	33.8	30.1	29.7
TSS (mg/l)	56.4	159	161	180	529	532	540	548
TS (mg/l)	102	216	211	228	564	566	570	578
TURB.(NTU)	23.7	38.0	45.0	58.0	323	325	335	340
Na (mg/l)	62.0	76.0	50.8	47.2	2.10	2.73	2.62	2.50
K (mg/l)	3.20	2.80	2.70	2.61	2.20	2.16	2.10	1.80
Ca^{2+}(mg/l)	5.00	4.81	3.60	3.10	1.60	1.52	1.43	1.31
Mg^{2+}(mg/l)	30.0	24.4	23.5	22.4	0.98	0.87	0.73	0.70
T.hardness (mg/l)	88.0	112	114	118	8.00	7.10	7.00	6.90
CaH (as mg /l $CaCO_3$)	9.00	12.0	11.8	10.4	4.00	3.80	3.11	2.71
MgH (as mg /l $CaCO_3$)	78.0	100	102	108	4.00	3.30	3.89	4.19
T Alkalinity (as mg/l $CaCO_3$)	30.0	40.0	28.7	25.0	15.8	14.0	13.8	13.3
Cl^- (mg/l)	23.0	24.0	23.8	23.2	7.62	7.40	7.20	6.93
F^- (mg/l)	1.00	0.69	0.58	0.43	0.09	0.08	0.06	BDL
NO^-_3 (mg/l as NO_3)	1.40	BDL	1.38	1.32	BDL	0.98	0.80	0.79
NO_2 (mg/l as NO_3)	BDL	0.06	0.04	0.01	BDL	BDL	0.01	BDL
NH_3 (mg/l)	0.44	1.96	1.80	1.76	0.36	0.40	0.45	0.50
SO_4^{2}-(mg/l)	36.6	31.3	30.0	28.60	15.1	14.2	13.7	12.5
PO_4^{3}- (mg/l)	1.36	2.78	2.50	1.90	0.31	0.32	0.30	0.27
TOC (mg/l)	7.60	2.78	2.50	1.90	0.31	0.32	0.30	0.27
BOD (mg/l)	6.00	6.00	5.10	5.30	0.70	0.60	0.40	0.10
COD (mg/l)	10.0	12.0	12.4	12.6	13.0	12.4	11.8	10.2
DO (mg/l)	10.5	3.80	4.60	5.00	7.50	5.21	4.30	4.10
T. coliform cfu, 100ml	100	100	100	100	300	420	320	350
E.coli cfu/100ml.	100	100	50.0	70.0	300	100	150	150

TABLE 16: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 42' 54''N, 6^0 44' 33'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	7.80	7.10	7.40	7.50	7.30	7.40	7.60	7.60
TEMP. (^{0}C)	32.0	31.0	32.0	32.0	32.0	32.0	32.0	32.0
COLOUR(Pt-Co)	386	210	280	300	500	520	540	545
COND.µS/CM	73.8	87.9	86.0	85.0	76.3	78.0	84.0	86.0
TDS (mg/l)	50.1	52.7	50.0	50.0	45.8	44.5	43.0	43.0
TSS (mg/l)	73.7	79.3	80.4	97.0	194	196	197	205
TS (mg/l)	124	132	130	147	240	241	240	248
TURB.(NTU)	23.1	33.1	38.0	44.0	155	158	170	176
Na (mg/l)	58.0	60.0	60.0	64.0	3.50	3.20	3.00	2.80
K (mg/l)	2.50	3.00	3.01	2.79	2.70	2.50	2.30	2.01
Ca^{2+}(mg/l)	4.60	4.81	4.92	4.98	6.41	6.32	6.28	6.20
Mg^{2+}(mg/l)	5.40	5.86	4.62	3.81	1.95	1.90	1.20	1.10
T.hardness (mg/l)	65.0	36.0	34.0	33.8	24.0	23.4	22.8	21.4
CaH (as mg /l $CaCO_3$)	9.00	12.0	10.2	10.0	16.0	14.0	13.40	12.8
MgH (as mg /l $CaCO_3$)	56.0	24.0	23.8	23.8	8.0	9.40	9.40	8.60
T Alkalinity (as mg/l $CaCO_3$)	31.5	22.5	22.4	20.8	31.5	30.2	28.4	26.2
Cl^- (mg/l)	30.0	12.0	10.8	10.2	5.71	5.60	5.40	5.20
F^- (mg/l)	1.02	0.78	0.65	0.62	0.24	0.21	0.20	0.19
NO^-_3 (mg/l as NO_3)	0.50	BDL	2.01	2.50	2.80	2.40	2.10	2.00
NO_2 (mg/l as NO_3)	BDL	0.07	0.05	0.04	0.01	BDL	0.01	BDL
NH_3 (mg/l)	0.56	0.29	0.24	0.22	BDL	0.19	0.15	0.12
SO_4^2-(mg/l)	26.8	22.1	20.6	20.2	11.5	10.2	10.1	9.60
PO_4^3- (mg/l)	1.78	0.83	0.81	0.78	0.11	0.10	BDL	BDL
TOC (mg/l)	4.20	2.40	2.29	2.25	5.00	4.20	4.10	3.80
BOD (mg/l)	6.40	4.80	4.30	4.10	1.55	1.42	1.38	1.27
COD (mg/l)	13.0	13.0	12.8	11.8	15.0	14.2	13.7	13.5
DO (mg/l)	18.0	3.2	4.80	5.70	7.80	7.50	6.80	6.40
T. coliform cfu, 100ml	0.00	0.00	150	250	1200	1000	1500	15.50
E.coli cfu/100ml.	0.00	0.00	200	300	850	750	800	860

TAB LE 17: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 43' 58" N, 6^0 44 '37'' E

PARAMETERS	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
pH	8.20	7.10	7.40	7.30	7.20	7.50	8.20	8.30
TEMP. (^{0}C)	32.0	31.0	32.0	32.0	31.0	31.0	31.0	31.0
COLOUR(Pt-Co)	378	114	204	250	517	520	530	530
COND.µS/CM	50.2	83.4	84.7	80.3	76.8	77.0	80.2	80.4
TDS (mg/l)	53.2	50.2	48.4	47.6	46.1	45.2	43.1	42.8
TSS (mg/l)	77.1	81.8	85.3	86.1	142	145	150	152
TS (mg/l)	130	132	134	134	188	190	193	195
TURB.(NTU)	38.4	24.1	25.8	26.7	126	128	130	1.35
Na (mg/l)	50.5	51.0	48.0	42.2	3.40	2.10	1.80	1.60
K (mg/l)	2.80	2.70	2.68	2.70	2.70	2.60	2.40	2.10
Ca^{2+}(mg/l)	4.80	4.81	4.80	4.80	4.81	4.70	4.60	4.20
Mg^{2+}(mg/l)	19.8	20.5	18.2	17.8	3.90	3.40	3.20	3.00
T.hardness (mg/l)	118	96.0	92.0	80.4	28.0	27.0	26.8	26.4
CaH (as mg /l $CaCO_3$)	13.0	12.0	11.8	11.7	12.0	11.8	11.5	11.1
MgH (as mg /l $CaCO_3$)	105	84.0	80.2	68.7	16.0	15.2	15.3	15.3
T Alkalinity (as mg/l $CaCO_3$)	32.5	22.5	23.0	34.8	38.9	36.0	35.8	35.1
Cl^- (mg/l)	24.0	24.0	23.7	22.1	8.57	7.60	6.58	6.10
F^- (mg/l)	1.00	0.84	0.80	0.76	0.19	0.14	0.12	0.100
NO^-_3 (mg/l as NO_3)	0.70	BDL	0.65	0.50	2.40	2.10	1.82	1.70
NO_2 (mg/l as NO_3)	BDL	0.05	0.04	0.01	0.02	0.01	0.01	BDL
NH_3 (mg/l)	1.20	0.40	0.45	0.05	BDL	0.64	0.70	0.82
SO_4^2-(mg/l)	38.4	20.0	19.8	19.6	12.1	11.8	11.5	10.8
PO_4^3- (mg/l)	3.40	1.22	1.20	1.15	0.10	0.08	0.03	BDL
TOC (mg/l)	7.40	BDL	6.50	5.20	4.50	4.40	4.20	4.00
BOD (mg/l)	6.20	4.05	4.02	4.00	1.50	1.30	1.20	0.98
COD (mg/l)	15.0	BDC	12.0	11.8	11.0	10.8	9.60	8.40
DO (mg/l)	12.0	4.50	4.10	3.60	7.70	6.70	5.40	3.40
T. coliform cfu, 100ml	0.00	0.00	100	120	140	170	100	200
E.coli cfu/100ml.	0.00	0.00	150	100	140	200	150	180

TAB LE 18: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 43 '58" N, 6^0 44 '48''E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOMBER
PARAMETERS								
pH	7.70	7.20	7.40	7.50	7.80	7.60	7.70	7.80
TEMP. (^{0}C)	32.0	31.0	32.0	32.0	31.0	31.0	31.0	31.0
COLOUR(Pt-Co)	87.0	126	125	128	517	520	524	520
COND.µS/CM	90.4	79.2	78.6	77.4	76.8	75.3	74.0	72.0
TDS (mg/l)	57.2	47.5	46.4	46.2	46.1	45.8	45.3	45.1
TSS (mg/l)	67.0	84.5	83.7	82.8	142	143	145	146
TS (mg/l)	124	132	130	129	188	189	190	191
TURB.(NTU)	18.2	21.5	23.8	40.6	126	128	130	131
Na (mg/l)	61.0	60.0	50.8	40.3	3.40	3.20	3.10	2.80
K (mg/l)	4.00	3.00	3.00	2.83	2.70	2.68	2.60	2.54
Ca^{2+}(mg/l)	4.70	4.81	4.78	4.80	4.81	4.70	4.65	4.50
Mg^{2+}(mg/l)	18.0	17.6	17.4	16.2	3.90	3.82	3.75	3.69
T.hardness (mg/l)	134	84.0	83.7	83.0	28.0	27.8	27.7	27.2
CaH (as mg /l $CaCO_3$)	10.0	12.0	23.7	29.5	12.0	12.2	12.4	12.2
MgH (as mg /l $CaCO_3$)	124	72.0	60.0	54.0	16.0	15.6	15.2	15.0
T Alkalinity (as mg/l $CaCO_3$)	30.0	22.5	22.7	22.9	20.0	20.0	19.8	19.4
Cl^- (mg/l)	20.0	21.0	21.2	19.4	4.76	4.50	4.20	4.10
F^- (mg/l)	0.98	0.87	0.85	0.80	0.23	0.21	0.19	0.15
NO^-_3 (mg/l as NO_3)	50.0	BDL	BDL	1.00	1.30	1.27	1.25	1.20
NO_2 (mg/l as NO_3)	BDL	0.06	0.04	0.04	0.02	0.01	0.01	BDL
NH_3 (mg/l)	1.30	1.10	1.15	1.19	BDL	1.20	1.26	1.30
SO_4^{2}-(mg/l)	34.4	19.7	19.5	19.0	7.45	7.30	7.20	7.15
PO_4^{3}- (mg/l)	1.77	2.26	2.22	2.20	0.10	0.09	0.08	0.04
TOC (mg/l)	6.80	7.20	6.50	6.25	4.20	4.10	3.80	3.50
BOD (mg/l)	6.30	2.55	2.50	2.40	1.20	1.10	1.00	0.95
COD (mg/l)	17.0	BDL	15.0	14.8	7.00	6.80	6.50	6.10
DO (mg/l)	11.5	4.60	4.40	4.20	7.60	6.80	5.00	4.50
T. coliform cfu, 100ml	100	100	200	210	240	300	250	200
E.coli cfu/100ml.	100	100	150	180	240	150	200	100

TAB LE 19: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 43 ‘26N, 6^0 44 ‘44’’E

PARAMETERS	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOMBER
pH	7.60	7.10	7.40	7.50	7.90	7.70	7.80	7.50
TEMP. (^{0}C)	310	31.0	31.0	31.0	31.0	32.0	31.0	32.0
COLOUR(Pt-Co)	128	147	210	230	550	560	580	585
COND.µS/CM	76.0	74.4	73.8	73.5	77.0	76.0	74.5	73.8
TDS (mg/l)	41.4	44.7	44.6	44.3	40.2	38.6	38.4	38.0
TSS (mg/l)	100	81.3	86.4	88.2	370	372	375	378
TS (mg/l)	141	125	131	133	416	411	413	416
TURB.(NTU)	19.4	20.9	35.6	40	141	146	152	160
Na (mg/l)	56.0	57.0	55.0	50.4	3.50	3.20	3.10	2.90
K (mg/l)	2.98	2.10	2.10	1.90	2.70	2.60	2.55	2.40
Ca^{2+}(mg/l)	6.50	6.47	6.44	6.43	6.41	6.30	6.20	619
Mg^{2+}(mg/l)	15.0	10.7	10.5	9.80	2.44	2.20	2.00	1.89
T.hardness (mg/l)	123	60.0	54.0	50.0	26.0	25.3	25.1	24.8
CaH (as mg /l $CaCO_3$)	12.0	16.0	16.0	15.8	16.0	15.7	15.5	15.1
MgH (as mg /l $CaCO_3$)	111	44.0	38..0	34.2	10.0	9.60	9.60	9.70
T Alkalinity (as mg/l $CaCO_3$)	22.0	22.5	23.0	25.0	31.5	28.7	28.5	27.8
Cl^- (mg/l)	16.0	15.0	15.0	13.60	4.76	4.50	4.20	3.90
F^- (mg/l)	0.87	0.63	0.60	0.58	0.05	0.02	0.01	BDL
NO^-_3 (mg/l as NO_3)	0.40	BDL	0.35	0.30	BDL	0.28	0.30	0.27
NO_2 (mg/l as NO_3)	BDL	0.06	0.40	0.03	0.01	0.01	BDL	0.01
NH_3 (mg/l)	1.25	BDL	1.40	1.45	BDL	1.50	1.52	1.58
$SO_4{}^2$-(mg/l)	25.6	25.7	24.8	24.5	8.82	7.50	7.20	700
$PO_4{}^3$- (mg/l)	0.76	1.40	0.90	0.84	0.07	0.05	0.02	0.01
TOC (mg/l)	5.64	BDL	5.60	5.50	5.02	5.01	4.86	4.50
BOD (mg/l)	3.15	3.90	3.60	3.50	1.30	1.20	1.15	1.00
COD (mg/l)	BDL	BDL	8.60	10.50	10.0	9.80	9.50	9.20
DO (mg/l)	13.5	5.2	6.80	6.50	7.70	7.50	7.30	6.80
T. coliform cfu, 100ml	0.00	0.00	100	180	260	300	200	150
E.coli cfu/100ml.	0.00	0.00	120	140	60	150	100	100

TAB LE 20: Physico-Chemicaland Microbial Analyses Results in Water (2014) Location: 7^0 43 ‘48”N, 6^0 44 ‘38’’ E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOMBER
PARAMETERS								
pH	7.90	7.20	7.40	7.50	7.70	7.60	740	7.70
TEMP. (^{0}C)	32.0	31.0	31.0	31.0	31.0	32.0	32.0	32.0
COLOUR(Pt-Co)	149	157	167	190	549	450	556	56.0
COND.µS/CM	78.2	90	80	70.5	58.3	56.7	55.0	50.8
TDS (mg/l)	48.2	54.4	40.8	40.5	35.0	34.8	33.5	32.7
TSS (mg/l)	95.0	59.6	60.8	70.8	545	548	550	552
TS (mg/l)	143	114	102	111	580	583	584	585
TURB.(NTU)	34.5	29.0	35.8	39.7	432	430	443	445
Na (mg/l)	70.0	69.0	40.8	30.4	2.80	2.50	2.41	2.30
K (mg/l)	2.80	2.40	2.40	2.30	2.20	2.15	2.10	2.00
Ca^{2+}(mg/l)	6.84	6.41	6.30	6.32	7.21	7.20	6.80	6.65
Mg^{2+}(mg/l)	20.0	19.5	15.0	14.8	0.98	0.94	0.88	0.70
`T.hardness (mg/l)	91.0	96.0	98.0	98.8	22.0	21.8	20.4	20.4
CaH (as mg /l $CaCO_3$)	13.0	16.0	15.0	17.5	18.0	17.8	17.5	17.4
MgH (as mg /l $CaCO_3$)	78.0	80.0	83.0	81.3	4.00	4.00	2.90	3.0
T Alkalinity (as mg/l $CaCO_3$)	17.0	30.0	29.8	29.5	28.4	28.2	27.8	27.5
Cl^- (mg/l)	25.0	18.0	17.8	16.4	8.57	8.20	7.95	7.50
F^- (mg/l)	0.88	0.84	0.70	0.68	0.25	0.223	0.21	0.20
NO^-_3 (mg/l as NO_3)	BDL	BDL	BDL	1.80	1.80	1.75	1.62	1.50
NO_2 (mg/l as NO_3)	BDL	0.06	0.04	0.02	0.01	0.01	BDL	BDL
NH_3 (mg/l)	0.96	BDL	1.20	1.52	BDL	1.60	1.70	1.87
$SO_4{}^2$-(mg/l)	13.2	25.2	24.0	23.5	20.0	19.2	8.4	18.2
$PO_4{}^3$- (mg/l)	0.89	1.71	1.50	0.90	0.31	0.30	0.28	0.20
TOC (mg/l)	2.40	2.40	2.50	2.70	4.20	4.18	4.15	4.00
BOD (mg/l)	3.20	5.10	4.80	4.20	1.10	1.08	1.60	BDL
COD (mg/l)	BDL	BDL	20.8	22.5	24.0	23.8	22.7	22.5
DO (mg/l)	10.9	5.8	6.8	7.50	7.60	7.50	2.20	710
T. coliform cfu, 100ml	50	50	100	150	2600	2650	800	500
E.coli cfu/100ml.	0	0	200	200	2440	2,500	1000	800

TAB LE 21: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 46 '10"N, 6^0 44 '27''E

PARAMETERS	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOMBER
pH	7.30	7.20	7.40	750	7.80	7.70	7.80	7.70
TEMP. (^{0}C)	32.0	32.0	32.0	320	31.0	31.0	31.0	3.10
COLOUR(Pt-Co)	160	177	190	220	1375	1380	1400	1410
COND.µS/CM	90.6	88.2	86.4	85.0	76.6	76.0	75.5	74.8
TDS (mg/l)	34.7	52.9	51.4	50.0	45.9	45.5	45.0	43.2
TSS (mg/l)	83.7	49.1	50.2	50.8	134	135	137	140
TS (mg/l)	118	102	102	101	180	183	182	183
TURB.(NTU)	23.5	26.1	29.0	30.8	179	180	187	190
Na (mg/l)	58.4	57.0	56.0	50.8	3.40	3.20	3.10	2.80
K (mg/l)	4.20	3.30	3.28	3.25	2.70	2.50	2.40	2.10
Ca^{2+}(mg/l)	6.20	6.41	6.40	6.30	6.41	6.20	6.10	6.00
Mg^{2+}(mg/l)	10.4	10.7	10.5	10.1	1.46	1.40	1.30	1.20
T.hardness (mg/l)	86.0	60.0	55.0	40.8	22.0	21.8	20.7	20.5
CaH (as mg /l $CaCO_3$)	10.0	16.0	16.2	16.3	16.0	15.8	15.5	15.0
MgH (as mg /l $CaCO_3$)	76.0	44.0	38.8	24.5	6.00	6.00	5.20	5.50
T Alkalinity (as mg/l $CaCO_3$)	15.0	7.50	6.50	6.80	36.8	30.6	30.5	29.5
Cl^- (mg/l)	14.0	21.0	15.5	142	8.57	7.60	7.20	7.10
F^- (mg/l)	0.56	0.42	0.38	0.35	0.12	0.10	0.08	0.05
NO^-_3 (mg/l as NO_3)	BDL	BDL	BDL	BDL	0.80	0.70	0.65	0.50
NO_2 (mg/l as NO_3)	BDL	0.06	0.05	0.05	0.01	0.01	BDL	0.01
NH_3 (mg/l)	0.87	0.04	0.60	0.80	BDL	01.00	1.50	1.55
SO_4^2-(mg/l)	11.6	26.	20.8	20.5	11.3	11.0	10.8	10.5
PO_4^3- (mg/l)	0.08	3.00	2.64	2.50	0.14	0.12	0.10	0.08
TOC (mg/l)	3.60	BDL	3.40	3.20	3.80	3.50	3.20	3.00
BOD (mg/l)	4.80	2.40	2.20	2.10	1.30	1.20	1.15	1.00
COD (mg/l)	BDL	BDL	18.0	15.0	12.0	10.0	8.00	6.00
DO (mg/l)	14.6	7.00	7.00	8.30	7.90	7.80	7.70	7.50
T. coliform cfu, 100ml	850	850	1000	100	220	250	100	100
E.coli cfu/100ml.	0.00	0.00	200	50.0	60.0	200	50.0	100

TAB LE 22: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 46 '45"N, 6^0 44 '18''E

PARAMETERS	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
pH	7.90	7.40	7.50	7.40	7. 60	7. 70	7.80	7.90
TEMP. (^{0}C)	32.0	32.0	32.0	32.0	31	31.0	31.0	32.0
COLOUR(Pt-Co)	67.0	129	130	136	525	528	530	536
COND.µS/CM	89.4	46.5	48.0	50.6	79.3	76.8	76.5	758
TDS (mg/l)	48.2	23.9	30.5	31.4	47.3	47.0	46.8	46.0
TSS (mg/l)	121	84.1	89.5	89.8	196	189	179	202
TS (mg/l)	169	108	120	121	244	245	246	248
TURB.(NTU)	34.6	26.6	30.0	38.0	127	128	131	135
Na (mg/l)	54.0	51.0	40.0	38.0	3.50	3.20	3.10	3.00
K (mg/l)	2.48	2.40	2.38	2.30	2.80	2. 70	2.50	2.20
Ca^{2+}(mg/l)	4.90	4.81	4.80	4. 78	5.61	5.60	5.45	5.20
Mg^{2+}(mg/l)	14.8	14.6	14.5	14.3	2.93	2.90	2.80	2.78
T.hardness (mg/l)	99.0	72.0	50.0	48.5	26.0	26.0	25.5	25.2
CaH (as mg /l $CaCO_3$)	11.0	12.0	13.5	13.3	14.0	13.5	13.2	12.8
MgH (as mg /l $CaCO_3$)	89.0	60.0	36.5	35.3	12.0	12.5	12.3	12.4
T Alkalinity (as mg/l $CaCO_3$)	18.5	37.5	37.2	37.0	31.5	31.3	30.8	30.5
Cl^- (mg/l)	15.0	21.0	19.6	19.2	6.66	6.50	6.30	6.00
F^- (mg/l)	0.67	0. 75	0.68	0.65	0.01	0.01	BDL	BDL
NO^-_3 (mg/l as NO_3)	BDL	BDL	2.01	1.89	1.20	1.18	1.15	1.00
NO_2 (mg/l as NO_3)	0.02	0.04	BDL	BDL	0.02	0.01	0.01	0.01
NH_3 (mg/l)	0.98	BDL	1.00	1.10	BDL	1.12	1.15	1.70
SO_4^2-(mg/l)	20.8	20. 7	20.0	20.2	9.61	9.50	9.20	9.10
PO_4^3- (mg/l)	0.46	1. 77	1. 70	1.65	0.19	0.17	0.15	0.10
TOC (mg/l)	BDL	4.80	4. 70	4.50	4.60	4.40	4.20	4.00
BOD (mg/l)	4.80	3.45	4.42	3.41	1.40	1.38	1.35	1.30
COD (mg/l)	BDL	BDL	6.00	5.00	9.00	8.80	8.50	8.20
DO (mg/l)	14.8	6. 70	6.50	6.30	7.90	7.60	7.50	7.30
T. coliform cfu, 100ml	0.00	0.00	100	150	220	310	280	250
E.coli cfu/100ml.	0.00	0.00	500	100	220	200	150	150

TABLE 23: Physico-Chemical and Microbial Analyses ResultS in Water (2014) Location: 7^0 47' 52''N, 6^0 44' 36'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PARAMETERS:								
pH	7.30	7.20	7.40	7.50	7.80	7.70	7.80	7.70
TEMP. (^{0}C)	32.0	32.0	32.0	32.0	31.0	31.0	31.0	31.0
COLOUR(Pt-Co)	160	177	190	220	1375	1380	1400	1410
COND.µS/CM	90.6	88.2	86.4	85.0	76.6	76.0	75.5	74.8
TDS (mg/l)	34.7	52.9	51.4	50.0	45.9	45.5	45.0	43.2
TSS (mg/l)	83.7	49.1	50.2	50.8	134	135	137	140
TS (mg/l)	118	102	102	101	180	183	182	183
TURB.(NTU)	23.5	26.1	29.0	30.8	179	180	187	190
Na (mg/l)	58.4	57.0	56.0	50.8	3.40	3.20	3.10	2.80
K (mg/l)	4.20	3.30	3.28	3.25	2.70	2.50	2.40	2.10
Ca^{2+}(mg/l)	6.20	6.41	6.40	6.30	6.41	6.20	6.10	6.00
Mg^{2+}(mg/l)	10.4	10.7	10.5	10.1	1.46	1.40	1.30	1.20
T.hardness (mg/l)	86.0	60.0	55.0	40.8	22.0	21.8	20.7	20.5
CaH (as mg /l $CaCO_3$)	10.0	16.0	16.2	16.3	16.0	15.8	15.5	15.0
MgH (as mg /l $CaCO_3$)	76.0	44.0	38.8	24.5	6.00	6.00	5.20	5.50
T Alkalinity (as mg/l $CaCO_3$)	15.0	7.50	6.50	6.80	36.8	30.6	30.5	29.5
Cl^- (mg/l)	14.0	21.0	15.5	14.2	8.57	7.60	7.20	7.10
F^- (mg/l)	0.56	0.42	0.38	0.35	0.12	0.10	0.08	0.05
NO^-_3 (mg/l as NO_3)	BDL	BDL	BDL	BDL	0.80	0.70	0.65	0.50
NO_2 (mg/l as NO_3)	BDL	0.06	0.05	0.05	0.01	0.01	BDL	0.01
NH_3 (mg/l)	0.87	0.40	0.60	0.80	BDL	01.00	1.50	1.55
SO_4^2-(mg/l)	11.6	26.7	20.8	20.5	11.3	11.0	10.8	10.5
PO_4^3- (mg/l)	0.08	3.00	2.64	2.50	0.14	0.12	0.10	0.08
TOC (mg/l)	7.40	2.40	2.46	2.50	4.20	4.10	3.90	3.80
BOD (mg/l)	4.80	2.40	2.20	2.10	1.30	1.20	1.15	1.00
COD (mg/l)	BDL	BDL	18.0	15.0	12.0	10.0	8.00	6.00
DO (mg/l)	14.6	7.00	7.00	8.30	7.90	7.80	7.70	7.50
T. coliform cfu, 100ml	850	850	1000	100	220	250	100	100
E.coli cfu/100ml.	0.00	0.00	200	50.0	60.0	200	50.0	100

TABLE 24: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 48’ 36’’N, 6^0 44’ 57’’ E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	7.90	7.40	7.50	7.40	7.60	7.70	7.80	7.90
TEMP. (^{0}C)	32.0	32.0	32.0	32.0	31.0	31.0	31.0	32.0
COLOUR(Pt-Co)	67.0	129	130	136	525	528	530	536
COND.µS/CM	89.4	46.5	48.0	50.6	79.3	76.8	76.5	75.9
TDS (mg/l)	48.2	23.9	30.5	31.4	47.3	47.0	46.8	46.0
TSS (mg/l)	121	84.1	89.5	89.8	196	198	199	202
TS (mg/l)	169	108	120	121	244	245	246	248
TURB.(NTU)	34.6	26.6	30.0	38.0	127	128	131	135
Na (mg/l)	54.0	57.0	40.0	38.0	3.50	3.20	3.10	3.00
K (mg/l)	2.48	2.40	2.38	2.30	2.80	2.70	2.50	2.20
Ca^{2+}(mg/l)	4.90	4.81	4.80	4.78	5.61	5.60	5.45	5.20
Mg^{2+}(mg/l)	14.8	14.6	14.5	14.3	2.93	2.90	2.80	2.78
T.hardness (mg/l)	99.0	72.0	50.0	48.5	26.0	26.0	25.5	25.2
CaH (as mg /l $CaCO_3$)	11.0	12.0	13.5	13.2	14.0	13.5	13.2	12.8
MgH (as mg /l $CaCO_3$)	89.0	60.0	36.5	35.3	12.0	12.5	12.3	12.4
T Alkalinity (as mg/l $CaCO_3$)	18.5	37.5	87.2	37.0	31.5	31.3	30.8	30.5
Cl^- (mg/l)	15.0	21.0	19.6	19.2	6.66	6.50	6.30	6.00
F^- (mg/l)	0.67	0.75	2.68	0.65	0.01	0.01	BDL	BDL
NO^-_3 (mg/l as NO_3)	BDL	BDL	2.01	1.89	1.20	1.18	1.15	1.00
NO_2 (mg/l as NO_3)	0.02	0.04	BDL	BDL	0.02	0.01	0.01	0.01
NH_3 (mg/l)	0.98	BDL	1.00	1.10	BDL	1.12	1.15	1.70
SO_4^{2}-(mg/l)	20.8	20.7	20.5	20.2	9.61	9.50	9.20	9.10
PO_4^{3}- (mg/l)	0.46	1.77	1.70	1.65	0.19	0.17	0.15	0.10
TOC (mg/l)	BDL	4.80	4.70	4.50	4.60	4.40	4.20	4.00
BOD (mg/l)	4.80	3.45	3.42	3.41	1.40	1.38	1.35	1.30
COD (mg/l)	BDL	BDL	6.00	5.00	9.00	8.80	8.50	8.20
DO (mg/l)	14.8	6.70	6.50	6.30	7.90	7.60	7.50	7.30
T. coliform cfu, 100ml	0.00	0.00	100	150	220	310	280	250
E.coli cfu/100ml.	0.00	0.00	500	100	220	200	150	150

TABLE 25: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 49' 2''N, 6^0 44' 57'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	7.80	7.40	7.60	7.50	7.30	7.40	7.50	7.40
TEMP. (^{0}C)	32.0	31.0	31.0	31.0	31.0	32.0	32.0	32.0
COLOUR(Pt-Co)	345	388	400	450	489	490	495	498
COND.μS/CM	84.5	83.7	83.5	83.0	77.6	76.8	76.5	76.1
TDS (mg/l)	32.7	50.2	49.5	49.1	46.6	46.0	45.8	45.5
TSS (mg/l)	112	57.8	89.0	58.2	57.4	57.6	57.8	58.3
TS (mg/l)	145	108	108	107	104	104	104	104
TURB.(NTU)	26.3	34.4	35.0	37.0	129	130	133	135
Na (mg/l)	64.0	63.0	60.2	56.7	3.50	3.48	3.45	3.40
K (mg/l)	3.00	2.40	2.40	2.40	2.80	2.60	2.20	1.80
Ca^{2+}(mg/l)	6.20	6.41	6.40	6.38	6.41	6.38	6.35	6.30
Mg^{2+}(mg/l)	35.0	39.0	36.0	35.0	1.95	1.60	1.54	1.52
T.hardness (mg/l)	33.0	176	175	170	24.0	22.0	21.8	20.5
CaH (as mg /l $CaCO_3$)	10.0	16.0	15.8	15.9	16.0	15.9	15.7	15.5
MgH (as mg /l $CaCO_3$)	23.0	160	159	154	8.00	6.10	6.10	5.10
T Alkalinity (as mg/l $CaCO_3$)	30.0	30.0	82.6	26.8	25.2	25.0	24.5	23.8
Cl^- (mg/l)	13.0	40.0	37.0	28.5	4.76	4.52	4.50	4.20
F^- (mg/l)	0.58	0.16	0.14	0.12	1.60	1.53	1.46	1.20
NO^-_3 (mg/l as NO_3)	BDL	BDL	3.50	3.6	3.20	3.15	3.10	2.80
NO_2 (mg/l as NO_3)	0.08	0.04	BDL	BDL	0.04	0.03	0.02	0.01
NH_3 (mg/l)	0.89	1.96	2.50	2.60	BDL	2.80	2.95	3.20
SO_4^{2}-(mg/l)	26.6	36.2	20.8	20.5	6.00	6.00	5.48	5.20
PO_4^{3}- (mg/l)	0.13	0.73	0.58	0.48	0.19	0.16	0.14	0.10
TOC (mg/l)	BDL	BDL	5.20	6.80	7.20	7.10	6.91	6.50
BOD (mg/l)	21.40	5.40	4.80	4.50	1.70	1.65	1.60	1.58
COD (mg/l)	11.0	BDL	14.1	14.0	13.0	12.50	12.20	12.10
DO (mg/l)	17.5	14.8	12.5	11.20	7.90	7.60	7.50	7.20
T. coliform cfu, 100ml	50.0	0.00	100	100	60.0	80.0	100	50.0
E.coli cfu/100ml.	0.00	0.00	50.0	100	60.0	50.0	150	100

TABLE 26: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 49' 47''N, 6^0 45' 0'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	7.70	7.50	7.80	7.60	7.10	7.50	7.80	7.70
TEMP. (^{0}C)	31.0	31.0	31.0	31.0	32.0	32.0	32.0	32.0
COLOUR(Pt-Co)	351	388	390	420	1375	1380	1400	1410
COND.µS/CM	92.3	83.7	80.5	70.7	57.8	57.5	57.0	56.5
TDS (mg/l)	46.5	50.2	46.8	45.2	34.5	34.5	33.0	32.5
TSS (mg/l)	132	57.8	59.6	60.4	233	235	238	242
TS (mg/l)	145	108	106	107	268	270	272	275
TURB.(NTU)	25.9	34.4	36.2	38.7	302	310	315	320
Na (mg/l)	62.0	63.0	60.2	60.5	2.90	2.50	2.30	2.00
K (mg/l)	2.45	2.40	2.30	2.10	2.40	2.30	2.10	1.89
Ca^{2+}(mg/l)	6.80	6.41	5.40	5.10	4.81	4.50	4.48	4.20
Mg^{2+}(mg/l)	2.00	1.95	2.00	2.50	3.90	3.80	3.50	3.10
T.hardness (mg/l)	141	24.0	26.0	27.0	28.0	27.0	26.5	25.4
CaH (as mg /l $CaCO_3$)	9.0	16.0	15.8	13.4	12.0	10.9	10.5	10.2
MgH (as mg /l $CaCO_3$)	132	8.00	10.2	13.6	16.0	16.1	16.0	15.2
T Alkalinity (as mg/l $CaCO_3$)	32.5	37.5	37.2	37.0	31.5	30.8	30.5	30.1
Cl^- (mg/l)	14.0	21.0	18.0	15.0	5.71	4.80	4.50	4.10
F^- (mg/l)	0.89	0.42	0.410	0.40	0.05	0.05	0.04	0.02
NO^-_3 (mg/l as NO_3)	BDL	BDL	2.90	2.81	2.50	2.48	2.45	2.40
NO_2 (mg/l as NO_3)	0.04	0.03	0.02	0.02	0.02	0.01	0.01	BDL
NH_3 (mg/l)	0.67	7.15	0.95	0.80	0.72	1.58	1.69	1.70
$SO_4{}^2$-(mg/l)	25.2	26.9	26.5	26.1	7.10	7.00	6.53	6.40
$PO_4{}^3$- (mg/l)	0.13	0.86	0.81	0.78	0.40	0.35	0.28	0.25
TOC (mg/l)	4.80	BDL	BDL	4.60	6.90	6.50	6.30	6.10
BOD (mg/l)	4.60	3.90	3.70	3.50	0.80	0.70	0.75	0.70
COD (mg/l)	10.0	BDL	9.00	8.70	8.00	7.80	7.50	7.20
DO (mg/l)	13.4	5.30	5.80	5.70	7.80	7.50	7.42	7.35
T. coliform cfu, 100ml	0.00	0.00	80.0	100	380	250	295	300
E.coli cfu/100ml.	0.00	0.00	50.0	150	320	200	300	150

TABLE 27: Physico-Chemical and Microbial Analyses Results in Water (2014) Location:7^0 49’ 57” N, 6^0 45’ 48” E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PARAMETERS								
pH	7.80	7.40	7.80	7.70	7.30	7.80	7.60	7.70
TEMP. (^{0}C)	31.0	32.0	31.0	31.0	31.0	32.0	32.0	32.0
COLOUR(Pt-Co)	259	255	265	278	137.5	1380	1382	1385
COND.µS/CM	88.0	90.9	88.5	88.1	57.7	57.5	56.8	56.2
TDS (mg/l)	46.5	54.9	54.5	54.2	34.6	34.2	33.8	33.5
TSS (mg/l)	108	113	118	120	313	317	320	325
TS (mg/l)	155	168	173	174	348	351	354	359
TURB.(NTU)	21.4	20.5	30.6	35.7	359	361	365	370
Na (mg/l)	61.0	60.0	50.0	40.3	2.70	2.50	2.48	2.40
K (mg/l)	3.20	3.00	3.00	2.88	2.40	2.31	2.20	2.10
Ca^{2+}(mg/l)	4.80	4.81	4.75	4.70	5.61	5.10	4.80	4.30
Mg^{2+}(mg/l)	25.0	20.5	20.1	19.2	1.46	1.30	1.25	1.19
T.hardness (mg/l)	112	96.0	80.5	50.6	20.0	20.0	18.6	17.6
CaH (as mg /l $CaCO_3$)	8.00	12.0	10.4	9.60	14.0	13.2	0.3	9.60
MgH (as mg /l $CaCO_3$)	104	84.0	70.1	41.0	6.00	6.80	8.30	8.00
T Alkalinity (as mg/l $CaCO_3$)	16.5	30.0	28.2	27.5	24.2	23.6	22.4	20.5
Cl^- (mg/l)	16.0	36.0	31.4	30.5	9.52	8.60	8.20	7.81
F^- (mg/l)	0.47	1.68	0.98	0.80	0.10	0.10	BDL	BDL
NO^-_3 (mg/l as NO_3)	BDL	BDL	5.20	4.10	2.30	2.10	1.98	1.80
NO_2 (mg/l as NO_3)	0.08	BDL	0.05	0.04	BDL	0.04	0.03	0.02
NH_3 (mg/l)	1.31	BDL	1.28	1.20	0.64	0.60	0.57	0.52
SO_4^2-(mg/l)	19.7	39.4	30.3	20.7	4.38	4.20	4.10	3.70
PO_4^3- (mg/l)	0.06	3.24	2.60	2.10	0.37	0.30	0.28	0.20
TOC (mg/l)	6.40	4.80	4.90	5.00	7.00	5.00	4.80	4.10
BOD (mg/l)	3.15	6.60	6.20	2.10	0.37	0.30	0.28	0.26
COD (mg/l)	12.0	BDL	8.70	9.80	12.0	10.8	10.4	10.2
DO (mg/l)	22.3	5.80	5.40	5.10	7.40	6.50	5.40	4.60
T. coliform cfu, 100ml	100	100	200	150	140	150	200	250
E.coli cfu/100ml.	50.0	100	100	100	120	130	150	200

TABLE 28: Physico-Chemicaland Microbial Analyses Results in Water (2014) Location: 7^0 50’ 14” N, 6^0 44’ 55” E

PARAMETERS	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
pH	7.60	7.60	7.70	7.60	7.90	7.80	7.90	7.80
TEMP. (^{0}C)	31.0	32.0	31.0	31.0	31.0	32.0	32.0	32.0
COLOUR(Pt-Co)	332	540	555	560	1245	1250	1265	1268
COND.µS/CM	45.5	88.5	60.8	70.5	57.6	50.8	50.5	49.6
TDS (mg/l)	47.8	53.1	52.4	51.8	34.5	34.3	33.8	33.5
TSS (mg/l)	134	30.9	40.2	48.0	334	340	345	348
TS (mg/l)	182	84.0	92.6	99.8	368	374	379	382
TURB.(NTU)	35.0	22.1	28.5	40.2	316	318	320	325
Na (mg/l)	62.0	60.0	50.2	48.4	2.70	2.50	2.30	2.00
K (mg/l)	3.00	2.70	2.60	2.48	2.40	2.30	2.10	1.82
Ca^{2+}(mg/l)	6.50	6.41	6.20	6.10	5.61	5.40	4.30	3.80
Mg^{2+}(mg/l)	25.0	22.4	20.40	19.8	1.95	1.70	1.65	1.50
T.hardness (mg/l)	119	72.0	60.8	50.5	22.0	21.5	20.6	19.8
CaH (as mg /l $CaCO_3$)	10.0	16.0	15.8	15.0	14.0	13.8	12.2	10.8
MgH (as mg /l $CaCO_3$)	109	56.0	45.0	35.5	8.00	7.80	8.40	9.00
T Alkalinity (as mg/l $CaCO_3$)	18.5	30.0	25.0	27.0	23.1	22.1	20.3	20.2
Cl^- (mg/l)	24.0	24.0	20.4	19.8	7.62	7.50	6.30	5.30
F^- (mg/l)	0.34	0.78	0.64	0.58	0.24	0.23	0.20	0.18
NO^-_3 (mg/l as NO_3)	3.80	3.90	3.60	3.40	2.10	2.10	2.00	1.94
NO_2 (mg/l as NO_3)	0.02	0.03	0.03	0.02	0.01	0.01	0.10	0.01
NH_3 (mg/l)	1.32	0.36	0.32	0.30	0.53	0.60	0.70	0.91
SO_4^{2}-(mg/l)	21.6	25.4	24.8	23.5	8.46	8.20	7.80	7.50
PO_4^{3}- (mg/l)	0.08	0.40	0.30	0.10	0.37	0.30	0.27	0.18
TOC (mg/l)	7.20	BDL	7.80	7.50	7.40	7.20	7.10	6.40
BOD (mg/l)	3.25	3.00	3.00	3.00	0.70	0.60	0.57	0.48
COD (mg/l)	BDL	BDL	15.0	14.8	13.0	12.8	12.5	12.2
DO (mg/l)	21.3	7.20	7.80	7.60	7.50	7.30	7.10	7.00
T. coliform cfu, 100ml	200	250	100	100	20.0	50.0	80.0	100
E.coli cfu/100ml.	100	0.00	150	100	20.0	50.0	100	150

TABLE 29: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 50' 42''N, 6^0 45' 6'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	7.60	7.50	7.60	7.80	8.00	8.10	8.00	7.90
TEMP. (^{0}C)	32.0	32.0	32.0	32.0	31.0	31.0	31.0	31.0
COLOUR(Pt-Co)	380	354	350	348	508	510	512	515
COND.µS/CM	73.2	77.9	80.0	76.8	77.6	78.6	79.8	80.2
TDS (mg/l)	57.2	52.0	51.8	50.4	46.6	45.3	45.1	44.8
TSS (mg/l)	125	74.0	73.8	72.4	55.4	60.8	62.5	63.2
TS (mg/l)	182	126	126	123	102	106	106	108
TURB.(NTU)	23.4	27.6	27.8	30.7	124	125	120	115
Na (mg/l)	47.0	45.0	42.8	41.6	3.40	3.20	2.80	2.50
K (mg/l)	4.20	3.30	3.10	3.00	2.80	2.40	2.10	2.00
Ca^{2+}(mg/l)	4.84	4.81	4.50	4.40	8.02	8.00	7.60	5.60
Mg^{2+}(mg/l)	3.00	2.93	2.75	2.60	1.95	1.80	1.60	1.40
T.hardness (mg/l)	132	24.0	23.9	24.0	28.0	29.7	30.4	35.2
CaH (as mg /l $CaCO_3$)	9.0	12.0	12.8	13.5	20.0	21.3	21.8	22.4
MgH (as mg /l $CaCO_3$)	123	12.0	11.1	10.6	8.00	8.40	8.60	12.8
T Alkalinity (as mg/l $CaCO_3$)	24.5	30.0	31.0	31.8	32.6	33.4	34.6	34.8
Cl^- (mg/l)	25.0	30.0	31.8	31.9	7.62	7.60	7.52	7.40
F^- (mg/l)	0.64	0.75	0.74	0.73	0.23	0.22	0.19	0.15
NO^-_3 (mg/l as NO_3)	2.5	BDL	1.30	1.40	1.70	1.65	1.60	1.54
NO_2 (mg/l as NO_3)	0.03	BDL	0.03	0.04	0.04	0.03	0.02	0.01
NH_3 (mg/l)	1.28	1.02	0.98	0.90	0.97	0.98	1.10	1.20
SO_4^{2}-(mg/l)	28.3	12.1	11.40	10.8	6.39	6.20	6.00	5.89
PO_4^{3}- (mg/l)	2.28	1.65	1.60	1.55	0.18	0.17	0.15	0.14
TOC (mg/l)	4.20	BDL	4.10	4.50	7.20	7.10	6.90	6.50
BOD (mg/l)	2.40	2.70	2.65	2.60	1.10	1.00	0.97	0.80
COD (mg/l)	BLD	BDL	10.8	11.8	12.0	11.00	10.8	10.5
DO (mg/l)	12.6	3.80	4.20	4.50	8.10	7.60	7.40	7.20
T. coliform cfu, 100ml	300	700	200	150	40	40	50	100
E.coli cfu/100ml.	20.0	200	150	100	20	20	20	50

TABLE 30: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 50’ 53’’N, 6^0 45’ 20’’ E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	7.40	7.40	7.50	7.60	7.60	7.80	8.10	8.10
TEMP. (^{0}C)	32.0	32.0	32.0	30.0	31.0	30.0	30.0	30.0
COLOUR(Pt-Co)	255	222	228	230	436	440	445	450
COND.µS/CM	25.3	72.0	73.0	75.0	77.8	78.4	78.5	79.0
TDS (mg/l)	43.4	43.1	42.8	42.5	46.7	46.5	46.2	46.0
TSS (mg/l)	56.9	30.9	42.3	44.0	65.3	66.8	67.0	68.2
TS (mg/l)	100	74.0	85.1	86.5	112	113	113	114
TURB.(NTU)	31.2	21.8	23.0	25.0	124	125	128	132
Na (mg/l)	35.0	36.0	28.5	27.3	3.50	3.30	3.20	3.05
K (mg/l)	2.80	2.40	2.30	2.10	2.80	2.68	2.64	2.50
Ca^{2+}(mg/l)	4.68	4.81	4.76	4.70	7.21	7.20	7.10	7.00
Mg^{2+}(mg/l)	15.0	14.6	13.2	11.1	1.95	1.88	1.50	1.30
T.hardness (mg/l)	136	72.0	71.0	68.4	26.0	25.8	25.6	25.2
CaH (as mg /l $CaCO_3$)	14.0	12.0	11.2	10.4	18.0	17.8	17.6	17.2
MgH (as mg /l $CaCO_3$)	122	60.0	59.8	58.0	8.00	8.00	8.00	8.00
T Alkalinity (as mg/l $CaCO_3$)	35.0	30.0	30.8	31.0	31.5	31.2	30.6	30.8
Cl^- (mg/l)	23.0	33.0	30.7	30.2	7.62	7.40	6.85	6.70
F^- (mg/l)	0.87	0.72	0.70	0.68	0.20	0.18	0.16	0.10
NO^-_3 (mg/l as NO_3)	4.60	BDL	4.30	4.10	2.30	2.10	1.96	1.87
NO_2 (mg/l as NO_3)	0.05	BDL	0.07	0.08	0.03	0.03	BDL	0.01
NH_3 (mg/l)	1.27	1.05	1.00	0.95	0.67	0.87	0.96	0.98
SO_4^2-(mg/l)	12.5	10.1	9.80	9.50	BDL	6.50	6.20	6.10
PO_4^3- (mg/l)	1.34	0.24	0.22	0.20	0.19	0.16	0.14	0.10
TOC (mg/l)	7.20	2.40	2.10	2.00	6.80	6.80	6.40	6.20
BOD (mg/l)	3.75	3.40	3.10	3.00	0.90	0.88	0.80	0.79
COD (mg/l)	10.0	BDL	11.8	11.40	10.0	9.80	9.60	9.40
DO (mg/l)	20.2	4.50	4.40	4.60	7.70	7.40	7.00	6.90
T. coliform cfu, 100ml	400	600	400	300	180	150	130	120
E.coli cfu/100ml.	200	150	100	150	20.0	30.0	50.0	60.0

TABLE 31: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 51' 13''N, 6^0 45' 32'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	7.40	7.40	7.50	7.60	7.80	7.90	8.00	7.90
TEMP. (^{0}C)	32.0	32.0	32.0	32.0	31	31.0	31.0	31.0
COLOUR(Pt-Co)	255	252	254	258	436	437	440	443
COND.μS/CM	25.3	14.4	15.8	16.4	57.6	58.2	60.3	64.1
TDS (mg/l)	43.4	7.17	7.40	7.60	34.6	32.0	31.0	30.4
TSS (mg/l)	56.9	66.8	68.4	68.6	353	355	358	361
TS (mg/l)	100	74.0	75.8	76.2	388	387	389	391
TURB.(NTU)	31.2	40.8	42.0	43.2	331	333	335	340
Na (mg/l)	35.0	36.0	38.0	34.0	2.80	2.80	2.40	2.10
K (mg/l)	3.20	2.40	2.10	2.20	2.30	2.00	1.82	1.60
Ca^{2+}(mg/l)	4.90	4.81	4.76	4.72	6.41	6.30	6.20	6.00
Mg^{2+}(mg/l)	20.0	11.7	11.50	11.20	1.46	1.42	1.40	1.38
T.hardness (mg/l)	136	60.0	60.0	53.4	22.0	20.8	19.6	19.2
CaH (as mg /l $CaCO_3$)	14.0	12.0	11.0	10.2	16.0	15.3	14.2	13.5
MgH (as mg /l $CaCO_3$)	122	48.0	49.0	43.2	6.00	5.50	5.40	5.70
T Alkalinity (as mg/l $CaCO_3$)	35.0	22.5	22.4	21.8	22.1	11.9	20.3	19.8
Cl^- (mg/l)	23.0	15.0	14.8	13.5	13.3	13.1	12.8	12.4
F^- (mg/l)	0.87	0.48	0.46	0.42	0.16	0.14	0.12	0.12
NO^-_3 (mg/l as NO_3)	4.60	1.80	1.90	1.96	2.50	2.40	2.30	2.10
NO_2 (mg/l as NO_3)	0.05	BDL	0.06	0.07	0.02	0.02	0.01	0.01
NH_3 (mg/l)	1.27	1.23	1.24	1.30	0.84	0.90	0.92	0.95
SO_4^{2}-(mg/l)	12.5	13.6	13.5	12.7	BDL	5.60	5.40	5.20
PO_4^{3}- (mg/l)	1.34	0.35	0.36	0.38	0.28	0.21	0.20	0.16
TOC (mg/l)	7.20	BDL	7.40	7.20	6.40	6.20	6.10	5.86
BOD (mg/l)	3.75	2.40	2.20	2.10	0.80	0.78	0.76	0.64
COD (mg/l)	10.0	BDL	9.60	8.70	4.00	3.50	3.40	3.10
DO (mg/l)	20.2	4.50	4.20	4.10	7.60	7.20	7.00	6.50
T. coliform cfu, 100ml	50.0	0.00	100	150	120	200	250	150
E.coli cfu/100ml.	50.0	0.00	50.0	50.0	40.0	100	100	50.0

TABLE 32: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 51' 29''N, 6^0 45' 36" E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	7.40	7.30	7.50	7.60	7.50	7.60	7.70	7.80
TEMP. (^{0}C)	32.0	32.0	32.0	32.0	31.0	31.0	31.0	31.0
COLOUR(Pt-Co)	248	282	283	295	1375	1380	1382	1385
COND.µS/CM	80.0	72.3	73.0	73.6	61.4	61.6	62.0	62.8
TDS (mg/l)	46.6	43.3	42.0	42.0	36.8	36.4	36.0	35.8
TSS (mg/l)	90.0	143	148	150	532	540	543	545
TS (mg/l)	137	138	191	192	572	576	579	581
TURB.(NTU)	36.6	33.4	35.8	36.0	296	298	300	302
Na (mg/l)	37.0	39.0	36.0	30.5	2.90	2.62	2.50	2.20
K (mg/l)	3.00	2.40	2.32	2.30	2.10	2.08	2.00	1.96
Ca^{2+}(mg/l)	3.40	3.21	3.18	3.16	5.61	5.40	5.20	5.10
Mg^{2+}(mg/l)	20.0	18.5	18.4	16.3	0.98	0.80	0.78	0.70
T.hardness (mg/l)	96.0	84.0	70.0	64.0	18.0	18.0	17.8	16.4
CaH (as mg /l $CaCO_3$)	15.0	8.00	7.60	7.00	14.0	13.8	12.9	12.5
MgH (as mg /l $CaCO_3$)	81.0	76.0	63.0	57.0	4.00	4.20	4.90	3.90
T Alkalinity (as mg/l $CaCO_3$)	35.5	22.5	23.0	24.6	24.2	23.8	23.6	23.0
Cl^- (mg/l)	34.0	30.0	28.2	27.6	7.62	7.50	7.38	7.20
F^- (mg/l)	0.78	0.30	0.20	0.40	0.09	0.06	0.04	0.01
NO^-_3 (mg/l as NO_3)	3.00	BDL	2.80	2.10	4.30	4.20	4.18	4.00
NO_2 (mg/l as NO_3)	0.03	BDL	0.02	0.01	0.01	0.01	BDL	0.01
NH_3 (mg/l)	0.54	1.34	1.40	1.45	1.76	1.80	1.86	1.90
SO_4^{2}-(mg/l)	13.8	21.9	20.1	19.5	BDL	18.6	18.2	18.0
PO_4^{3}- (mg/l)	1.98	0.06	0.05	0.06	0.12	0.10	0.08	0.04
TOC (mg/l)	6.80	4.80	4.70	4.30	6.60	6.70	6.50	6.20
BOD (mg/l)	2.40	3.30	3.20	3.00	21.6	21.2	20.4	20.1
COD (mg/l)	12.0	BDL	12.1	11.8	17.0	16.8	16.2	16.0
DO (mg/l)	14.3	4.6	4.40	4.10	1.20	1.10	1.00	0.96
T. coliform cfu, 100ml	50	0.00	100	50.0	180	100	250	150
E.coli cfu/100ml.	0.00	0.00	100	100	180	50.0	100	50.0

TABLE 33: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 51' 50''N, 6^0 45' 37'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	7.50	7.30	7.40	7.50	7.40	7.60	7.80	7.70
TEMP. (^{0}C)	32.0	32.0	32.0	32.0	31.0	31.0	31.0	31.0
COLOUR(Pt-Co)	134	615	620	650	549	580	585	588
COND.µS/CM	87.4	72.9	72.8	70.8	58.6	59.2	58.5	58.8
TDS (mg/l)	44.0	43.7	42.8	42.8	34.8	33.7	33.5	32.8
TSS (mg/l)	78.4	118	120	125	305	310	312	315
TS (mg/l)	122	162	163	168	340	344	346	348
TURB.(NTU)	23.2	33.6	34.0	35.6	345	348	350	352
Na (mg/l)	38.0	39.0	30.0	28.2	2.80	2.60	2.10	2.00
K (mg/l)	3.60	2.40	2.30	2.10	2.20	2.00	1.88	1.70
Ca^{2+}(mg/l)	4.90	4.18	4.70	4.78	4.81	4.20	3.80	3.50
Mg^{2+}(mg/l)	9.40	8.78	8.50	8.40	1.46	1.38	1.30	1.28
T.hardness (mg/l)	104	48.0	47.6	46.8	18.0	17.9	17.6	17.2
CaH (as mg /l $CaCO_3$)	17.0	12.0	11.7	11.1	12.0	11.8	11.6	10.2
MgH (as mg /l $CaCO_3$)	87.0	36.0	35.9	35.7	6.00	6.10	6.00	7.00
T Alkalinity (as mg/l $CaCO_3$)	24.5	22.5	22.2	22.1	22.1	22.0	21.9	21.5
Cl^- (mg/l)	21.0	15.0	14.30	13.8	7.62	7.60	7.57	7.50
F^- (mg/l)	0.88	0.03	0.02	0.02	0.01	0.01	BDL	BDL
NO^-_3 (mg/l as NO_3)	BDL	0.30	0.28	0.25	3.20	2.86	2.70	2.20
NO_2 (mg/l as NO_3)	0.04	BDL	0.03	0.02	0.01	0.02	0.01	0.01
NH_3 (mg/l)	0.65	1.20	1.30	1.38	1.13	1.50	1.55	1.58
SO_4^{2}-(mg/l)	21.8	25.0	24.8	24.6	0.48	0.45	0.40	0.38
PO_4^{3}- (mg/l)	1.43	0.03	0.02	0.02	0.27	0.25	0.23	0.20
TOC (mg/l)	BDL	4.80	4.80	4.50	5.70	5.40	5.10	5.00
BOD (mg/l)	3.30	2.40	2.38	2.35	0.70	0.60	0.60	0.40
COD (mg/l)	13.0	BDL	12.0	11.8	29.0	28.0	27.0	24.0
DO (mg/l)	12.8	5.20	4.80	4.60	7.70	7.50	7.20	7.30
T. coliform cfu, 100ml	100	0.00	100	150	40.0	100	200	150
E.coli cfu/100ml.	50.0	0.00	50.0	50.0	0.00	50	100	50.0

TABLE 34: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 52' 25''N, 6^0 45' 27'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	8.00	7.30	7.40	7.50	7.60	7.80	7.80	7.90
TEMP. (^{0}C)	32.0	31.0	32.0	32.0	32.0	31.0	31.0	31.0
COLOUR(Pt-Co)	123	243	240	245	1375	1380	1370	1950
COND.µS/CM	89.2	72.9	70.8	70.5	57.7	56.0	54.3	53.7
TDS (mg/l)	32.7	43.5	42.8	42.5	34.8	33.8	32.8	32.5
TSS (mg/l)	78.9	131	134	135	409	418	420	425
TS (mg/l)	112	174	177	178	444	452	453	458
TURB.(NTU)	24.29	35.6	35.8	36.0	347	348	350	365
Na (mg/l)	40.0	42.0	40.8	40.0	2.70	2.50	2.30	1.80
K (mg/l)	3.00	2.70	2.40	2.30	2.20	2.10	2.00	1.76
Ca^{2+}(mg/l)	3.80	3.21	3.18	3.15	5.61	5.20	5.00	4.80
Mg^{2+}(mg/l)	14.5	12.7	12.5	12.10	1.46	1.40	1.38	1.35
T.hardness (mg/l)	91.0	60.0	50.8	50.5	20.0	20.0	19.5	18.6
CaH (as mg /l $CaCO_3$)	13.0	8.0	10.8	11.5	14.0	13.2	12.0	11.4
MgH (as mg /l $CaCO_3$)	78.0	52.0	40.0	39.0	6.00	6.80	6.40	7.20
T Alkalinity (as mg/l $CaCO_3$)	23.0	22.5	22.40	22.3	22.1	21.8	21.5	20.5
Cl^- (mg/l)	17.0	15.0	14.2	13.11	9.52	8.30	7.10	6.50
F^- (mg/l)	1.00	BDL	1.00	0.90	BDL	0.45	0.20	0.20
NO^-_3 (mg/l as NO_3)	BDL	BDL	0.5	0.8	3.50	3.10	2.80	1.95
NO_2 (mg/l as NO_3)	0.02	BDL	0.03	0.01	0.01	BDL	0.01	0.01
NH_3 (mg/l)	BDL	0.87	0.98	0.90	1.30	1.35	1.40	1.42
SO_4^{2}-(mg/l)	15.2	20.1	19.1	18.2	BDL	16.2	15.5	14.5
PO_4^{3}- (mg/l)	1.34	0.18	0.16	0.13	0.31	0.20	0.19	0.15
TOC (mg/l)	4.60	4.80	4.80	4.70	6.70	6.65	6.00	5.86
BOD (mg/l)	3.35	3.15	3.13	3.00	0.70	0.50	0.49	0.30
COD (mg/l)	14.0	BDL	13.5	12.8	9.00	9.00	8.60	8.20
DO (mg/l)	17.7	5.30	5.10	5.00	7.90	7.50	7.20	7.00
T. coliform cfu, 100ml	0.00	0.00	100	150	100	200	150	100
E.coli cfu/100ml.	0.00	0.00	50.0	100	80.0	100	50.0	50.0

TABLE 35: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 53' 10''N, 6^0 45' 20'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	8.20	7.30	7.40	8.00	7.70	7.80	7.60	8.20
TEMP. (^{0}C)	32.0	31.0	31.0	31.0	31.0	32.0	32.0	32.0
COLOUR(Pt-Co)	170	305	310	315	1375	1378	1378	1380
COND.µS/CM	78.3	74.3	74.2	74.00	57.7	56.0	55.8	55.5
TDS (mg/l)	56.0	45.2	45.0	44.0	34.6	33.8	33.5	33.0
TSS (mg/l)	90.4	135	137	139	533	535	540	545
TS (mg/l)	146	180	182	183	568	569	574	578
TURB.(NTU)	21.5	35.5	38.6	38.8	357	358	360	362
Na (mg/l)	34.80	35.0	28.0	28.0	2.80	2.50	2.40	2.30
K (mg/l)	2.80	2.50	2.40	2.38	2.30	2.10	1.98	1.90
Ca^{2+}(mg/l)	4.40	3.21	3.19	3.15	6.41	6.39	6.30	6.00
Mg^{2+}(mg/l)	14.2	12.7	10.8	9.80	0.98	0.88	0.85	0.78
T.hardness (mg/l)	117	60.0	60.0	58.2	20.0	19.5	18.6	18.2
CaH (as mg /l $CaCO_3$)	12.0	8.00	8.00	7.50	16.0	15.40	14.8	14.5
MgH (as mg /l $CaCO_3$)	105	52.0	52.00	50.7	4.00	4.10	3.80	3.70
T Alkalinity (as mg/l $CaCO_3$)	18.0	25.0	24.8	24.5	23.1	22.8	22.5	22.2
Cl^- (mg/l)	14.0	25.0	24.8	23.5	9.52	8.60	8.20	7.50
F^- (mg/l)	1.05	0.80	0.90	0.85	0.18	0.15	0.10	0.90
NO^-_3 (mg/l as NO_3)	BDL	BDL	1.80	1.85	2.10	2.05	1.82	1.80
NO_2 (mg/l as NO_3)	0.02	BDL	0.01	0.01	0.01	0.02	0.01	0.01
NH_3 (mg/l)	0.21	1.21	1.25	1.85	2.47	2.50	2.53	2.55
SO_4^2-(mg/l)	17.6	35.1	34.6	34.2	13.3	12.8	12.5	12.2
PO_4^3- (mg/l)	1.66	0.24	0.20	0.20	0.30	0.28	0.25	0.20
TOC (mg/l)	4.60	BDL	4.20	4.80	6.20	6.10	6.00	5.80
BOD (mg/l)	4.35	5.25	5.20	5.10	0.40	0.38	0.30	0.28
COD (mg/l)	BDL	BDL	20.0	18.6	17.0	16.5	16.1	5.90
DO (mg/l)	16.5	5.0	4.80	4.96	7.40	7.30	7.20	7.10
T. coliform cfu, 100ml	150	300	200	150	120	100	100	200
E.coli cfu/100ml.	50.0	0.00	100	50.0	60.0	20.0	50.0	100

TABLE 36: Physico-Chemicaland Microbial Analyses Results in Water (2014) Location: 7^0 53’ 23’’N, 6^0 45’ 15’’ E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	7.80	7.40	7.60	7.80	7.70	7.80	7.90	8.00
TEMP. (^{0}C)	32.0	31.0	31.0	32	32.0	32.0	31.0	31.0
COLOUR(Pt-Co)	145	243	245	305	469	470	472	475
COND.µS/CM	84.1	72.3	70.3	68.2	78.4	77.0	76.5	76.1
TDS (mg/l)	24.6	43.4	42.5	40.8	48.0	47.6	47.2	46.3
TSS (mg/l)	69.8	131	100	98.6	80.0	85.0	86.4	87.6
TS (mg/l)	94.0	171	143	139	128	133	134	134
TURB.(NTU)	21.9	18.1	19.1	17.6	114	120	124	122
Na (mg/l)	14.0	12.0	11.3	10.9	3.50	3.10	3.00	2.80
K (mg/l)	2.80	2.40	2.32	2.40	2.70	2.60	2.53	2.56
Ca^{2+}(mg/l)	3.60	3.21	3.20	3.10	4.81	4.70	4.68	4.65
Mg^{2+}(mg/l)	12.2	12.7	12.5	12.1	2.44	2.40	2.36	2.30
T.hardness (mg/l)	136	60.0	56.7	55.8	22.0	21.5	20.6	20.5
CaH (as mg /l $CaCO_3$)	14.0	8.00	8.00	7.50	12.0	11.9	11.5	10.8
MgH (as mg /l $CaCO_3$)	122	52.0	48.7	48.3	10.0	9.60	9.10	9.70
T Alkalinity (as mg/l $CaCO_3$)	34.5	15.0	14.8	14.2	33.6	32.6	31.8	30.4
Cl^- (mg/l)	15.0	24.0	20.6	18.6	38.6	37.5	36.5	34.0
F^- (mg/l)	0.84	0.21	0.20	0.19	0.17	0.16	0.15	0.10
NO^-_3 (mg/l as NO_3)	BDL	BDL	2.50	2.60	3.70	3.60	3.40	3.10
NO_2 (mg/l as NO_3)	0.04	BDL	0.04	0.03	0.02	0.01	0.01	BDL
NH_3 (mg/l)	0.24	0.80	0.90	0.98	0.63	0.60	0.58	0.46
SO_4^2-(mg/l)	19.8	20.2	20.0	18.6	BDL	16.5	15.8	15.0
PO_4^3- (mg/l)	1.69	0.28	0.20	0.19	0.02	0.01	0.01	0.01
TOC (mg/l)	BDL	BDL	4.80	4.96	6.40	6.20	6.10	6.00
BOD (mg/l)	6.60	3.75	3.60	3.56	0.80	0.70	0.66	0.60
COD (mg/l)	BDL	BDL	8.40	8.60	10.0	9.80	9.70	9.60
DO (mg/l)	8.80	5.10	5.00	4.86	7.60	7.20	7.10	6.89
T. coliform cfu, 100ml	100	500	400	600	60.0	100	150	200
E.coli cfu/100ml.	100	150	200	150	40.0	50.0	50.0	100

TABLE 37: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 53' 56''N, 6^0 45' 11'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
PARAMETERS:								
pH	7.60	7.30	7.60	7.50	7.80	7.70	7.80	7.90
TEMP. (^{0}C)	32.0	32.0	32.0	32.0	32.0	31.0	31.0	31.0
COLOUR(Pt-Co)	430	185	190	198	465	468	480	500
COND.µS/CM	7.28	7.50	7.80	8.60	78.2	79.3	80.4	86.5
TDS (mg/l)	43.5	43.3	44.6	42.8	46.9	44.8	43.2	42.8
TSS (mg/l)	83.2	157	98.0	100	61.1	68.6	70.4	75.6
TS (mg/l)	127	200	143	143	108	113	114	119
TURB.(NTU)	25.8	22.5	24.8	40.8	86.0	87.6	88.9	88.8
Na (mg/l)	8.60	7.00	6.40	5.20	3.50	3.30	3.20	3.00
K (mg/l)	2.80	2.50	2.40	2.40	2.70	2.60	2.40	2.10
Ca^{2+}(mg/l)	7.20	6.41	6.20	6.10	8.02	8.00	7.65	7.50
Mg^{2+}(mg/l)	20.8	20.5	20.10	18.3	1.43	1.38	1.35	1.20
`T.hardness (mg/l)	98.0	100	100	99.0	26.0	25.1	24.8	23.9
CaH (as mg /l $CaCO_3$)	14.0	16.0	14.0	12.8	20.0	18.5	17.6	15.2
MgH (as mg /l $CaCO_3$)	79.0	84.0	86.0	86.2	6.00	6.60	7.20	8.70
T Alkalinity (as mg/l $CaCO_3$)	15.0	25.0	24.3	24.1	33.6	33.1	32.8	32.5
Cl^- (mg/l)	15.0	35.0	33.1	32.6	38.6	37.5	36.2	34.0
F^- (mg/l)	0.74	0.70	0.67	0.60	0.17	0.15	0.12	0.09
NO^-_3 (mg/l as NO_3)	BDL	BDL	4.20	4.00	3.70	3.60	3.40	3.10
NO_2 (mg/l as NO_3)	0.03	BDL	0.03	0.02	0.02	0.02	0.01	0.01
NH_3 (mg/l)	0.54	0.24	0.35	0.38	0.63	0.65	0.70	0.76
SO_4^{2}-(mg/l)	36.7	12.5	12.5	11.2	BDL	10.8	9.60	9.20
PO_4^{3}- (mg/l)	2.00	0.12	0.10	0.09	0.02	0.01	0.01	0.01
TOC (mg/l)	BDL	BDL	6.80	6.40	6.30	6.10	5.89	5.60
BOD (mg/l)	6.40	3.5	3.20	2.60	0.80	0.72	0.70	0.69
COD (mg/l)	BDL	BDL	12.0	11.90	10.0	0.09	0.08	0.04
DO (mg/l)	7.90	6.00	5.60	5.80	7.60	7.40	7.10	6.80
T. coliform cfu, 100ml	50.0	0.00	100	150	60.0	200	100	150
E.coli cfu/100ml.	0.00	0.00	50.0	100	40.0	50.0	50.0	100

TABLE 38: Physico-Chemical and Microbial Analyses Results in Water (2014) LocaTION: 7^0 54' 27''N, 6^0 45' 4'' E

PARAMETERS:	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPEMBER	OCTOBER
pH	7.50	7.30	7.50	7.60	7.60	7.60	7.80	8.10
TEMP. (^{0}C)	31.0	31.0	32.0	32.0	31.0	32.0	32.0	32.0
COLOUR(Pt-Co)	177	138	140	145	395	398	400	410
COND.µS/CM	89.4	72.3	73.0	74.5	78.7	79.5	81.5	82.0
TDS (mg/l)	35.4	43.9	40.0	42.0	47.2	46.0	45.6	45.1
TSS (mg/l)	89.4	64.1	65.1	67.8	68.8	69.2	70.2	71.5
TS (mg/l)	125	108	105	110	116	115	116	117
TURB.(NTU)	23.5	19.2	20.3	24.6	65.0	66.2	67.4	67.8
Na (mg/l)	10.00	112.0	11.7	10.6	3.60	3.50	3.80	2.90
K (mg/l)	3.40	2.40	2.30	2.10	2.70	2.50	2.42	2.20
Ca^{2+}(mg/l)	5.00	4.81	4.50	4.00	2.40	2.10	2.00	1.89
Mg^{2+}(mg/l)	12.00	11.7	10.8	10.2	3.90	3.50	2.89	2.40
T.hardness (mg/l)	100	60.0	58.2	57.7	22.0	21.8	21.2	20.9
CaH (as mg /l $CaCO_3$)	14.0	12.0	11.6	10.4	6.00	5.60	5.40	5.20
MgH (as mg /l $CaCO_3$)	86.0	48.0	46.6	47.3	16.0	16.2	15.8	15.7
T Alkalinity (as mg/l $CaCO_3$)	116	22.5	20.3	19.8	34.7	32.3	30.4	29.6
Cl^- (mg/l)	13.0	30.0	28.2	27.5	9.52	8.70	8.20	8.10
F^- (mg/l)	1.00	0.81	0.78	0.72	0.06	0.05	0.04	0.04
NO^-_3 (mg/l as NO_3)	BDL	BDL	1.50	1.49	1.40	1.20	1.18	1.16
NO_2 (mg/l as NO_3)	0.02	BDL	0.05	0.03	0.02	0.1	0.01	BDL
NH_3 (mg/l)	1.23	0.22	0.25	0.30	0.52	0.64	0.68	0.70
SO_4^{2}-(mg/l)	24.8	15.2	14.8	14.6	BDL	12.0	11.8	10.5
PO_4^{3}- (mg/l)	2.40	0.12	0.10	0.09	0.04	0.03	0.02	BDL
TOC (mg/l)	2.40	2.4	4.30	4.50	6.70	6.50	6.20	5.50
BOD (mg/l)	2.40	1.50	1.48	1.40	1.10	1.00	0.98	0.90
COD (mg/l)	BDL	BDL	9.60	9.60	8.00	8.00	7.56	7.40
DO (mg/l)	9.80	6.10	6.00	5.80	7.50	7.40	7.30	7.10
T. coliform cfu, 100ml	100	0.00	50.0	0.00	160	150	200	100
E.coli cfu/100ml.	0.00	0.00	100	0.00	80.0	50.0	50.0	50.0

TABLE 39: Physico-Chemicaland Microbial Analyses Results in Water (2014) Location: 7^0 54’ 53’’N, 6^0 44’ 56’’ E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PARAMETERS:								
pH	7.60	7.50	7.80	7.90	7.40	7.50	7.60	7.70
TEMP. (^{0}C)	31.0	32.0	31.0	31.0	31	31.0	31.0	31.0
COLOUR(Pt-Co)	132	116	120	122	454	458	460	464
COND.µS/CM	132	116	120	122	454	458	460	464
TDS (mg/l)	94.6	78.2	76.0	75.4	78.9	74.8	74.2	70.4
TSS (mg/l)	45.3	47.0	46.8	47.0	46.9	45.4	40/8	40.0
TS (mg/l)	74.3	79.0	79.0	12.2	161	162	164	168
TURB.(NTU)	120	126	126	127	208	207	207	208
Na (mg/l)	32.5	20.9	31.4	32.6	116	117	120	125
K (mg/l)	10.0	9.00	8.90	7.30	3.60	3.10	3.00	2.85
Ca^{2+}(mg/l)	5.00	2.00	2.10	3.87	2.70	2.60	2.20	2.00
Mg^{2+}(mg/l)	10.5	4.81	3.58	3.46	5.61	5.60	5.54	5.40
T.hardness (mg/l)	99.0	44.0	41.8	40.4	34.0	32.7	31.6	30.3
CaH (as mg /l $CaCO_3$)	87.0	32.0	30.8	30.5	20.0	19.3	18.6	17.5
MgH (as mg /l $CaCO_3$)	12.0	12.0	11.0	9.86	14.0	13.4	13.0	12.8
T Alkalinity (as mg/l $CaCO_3$)	75.0	20.0	19.8	20.6	6.00	5.90	5.60	4.70
Cl^- (mg/l)	16.0	30.0	30.0	28.1	33.6	30.6	29.4	26.3
F^- (mg/l)	12.0	20.0	18.2	17.3	9.52	8.60	8.20	7.98
NO^-_3 (mg/l as NO_3)	1.04	0.64	0.54	0.48	BDL	0.36	0.24	0.20
NO_2 (mg/l as NO_3)	BDL	BDL	3.00	2.84	2.50	2.30	2.00	2.00
NH_3 (mg/l)	0.04	BDL	0.05	0.03	0.02	0.02	0.01	0.01
SO_4^2-(mg/l)	1.95	1.31	1.30	1.30	0.56	0.60	0.78	0.80
PO_4^3- (mg/l)	35.6	19.7	17.4	16.3	BDL	3.40	2.89	1.20
TOC (mg/l)	1.54	0.15	0.13	0.11	0.70	0.64	0.50	0.46
BOD (mg/l)	2.40	4.80	4.70	4.64	6.50	6.40	6.01	5.96
COD (mg/l)	2.60	4.00	2.80	2.78	100	9.86	12.2	11.8
DO (mg/l)	10.2	6.20	5.80	5.75	7.90	7.50	7.20	7.00
T. coliform cfu, 100ml	50.0	0.00	0.00	100	120	150	200	100
E.coli cfu/100ml.	50.0	0.00	0.00	50.0	120	100	100	50.0

TABLE 40: Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 7^0 55' 31'N, 6^0 45' 2'' E

	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PARAMETERS:								
pH	7.60	7.40	7.50	7.80	7.60	7.80	7.90	8.00
TEMP. (^{0}C)	32.0	32.0	32.0	32.0	31.0	31.0	31.0	31.0
COLOUR(Pt-Co)	240	188	198	280	1375	1380	1385	1386
COND.µS/CM	91.0	86.4	87.8	89.8	57.3	55.0	50.4	50.8
TDS (mg/l)	48.0	51.2	50.8	48.6	43.4	30.2	30.8	29.6
TSS (mg/l)	75.0	80.8	90.8	100	410	411	413	415
TS (mg/l)	123	132	142	147	444	441	444	445
TURB.(NTU)	24.6	22.9	30.5	31.8	257	260	262	265
Na (mg/l)	20.0	18.0	15.0	14.2	2.70	2.50	2.20	2.00
K (mg/l)	2.60	2.40	2.40	2.20	2.20	2.10	1.80	1.50
Ca^{2+}(mg/l)	7.20	6.41	5.80	5.50	6.41	6.30	6.20	5.40
Mg^{2+}(mg/l)	8.20	7.81	7.70	7.60	1.46	1.20	1.00	0.90
T.hardness (mg/l)	110	48.0	45.0	42.0	22.0	20.8	20.1	19.8
CaH (as mg /l $CaCO_3$)	16.0	16.0	15.8	15.5	16.0	15.8	15.2	14.8
MgH (as mg /l $CaCO_3$)	94.0	32.0	29.2	26.5	6.00	5.00	4.90	5.00
T Alkalinity (as mg/l $CaCO_3$)	30.5	30.0	29.0	28.6	24.2	23.7	20.6	20.2
Cl^- (mg/l)	11.0	15.0	14.30	14.10	9.52	9.50	9.10	9.00
F^- (mg/l)	0.68	0.69	0.60	0.58	0.08	0.07	0.05	0.04
NO^-_3 (mg/l as NO_3)	BDL	BDL	3.50	3.50	3.40	3.20	3.10	3.00
NO_2 (mg/l as NO_3)	0.05	BDL	0.05	0.04	0.01	0.01	0.01	0.01
NH_3 (mg/l)	0.28	0.54	0.52	0.50	1.11	1.20	1.25	1.35
SO_4^2-(mg/l)	26.7	17.8	16.9	15.8	8.19	8.10	8.00	7.50
PO_4^3- (mg/l)	1.34	0.21	0.20	0.19	0.88	0.80	0.75	0.70
TOC (mg/l)	7.20	8.20	7.50	7.10	7.20	6.30	6.10	5.80
BOD (mg/l)	1.50	2.40	2.35	2.38	0.40	0.38	0.30	0.25
COD (mg/l)	BDL	BDL	5.20	5.10	BDL	4.80	4.20	4.00
DO (mg/l)	8.60	6.10	6.00	5.40	7.50	7.40	7.10	7.00
T. coliform cfu, 100ml	50.0	0.00	100	50.0	180	200	150	100
E.coli cfu/100ml.	50.0	0.00	50.0	50.0	100	100	50.0	50.0

TABLE 41: Concentration of Heavy Metal in Water of River (mg/l) March, 2014.

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
W1	ND	0.30	ND	0.01	0.01	0.20	0.10	0.05	0.00
W2	ND	0.42	ND	0.01	0.01	0.18	0.08	0.04	0.00
W3	ND	0.31	ND	ND	ND	0.19	0.10	0.00	0.00
W4	ND	0.16	ND	0.01	ND	0.20	0.05	0.00	0.00
W5	ND	0.20	0.10	ND	ND	0.25	0.08	0.00	0.00
W6	0.01	0.10	0.10	ND	0.01	0.18	0.06	0.01	0.00
W7	ND	0.10	ND	ND	0.01	0.12	0.09	0.01	0.00
W8	ND	0.12	0.10	ND	0.01	0.20	0.07	0.00	0.00
W9	ND	0.30	0.10	0.01	ND	0.13	0.06	0.00	0.00
W10	ND	0.31	ND	0.01	0.01	0.18	0.10	0.00	0.00
W11	ND	ND	0.10	ND	0.01	0.14	0.08	0.00	0.00
W12	ND	ND	0.10	0.01	ND	0.19	0.08	0.00	0.00
W13	ND	0.10	0.11	ND	ND	0.23	0.00	0.00	0.00
W14	ND	0.20	0.12	0.01	ND	0.15	0.00	0.00	0.00
W15	ND	0.30	0.12	0.01	0.01	0.28	0.10	0.03	0.00
W16	ND	0.21	0.18	ND	ND	0.11	0.09	0.02	0.00
W17	ND	0.10	0.01	0.01	ND	0.12	0.01	0.01	0.00
W18	ND	0.10	ND	0.01	ND	0.18	0.08	0.00	0.00
W19	ND	0.15	ND	0.01	0.01	0.15	0.09	0.00	0.00
W20	ND	0.18	0.01	ND	0.01	0.16	0.07	0.00	0.00
W21	ND	0.30	0.01	0.01	ND	0.22	0.02	0.00	0.00
W22	ND	0.10	0.01	0.01	ND	0.18	0.05	0.00	0.00
W23	ND	0.31	0.10	0.01	ND	0.20	0.06	0.00	0.00
W24	0.01	0.20	0.10	ND	0.01	0.15	0.07	0.02	0.00
W25	ND	0.17	0.01	ND	ND	0.10	0.01	0.01	0.00
W26	ND	0.19	0.01	ND	ND	0.41	0.10	0.00	0.00
W27	ND	0.35	ND	ND	0.01	0.37	0.38	0.00	0.00
W28	ND	0.22	ND	0.01	0.01	0.05	0.18	0.00	0.00
W29	ND	0.29	ND	ND	0.01	0.40	0.20	0.00	0.00
W30	ND	0.31	0.01	ND	ND	0.28	0.32	0.01	0.00
W31	ND	0.25	ND	ND	ND	0.30	0.31	0.00	0.00
W32	ND	0.38	0.21	ND	ND	0.29	0.01	0.00	0.00
W33	ND	0.20	0.10	ND	ND	0.58	0.09	0.00	0.00
W34	ND	0.21	ND	ND	ND	0.42	0.12	0.00	0.00
W35	ND	0.28	ND	0.01	ND	0.48	0.11	0.02	0.00
W36	ND	0.91	0.10	0.01	ND	0.20	0.07	0.01	0.00
W37	ND	0.30	0.10	ND	ND	0.10	0.01	0.00	0.00
W38	ND	0.35	ND	0.01	ND	0.29	0.08	0.02	0.00
W39	ND	0.23	ND	ND	ND	0.13	0.05	0.01	0.00
W40	ND	0.10	0.10	ND	ND	0.10	0.07	0.02	0.00

TABLE 42: Concentration of Heavy Metal (Mg/l) April, 2014

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
W1	ND	0.12	0.01	ND	ND	0.16	0.08	0.03	0.00
W2	ND	0.11	0.01	ND	ND	0.12	0.09	0.02	0.00
W3	ND	0.20	0.01	ND	0.01	0.15	0.10	0.01	0.00
W4	0.01	0.18	0.10	0.01	ND	0.17	0.03	0.01	0.00
W5	ND	0.16	0.12	0.01	0.01	0.20	0.06	0.01	0.00
W6	ND	0.01	0.10	ND	ND	0.14	0.04	0.01	0.00
W7	ND	0.04	0.02	ND	ND	0.10	0.07	0.00	0.00
W8	ND	0.08	0.06	ND	ND	0.16	0.05	0.00	0.00
W9	ND	0.20	0.04	0.01	0.01	0.10	0.04	0.00	0.00
W10	ND	0.17	0.02	0.01	0.01	0.20	0.10	0.01	0.00
W11	ND	ND	0.01	0.01	0.01	0.12	0.08	0.00	0.00
W12	ND	ND	0.01	ND	ND	0.17	0.07	0.00	0.00
W13	ND	ND	ND	0.01	0.01	0.19	0.00	0.00	0.00
W14	ND	0.10	0.04	0.01	0.01	0.14	0.01	0.00	0.00
W15	ND	0.15	0.01	0.01	0.01	0.29	0.09	0.00	0.00
W16	0.01	0.23	ND	ND	ND	0.12	0.05	0.02	0.00
W17	ND	0.25	0.16	ND	ND	0.12	0.03	0.01	0.00
W18	ND	0.01	0.01	ND	0.01	0.13	0.06	0.00	0.00
W19	ND	0.01	0.08	ND	0.01	0.12	0.05	0.01	0.00
W20	ND	0.01	0.06	0.01	ND	0.15	0.04	0.00	0.00
W21	ND	0.10	0.04	0.01	ND	0.20	0.01	0.01	0.00
W22	ND	0.01	ND	0.01	ND	0.16	0.03	0.01	0.00
W23	ND	0.01	ND	ND	0.01	0.18	0.02	0.01	0.00
W24	ND	ND	ND	0.01	0.01	0.14	0.05	0.00	0.00
W25	ND	ND	0.01	0.01	ND	0.09	0.00	0.00	0.00
W26	0.01	ND	0.05	ND	ND	0.20	0.08	0.01	0.00
W27	ND	ND	ND	ND	ND	0.38	0.24	0.02	0.00
W28	ND	ND	0.01	ND	ND	0.03	0.16	0.01	0.00
W29	ND	ND	ND	ND	ND	0.36	0.18	0.00	0.00
W30	ND	ND	ND	ND	ND	0.26	0.28	0.00	0.00
W31	ND	0.01	ND	0.01	0.01	0.25	0.29	0.01	0.00
W32	ND	0.21	0.11	ND	0.01	0.15	0.07	0.00	0.00
W33	ND	0.13	0.10	ND	ND	0.48	0.04	0.00	0.00
W34	ND	0.10	0.01	0.01	ND	0.35	0.11	0.01	0.00
W35	ND	0.12	0.08	ND	ND	0.29	0.10	0.01	0.00
W36	ND	0.11	0.02	0.01	ND	0.08	0.01	0.01	0.00
W37	ND	0.13	0.04	0.01	ND	0.09	0.01	0.00	0.00
W38	ND	ND	ND	ND	ND	0.18	0.06	0.01	0.00
W39	ND	0.01	0.06	ND	ND	0.10	0.03	0.02	0.00
W40	ND	0.01	ND	ND	ND	0.11	0.06	0.01	0.00

ABLE 43: Concentration of Heavy Metals (mg/l) in Water Sample (May, 2014)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
W_1	ND	0.10	ND	ND	ND	0.31	0.06	0.08	0.00
W_2	ND	0.21	ND	0.01	ND	0.11	0.03	0.00	0.00
W_3	ND	0.21	0.10	ND	0.01	0.13	0.06	0.00	0.00
W_4	ND	0.01	ND	ND	ND	0.12	0.02	0.00	0.00
W_5	ND	0.09	0.10	ND	ND	0.18	0.06	0.00	0.00
W_6	ND	0.12	ND	ND	ND	0.14	0.05	0.06	0.00
W_7	ND	0.12	ND	ND	ND	0.09	0.05	0.00	0.00
W_8	ND	0.18	ND	ND	ND	0.16	0.04	0.00	0.00
W_9	ND	0.07	0.10	ND	ND	0.09	0.06	0.00	0.00
W_{10}	ND	0.11	0.10	ND	ND	0.13	0.06	0.02	0.00
W_{11}	ND	0.10	ND	ND	ND	0.12	0.06	0.02	0.00
W_{12}	ND	0.17	ND	ND	0.01	0.15	0.00	0.00	0.00
$W1_3$	ND	0.14	ND	0.01	ND	0.18	0.09	0.07	0.00
W_{14}	ND	0.10	ND	ND	ND	0.10	0.05	0.00	0.00
W_{15}	ND	0.18	0.10	0.01	0.01	0.21	0.09	0.00	0.00
W_{16}	ND	0.10	ND	ND	ND	0.09	0.06	0.00	0.00
W_{17}	ND	0.07	ND	0.01	ND	0.08	0.01	0.00	0.00
W_{18}	ND	0.08	ND	0.01	0.01	0.12	0.03	0.00	0.00
W_{19}	ND	0.11	ND	0.01	ND	0.19	0.05	0.00	0.00
W_{20}	ND	0.13	ND	ND	ND	0.11	0.04	0.00	0.00
W_{21}	ND	0.19	ND	ND	ND	0.18	0.03	0.00	0.00
W_{22}	ND	0.06	0.10	0.01	ND	0.11	0.02	0.00	0.00
W_{23}	ND	0.09	ND	ND	ND	0.16	0.03	0.00	0.00
W_{24}	ND	0.29	0.10	ND	ND	0.13	0.00	0.00	0.00
W_{25}	ND	0.18	ND	ND	ND	0.18	0.09	0.02	0.00
W_{26}	ND	0.13	ND	0.01	ND	0.09	0.00	0.00	0.00
W_{27}	ND	0.30	0.10	ND	ND	0.36	0.09	0.07	0.00
W_{28}	ND	0.16	ND	ND	ND	0.12	0.04	0.00	0.00
W_{29}	ND	021	0.01	ND	ND	0.17	0.01	0.00	0.00
W_{30}	ND	0.20	ND	ND	ND	0.30	0.07	0.00	0.00
W_{31}	ND	0.14	0.01	ND	ND	0.23	0.09	0.00	0.00
W_{32}	ND	0.25	ND	ND	ND	0.27	0.08	0.00	0.00
W_{33}	ND	0.30	ND	ND	ND	0.56	0.04	0.00	0.00
W_{34}	ND	0.14	ND	0.01	ND	0.34	0.00	0.00	0.00
W_{35}	ND	0.20	0.10	0.01	ND	0.40	0.04	0.00	0.00
W_{36}	ND	0.13	0.10	0.01	ND	0.15	0.07	0.00	0.00
W_{37}	ND	0.05	0.10	ND	ND	0.06	0.07	0.00	0.00
W_{38}	ND	0.22	ND	ND	ND	0.26	0.08	0.04	0.00
W_{39}	ND	0.12	ND	ND	0.01	0.10	0.05	0.00	0.00
W_{40}	ND	0.09	ND	0.01	ND	0.05	0.02	0.04	

TABLE 44: Concentration of Heavy Metals (mg/l) in Water Sample (June, 2014)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
W_1	0.01	0.19	ND	ND	ND	0.10	0.01	0.01	0.00
W_2	ND	0.21	ND	0.01	ND	0.13	0.02	0.00	0.00
W_3	0.01	0.17	ND	0.01	ND	0.05	0.00	0.00	0.00
W_4	ND	0.31	ND	ND	ND	0.19	0.01	0.00	0.00
W_5	ND	0.19	0.10	ND	ND	0.11	0.01	0.00	0.00
W_6	ND	0.21	ND	ND	ND	0.08	0.01	0.06	0.00
W_7	ND	0.20	ND	0.02	ND	0.05	0.00	0.00	0.00
W_8	ND	0.16	0.10	0.01	ND	0.08	0.00	0.00	0.00
W_9	ND	0.23	ND	ND	ND	0.12	0.04	0.00	0.00
W_{10}	ND	0.18	ND	ND	ND	0.04	0.01	0.00	0.00
W_{11}	ND	0.13	0.10	ND	ND	0.06	0.02	0.00	0.00
W_{12}	ND	0.18	0.10	ND	ND	0.08	0.01	0.00	0.00
W_{13}	ND	0.13	ND	0.01	ND	0.04	0.00	0.00	0.00
W_{14}	ND	0.20	0.10	0.01	ND	0.17	0.00	0.02	0.00
W_{15}	ND	0.18	ND	ND	ND	0.03	0.00	0.03	0.00
W_{16}	ND	0.12	ND	0.01	ND	0.07	0.00	0.00	0.00
W_{17}	ND	0.14	0.01	ND	ND	0.02	0.00	0.00	0.00
W_{18}	ND	0.11	ND	ND	ND	0.05	0.03	0.00	0.00
W_{19}	ND	0.14	ND	0.01	0.01	0.26	0.01	0.01	0.00
W_{20}	ND	0.17	ND	0.01	ND	0.08	0.02	0.00	0.00
W_{21}	ND	0.26	ND	ND	ND	0.20	0.02	0.00	0.00
W_{22}	ND	0.19	ND	ND	ND	0.09	0.04	0.00	0.00
W_{23}	ND	0.17	ND	0.01	ND	0.15	0.01	0.00	0.00
W_{24}	ND	0.28	ND	ND	ND	0.17	0.08	0.10	0.00
W_{25}	ND	0.17	ND	ND	ND	0.09	0.04	0.00	0.00
W_{26}	0.02	0.12	0.10	0.01	0.01	0.10	0.01	0.00	0.00
W_{27}	ND	0.27	ND	ND	ND	0.12	0.03	0.00	0.00
W_{28}	ND	0.51	0.10	0.01	ND	0.13	0.04	0.00	0.00
W_{29}	ND	0.13	ND	ND	ND	0.08	0.08	0.00	0.00
W_{30}	ND	0.20	ND	ND	ND	0.12	0.03	0.00	0.00
W_{31}	ND	0.24	0.01	0.01	ND	0.14	0.09	0.00	0.00
W_{32}	ND	0.34	ND	ND	ND	0.25	0.03	0.00	0.00
W_{33}	ND	0.37	0.01	ND	ND	0.24	0.02	0.00	0.00
W_{34}	ND	0.19	ND	ND	ND	0.18	0.04	0.00	0.00
W_{35}	ND	0.28	ND	ND	ND	0.10	0.05	0.00	0.00
W_{36}	ND	0.22	ND	ND	ND	0.06	0.02	0.00	0.00
W_{37}	ND	0.14	0.10	ND	ND	0.02	0.03	0.10	0.00
W_{38}	ND	0.11	ND	ND	0.01	0.09	0.03	0.07	0.00
W_{39}	ND	0.30	ND	ND	ND	0.27	0.07	0.03	0.00
W_{40}	ND	0.17	ND	ND	ND	0.11	0.06	0.00	0.00

TABLE 45: Concentration of Heavy Metals in Water Sample (July, 2014)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
W1	0.01	0.12	ND	0.01	ND	0.05	0.00	0.00	ND
W2	0.01	0.18	ND	0.01	ND	0.10	0.01	0.01	ND
W3	ND	0.14	ND	0.01	ND	0.02	0.01	0.00	ND
W4	0.02	0.28	0.01	ND	ND	0.12	0.02	0.01	ND
W5	ND	0.15	ND	ND	ND	0.10	0.02	0.02	ND
W6	ND	0.19	ND	0.02	ND	0.04	0.01	0.01	ND
W7	ND	0.17	0.01	0.01	ND	0.01	0.00	0.00	ND
W8	ND	0.13	0.01	0.01	ND	0.06	0.00	0.01	ND
W9	ND	0.20	0.02	0.01	0.01	0.03	0.01	0.01	ND
W10	ND	0.14	0.01	0.01	ND	0.10	0.02	0.00	ND
W11	ND	0.10	0.01	ND	ND	0.02	0.01	0.01	ND
W12	0.01	0.12	0.01	ND	ND	0.04	0.00	0.00	ND
W13	ND	0.11	0.01	ND	ND	0.05	0.00	0.01	ND
W14	ND	0.16	0.01	ND	ND	0.02	0.00	0.00	ND
W15	ND	0.17	ND	0.01	ND	0.01	0.00	0.01	ND
W16	ND	0.10	ND	0.01	ND	0.02	0.01	0.02	ND
W17	0.01	0.11	ND	0.01	0.01	0.01	0.01	0.00	ND
W18	0.01	0.10	0.01	0.01	ND	0.02	0.02	0.00	ND
W19	0.01	0.12	0.01	0.01	ND	0.20	0.00	0.00	ND
W20	0.01	0.15	0.01	0.02	ND	0.50	0.01	0.01	ND
W21	0.01	0.22	ND	ND	ND	0.16	0.01	0.00	ND
W22	0.01	0.16	ND	ND	0.01	0.05	0.03	0.00	ND
W23	ND	0.14	ND	ND	0.01	0.12	0.00	0.00	ND
W24	ND	0.20	ND	ND	0.01	0.14	0.04	0.06	ND
W25	ND	0.15	ND	0.01	0.0	0.03	0.02	0.00	ND
W26	0.01	0.10	0.01	0.01	ND	0.09	0.00	0.09	ND
W27	0.03	0.21	0.01	ND	ND	0.09	0.01	0.00	ND
W28	0.01	0.12	0.01	ND	ND	0.05	0.02	0.01	ND
W29	0.01	0.10	ND	ND	ND	0.06	0.05	0.00	ND
W30	0.01	0.17	0.01	ND	ND	0.10	0.01	0.01	ND
W31	0.01	0.19	0.01	ND	ND	0.12	0.06	0.01	ND
W32	0.01	0.10	ND	0.01	0.01	0.11	0.02	0.01	ND
W33	0.01	0.15	ND	0.01	0.01	0.20	0.01	0.01	ND
W34	0.01	0.21	ND	ND	0.01	0.20	0.02	0.00	ND
W35	ND	0.22	ND	ND	ND	0.12	0.03	0.00	ND
W36	ND	0.15	ND	ND	ND	0.09	0.01	0.00	ND
W37	0.01	0.10	ND	ND	ND	0.01	0.02	0.00	ND
W38	0.01	0.10	ND	ND	ND	0.08	0.01	0.09	ND
W39	ND	0.23	ND	0.01	ND	0.21	0.03	0.10	ND
W40	ND	0.15	ND	ND	ND	0.09	0.02	0.00	ND

TABLE 46: Concentration of Heavy Metals in Water Sample (August, 2014)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
W1	0.01	0.81	0.01	0.02	ND	0.08	0.01	0.01	ND
W2	0.01	0.20	0.01	ND	ND	0.15	0.02	0.01	ND
W3	0.01	0.19	0.01	ND	ND	0.06	0.03	ND	ND
W4	0.01	0.30	0.02	ND	ND	0.15	0.02	ND	0.01
W5	0.01	0.20	0.01	0.01	ND	0.18	0.02	0.01	ND
W6	ND	0.20	0.01	0.01	ND	0.10	0.01	0.03	ND
W7	0.01	0.81	0.01	0.01	0.01	0.05	0.02	0.02	ND
W8	ND	0.15	0.02	0.02	ND	0.09	0.02	0.01	ND
W9	ND	0.26	0.01	0.01	ND	0.08	0.03	ND	ND
W10	0.01	0.17	ND	0.02	ND	0.15	0.03	0.02	ND
W11	0.01	0.15	ND	0.01	ND	0.06	ND	0.01	ND
W12	0.01	0.15	ND	0.01	ND	0.08	0.01	0.02	ND
W13	ND	0.19	ND	ND	ND	0.10	0.01	ND	ND
W14	0.01	0.15	ND	ND	ND	0.05	0.01	0.02	0.01
W15	0.01	0.14	ND	0.01	ND	0.02	0.02	0.01	ND
W16	ND	0.15	0.01	ND	ND	0.06	0.03	0.02	ND
W17	ND	0.17	0.01	ND	0.01	0.04	0.02	0.01	ND
W18	ND	0.15	0.02	ND	0.01	0.05	0.03	0.01	ND
W19	0.01	0.81	0.01	ND	ND	0.30	0.01	0.01	ND
W20	0.02	0.30	0.01	0.01	ND	0.10	0.02	0.02	ND
W21	0.01	0.20	0.01	0.01	ND	0.20	0.02	0.01	ND
W22	0.01	0.81	ND	0.01	ND	0.08	0.03	0.01	ND
W23	0.01	0.15	0.01	0.01	ND	0.18	0.01	0.01	ND
W24	0.01	0.25	0.01	0.01	ND	0.16	0.05	0.06	ND
W25	ND	0.20	0.01	ND	ND	0.05	0.03	0.01	ND
W26	0.02	0.15	0.01	0.01	ND	0.10	0.01	0.10	ND
W27	0.01	0.28	ND	0.02	ND	0.18	0.02	0.01	ND
W28	0.02	0.16	ND	0.01	ND	0.09	0.03	0.02	ND
W29	0.01	0.15	0.01	0.01	ND	0.10	0.08	0.02	ND
W30	0.01	0.20	ND	ND	0.01	0.20	0.02	0.02	ND
W31	0.01	0.21	0.01	0.02	0.01	0.08	0.08	0.03	0.01
W32	0.02	0.15	0.01	ND	0.06	0.02	0.02	0.06	ND
W33	0.01	0.30	ND	0.01	0.01	0.30	0.02	0.01	ND
W34	0.01	0.31	ND	0.01	0.02	0.20	0.03	0.01	ND
W35	0.01	0.20	0.01	0.01	0.01	0.20	0.03	ND	ND
W36	0.01	0.12	ND	ND	0.01	0.15	0.02	ND	ND
W37	ND	0.16	ND	ND	0.01	0.18	0.01	ND	ND
W38	0.01	0.10	ND	ND	0.01	0.30	0.03	0.08	ND
W39	0.01	0.30	ND	ND	ND	0.30	0.02	0.02	ND
W40	0.01	0.20	ND	ND	ND	0.15	0.03	0.01	ND

Table 47: Concentration of Heavy Metals in Water Sample (September, 2014)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
W1	0.01	0.20	0.01	0.01	0.01	0.05	0.01	ND	ND
W2	0.02	0.30	0.02	ND	0.01	0.01	0.01	0.01	ND
W3	0.01	0.25	0.01	ND	0.01	0.01	ND	0.01	ND
W4	0.01	0.34	0.01	ND	0.01	0.10	ND	0.01	ND
W5	0.01	0.28	0.01	ND	0.01	0.15	0.02	ND	ND
W6	0.01	0.24	ND	0.01	0.01	0.08	0.02	0.02	ND
W7	ND	0.19	0.01	0.02	ND	0.05	0.03	ND	ND
W8	0.02	0.18	0.01	0.02	ND	0.08	ND	0.01	ND
W9	ND	0.30	0.01	0.02	ND	0.06	0.01	0.01	ND
W10	0.01	0.20	0.01	0.01	ND	0.15	0.01	0.02	ND
W11	0.03	0.19	0.01	ND	ND	0.04	0.02	ND	ND
W12	0.01	0.16	0.02	0.01	0.01	0.06	0.01	ND	ND
W13	0.01	0.18	ND	0ND	0.01	0.08	0.02	0.01	ND
W14	0.02	0.22	0.02	0.01	0.01	0.04	0.03	0.02	ND
W15	0.01	0.16	ND	0.01	0.02	0.03	ND	0.01	ND
W16	0.02	0.17	0.01	0.02	0.01	0.02	0.01	0.02	ND
W17	ND	0.18	0.01	0.01	ND	0.23	0.01	ND	ND
W18	0.01	0.20	0.01	ND	0.01	0.06	0.04	ND	ND
W19	ND	0.18	0.02	ND	0.01	0.20	ND	ND	ND
W20	0.02	0.20	ND	ND	0.01	0.08	0.03	0.01	ND
W21	0.03	0.32	ND	0.01	ND	0.15	0.01	0.02	ND
W22	0.01	0.25	ND	0.02	ND	0.20	0.01	0.01	ND
W23	ND	0.20	0.02	0.01	ND	0.05	0.02	ND	0.01
W24	0.02	0.19	0.01	0.01	ND	0.10	0.01	0.05	ND
W25	0.01	0.30	0.01	0.01	ND	0.08	ND	0.04	ND
W26	0.03	0.23	0.01	ND	0.01	0.11	ND	ND	ND
W27	0.02	0.18	0.02	ND	0.01	0.08	0.02	0.06	ND
W28	0.03	0.30	ND	0.01	0.02	0.09	0.01	0.08	ND
W29	0.04	0.19	ND	0.02	ND	0.12	0.01	0.10	ND
W30	0.01	0.25	0.01	0.02	ND	0.11	0.05	0.01	ND
W31	0.01	0.28	0.02	0.01	0.01	0.15	0.04	0.01	ND
W32	0.03	0.81	0.01	ND	0.01	0.03	0.03	0.08	0.01
W33	0.01	0.32	0.01	ND	0.01	0.35	0.03	0.02	ND
W34	0.01	0.40	0.01	ND	ND	0.26	0.05	0.03	ND
W35	0.1	0.31	0.01	ND	ND	0.23	0.04	0.01	0.01
W36	ND	0.16	ND	0.01	0.01	0.81	0.02	0.01	ND
W37	0.02	0.81	0.01	0.01	0.01	0.20	0.04	ND	ND
W38	ND	0.15	0.01	ND	0.01	0.32	0.02	0.07	ND
W39	0.02	0.32	0.01	0.01	0.01	0.35	0.06	ND	ND
W40	ND	0.22	0.01	0.01	0.02	0.19	0.08	0.03	ND

TABLE 48: Concentration of Heavy Metals (mg/l) in Water Sample (October, 2014)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
W1	0.02	0.25	0.02	0.02	0.01	0.08	ND	0.02	0.01
W2	0.01	0.32	0.01	0.02	0.02	0.02	0.01	0.02	0.01
W3	ND	0.28	0.02	0.02	0.02	0.02	0.01	0.01	0.01
W4	0.01	0.36	0.02	0.03	0.02	0.11	0.02	0.03	0.01
W5	0.01	0.29	0.01	0.01	ND	0.18	0.01	0.02	0.01
W6	0.01	0.28	0.02	0.02	ND	0.10	0.02	0.03	0.01
W7	ND	0.20	0.01	0.02	ND	0.07	0.01	0.01	0.01
W8	ND	0.21	0.02	0.01	ND	0.10	0.01	0.02	0.01
W9	0.01	0.32	0.02	0.02	0.01	0.09	0.01	0.02	0.01
W10	0.02	0.25	0.01	0.02	0.02	0.18	0.02	0.02	0.01
W11	ND	0.22	0.01	0.01	0.03	0.06	0.03	0.02	ND
W12	0.01	0.18	ND	0.02	0.02	0.08	0.01	0.02	ND
W13	ND	0.20	ND	0.02	0.01	0.10	0.01	0.03	0.01
W14	ND	0.24	ND	0.01	0.01	0.06	0.02	0.03	0.01
W15	ND	0.19	0.01	0.03	0.01	0.05	0.03	0.02	0.01
W16	ND	0.20	0.02	0.02	0.01	0.04	0.01	0.04	0.01
W17	0.02	0.20	0,03	0.03	0.01	0.25	0.01	0.01	0.01
W18	0.03	0.25	0.03	0.02	ND	0.08	0.01	0.03	0.01
W19	0.02	0.21	0.02	0.01	0.01	0.26	0.01	0.01	ND
W20	0.03	0.25	0.02	0.02	0.01	0.10	0.02	0.01	ND
W21	0.01	0.34	0.01	0.01	0.02	0.18	0.03	0.01	0.01
W22	0.04	0.27	ND	0.03	0.02	0.25	0.01	0.04	0.01
W23	0.05	0.24	ND	0.02	0.01	0.10	0.02	0.03	0.02
W24	0.03	0.35	0.01	0.03	0.01	0.15	0.02	0.03	0.01
W25	0.01	0.26	0.02	0.02	0.02	0.10	0.02	0.02	0.01
W26	ND	0.26	0.02	0.03	ND	0.15	0.02	0.02	0.01
W27	ND	0.20	0.01	0.02	ND	0.10	0.03	0.02	0.01
W28	0.02	0.35	0.01	0.01	0.01	0.11	0.01	0.02	0.01
W29	0.03	0.21	0.01	0.02	0.02	0.15	0.03	0.01	0.01
W30	0.01	0.28	0.01	0.03	0.01	0.15	0.01	0.03	0.01
W31	0.04	0.30	0.01	0.02	0.03	0.20	0.01	0.01	0.01
W32	0.03	0.20	0.02	0.01	0.05	0.05	0.02	0.07	ND
W33	0.01	0.32	0.01	0.01	0.02	0.32	0.02	0.02	0.01
W34	0.01	0.34	0.01	0.01	0.03	0.24	0.03	0.01	0.01
W35	0.02	0.28	0.01	0.01	0.02	0.23	0.04	0.01	0.01
W36	0.02	0.18	0.01	0.01	0.02	0.18	0.02	0.01	0.01
W37	0.02	0.18	0.01	0.01	0.02	0.20	0.01	0.01	ND
W38	0.01	0.15	ND	ND	0.01	0.32	0.03	ND	0.01
W39	0.01	0.32	0.01	0.01	0.01	0.34	0.03	ND	0.01
W40	0.01	0.25	0.02	0.02	0.01	0.18	0.01	0.01	ND

TABLE 49: Concentration of Heavy Metals in Sediment Sample of R. Niger (March 2014)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
S_1	0.42	130	5.20	2.82	0.02	1.40	1.52	0.03	0.02
S_2	0.42	25.0	2.86	0.81	0.16	1.38	0.81	0.02	0.02
S_3	0.25	28.7	1.00	1.00	0.19	7.80	0.92	0.90	0.01
S_4	0.20	22.2	0.86	0.98	0.20	32.7	1.10	0.02	0.02
S_5	0.28	17.5	0.42	0.69	0.20	13.5	0.98	0.15	0.01
S_6	0.38	26.4	3.20	0.67	0.32	23.8	0.73	3.00	0.02
S_7	0.15	28.3	1.00	0.92	0.20	6.20	0.62	1.50	0.02
S_8	0.22	20.0	0.92	0.54	0.09	21.9	0.78	2.30	0.02
S_9	0.30	22.7	3.20	0.98	0.04	2.60	0.52	1.25	0.00
S_{10}	0.10	48.6	1.20	0.80	0.08	3.03	0.82	1.50	0.02
S_{11}	0.20	21.0	3.20	0.82	0.04	12.8	0.52	1.00	0.03
S_{12}	0.25	22.6	1.10	0.52	0.04	25.2	1.30	0.08	0.02
S_{13}	0.30	20.7	5.20	4.20	0.08	27.6	8.20	1.82	0.01
S_{14}	0.17	152	4.20	5.00	0.50	24.8	0.16	1.92	0.02
S_{15}	0.42	163	9.40	3.01	0.52	33.8	0.62	1.97	0.01
S_{16}	0.45	109	5.20	2.20	0.06	5.60	0.48	1.82	0.01
S_{17}	0.16	49.6	2.86	3.00	0.30	2.40	0.42	1.00	0.01
S_{18}	0.32	120	4.78	1.00	0.34	2.20	0.52	1.00	0.00
S_{19}	0.21	20.6	0.40	1.02	0.05	8.7	0.63	0.98	0.02
S_{20}	0.32	22.2	3.00	1.10	0.42	3.20	1.00	1.50	0.02
S_{21}	0.10	21.3	2.86	2.00	0.43	26.2	0.82	1.86	0.03
S_{22}	0.28	75.6	2.90	1.12	0.08	22.6	0.52	3.30	0.02
S_{23}	0.30	19.3	5.60	4.00	0.09	18.7	0.57	2.20	0.01
S_{24}	0.31	100.	6.02	2.00	0.32	32.1	1.00	2.50	0.02
S_{25}	0.35	80.6	2.06	0.62	0.28	16.2	0.51	0.80	0.01
S_{26}	0.18	23.7	0.86	0.35	0.07	17.7	0.56	1.93	0.02
S_{27}	0.97	20.6	0.67	2.00	0.08	4.10	2.00	1.63	0.01
S_{28}	0.10	42.5	2.80	0.93	0.09	4.70	0.87	1.52	0.01
S_{29}	0.12	26.2	1.30	0.72	0.35	3.02	1.72	1.82	0.01
S_{30}	0.10	24.6	1.92	0.82	0.08	35.8	0.92	1.72	0.02
S_{31}	0.31	152	7.20	7.30	0.80	37.6	3.10	1.86	0.01
S_{32}	0.30	142	7.20	1.40	0.80	15.0	0.80	0.02	0.01
S_{33}	0.10	37.3	0.10	0.90	0.09	22.6	0.30	0.02	0.01
S_{34}	0.08	19.6	0.13	0.80	0.10	35.1	0.56	0.02	0.01
S_{35}	0.30	90.0	3.10	3.20	0.50	15.4	0.62	0.01	0.02
S_{36}	0.08	98.0	3.00	4.20	0.10	7.40	0.67	0.02	0.01
S_{37}	0.28	15.4	0.96	1.00	0.48	22.6	0.38	0.02	0.01
S_{38}	0.30	25.6	2.96	1.00	0.10	2.90	0.45	0.03	0.01
S_{39}	0.10	100	2.44	2.96	0.10	20.6	2.10	0.02	0.01
S_{40}	0.29	140	8.60	3.12	1.12	22.6	1.00	0.04	0.01

TABLE 50: Concentration of Heavy Metals in Sediment of R.Niger (April, 2014)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
S_1	0.30	119	4.60	2.60	0.01	1.32	1.40	0.02	0.01
S_2	0.10	20.2	2.40	0.60	0.10	1.20	0.62	0.01	0.00
S_3	0.15	26.3	0.82	0.75	0.10	7.50	0.80	0.80	0.01
S_4	0.10	20.1	0.71	0.68	0.10	31.6	0.92	0.01	0.00
S_5	0.23	15.2	0.38	0.28	0.10	12.2	0.55	0.10	0.00
S_6	0.21	24.8	2.51	0.52	0.24	22.1	0.68	2.50	0.02
S_7	0.12	27.3	0.62	0.74	0.10	5.20	0.20	1.00	0.01
S_8	0.11	18.2	0.52	0.42	0.02	20.8	0.61	2.15	0.01
S_9	ND	20.5	2.87	0.90	0.01	1.87	0.43	1.12	0.01
S_{10}	ND	45.3	0.69	0.85	0.02	2.93	0.67	1.00	0.00
S_{11}	0.10	19.1	2.52	0.43	0.01	11.2	0.46	0.80	0.00
S_{12}	0.15	20.8	0.63	0.76	0.01	23.0	1.00	0.04	0.00
S_{13}	0.10	18.5	4.47	0.47	0.02	26.1	7.30	1.60	0.00
S_{14}	0.13	148	4.30	3.82	0.25	22.6	0.12	1.65	0.00
S_{15}	0.38	150	8.20	4.92	0.43	32.3	0.56	1.70	0.00
S_{16}	0.22	90.2	4.10	2.72	0.02	4.50	0.39	1.50	0.00
S_{17}	0.13	48.2	2.40	1.83	0.26	2.10	0.20	0.90	0.00
S_{18}	0.21	110	4.32	2.60	0.28	1.84	0.30	0.95	0.01
S_{19}	0.10	18.0	0.10	0.92	0.02	16.3	0.42	0.86	0.01
S_{20}	0.21	20.1	2.60	0.84	0.29	2.75	0.79	1.20	0.01
S_{21}	0.08	20.2	2.54	0.72	0.30	24.2	0.45	2.60	0.01
S_{22}	0.24	70.3	2.65	1.62	0.04	20.4	0.38	1.86	0.00
S_{23}	0.23	18.2	4.82	0.86	0.05	15.10	0.46	2.10	0.00
S_{24}	0.24	96.7	4.93	3.52	0.23	31.6	0.86	0.60	0.00
S_{25}	0.23	76.5	6.42	1.89	0.22	14.6	0.42	0.40	0.00
S_{26}	0.07	22.3	0.85	0.49	0.02	16.4	0.51	1.32	0.00
S_{27}	0.87	18.5	0.69	0.28	0.04	3.62	1.86	1.40	0.00
S_{28}	0.05	38.2	2.43	1.67	0.03	3.64	0.76	1.32	0.00
S_{29}	0.06	24.2	0.50	0.82	0.26	2.86	0.92	1.40	0.01
S_{30}	0.07	22.6	0.42	0.63	0.02	34.6	0.50	1.35	0.01
S_{31}	0.26	14.6	2.63	6.10	0.65	36.2	2.10	1.45	0.00
S_{32}	0.23	136	6.52	1.20	0.50	12.70	0.60	0.01	0.00
S_{33}	0.07	35.4	0.09	0.50	0.03	21.4	0.20	0.01	0.01
S_{34}	0.06	18.2	0.08	0.25	0.08	33.2	0.41	0.01	0.00
S_{35}	0.28	81.0	2.10	2.80	0.42	12.3	0.48	0.01	0.00
S_{36}	0.04	95.0	2.30	3.60	0.06	6.82	0.52	0.01	0.00
S_{37}	0.22	12.3	0.84	0.82	0.31	21.4	0.23	0.01	0.00
S_{38}	0.24	24.5	2.11	0.95	0.05	1.50	0.34	0.00	0.01
S_{39}	0.03	89.2	2.32	2.30	0.06	19.3	1.82	0.01	0.01
S_{40}	0.24	136	6.50	2.92	0.87	20.2	0.65	0.02	0.00

TABLE 51: Concentration of Heavy Metals in Sediment of R.Niger (May, 2014)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
S_1	0.20	109	4.00	2.40	ND	1.20	1.35	0.00	0.00
S_2	ND	16.2	2.00	0.20	ND	1.00	0.20	0.00	0.00
S_3	ND	24.8	ND	0.40	ND	7.30	0.30	0.50	0.00
S_4	ND	18.2	ND	0.60	ND	30.5	0.70	0.00	0.00
S_5	ND	13.2	ND	0.20	ND	11.0	0.35	0.09	0.00
S_6	0.20	23.2	2.00	0.40	0.20	20.5	0.56	2.10	0.00
S_7	ND	26.2	ND	0.60	ND	4.20	0.16	0.90	0.00
S_8	ND	15.6	ND	0.40	ND	20.2	0.54	2.10	0.00
S_9	ND	19.2	2.00	0.80	ND	1.20	0.32	0.95	0.00
S_{10}	ND	44.2	ND	0.60	ND	2.80	0.35	0.70	0.00
S_{11}	ND	18.2	ND	0.40	ND	10.5	0.32	0.10	0.00
S_{12}	ND	19.0	2.00	0.60	ND	20.8	0.71	0.00	0.00
S_{13}	ND	16.4	ND	0.40	ND	25.6	6.20	1.20	0.00
S_{14}	ND	146	4.00	3.20	0.20	20.5	0.08	1.40	0.00
S_{15}	0.40	146	8.00	4.60	0.40	30.1	0.50	1.50	0.00
S_{16}	0.20	81.8	4.00	2.40	ND	3.10	0.32	1.20	0.00
S_{17}	ND	45.8	2.00	1.00	0.20	1.20	0.16	0.80	0.00
S_{18}	0.20	105.	4.00	2.40	0.20	1.30	0.28	1.00	0.00
S_{19}	ND	15.0	ND	0.60	ND	15.2	0.31	0.72	0.00
S_{20}	0.20	18.0	2.00	0.40	0.20	2.50	0.71	0.91	0.00
S_{21}	ND	18.0	2.00	0.40	0.20	22.6	0.35	2.50	0.00
S_{22}	0.20	69.2	2.00	1.40	ND	19.6	0.33	1.00	0.00
S_{23}	0.20	17.2	4.00	0.40	ND	14.8	0.32	1.10	0.00
S_{24}	0.20	92.4	4.00	3.00	0.20	30.7	0.72	0.00	0.00
S_{25}	0.20	63.8	6.00	1.60	0.20	13.5	0.20	0.00	0.00
S_{26}	ND	21.0	ND	0.40	ND	15.3	0.31	1.00	0.00
S_{27}	0.80	16.4	ND	0.20	ND	2.50	1.52	1.12	0.00
S_{28}	ND	36.8	2.00	1.00	ND	3.40	0.40	1.22	0.00
S_{29}	ND	23.6	ND	0.60	0.20	2.50	0.80	1.35	0.00
S_{30}	ND	21.6	ND	0.40	ND	32.6	0.43	1.20	0.00
S_{31}	0.20	147	2.00	5.20	0.40	32.2	1.00	2.00	0.00
S_{32}	0.20	136	6.00	1.80	0.20	12.5	0.40	0.00	0.00
S_{33}	ND	31.6	ND	0.40	ND	20.5	0.18	0.00	0.00
S_{34}	ND	16.2	ND	0.20	ND	30.6	0.38	0.00	0.00
S_{35}	0.20	79.4	2.00	2.40	0.20	10.6	0.35	0.00	0.00
S_{36}	ND	92.0	2.00	3.40	ND	6.20	0.45	0.00	0.00
S_{37}	0.20	11.6	ND	0.40	0.20	20.5	0.17	0.00	0.00
S_{38}	0.20	22.2	2.00	0.60	ND	1.20	0.18	0.00	0.00
S_{39}	ND	86.2	2.00	1.80	ND	1.50	1.42	0.00	0.00
S_{40}	0.20	134	6.00	2.80	0.40	18.6	0.32	0.00	0.00

TABLE 52: Concentration of Heavy Metals in Sediments Sample of River Niger (June)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
S_1	0.40	110	4.51	2.70	0.20	1.30	1.86	0.02	0.00
S_2	0.20	18.2	2.82	0.40	0.20	1.12	0.60	0.04	0.00
S_3	0.20	26.2	2.51	0.60	0.20	7.50	0.80	0.08	0.00
S_4	0.20	20.1	0.40	0.92	0.20	31.2	1.00	0.20	0.00
S_5	0.20	14.6	0.31	0.32	0.25	11.9	0.40	0.10	0.00
S_6	0.30	24.8	2.20	0.45	0.20	20.8	0.72	2.62	0.00
S_7	0.20	28.2	0.20	0.78	0.20	4.52	0.23	1.00	0.00
S_8	0.20	18.7	0.20	0.62	0.20	21.1	0.82	2.30	0.00
S_9	0.10	20.7	2.11	1.10	0.20	2.50	0.51	1.20	0.00
S_{10}	0.10	45.6	0.20	0.82	0.18	3.10	0.62	1.10	0.00
S_{11}	0.10	19.7	0.30	0.75	0.19	11.2	0.73	0.40	0.00
S_{12}	0.20	21.2	2.24	0.93	0.16	20.9	0.92	0.20	0.00
S_{13}	0.20	18.1	0.24	0.55	0.20	26.7	7.10	1.40	0.00
S_{14}	0.20	148	4.10	3.80	0.25	21.6	0.12	1.80	0.00
S_{15}	0.50	151	8.21	4.72	0.48	30.8	0.81	2.00	0.00
S_{16}	0.40	90.6	4.30	2.75	0.21	2.82	0.51	1.70	0.00
S_{17}	0.20	48.2	2.10	1.32	0.28	1.71	0.34	1.10	0.00
S_{18}	0.30	106	4.21	2.86	0.32	1.42	0.40	1.20	0.00
S_{19}	0.20	18.1	0.30	0.91	0.20	15.8	0.41	1.00	0.00
S_{20}	0.30	20.2	2.21	0.83	0.31	2.70	0.86	2.72	0.00
S_{21}	0.10	70.3	2.18	0.82	0.32	22.8	0.43	1.30	0.00
S_{22}	0.25	18.6	2.20	1.61	0.20	20.1	0.48	1.20	0.00
S_{23}	0.28	93.8	4.26	0.48	0.22	22.3	0.52	0.40	0.00
S_{24}	0.22	64.2	4.18	3.20	0.26	15.1	1.20	0.20	0.00
S_{25}	0.23	24.8	6.30	1.80	0.27	40.3	1.00	1.20	0.00
S_{26}	0.18	18.2	0.21	0.95	0.22	16.6	0.41	1.32	0.00
S_{27}	0.87	38.1	0.24	0.72	0.20	2.86	1.85	1.42	0.00
S_{28}	0.20	25.0	2.26	1.33	0.20	3.72	0.73	1.63	0.00
S_{29}	0.20	27.7	0.45	0.80	0.31	2.72	0.97	1.53	0.00
S_{30}	0.20	24.8	0.31	0.71	0.20	33.7	0.85	1.42	0.00
S_{31}	0.24	150	2.32	5.93	0.62	35.3	1.50	2.80	0.00
S_{32}	0.32	140	6.30	1.92	0.40	15.2	0.80	0.20	0.00
S_{33}	0.04	33.8	2.10	0.62	0.20	26.3	0.25	0.20	0.00
S_{34}	0.08	18.2	2.50	0.40	0.20	33.2	0.52	0.20	0.00
S_{35}	0.40	80.2	2.72	2.60	0.40	15.8	0.62	0.40	0.00
S_{36}	0.20	100	1.20	3.84	0.20	7.30	0.71	0.20	0.00
S_{37}	0.60	15.3	2.63	0.72	0.40	25.1	0.20	0.20	0.00
S_{38}	0.47	23.6	2.84	0.82	0.20	1.80	0.24	0.40	0.00
S_{39}	0.20	90.3	2.90	7.10	0.20	2.10	1.83	0.30	0.00
S_{40}	0.40	142	6.31	3.62	0.86	19.20	0.70	0.20	0.00

TABLE 53: Concentration of Heavy Metals in Sediment Sample of River Niger (July)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
S_1	0.35	90.8	4.38	2.50	0.18	1.22	1.50	0.01	0.01
S_2	0.16	17.6	2.10	0.30	0.15	1.00	0.30	0.02	0.00
S_3	0.17	25.5	2.12	0.52	0.10	6.80	0.40	0.06	0.00
S_4	0.16	19.3	0.29	0.81	0.12	30.6	0.80	0.18	0.01
S_5	0.18	14.0	0.10	0.28	0.20	11.0	0.20	0.09	0.00
S_6	0.26	23.2	2.10	0.41	0.16	19.1	0.58	2.40	0.01
S_7	0.19	24.1	0.10	0.69	0.14	3.80	0.18	0.80	0.00
S_8	0.09	15.3	0.12	0.58	0.17	20.8	0.74	2.00	0.00
S_9	0.08	18.4	2.00	0.96	0.10	1.90	0.48	1.00	0.00
S_{10}	0.10	42.3	0.10	0.76	0.10	2.90	0.53	1.00	0.00
S_{11}	0.09	18.2	0.22	0.71	0.16	10.0	0.68	0.28	0.01
S_{12}	0.18	20.1	2.20	0.92	0.12	18.8	0.76	0.15	0.00
S_{13}	0.17	15.3	0.20	0.53	0.15	25.1	0.81	1.32	0.00
S_{14}	0.16	12.0	3.80	3.28	0.20	20.1	6.50	1.35	0.00
S_{15}	0.45	148	7.40	4.23	0.32	28.2	0.09	1.65	0.01
S_{16}	0.37	60.8	3.20	1.86	0.18	3.10	0.60	1.62	0.00
S_{17}	0.18	41.2	1.80	1.30	0.26	0.90	0.38	1.00	0.00
S_{18}	0.29	105	4.00	2.63	0.25	1.10	0.21	1.02	0.00
S_{19}	0.18	17.0	0.21	0.52	0.16	14.6	0.36	0.80	0.01
S_{20}	0.25	19.3	2.10	0.61	0.20	2.10	0.35	2.12	0.00
S_{21}	0.08	68.2	2.00	0.71	0.22	20.8	0.76	1.10	0.00
S_{22}	0.23	17.4	2.10	0.92	0.16	18.5	0.34	1.00	0.00
S_{23}	0.25	90.2	2.00	0.41	0.19	20.2	0.33	0.30	0.00
S_{24}	0.20	61.3	3.88	3.00	0.22	14.6	0.40	0.12	0.00
S_{25}	0.20	21.4	4.00	1.20	0.24	36.4	0.96	1.00	0.01
S_{26}	0.15	17.1	5.78	0.73	0.21	15.3	0.92	1.11	0.00
S_{27}	0.63	32.5	0.10	0.64	0.18	1.80	0.31	1.25	0.00
S_{28}	0.16	24.1	0.20	1.28	0.16	2.96	0.66	1.36	0.00
S_{29}	0.18	26.8	2.11	0.76	0.23	2.10	0.85	1.48	0.00
S_{30}	0.19	23.4	0.32	0.62	0.15	30.6	0.56	1.20	0.00
S_{31}	0.20	140	0.28	4.86	0.49	34.8	1.38	1.92	0.00
S_{32}	0.30	129	6.10	1.22	0.35	14.8	0.60	0.16	0.00
S_{33}	0.02	17.0	1.82	0.41	0.18	25.2	0.20	0.15	0.01
S_{34}	0.06	78.2	2.10	0.23	0.30	80.3	0.48	0.17	0.01
S_{35}	0.35	80.5	2.40	2.10	0.10	15.2	0.58	0.29	0.00
S_{36}	0.20	13.2	1.00	2.36	0.30	6.80	0.63	0.19	0.01
S_{37}	0.52	20.3	2.10	0.50	0.12	22.4	0.17	0.16	0.01
S_{38}	0.42	75.6	2.25	0.65	0.15	0.96	0.21	0.30	0.00
S_{39}	0.17	73.8	2.40	2.30	0.10	1.80	1.20	0.25	0.01
S_{40}	0.34	138	5.92	3.40	0.60	17.20	0.50	0.18	0.00

TABLE 54: Concencentrtion (PPM) of Heavy Metal in Sediment Sample of River Niger (August)

SAMPLE	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
S_1	ND	16.2	2.00	0.60	ND	1.60	1.40	0.00	0.00
S_2	ND	16.8	ND	0.20	ND	1.20	0.20	0.00	0.00
S_3	ND	48.0	2.00	0.60	ND	8.40	0..40	0.60	0.00
S_4	0.80	582	10.0	5.60	0.80	35.8	0.80	0.00	0.00
S_5	0.20	75.6	4.00	1.60	ND	1.2	0.40	0.00	0.00
S_6	0.20	110	6.00	2.60	1.20	23.6	0.60	2.00	0.00
S_7	ND	18.8	2.00	0.40	ND	5.60	0.20	1.00	0.00
S_8	0.20	134	6.00	4.00	0.20	26.2	0.60	2.20	0.00
S_9	0.20	18.8	2.00	0.40	0.20	1.60	0.40	0.00	0.00
S_{10}	ND	17.2	ND	0.20	ND	3.60	0.40	0.80	0.00
S_{11}	ND	73.6	4.00	2.40	ND	16.2	0.40	0.00	0.00
S_{12}	1.20	133	8.00	4.60	0.60	31.4	0.80	0.00	0.00
S_{13}	0.20	114	2.00	3.60	0.20	27.8	6.00	1.40	0.00
S_{14}	0.20	110	6.00	2.40	0.20	22.6	0.00	1.80	0.00
S_{15}	0.20	111	6.00	3.40	0.60	35.0	0.60	1.80	0.00
S_{16}	ND	20.2	2.00	0.40	ND	3.20	0.40	1.40	0.00
S_{17}	0.20	17.2	4.00	0.40	0.40	1.40	0.20	0.00	0.00
S_{18}	0.20	20.0	2.00	0.40	0.20	1.60	0.40	0.00	0.00
S_{19}	ND	29.0	2.00	1.00	ND	20.2	0.40	0.00	0.00
S_{20}	ND	16.2	ND	0.60	ND	3.40	0-.80	0.00	0.00
S_{21}	0.20	125	6.00	3.00	0.40	25.8	0.40	2.80	0.00
S_{22}	2.60	107	10.0	3.00	1.60	20.8	0.40	1.40	0.00
S_{23}	0.20	42.4	2.00	1.00	0.40	19.3	0.40	1.60	0.00
S_{24}	0.40	90.0	4.00	2.80	0.20	36.0	0.40	0.00	0.00
S_{25}	0.40	62.0	2.00	2.00	0.20	15.2	0.40	0.00	0.00
S_{26}	0.20	88.6	6.00	3.00	0.20	19.4	0.80	0.00	0.00
S_{27}	0.20	18.4	2.00	0.60	ND	3.20	0.20	0.00	0.00
S_{28}	0.20	22.0	2.00	0.80	ND	5.00	0.40	0.60	0.00
S_{29}	ND	15.4	2.00	0.40	ND	3.20	1.60	0.00	0.00
S_{30}	0.20	139	2.00	4.20	2.80	35.8	0.60	3.40	0.00
S_{31}	3.60	470	12.0	5.40	1.60	34.6	1.00	0.00	0.00
S_{32}	0.40	72.4	4.00	4.00	3.00	13.8	0.60	0.00	0.00
S_{33}	0.40	15.2	6.00	6.00	3.40	23.2	0.20	0.00	0.00
S_{34}	0.20	68.2	6.00	6.00	2.60	38.8	0.40	0.00	0.00
S_{35}	0.20	75.0	4.00	4.00	3.00	13.6	0.40	0.00	0.00
S_{36}	0.20	60.2	6.00	6.00	0.60	7.60	0.60	0.00	0.00
S_{37}	0.20	140	4.00	4.00	5.00	22.8	0.20	0.00	0.00
S_{38}	ND	13.6	ND	ND	0.18	1.40	0.20	0.00	0.00
S_{39}	0.20	10.6	2.00	2.00	0.40	1.80	1.60	0.00	0.00
S_{40}	0.20	141	6.00	6.00	3.40	20.0	0.40	0.00	0.00

TABLE 55: Concencentrtion of Heavy Metal in Sediment Sample of River. Niger (September)

Sample	Cr	Mn	Pb	Co	Ni	Fe	Zn	Cu	Cd
S_1	1.10	16.8	3.10	0.80	1.10	1.80	1.85	1.10	0.00
S_2	1.10	18.2	1.20	1.30	1.10	0.40	0.50	0.60	0.00
S_3	1.10	50.2	2.84	0.82	1.00	9.60	0.87	0.80	0.00
S_4	1.20	78.6	10.8	7.00	1.00	38.2	0.87	1.00	0.00
S_5	1.20	120	6.70	2.00	0.80	12.5	0.48	2.20	0.00
S_6	0.30	118	7.00	2.85	1.80	24.3	0.80	2.50	0.00
S_7	0.21	20.1	2.40	0.60	1.10	7.70	0.50	1.20	0.00
S_8	0.40	140	7.10	7.00	1.20	27.1	0.80	2.80	0.00
S_9	0.60	19.8	3.40	0.40	ND	4.10	0.60	1.20	0.00
S_{10}	1.00	18.4	1.00	0.80	1.12	4.00	0.60	0.87	0.00
S_{11}	0.80	74.0	5.10	3.10	1.00	18.2	0.70	0.80	0.00
S_{12}	1.25	140	10.0	6.20	0.80	33.2	0.87	1.00	0.00
S_{13}	0.40	116	2.60	4.40	0.31	28.2	7.10	1.80	0.00
S_{14}	0.50	120	8.50	2.62	0.40	23.4	1.00	1.90	0.00
S_{15}	0.40	112	7.00	3.60	0.82	35.7	0.72	2.00	0.00
S_{16}	1.00	25.2	2.60	0.70	1.00	3.80	0.61	1.82	0.00
S_{17}	0.40	18.2	6.30	0.70	0.62	1.80	0.35	1.00	0.00
S_{18}	0.25	23.1	2.60	0.70	0.50	1.80	0.60	0.80	0.00
S_{19}	0.86	30.6	2.40	1.60	0.80	21.2	0.45	1.00	0.00
S_{20}	1.00	17.5	ND	0.80	1.00	3.85	0.87	0.00	0.00
S_{21}	0.38	130	7.00	4.30	0.60	26.7	0.80	3.0	0.00
S_{22}	2.80	110	11.2	4.20	1.70	22.4	0.60	1.80	0.00
S_{23}	0.32	45.0	2.20	1.20	0.60	21.2	0.60	1.80	0.00
S_{24}	0.52	100	6.10	3.10	0.25	37.2	0.60	0.80	0.00
S_{25}	0.80	70.2	3.10	3.00	0.32	18.2	0.60	1.00	0.00
S_{26}	0.31	92.0	6.80	3.20	0.80	21.1	1.00	0.70	0.00
S_{27}	0.35	20.2	3.10	0.80	0.75	4.10	0.60	0.60	0.00
S_{28}	0.42	23.1	3.10	0.90	0.60	6.20	0.60	0.80	0.00
S_{29}	0.45	16.2	3.20	0.60	0.40	3.60	1.80	0.60	0.00
S_{30}	0.30	142	2.80	4.80	3.32	38.2	0.80	4.10	0.00
S_{31}	3.80	480	13.8	6.20	1.80	35.2	1.10	0.40	0.00
S_{32}	0.60	75.2	4.20	3.10	0.70	15.2	0.80	0.80	0.00
S_{33}	0.60	16.2	7.20	3.80	0.80	24.1	0.40	0.60	0.00
S_{34}	0.50	69.0	6.80	3.10	0.40	39.2	0.50	0.20	0.00
S_{35}	0.31	78.0	4.32	3.81	0.71	13.6	0.60	0.00	0.00
S_{36}	0.35	60.8	7.00	0.80	0.60	7.80	0.86	0.20	0.00
S_{37}	0.32	148	5.62	5.20	0.35	25.1	0.35	0.40	0.00
S_{38}	0.40	14.8	0.20	0.32	0.40	1.80	0.40	0.60	0.00
S_{39}	0.32	11.8	2.80	0.46	0.41	2.30	2.10	0.00	0.00
S_{40}	0.42	148	7.00	4.20	0.60	21.7	0.60	0.20	0.00

TABLE 56: Concencentrtion of Heavy Metal in Sediment Sample of River Niger (October)

Sample	**Cr**	Mn	**Pb**	**Co**	**Ni**	**Fe**	**Zn**	**Cu**	**Cd**
S_1	1.20	17.3	3.60	1.20	1.30	2.21	2.00	2.34	0.01
S_2	1.25	20.4	1.80	1.60	1.50	1.62	1.00	1.72	0.01
S_3	1.35	52.1	2.90	2.00	1.60	10.1	1.80	1.23	0.01
S_4	1.40	79.8	11.8	7.92	1.82	40.3	1.20	2.20	0.01
S_5	1.20	130	7.90	2.60	1.20	13.2	0.85	2.80	ND
S_6	0.80	120	8.42	2.90	2.00	8.10	0.70	2.92	ND
S_7	0.72	27.2	2.50	1.20	1.32	8.00	0.80	1.35	0.01
S_8	0.84	148	7.60	7.60	1.53	28.2	0.93	2.96	0.02
S_9	1.20	21.6	3.45	0.80	1.00	4.80	0.75	1.42	0.01
S_{10}	1.40	20.3	1.30	1.20	1.43	4.92	0.78	0.93	0.01
S_{11}	1.20	75.2	5.20	3.60	1.35	18.7	0.87	0.95	0.02
S_{12}	1.50	143	10.50	6.92	1.10	35.5	0.96	1.20	0.01
S_{13}	0.80	120	2.80	4.80	0.89	28.9	7.86	2.10	ND
S_{14}	0.92	123	9.20	2.91	0.80	23.7	1.43	2.00	ND
S_{15}	0.65	115	7.30	4.10	0.90	36.3	0.74	2.31	ND
S_{16}	1.32	27.2	2.80	1.20	1.36	3.98	0.70	1.96	ND
S_{17}	0.72	19.1	7.20	1.31	1.01	2.10	0.62	1.32	ND
S_{18}	0.50	24.2	2.80	1.20	0.75	2.15	0.73	0.92	0.02
S_{19}	1.22	33.7	2.80	1.81	0.96	22.6	0.52	1.25	0.01
S_{20}	1.42	20.2	1.20	1.00	1.52	4.00	0.90	1.00	ND
S_{21}	0.85	138	8.20	4.86	0.93	27.2	1.10	3.12	ND
S_{22}	4.32	49.2	11.5	4.87	1.83	23.7	0.86	2.10	0.01
S_{23}	0.95	120	2.80	1.57	0.95	22.7	0.92	2.23	0.01
S_{24}	0.82	80.3	6.92	3.81	0.49	38.9	0.95	0.97	0.01
S_{25}	1.10	78.2	4.20	3.42	0.63	20.1	0.96	1.50	0.02
S_{26}	0.63	110	7.10	3.51	0.94	21.9	1.20	0.96	0.02
S_{27}	0.86	26.3	3.85	1.10	1.10	5.10	0.76	0.98	0.02
S_{28}	0.69	24.4	3.90	1.23	0.83	6.70	0.75	0.89	0.02
S_{29}	0.70	17.5	3.60	0.89	0.72	3.92	2.10	0.87	0.01
S_{30}	0.65	145	3.10	4.93	3.97	39.5	0.96	4.35	0.01
S_{31}	4.30	482	14.1	7.12	2.10	36.4	1.50	0.63	0.01
S_{32}	0.86	75.9	4.30	3.50	0.79	15.8	1.10	1.86	0.02
S_{33}	0.92	18.5	7.92	4.20	0.93	24.9	0.86	1.10	0.04
S_{34}	0.72	70.6	6.95	3.60	0.68	40.1	0.93	0.40	0.01
S_{35}	0.63	80.3	5.20	4.42	0.85	14.8	0.87	1.20	0.02
S_{36}	0.54	69.5	7.60	1.10	0.69	8.90	1.21	0.90	0.01
S_{37}	0.62	150	6.10	6.20	0.42	26.2	0.67	0.80	0.01
S_{38}	0.82	15.8	0.62	0.84	0.72	1.92	0.73	1.00	0.02
S_{39}	0.74	13.7	3.10	0.73	0.84	2.56	3.10	1.10	0.03
S_{40}	0.83	152	7.95	4.92	0.91	21.9	1.10	0.85	0.02

APPENDIX XXI

Correlation Analysis of Heavy Metal in Water and Sediment of River Niger

Table: 57 Dry Season Concentration of Heavy Metal in Water and in Sediment

			Dry season concentration of heavy metals in water	Dry season concentrations of heavy metals in sediments
Spearman's rho	Dry season concentration of heavy metals in water	Correlation Coefficient	1.000	.848
		Sig. (2-tailed)	.	.004
		N	9	9
	Dry season concentrations of heavy metals in sediments	Correlation Coefficient	.848**	1.000**
		Sig. (2-tailed)	.004	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table:58: Wet Season Concentration of Heavy Metal in Water and in Sediment

			Wet season concentrations of heavy metals in water	Wet season concentrations of heavy metals in sediments
Spearman's rho	Wet season concentrations of heavy metals in water	Correlation Coefficient	1.000	.803
		Sig. (2-tailed)	.	.009
		N	9	9
	Wet season concentrations of heavy metals in sediments	Correlation Coefficient	.803**	1.000**
		Sig. (2-tailed)	.009	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table: 59Dry and Wet Seasons Concentration of Heavy Metals in Water

			Dry season concentration of heavy metals in water	Wet season concentrations of heavy metals in water
Spearman's rho	Dry season concentration of heavy metals in water	Correlation Coefficient	1.000	.936
		Sig. (2-tailed)	.	.000
		N	9	9
	Wet season concentrations of heavy metals in water	Correlation Coefficient	.936**	1.000**
		Sig. (2-tailed)	.000	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table: 60 Dry and Wet Seasons Concentration of Heavy Metals in Sediment

			Dry season concentrations of heavy metals in sediments	Wet season concentrations of heavy metals in sediments
Spearman's rho	Dry season concentrations of heavy metals in sediments	Correlation Coefficient	1.000	1.000
		Sig. (2-tailed)	.	0.000
		N	9	9
	Wet season concentrations of heavy metals in sediments	Correlation Coefficient	1.000**	1.000**
		Sig. (2-tailed)	0.000.	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX XXII

GRAPH OF THE SEASONAL CORRELATION OF HEAVY METALS IN WATER AND SEDIMENT

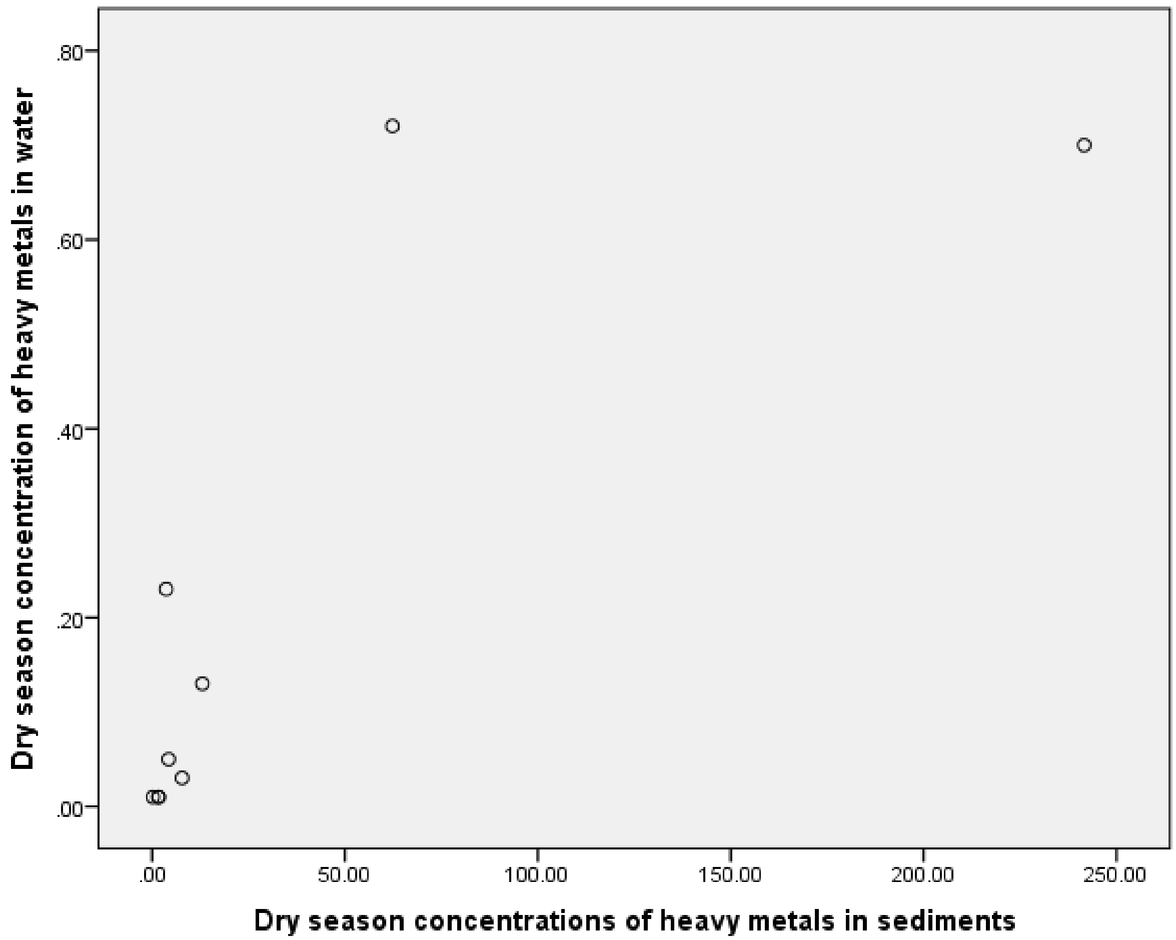


Fig 1:scatter plot of dry season concentration of heavy metal in water Vs in sediment

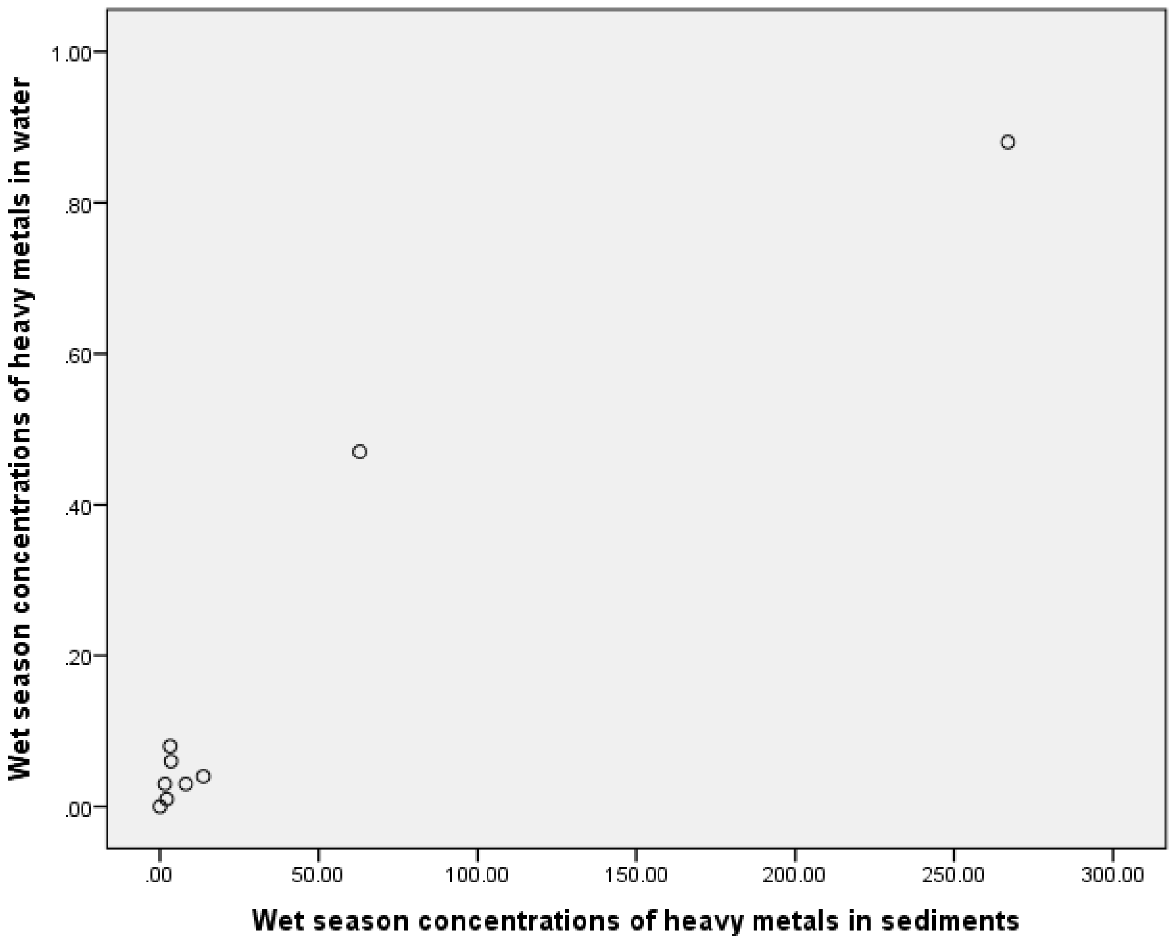


Fig 2:scatter plot of wet seasons concentration of heavy metal in water Vs in sediment

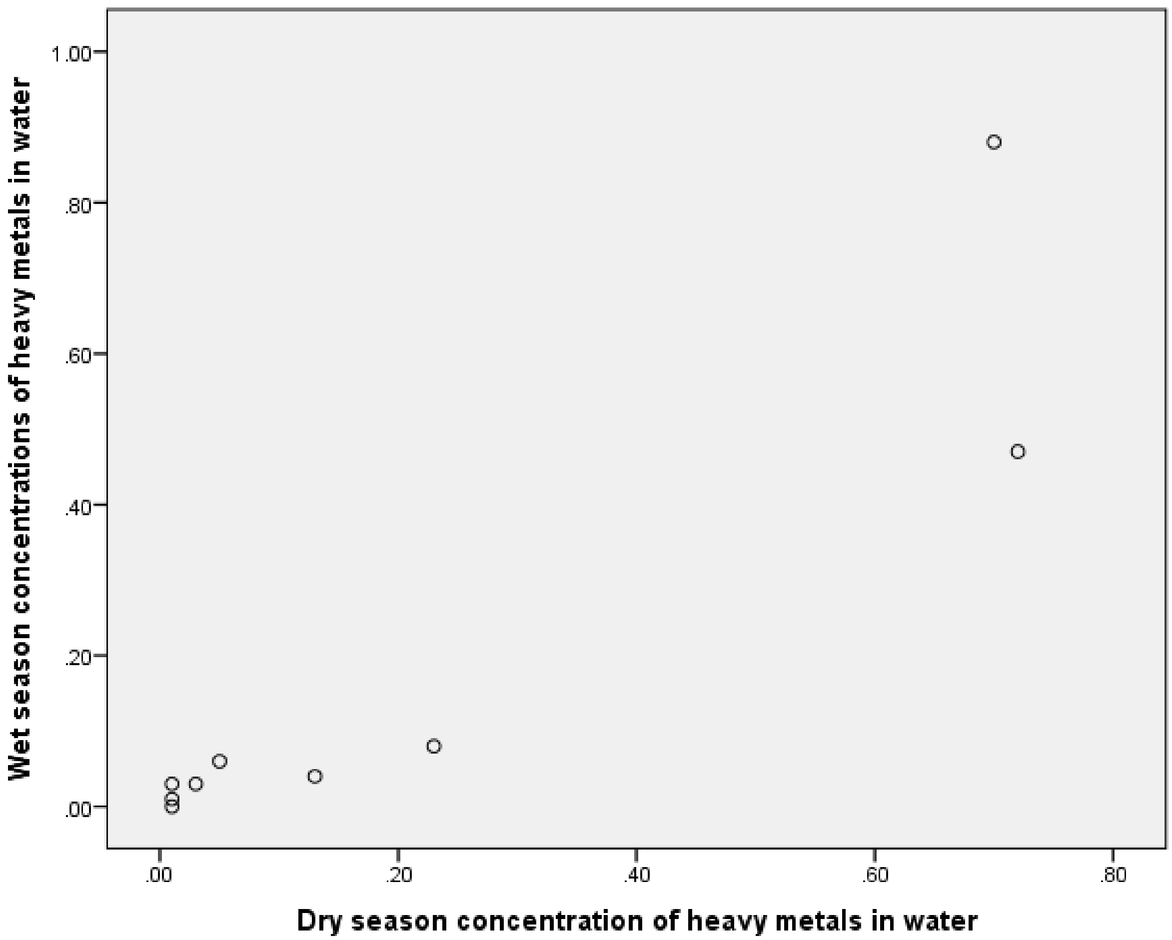


Fig 3: Scatter plot of wet season concentration of heavy metal in water Vs dry season concentration in water

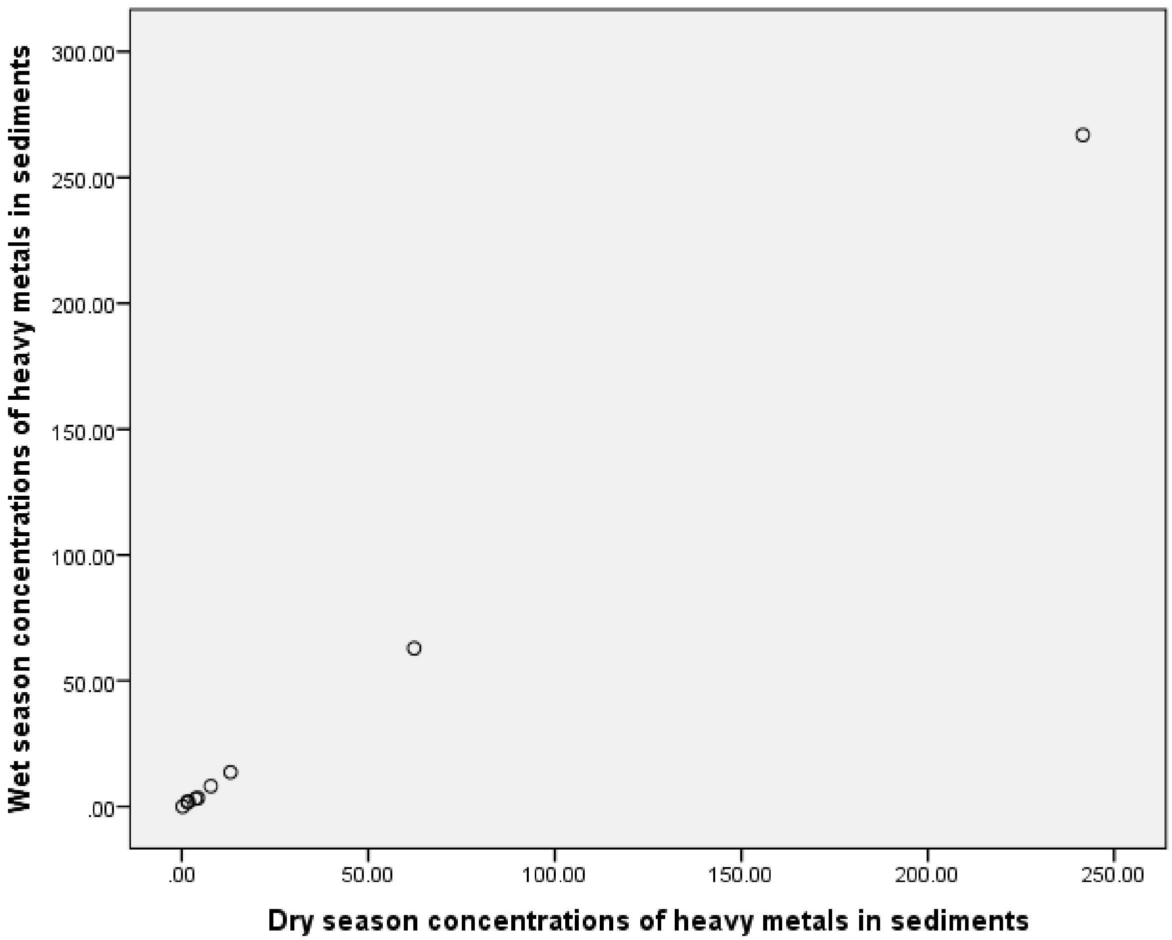


Fig 3:Scatter plot of wet season concentration of heavy metal in sedimentVs dry season concentration in sediments.

APPENDIX XXIII

Correlation's Analysis of Heavy Metals in Fish Samples

Table 61: correlation of heavy metals concentrations in tilapia and catfish from lokoja.

		concentrations of heavy metals in Tilapia from lokoja	concentrations of heavy metals in catfish from Lokoja
concentrations of heavy metals in Tilapia from lokoja	Pearson Correlation	1	.988**
	Sig. (2-tailed)		.000
	N	9	s9
concentrations of heavy metals in catfish from lokoja	Pearson Correlation	.988**	1
	Sig. (2-tailed)	.000	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 62: Correlation of heavy metals concentrations in tilapia and in catfish from Itobe

		concentrations of heavy metals in Tilapia from itobe	Concentration of heavy metals in catfish from itobe
concentrations of heavy metals in Tilapia from itobe	Pearson Correlation	1	.999**
	Sig. (2-tailed)		.000
	N	9	9
Concentration of heavy metals in catfish from itobe	Pearson Correlation	.999**	1
	Sig. (2-tailed)	.000	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).\

Table 64: Concentration of Heavy Metals In Catfish From Lokoja and Itobe

		concentrations of heavy metals in catfish from lokoja	Concentration of heavy metals in catfish from itobe
concentrations of heavy metals in catfish from lokoja	Pearson Correlation	1	.975**
	Sig. (2-tailed)		.000
	N	9	9
Concentration of heavy metals in catfish from itobe	Pearson Correlation	.975**	1
	Sig. (2-tailed)	.000	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 65. concentration of heavy metals in tilapia and catfish from idah

		Concentration of heavy metals in Tilapia from Idah	Concentration of heavy metals in catfish from idah
Concentration of heavy metals in Tilapia from Idah	Pearson Correlation	1	.973**
	Sig. (2-tailed)		.000
	N	9	9
Concentration of heavy metals in catfish from idah	Pearson Correlation	.973**	1
	Sig. (2-tailed)	.000	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 66: concentration of heavy metals in tilapia from Lokoja and Idah

		concentrations of heavy metals in Tilapia from lokoja	Concentration of heavy metals in Tilapia from Idah
concentrations of heavy metals in Tilapia from lokoja	Pearson Correlation	1	.993**
	Sig. (2-tailed)		.000
	N	9	9
Concentration of heavy metals in Tilapia from Idah	Pearson Correlation	.993**	1
	Sig. (2-tailed)	.000	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 67: concentration of heavy metals in catfish from Lokoja and Idah

		concentrations of heavy metals in catfish from lokoja	Concentration of heavy metals in catfish from idah
concentrations of heavy metals in catfish from lokoja	Pearson Correlation	[illegible]	.999**
	Sig. (2-tailed)		.000
	N	9	9
Concentration of heavy metals in catfish from idah	Pearson Correlation	.999*	1
	Sig. (2-tailed)	.000	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 68: Concentration of heavy metals in Tilapia from Itobe and Idah

		concentrations of heavy metals in Tilapia from itobe	Concentration of heavy metals in Tilapia from Idah
concentrations of heavy metals in Tilapia from itobe	Pearson Correlation	1	.996**
	Sig. (2-tailed)		.000
	N	9	9
Concentration of heavy metals in Tilapia from Idah	Pearson Correlation	.996**	1
	Sig. (2-tailed)	.000	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 69: Concentration of heavy metal in catfish from Itobe and Idah

		Concentration of heavy metals in catfish from itobe	Concentration of heavy metals in catfish from idah
Concentration of heavy metals in catfish from itobe	Pearson Correlation	1	.969**
	Sig. (2-tailed)		.000
	N	9	9
Concentration of heavy metals in catfish from idah	Pearson Correlation	.969**	1
	Sig. (2-tailed)	.000	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX XXIV

Correlation Of Heavy Metals In Water And Sediment

Table 70: Dry season concentration of heavy metals in water and in sediment

			Dry season concentration of heavy metals in water	Dry season concentrations of heavy metals in sediments
Spearman's rho	Dry season concentration of heavy metals in water	Correlation Coefficient	1.000	.848
		Sig. (2-tailed)	.	.004
		N	9	9
	Dry season concentrations of heavy metals in sediments	Correlation Coefficient	.848**	1.000**
		Sig. (2-tailed)	.004	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 71: Wet season concentration in water and sediment

			Wet season concentrations of heavy metals in water	Wet season concentrations of heavy metals in sediments
Spearman's rho	Wet season concentrations of heavy metals in water	Correlation Coefficient	1.000	.803
		Sig. (2-tailed)	.	.009
		N	9	9
	Wet season concentrations of heavy metals in sediments	Correlation Coefficient	.803**	1.000**
		Sig. (2-tailed)	.009	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 72: Dry and wet season concentration of heavy metals in water.

			Dry season concentration of heavy metals in water	Wet season concentrations of heavy metals in water
Spearman's rho	Dry season concentration of heavy metals in water	Correlation Coefficient	1.000	.936
		Sig. (2-tailed)	.	.000
		N	9	9
	Wet season concentrations of heavy metals in water	Correlation Coefficient	.936**	1.000**
		Sig. (2-tailed)	.000	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 73: dry and wet season concentration of heavy metals in sediment

			Dry season concentrations of heavy metals in sediments	Wet season concentrations of heavy metals in sediments
Spearman's rho	Dry season concentrations of heavy metals in sediments	Correlation Coefficient	1.000	1.000
		Sig. (2-tailed)	.	0.000
		N	9	9
	Wet season concentrations of heavy metals in sediments	Correlation Coefficient	1.000**	1.000**
		Sig. (2-tailed)	0.000.	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 74: Dry season concentration of heavy metals in water and in sediment

			Dry season concentration of heavy metals in water	Dry season concentrations of heavy metals in sediments
Spearman's rho	Dry season concentration of heavy metals in water	Correlation Coefficient	1.000	.848
		Sig. (2-tailed)	.	.004
		N	9	9
	Dry season concentrations of heavy metals in sediments	Correlation Coefficient	.848**	1.000**
		Sig. (2-tailed)	.004	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 75: wet season concentration of heavy metals in water and in sediment

			Wet season concentrations of heavy metals in water	Wet season concentrations of heavy metals in sediments
Spearman's rho	Wet season concentrations of heavy metals in water	Correlation Coefficient	1.000	.803
		Sig. (2-tailed)	.	.009
		N	9	9
	Wet season concentrations of heavy metals in sediments	Correlation Coefficient	.803**	1.000**
		Sig. (2-tailed)	.009	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 76: Dry and wet season concentration of heavy metals in water

			Dry season oncentration of ıeavy metals in water	Wet season concentrations of heavy metals in water
Spearman's rho	Dry season concentration of heavy metals in water	Correlation Coefficient	1.000	.936
		Sig. (2-tailed)	.	.000
		N	9	9
	Wet season concentrations of heavy metals in water	Correlation Coefficient	.936**	1.000**
		Sig. (2-tailed)	.000	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Table 77: Dry and wet season concentration of heavy metals in sediment

			Dry season concentrations of heavy metals in sediments	Wet season concentrations of heavy metals in sediments
Spearman's rho	Dry season concentrations of heavy metals in sediments	Correlation Coefficient	1.000	1.000
		Sig. (2-tailed)	.	0.000
		N	9	9
	Wet season concentrations of heavy metals in sediments	Correlation Coefficient	1.000**	1.000**
		Sig. (2-tailed)	0.000.	
		N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX XXV

SCATTER PLOTS OF THE CONCENTRATION OF METALS IN FISH SAMPLES

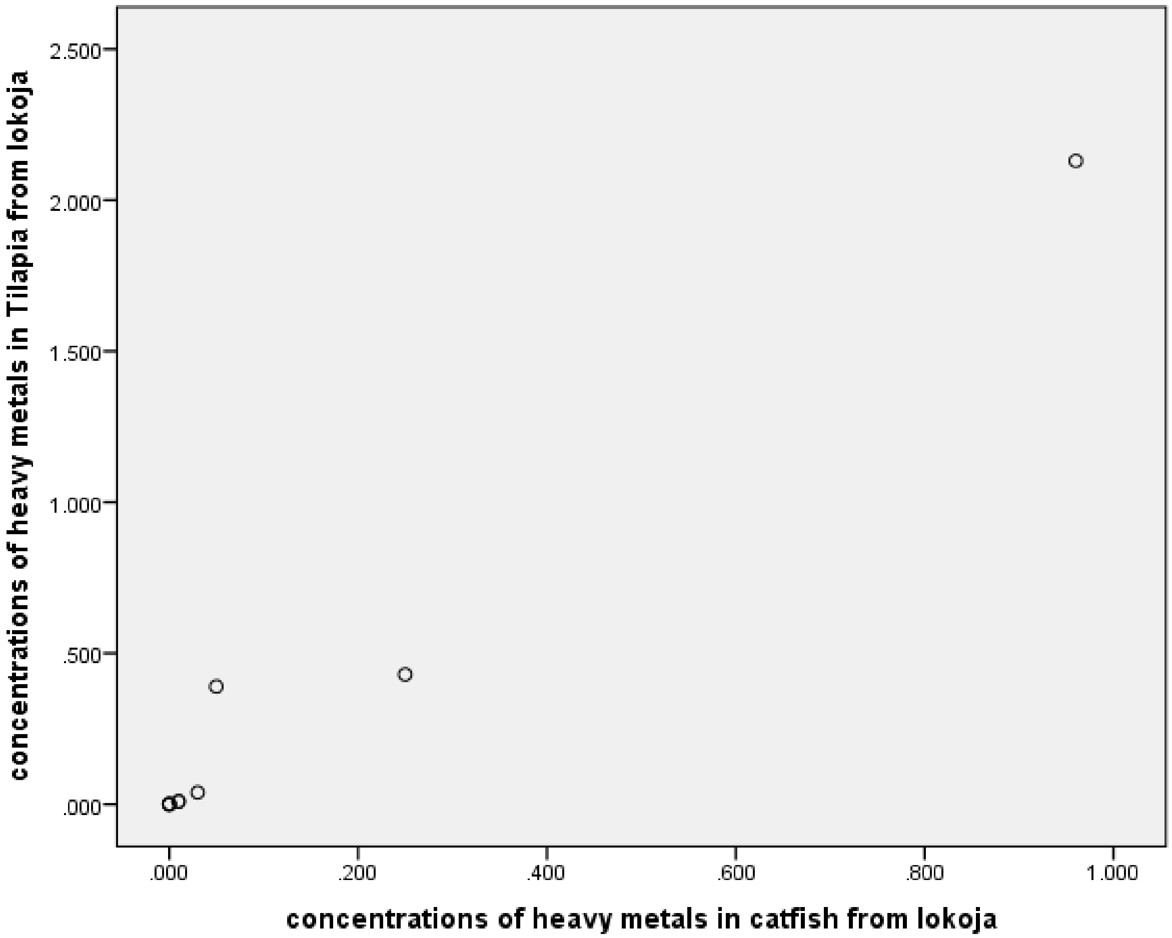


Fig. 1: Metals in Tilapia VS metals in catfish from lokoja

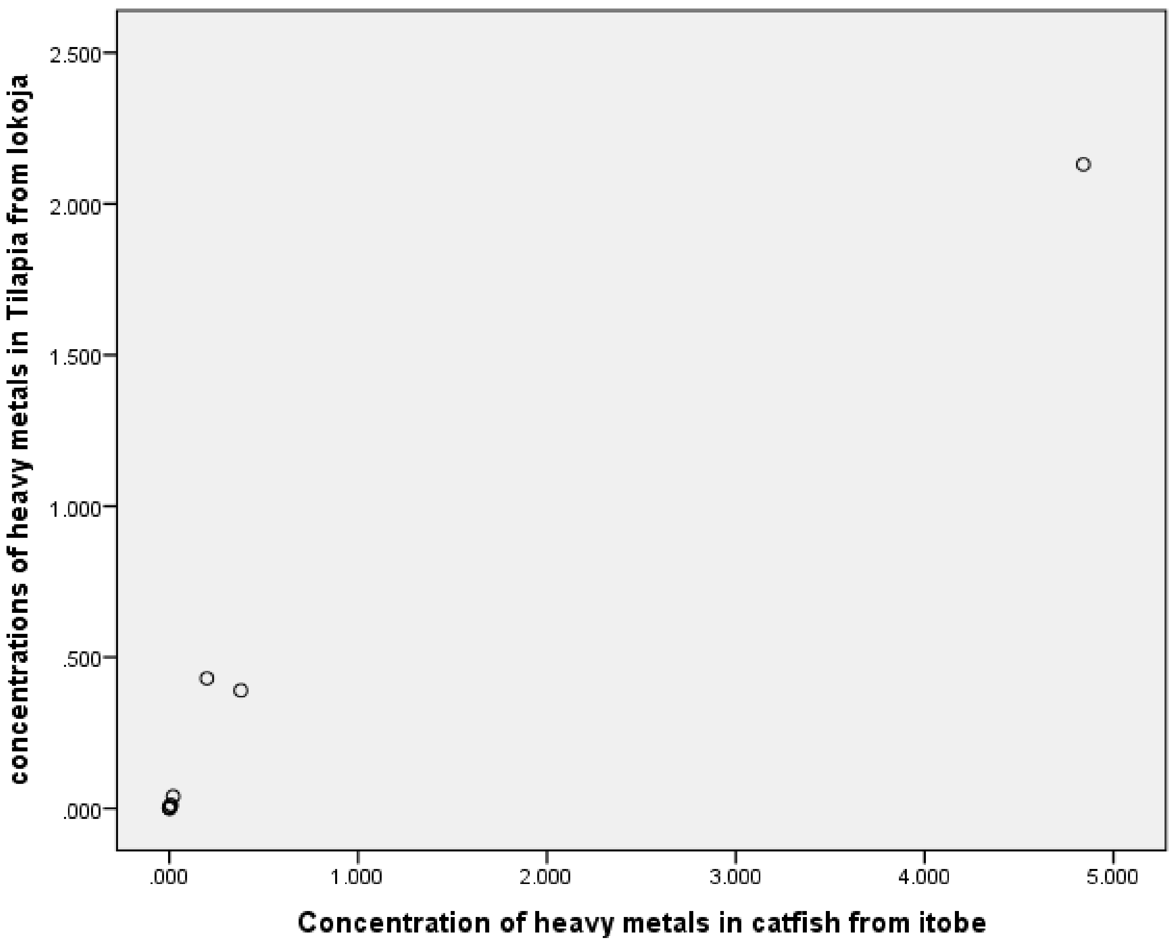


Fig. 2: metals in tilapia from Lokoja VS metals in Catfish from Itobe

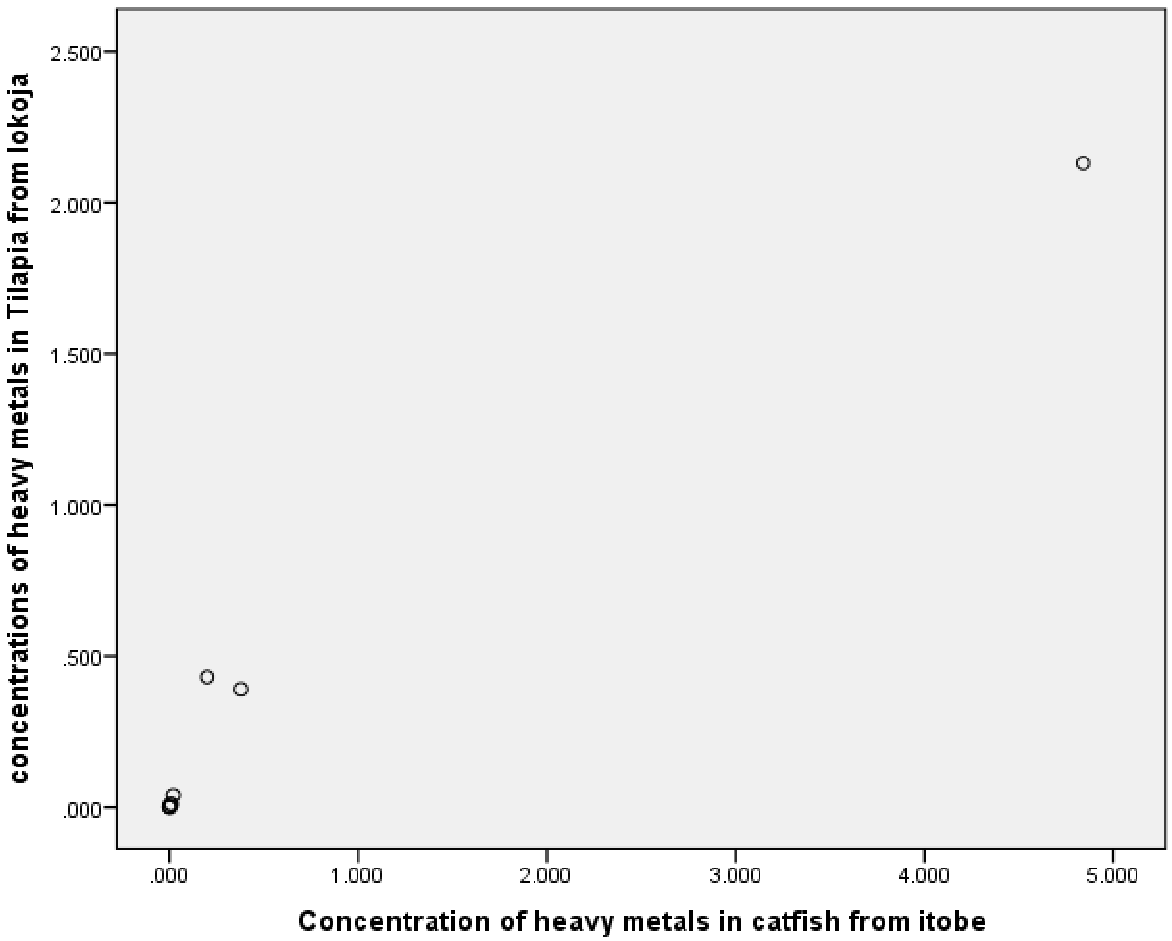


Fig. 3: Metals in Tilapia from Lokoja VS Metals in Catfish from Itobe

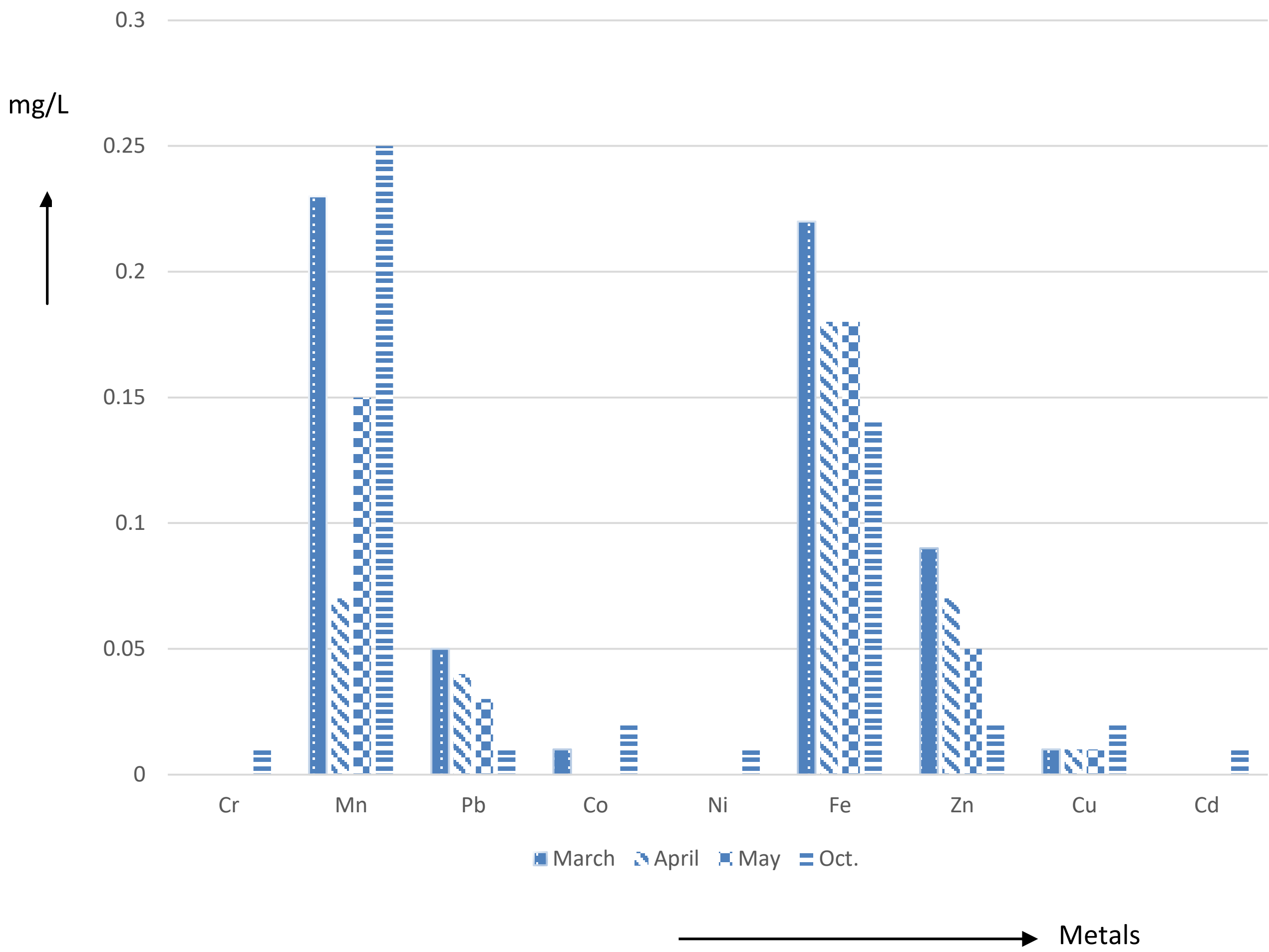


Fig 4.1: Results of dry season concentration of metals in water of River Niger.

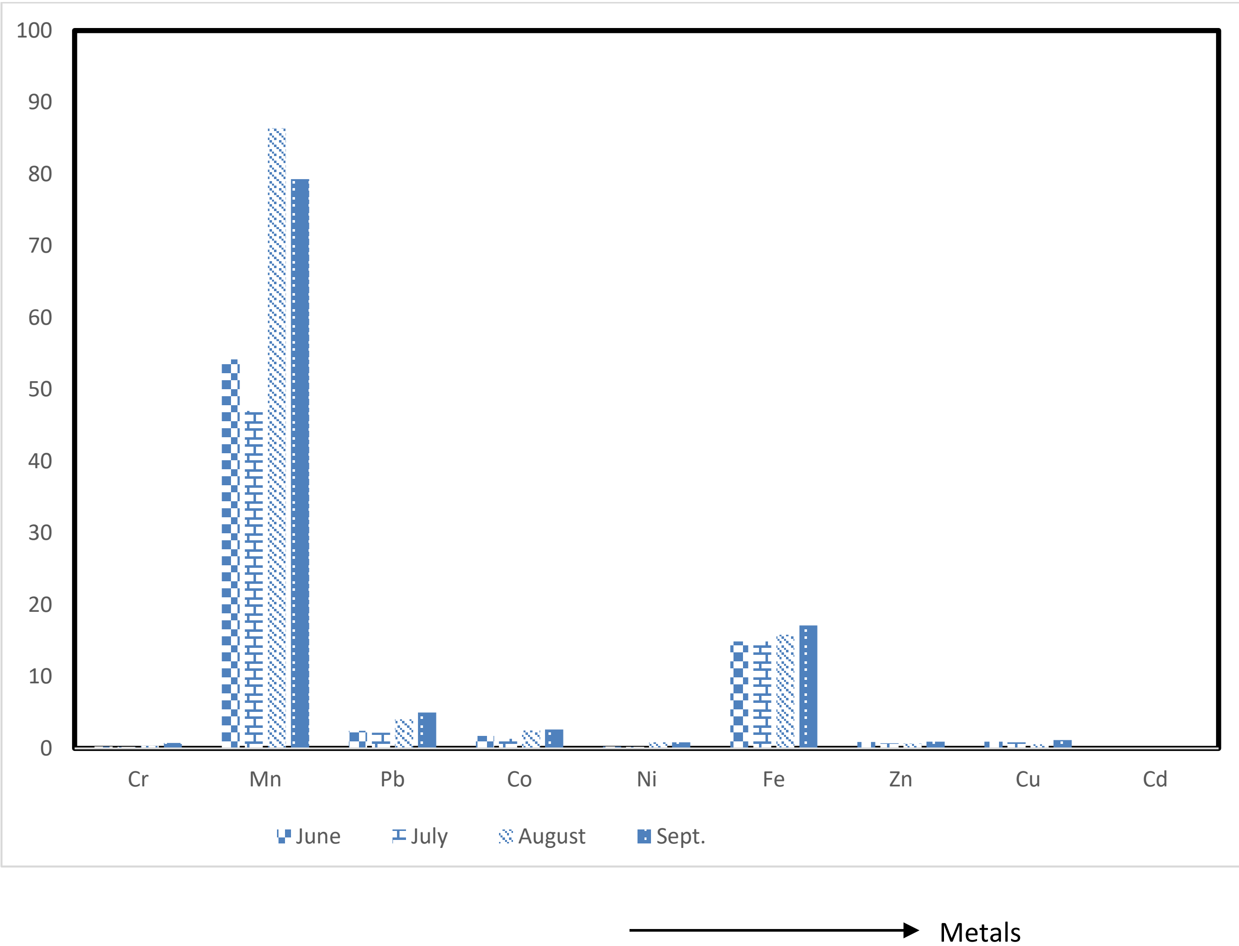


Fig4.2: Results of the wet season concentration of metals in water of Niger River

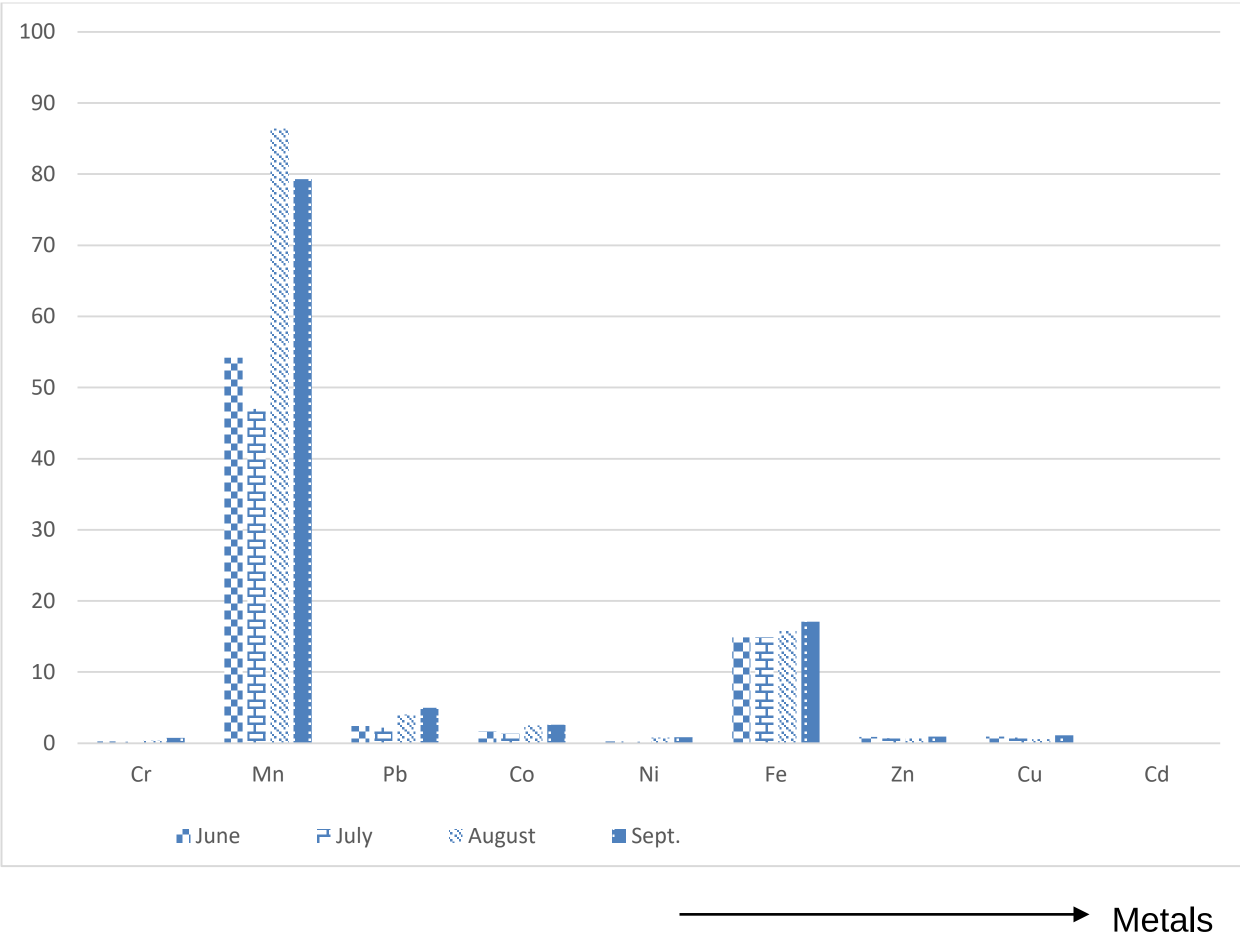


Fig4.3: Results of the wet season concentration of metals in sediments of Niger River

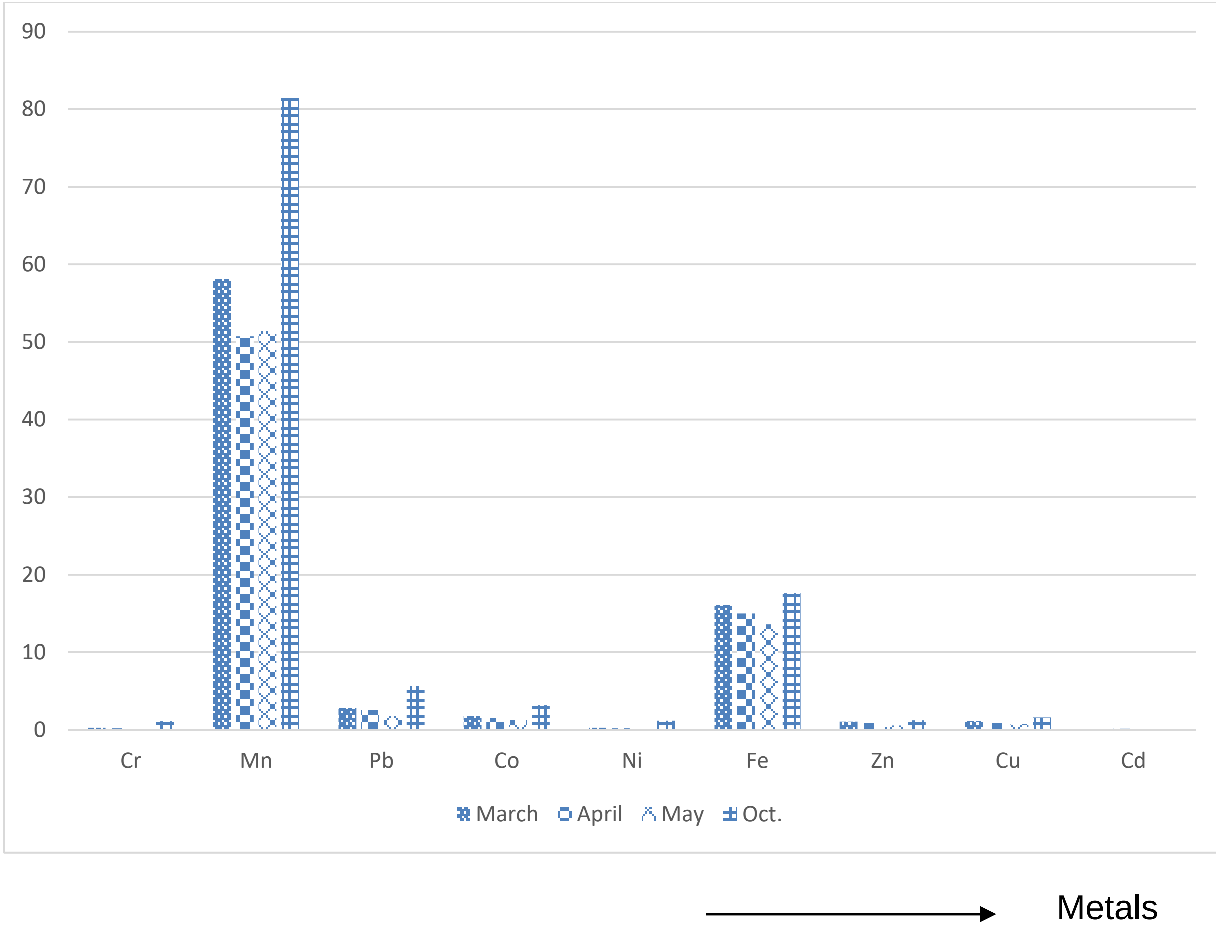


Fig4.4:
Barchart representation of dry season concentration of metals in sediments of River Niger