#### CHAPTER ONE INTRODUCTION

* 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).

#### 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.

#### 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:

* + 1. determine the physicochemical characteritics of the water,
    2. determine the concentration of heavy metals in water, sediments and some fishes,
    3. determine some microbiological pollution level of the river.
    4. 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.

#### 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.

#### 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.

#### 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 2117700km2 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 70 5′ 4″ N to longitude 70 55′ 31′″ N and latitude 60 43′ 55″ E to 60 45′ 2″E.

#### CHAPTER TWO LITERATURE REVIEW

* 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 H2O. It is formed by the direct reaction of hydrogen with oxygen (Duward *et al.,* 1994).

#### 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 19th 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).

#### 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.

#### 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).

#### 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, NO4-–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- and PO 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.

3 4

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 (Ca2+) ,Magnesium ion (mg2+), Sodium ion (Na+), Potassium ion (K+), Chloride (Cl-), Floride (F-), Nitrate (NO3-), Sulphate (SO42-), and Phosphate(PO43-). 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.

#### 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.

#### 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:

1. Natural sources: Trace metals which are found in the earth geological structures can enter water through leaching and rock weathering.
2. 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.
3. Agricultural sources: Agricultural activities such as fertilizer application pesticide spraying and irrigation which often contains heavy metals can contribute to water pollution.
4. 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.

#### 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, NO3- 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.

#### 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.

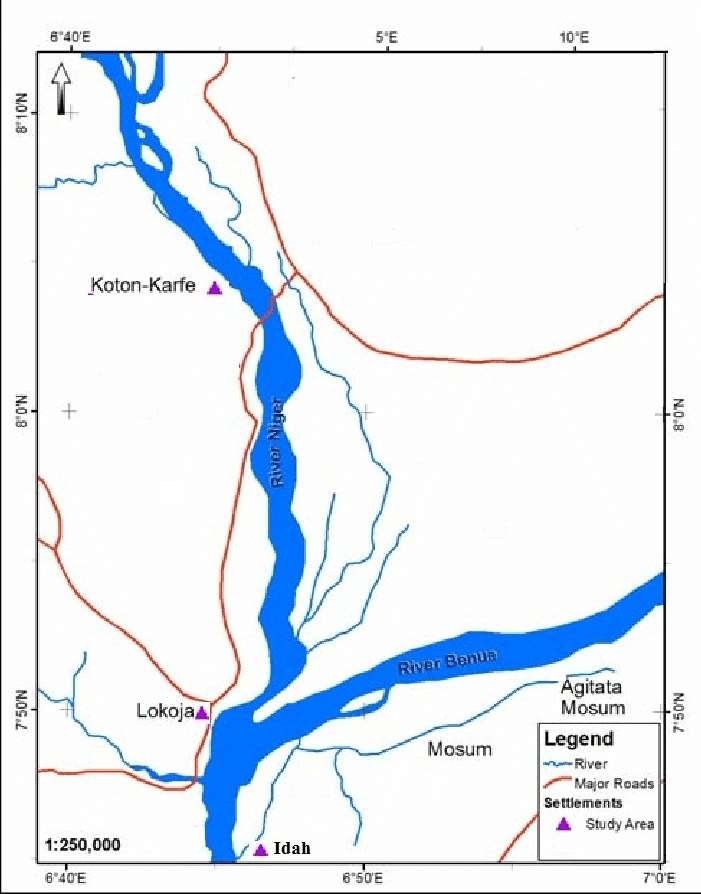
#### CHAPTER THREE MATERIALS AND METHODS

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

#### 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 36km2 with the total population of 79,815 (2006 census). While Lokoja covers area of 3180km2 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)

#### 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% HNO3, placed in an ice bath and brought to the laboratory. The samples were filtered using whatman No.1 filter paper and stored at 40C 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.

#### 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.

#### 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 -180C 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 800C 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.

#### 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.

#### Reagents

Analar nitic acid solution 50% HCl solution

De – ionized water Concentrated HNO3 solotion Hach customised reagents

Sodium trioxocabornate (iv) solution Buffer solutions

K2Cr2O4 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.

#### Digestion of Samples for Trace Metal Analysis

* + 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.

#### 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 HClO4 and HNO3 (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) HNO3. The solution was filtered using an acid washed filter paper (Whatman No.42) and the filtrate was made up to 20cm3 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.

#### 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.

#### 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.

#### 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 25oC). 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.

#### Determination of Total Alkalinity by Potentiometric Titration

* + 1. **Standardization**

Two replicates of 10.0 mL of 0.05M Na2CO3 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:

Molarity = Ax B/106 xC (3.1) Where A = g Na2CO3 weighed into the 500 mL flask

B = mL Na2CO3 solution taken for titration and C = mL acid used

106 = molar mass of Na2CO3 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, mgCaCO3/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)

#### 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.

#### 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.

#### 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 K2CrO4 was added to the sample as indicator and then titrated with standard 0.0141AgNO3 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- (mg/L) = (A-B) x M x 34500/m of sample used ( 3.3) mL of sample used

Where A = volume of titrant used for the sample B = volume of titrant used for the blank

M = molarity of the titrant used

#### 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.

#### 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).

#### Determination of Calcium Hardness by Titrimetry

* + 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 mgCaCO3 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 CaCO3 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 = mgCaCO3/L equivalent to

1.00ml EDTA titrant

= 5mg CaCO3 std/(C-B) ≈ 1

#### 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:

Total hardness as CaCO3mg/L = (A-B) x D x 1000/mL sample (3.5)

Where

A = mL of titrant used for the sample B = mL of titrant used for the blank

D = mgCaCO3 equivalent to 1.00mL EDTA titrant

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

#### 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 = (Max. Ci/Lij)2 -1 (Mean Ci/Lij)2 (3.6)

2 55

#### 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:

MIF X CMF **=** EDI (mg/kg – BW/day) 3.7

BW

MIF = Mass of fish ingested per day CMF= 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)

#### Target Hazard Quotient (THQ)

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

EF X ED X MI X CM

THQ = 10 -3 x ( 3.8) ORD x BW x AT

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).

#### 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 = ∑ THQi (3.9)

where I is the distinct heavy metals tested HI= Hazard index

THQ= Tardet Hazard Quotient

#### 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 = ∑ n Ci

# (3.10)

i = 1

MAC

|  |  |  |
| --- | --- | --- |
| 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. (0C) | 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 |

Ca2+ Mg2+

|  |  |  |  |
| --- | --- | --- | --- |
| 4.80±1.74 | 4.31±2.17 | 4.54±1.48 | 4.62±2.45 |
| 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 CaCO3) | 13.7±12.4 | 11.2±6.55 | 13.5±6.25 | 12.6±3.70 |
| MgH (as mg/L CaCO3) | 97.0±27.6 | 85.0±5.06 | 79.9±4.42 | 9.95±3.94 |
| T Alkalinity (as mg/l CaCO3) | 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 NO3) | 4.37±18.1 | 2.85±11.4 | 3.75±11.1 | 3.65±0.80 |
| NO2(mg/L as NO3) | 0.05±0.005 | 0.06±0.01 | 0.16±0.004 | 0.08±0.003 |
| NH3 | 1.50±0.54 | 0.88±0.24 | 0.91±0.55 | 1.17±0.92 |

SO42- PO43-

|  |  |  |  |
| --- | --- | --- | --- |
| 24.7±10.6 | 21.9±8.67 | 21.6±8.13 | 8.29±4.53 |
| 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. (0C) | 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 |

Ca2+ Mg2+

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 5.70±6.50 | 5.25±1.44 | 5.35±1.67 | 5.12±1.80 | <100 |
| 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 CaCO3) | 13.9±5.80 | 13.8±3.78 | 13.8±3.75 | 13.0±3.78 | - |
| MgH (as mg /LCaCO3) | 58.7±4.05 | 10.7±4.74 | 10.3±4.66 | 10.2±4.24 | 100 |
| T Alkalinity (as mg/L CaCO3) | 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 NO3) | 3.81±1.08 | 2.39±1.51 | 2.37±1.29 | 2.14±1.29 | 0.2 |
| NO2 (mg/L as NO3) | 0.14±0.45 | 0.03±0.08 | 0.10±0.38 | 0.09±0.34 | - |
| NH3 | 0.90±0.30 | 1.14±0.51 | 1.33±0.34 | 1.43±0.12 | 500 |

SO42- PO43-

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 19.3±7.51 | 7.53±5.56 | 9.08±4.82 | 8.50±4.60 | 6.5 |
| 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 – 31.70C 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 (Ca2+) 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 (Mg2+) 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 NH3 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 PHYSICOCHEMI CAL PARAMETER OF

R. NIGER(2014)

Pearson Correlation 1 .830\*\*

Sig. (2-tailed) .000

N

29 29

1

DRY SEASON MEAN VALUE OF PHYSICOCHEMI CAL PARAMETER OF

R. NIGER(2014)

Pearson Correlation .830\*\*

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 |

Ca2+ Mg2+

|  |  |  |
| --- | --- | --- |
| 4.80 | 100 | 0.05 |
| 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 |
| NH3 | 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 (Pij) = 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 |

Ca2+ Mg2+

|  |  |  |
| --- | --- | --- |
| 5.7 | 100 | 0.06 |
| 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 |
| NH3 | 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 (Pij) = 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** | **Cr** | **Mn** | **Pb** | **Co** | **METALS**  **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)** | **MPI** | |
| **WHO (2011)** | | | | |
| 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 |

#### : 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** |  |  |  |

* 1. **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** |  |  |  |

#### : 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

#### : 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

#### : 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**

**1 2 3 4**

**5 Mean value ±S.D**

**WHO (mg/kg)**

**Metal mg/kg mg/kg mg/kg mg/kg mg/kg (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

#### 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 | - | - |

* 1. **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 |  |

#### 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**

#### 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.

#### 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.

#### 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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946-949.

#### APPENDICES

**Appendix I: Summary of the statistical package used**

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

#### APPENDIX II

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

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 95% Confidence Interval for Mean  N Mean Std. Deviation | | | Std. Error | Lower Bound | Upper Bound | Minimum | Maximum |
| 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**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mean 95% Confidence Interval  (1) MONTHS (J) MONTHS Difference (I-J) Std. Error Sig. 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 |

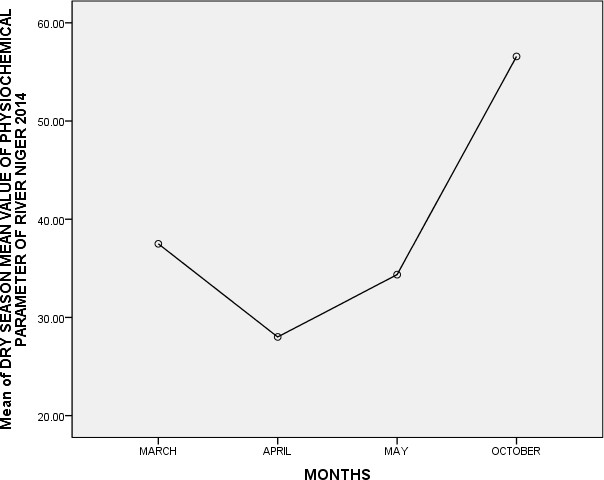
#### Dependent Variable

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (2) MONTHS (J) | MONTHS | Mean Difference (I-J) | Std. Error | 95% Confidence Interval  Sig. 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 values of the dry season physiocohemical parameter 2014

#### 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

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N | Mean | Std. Deviation | 95% Confidence Interval for Mean  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

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|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | (J) METAL | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval  Lower Bound Upper Bound | |
| Cr | Mn | -.21250\* | .013 | .000 | -.2410 | -.1840 |
|  | Pb | -.00250 | .013 | .858 | -.0310 | .0260 |
|  | C0 | .00000 | .013 | 1.000 | -.0285 | .0285 |
|  | Ni | .00500 | .013 | .721 | -.0235 | .0335 |
|  | Fe | -.11000\* | .013 | .000 | -.1385 | -.0815 |
|  | Zn | -.01250 | .013 | .376 | -.0410 | .0160 |
|  | Cu | -.00750 | .013 | .593 | -.0360 | .0210 |
|  | Cd | .00750 | .013 | .593 | -.0210 | .0360 |
| Mn | Cr | .21250\* | .013 | .000 | .1840 | .2410 |
|  | Pb | .21000\* | .013 | .000 | .1815 | .2385 |
|  | C0 | .21250\* | .013 | .000 | .1840 | .2410 |
|  | Ni | .21750\* | .013 | .000 | .1890 | .2460 |
|  | Fe | .10250\* | .013 | .000 | .0740 | .1310 |
|  | Zn | .20000\* | .013 | .000 | .1715 | .2285 |
|  | Cu | .20500\* | .013 | .000 | .1765 | .2335 |
|  | Cd | .22000\* | .013 | .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 |

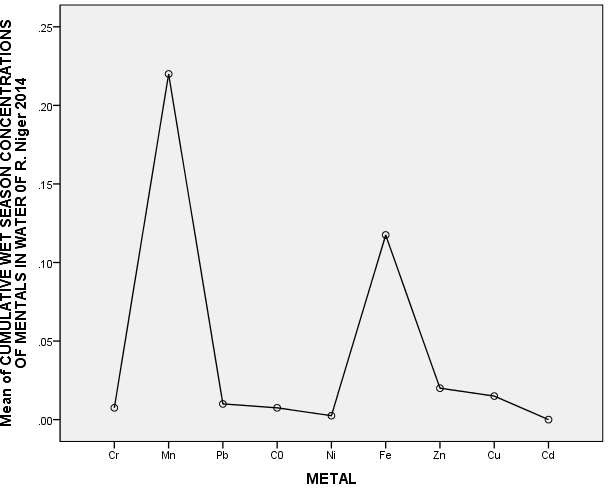
|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fe | Cr | .11000\* |  | .01388 |  | .000 |  | .0815 | .1385 |
|  | Mn | -.10250\* |  | .01388 |  | .000 |  | -.1310 | -.0740 |
|  | Pb | .10750\* |  | .01388 |  | .000 |  | .0790 | .1360 |
|  | C0 | .11000\* |  | .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**



Mean values of metals (mg/l)

#### 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 |
| Tot |  | | | | | | | | |
| 36  al | | | .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-

Std. Error Sig. 95% Confidence Interval

Cr Mn

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| J) |  |  |  |  |  | Lower Bound | Upper Bound |
| -.17250\* |  | .02262 |  | .000 |  | -.2189 | -.1261 |
| -.03000 .02262 | | | .196 | | -.0764 | | .0164 |

Pb

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 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 | .0226 | .196 | -.0164 | .0764 |
|  | Mn | -.14250\* | .0226 | .000 | -.1889 | -.0961 |
|  | Co | .02500 | .0226 | .279 | -.0214 | .0714 |
|  | Ni | .03000 | .0226 | .196 | -.0164 | .0764 |
|  | Fe | -.14750\* | .0226 | .000 | -.1939 | -.1011 |
|  | Zn | -.02500 | .0226 | .279 | -.0714 | .0214 |
|  | Cu | .02000 | .0226 | .384 | -.0264 | .0664 |
|  | Cd | .03000 | .0226 | .196 | -.0164 | .0764 |
| Co | Cr | .00500 | .0226 | .827 | -.0414 | .0514 |
|  | Mn | -.16750\* | .0226 | .000 | -.2139 | -.1211 |
|  | Pb | -.02500 | .0226 | .279 | -.0714 | .0214 |
|  | Ni | .00500 | .0226 | .827 | -.0414 | .0514 |
|  | Fe | -.17250\* | .0226 | .000 | -.2189 | -.1261 |
|  | Zn | -.05000\* | .0226 | .036 | -.0964 | -.0036 |
|  | Cu | -.00500 | .0226 | .827 | -.0514 | .0414 |
|  | Cd | .00500 | .0226 | .827 | -.0414 | .0514 |
| Ni | Cr | .00000 | .0226 | 1.000 | -.0464 | .0464 |
|  | Mn | -.17250\* | .0226 | .000 | -.2189 | -.1261 |
|  | Pb | -.03000 | .0226 | .196 | -.0764 | .0164 |
|  | Co | -.00500 | .0226 | .827 | -.0514 | .0414 |
|  | Fe | -.17750\* | .0226 | .000 | -.2239 | -.1311 |
|  | Zn | -.05500\* | .0226 | .022 | -.1014 | -.0086 |
|  | Cu | -.01000 | .0226 | .662 | -.0564 | .0364 |
|  | Cd | .00000 | .0226 | 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 |

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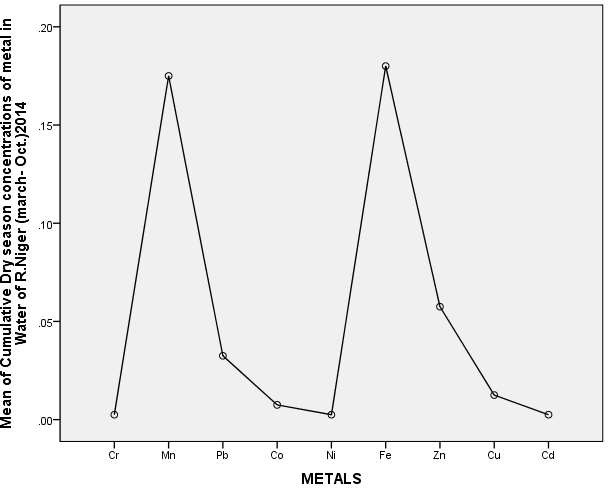
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Cu | Cr | .01000 | .02262 | .662 | -.0364 | .0564 |
|  | Mn | -.16250\* | .02262 | .000 | -.2089 | -.1161 |
|  | Pb | -.02000 | .02262 | .384 | -.0664 | .0264 |
|  | Co | .00500 | .02262 | .827 | -.0414 | .0514 |
|  | Ni | .01000 | .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**

Mean values of metals (mg/l)



#### APPENDIX XIV

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

95% Confidence Interval for

Mean

N ean

M

6

Std. Deviation

Std. Error

Lower Bound Upper Bound

Minimum

Maximum

Cr 4 .3925 .23796 .11898 .0139 .7711 .22 .74

Mn 4 6.7250 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 5.6750 1.04043 .52022 14.0194 17.3306 14.90 17.10

1

1

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 0.0481 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)

(J)

Mean Difference

95% Confidence Interval

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| METALS | METALS | (I-J) | Std. Error | Sig. | Lower Bound | 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 |

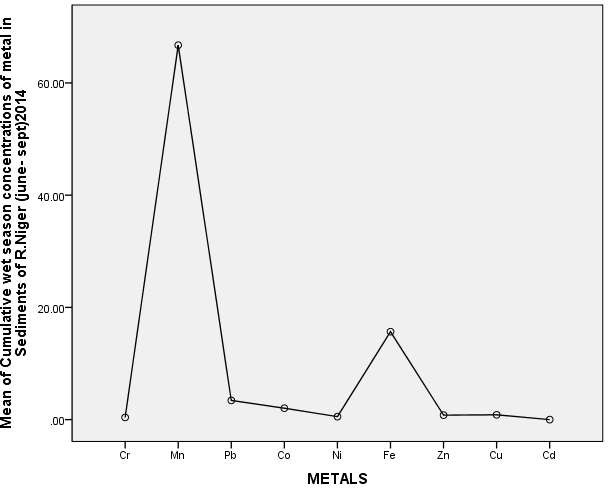
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Cd | Cr | -.39250 | 4.51685 | .931 | -9.6603 | 8.8753 |
|  | Mn | -66.72500\* | 4.51685 | .000 | -75.9928 | -57.4572 |
|  | Pb | -3.42000 | 4.51685 | .456 | -12.6878 | 5.8478 |
|  | Co | -2.03250 | 4.51685 | .656 | -11.3003 | 7.2353 |
|  | 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

Means values of metals



#### 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**

\*

Cd .36250 3.44941 .917 -6.7151 7.4401

#### 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% Confide  Lower Bound |  | nce Interval  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 |
| 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 |

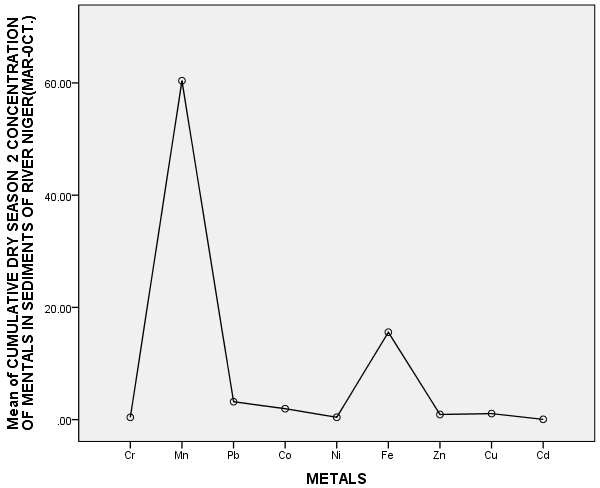
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Zn | Cr | .50250 | 3.44941 | .885 | -6.5751 | 7.5801 |
|  | Mn | -59.48750\* | 3.44941 | .000 | -66.5651 | -52.4099 |
|  | Pb | -2.27750 | 3.44941 | .515 | -9.3551 | 4.8001 |
|  | Co | -1.03000 | 3.44941 | .768 | -8.1076 | 6.0476 |
|  | 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**

Mean metal



value of

(mg/l)

#### APPENDIX XX (TABLE 1 -56)

**TABLE 1:** Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 70 5’47” N, 60

43’ 55” E

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER |
| PARAMETER  pH | 5.90 | 4.50 | 7.80 | 7.60 | 7.50 | 7.80 | 7.70 | 7.80 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | BDL | BDL | 1.20 | 3.00 | 4.01 | 4.00 | 3.80 | 3.40 |
| Mg2+(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 CaCO3) | BDL | BDL | BDL | 10.0 | 10.0 | 9.40 | 9.60 | 9.20 |
| MgH (as mg /l CaCO3) | 100 | 216 | 220 | 20.0 | 18.0 | 17.6 | 15.4 | 15.8 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | BDL | 1.20 | 2.70 | 2.40 | 2.50 | 2.45 |
| NO2 (mg/l as NO3) | 0.04 | 0.08 | 0.10 | 0.09 | 0.01 | 0.03 | 0.02 | 0.03 |
| NH3 (mg/l) | 0.05 | 0.45 | 0.50 | 0.52 | 0.94 | 1.00 | 0.98 | 1.00 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 14.0 | 15.1 | 15.0 | 14.80 | 7.91 | 7.80 | 7.84 | 7.90 |
| 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 ,70 5’ 54” N,60 43’ 47” E

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER |
| PARAMETERS  Ph | 6.0 | 4.7 | 7.5 | 8.10 | 7.2 | 7.6 | 7.8 | 7.7 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | BDL | BDL | 1.00 | 1.20 | 5.61 | 4.60 | 4.40 | 5.10 |
| Mg2+(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 CaCO3) | 10.0 | BDL | 30.0 | 20.0 | 14.0 | 18.0 | 19.0 | 18.8 |
| MgH (as mg /l CaCO3) | 131 | 132 | 90.0 | 27.0 | 14.0 | 12.0 | 10.0 | 10.0 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | 0.10 | 2.21 | 4.50 | 4.70 | 4.50 | 4.60 |
| NO2 (mg/l as NO3) | 0.05 | 0.09 | 0.08 | 0.65 | 0.01 | 0.02 | 0.01 | 0.04 |
| NH3 (mg/l) | 0.23 | 0.22 | 0.40 | 0.40 | 0.70 | 0.60 | 0.68 | 0.64 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 25.0 | 21.1 | 20.5 | 10.5 | 7.48 | 7.20 | 0.25 | 0.23 |
| 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: 70 6’ 10’’ N, 60

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. (0C) | 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 |
| Ca2+(mg/l) | 3.60 | 4.81 | 4.90 | 5.20 | 4.81 | 4.40 | 4.30 | 4.32 |
| Mg2+(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 CaCO3) | BDL | 12.0 | 14.0 | 15 | 12.0 | 12.8 | 13.0 | 14.5 |
| MgH (as mg /l CaCO3) | 123 | 116 | 113 | 105 | 14.0 | 14.0 | 12.8 | 11.2 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | 68 | 70.4 | 71.0 | 70.0 | BDL | 70.0 | 70.0 | 70.2 |
| NO2 (mg/l as NO3) | 0.08 | 0.12 | 0.14 | 0.15 | 0.01 | 0.10 | 0.11 | 0.12 |
| NH3 (mg/l) | 0.34 | 0.39 | 0.40 | 0.52 | 0.91 | 0.98 | 0.97 | 0.98 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 27.0 | 26.0 | 26.5 | 26.8 | 0.08 | 0.06 | 0.07 | 0.05 |
| 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: 70 6’ 20’’ N, 60

43’ 18’’ E

MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER

PARAMETERS: PH

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 7.50 | 5.90 | 7.80 | 7.60 | 8.00 | 8.50 | 8.20 | 8.40 |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TEMP. (0C) | | |  | 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 |
| Ca2+(mg/l) | | |  | 4.00 | BDL | 4.10 | 3.60 | 6.41 | 10.0 | 11.20 | 13.0 |
| Mg2+(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 CaCO3) | | |  | 12.0 | BDL | 13.0 | 15.0 | 16.0 | 17.0 | 14.0 | 15.0 |
| MgH (as mg | | | /l | 113 | 168 | 156.8 | 85.0 | 14.0 | 18.0 | 17.40 | 13.8 |
| CaCO3) | | |  |  |  |  |  |  |  |  |  |
| T Alkalinity | (as | mg/l | | 30.0 | 30.0 | 28.2 | 28.4 | 27.3 | 26.4 | 26.2 | 25.0 |
| CaCO3) | | | |  |  |  |  |  |  |  |  |
| 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- (mg/l as NO )  3 3 | | | | 6.00 | 5.70 | 5.80 | 4.80 | 3.30 | 3.20 | 2.50 | 2.40 |
| NO2 (mg/l as NO3) | | | | 0.12 | 0.12 | 0.20 | 0.10 | 0.01 | BDL | BDL | 0.01 |
| NH3 (mg/l) | | | | 0.43 | 0.22 | 0.20 | 0.18 | 0.74 | 0.80 | 0.96 | 0.10 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 29.1 | 26.3 | 26.1 | 25.8 | 6.60 | 6.30 | 5.50 | 5.00 |
| 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: 70 6’ 51’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 4.40 | 4.20 | 4.20 | 4.10 | 4.10 | 3.80 | 3.20 | 2.60 |
| Mg2+(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 CaCO3) | 11.0 | BDL | 8.00 | 9.80 | 10.0 | 9.40 | 8.60 | 8.20 |
| MgH (as mg /l CaCO3) | 123 | 168 | 157 | 140 | 18.0 | 15.6 | 11.4 | 11.20 |
| T Alkalinity (as mg/l  CaCO3) | 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- (mg/l as NO )  3 3 | 8.00 | 3.00 | 3.10 | 2.80 | 2.40 | 230 | 2.10 | 2.00 |
| NO2 (mg/l as NO3) | 0.21 | 0.17 | 0.18 | 0.16 | BDL | 0.06 | 0.02 | 0.01 |
| NH3 (mg/l) | 0.56 | 2.36 | 2.40 | 2.10 | 0.81 | 0.06 | 0.02 | 0.01 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 32.3 | 27.0 | 26.0 | 24.8 | 11.1 | 10.8 | 9.40 | 8.60 |
| 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: 70 7’49” N, 60

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. (0C) | | | 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 |
| Ca2+(mg/l) | | | 4.20 | BDL | 3.80 | 3.40 | 641 | 6.52 | 6.20 | 5.80 |
| Mg2+(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 CaCO3) | | | 14.0 | BDL | 2.00 | 7.00 | 16.0 | 14.2 | 13.6 | 12.2 |
| MgH (as mg /l | | | 108 | 156 | 158 | 160 | 10.0 | 9.80 | 8.40 | 7.80 |
| CaCO3) | | |  |  |  |  |  |  |  |  |
| T Alkalinity | (as | mg/l | 34.0 | 30.0 | 28.0 | 28.6 | 27.3 | 26.0 | 26.5 | 25.0 |
| CaCO3) | | |  |  |  |  |  |  |  |  |
| 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- (mg/l as NO )  3 3 | | | BDL | 750 | 7.30 | 7.20 | 1.30 | 1.20 | 1.15 | 1.10 |
| NO2 (mg/l as NO3) | | | 0.11 | 0.13 | 0.14 | 0.12 | BDL | 0.08 | 0.06 | 0.05 |
| NH3 (mg/l) | | | 0.27 | 0.40 | 0.50 | 0.68 | 0.75 | 0.68 | 0.54 | 0.48 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 34.5 | 22.0 | 21.0 | 20.8 | 15.4 | 14.8 | 13.4 | 12.6 |
| 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: 7O 24’ 53’’ N, 6O 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. (0C) | 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 |
| Ca2+(mg/l) | 4.10 | 6.41 | 6.30 | 5.30 | 5.61 | 5.40 | 4.80 | 4.20 |
| Mg2+(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 CaCO3) | 13.0 | 16.0 | 15.6 | 14.0 | 14.0 | 13.2 | 12.8 | 12.2 |
| MgH (as mg /l CaCO3) | 107 | 104 | 84.4 | 36.0 | 14.0 | 11.8 | 11.2 | 9.80 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | 3.00 | BDL | 2.10 | 2.16 | 2.00 | 1.80 | 1.87 | 1.69 |
| NO2 (mg/l as NO3) | 0.13 | 0.13 | 0.12 | 0.10 | BDL | 0.08 | 0.06 | 0.02 |
| NH3 (mg/l) | 0.17 | 0.36 | 0.48 | 0.58 | 1.11 | 1.25 | 1.38 | 1.40 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 22.4 | 27.0 | 26.6 | 24.8 | 8.70 | 7.80 | 7.20 | 6.40 |
| 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; 70 25’ 36’’ N, 60

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. (0C) | 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 |
| Ca2+(mg/l) | 3.80 | BDL | 3.00 | 2.70 | 4.01 | 4.80 | 4.20 | 3.87 |
| Mg2+(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 CaCO3) | 17.0 | BDL | 10.0 | 18.0 | 10.0 | 11.0 | 12.0 | 12.0 |
| MgH (as mg /l CaCO3) | 127 | 132 | 11.0 | 100 | 14.0 | 12.8 | 11.2 | 10.8 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | 0.60 | BDL | 0.50 | 0.40 | 2.40 | 2.10 | 2.00 | 1.86 |
| NO2 (mg/l as NO3) | 0.10 | 0.15 | 0.13 | 0.10 | 0.01 | 0.01 | 0.02 | 0.01 |
| NH3 (mg/l) | 0.19 | 1.20 | 1.10 | 0.98 | 0.68 | 0.58 | 0.43 | 0.38 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 34.5 | 34.2 | 30.8 | 22.4 | 11.6 | 10.3 | 9.50 | 8.60 |
| 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 ,70 25’44” N,60 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. (0C) | 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 |
| Ca2+(mg/l) | 3.40 | BDL | 3.10 | 3.20 | 3.21 | 3.80 | 2.61 | 2.54 |
| Mg2+(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 CaCO3) | 14.0 | BDL | 10.7 | 9.8 | 8.00 | 7.8 | 7.4 | 7.00 |
| MgH (as mg /l CaCO3) | 126 | 132 | 124 | 100 | 14.0 | 13.0 | 11.0 | 10.4 |
| T Alkalinity (as mg/l 37.5 | | 17.50 | 16.0 | 15.0 | 25.2 | 23.4 | 21.8 | 20.1 |
| CaCO3) |  |  |  |  |  |  |  |  |
| 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- (mg/l as NO )  3 3 | BDL | 0.60 | 0.16 | 0.58 | 4.60 | 3.80 | 2.69 | 2.48 |
| NO2 (mg/l as NO3) | 0.18 | 0.13 | 0.12 | 0.10 | 0.01 | 0.02 | 0.01 | BDL |
| NH3 (mg/l) | 0.20 | 0.47 | 0.58 | 0.78 | 4.58 | 4.60 | 4.78 | 4.75 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 23.4 | 31.9 | 32.8 | 33.0 | 6.98 | 0.97 | 0.99 | 1.00 |
| 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 ,70 29’ 21” N,60 41’ 9” E

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER |
| PARAMETERS |  |  |  |  |  |  |  |  |
| pH | 7.50 | 7.00 | 7.40 | 7.80 | 7.80 | 8.00 | 7.90 | 8.00 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | 4.20 | 4.81 | 4.80 | 4.80 | 4.81 | 4.60 | 4.40 | 3.80 |
| Mg2+(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 CaCO3) | 12.0 | 12.0 | 11.0 | 11.0 | 12.0 | 9.20 | 7.20 | 6.80 |
| MgH (as mg /l CaCO3) | 134 | 168 | 88.0 | 89.0 | 8.00 | 16.6 | 12.4 | 12.6 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | 4.50 | 4.10 | 3.50 | 3.40 | 3.39 | 3.10 |
| NO2 (mg/l as NO3) | 0.16 | 0.11 | 0.10 | 0.12 | 0.11 | 0.90 | 0,88 | 0,84 |
| NH3 (mg/l) | 0.48 | 0.18 | 0.75 | 0.30 | 0.74 | 0.53 | 0.32 | 0.20 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 20.6 | 31.0 | 30.2 | 32.8 | 7.49 | 7.40 | 7.38 | 7.20 |
| 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 ,70 31’36” N,60 40’ 57” E

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER |
| PARAMETERS  pH | 8.50 | 7.40 | 7.50 | 7.60 | 7.50 | 8.10 | 7.80 | 7.90 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | 4.20 | 4.81 | 6.20 | 6.00 | 7.20 | 7.00 | 6.86 | 6.40 |
| Mg2+(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 CaCO3) | 12.0 | 12.0 | 10.0 | 9.80 | 18.0 | 17.6 | 16.2 | 15.5 |
| MgH (as mg /l CaCO3) | 95.0 | 144 | 148 | 130 | 12.0 | 11.0 | 12.0 | 12.4 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | 1.00 | 1.02 | 2.00 | 2.10 | 1.80 | 1.86 |
| NO2 (mg/l as NO3) | 0.14 | 0.15 | 0.18 | 0.17 | 0.02 | 0.01 | BDL | 0.01 |
| NH3 (mg/l) | 0.45 | 1.16 | 1.20 | 1.25 | 0.26 | 0.24 | 0.22 | 0.22 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 31.5 | 10.2 | 9.80 | 8.60 | 5.16 | 5.12 | 5.10 | 5.00 |
| 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: 70 34’ 21’’, 60

38’ 26’’ E

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PARAMETERS: | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER |
| pH | 7.60 | 7.30 | 7.40 | 7.50 | 7.70 | 7.80 | 7.60 | 8.00 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | 5.00 | 4.81 | 4.60 | 4.40 | 4.01 | 3.80 | 3.25 | 3.10 |
| Mg2+(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 CaCO3) | 15.0 | 12.0 | 11.0 | 8.40 | 10.0 | 9.20 | 9.00 | 8.80 |
| MgH (as mg /l CaCO3) | 89.0 | 96.0 | 95.0 | 93.6 | 12.0 | 11.60 | 10.2 | 9.80 |

T Alkalinity (as mg/l CaCO3)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 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- (mg/l as NO )  3 3 | BDL | 18.0 | 2.70 | 2.75 | 7.80 | 1.75 | 1.50 | 1.48 |
| NO2 (mg/l as NO3) | 0.16 | 0.03 | 0.03 | 0.02 | 0.02 | 0.01 | BDL | 0.01 |
| NH3 (mg/l) | 0.44 | 2.80 | 1.40 | 1.20 | 0.77 | 0.78 | 0.80 | 0.82 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 34.4 | 0.03 | 11.80 | 11.4 | 16.0 | 14.20 | 13.10 | 10.20 |
| 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 ,70 36’52” N,60 43’47” E

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER |
| PARAMETERS |  |  |  |  |  |  |  |  |
| pH | 7.70 | 7.10 | 7.40 | 7.60 | 7.40 | 7.80 | 7.60 | 7.50 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | 4.70 | 4.81 | 4.42 | 4.20 | 4.01 | 3.86 | 3.60 | 3.50 |
| Mg2+(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 CaCO3) | 17.0 | 12.0 | 14.7 | 25.2 | 10.0 | 10.2 | 9.80 | 10.5 |
| MgH (as mg /l CaCO3) | 76.0 | 96.0 | 94.3 | 92.8 | 20.0 | 19.8 | 19.6 | 18.3 |
| T Alkalinity (as mg/l 24.5 | | 15.0 | 17.0 | 18.4 | 23.1 | 22.7 | 22.4 | 22.2 |
| CaCO3) |  |  |  |  |  |  |  |  |
| 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- (mg/l as NO )  3 3 | 1.50 | 2.70 | 2.80 | 2.86 | 3.10 | 2.98 | 2.70 | 2.50 |
| NO2 (mg/l as NO3) | BDL | 0.10 | 0.09 | 0.07 | BDL | 0.04 | 0.03 | 0.01 |
| NH3 (mg/l) | 0.65 | 0.58 | 0.63 | 0.65 | 0.45 | 0.50 | 0.56 | 0.65 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 38.6 | 16.3 | 16.1 | 15.8 | 15.7 | 15.4 | 15.2 | 14.9 |
| 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 ,70 38’ 3”**

**N,60 40’ 56” E**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | MARCH | APRIL | MAY | JULY | JULY | AUGUST | SEPTEMBER | OCTOBER |
| PARAMETERS |  |  |  |  |  |  |  |  |
| pH | 7.80 | 7.10 | 7.60 | 7.50 | 7.40 | 750 | 7.60 | 7.40 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | 9.70 | 8.02 | 7.60 | 7.52 | 5.61 | 4.85 | 4.60 | 4.20 |
| Mg2+(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 CaCO3) | 16.0 | 20.0 | 29.6 | 29.0 | 14.0 | 12.4 | 13.4 | 12.4 |
| MgH (as mg /l CaCO3) | 67.0 | 88.0 | 70.4 | 68.9 | 20.0 | 18.0 | 16.6 | 15.8 |
| T Alkalinity (as mg/l 30.5 | | 37.5 | 37.4 | 37.0 | 37.8 | 36.6 | 35.5 | 34.3 |
| CaCO3) |  |  |  |  |  |  |  |  |
| 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- (mg/l as NO )  3 3 | 1.80 | BDL | BDL | 3.70 | 3.50 | 3.20 | 3.00 | 2.92 |
| NO2 (mg/l as NO3) | BDL | 0.05 | 0.04 | 0.01 | BDL | BDL | 0.01 | BDL |
| NH3 (mg/l) | BDL | 0.36 | 0.78 | 0.90 | BDL | 1.00 | 1.20 | 1.50 |

SO42-(mg/l) PO4 - (mg/l)

3

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 34.4 | 15.9 | 18.40 | 18.10 | 17.1 | 14.3 | 12.7 | 11.3 |
| 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: 70 41’ 57” N,

60 44’ 8’’ E

MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER PARAMETERS

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pH | 7.9 | 7.6 | 7.8 | 7.4 | 7.50 | 8.10 | 8.00 | 7.80 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | 5.00 | 4.81 | 3.60 | 3.10 | 1.60 | 1.52 | 1.43 | 1.31 |
| Mg2+(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 CaCO3) | 9.00 | 12.0 | 11.8 | 10.4 | 4.00 | 3.80 | 3.11 | 2.71 |
| MgH (as mg /l CaCO3) | 78.0 | 100 | 102 | 108 | 4.00 | 3.30 | 3.89 | 4.19 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | 1.40 | BDL | 1.38 | 1.32 | BDL | 0.98 | 0.80 | 0.79 |
| NO2 (mg/l as NO3) | BDL | 0.06 | 0.04 | 0.01 | BDL | BDL | 0.01 | BDL |
| NH3 (mg/l) | 0.44 | 1.96 | 1.80 | 1.76 | 0.36 | 0.40 | 0.45 | 0.50 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 36.6 | 31.3 | 30.0 | 28.60 | 15.1 | 14.2 | 13.7 | 12.5 |
| 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: 70 42’ 54’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 4.60 | 4.81 | 4.92 | 4.98 | 6.41 | 6.32 | 6.28 | 6.20 |
| Mg2+(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 CaCO3) | 9.00 | 12.0 | 10.2 | 10.0 | 16.0 | 14.0 | 13.40 | 12.8 |
| MgH (as mg /l CaCO3) | 56.0 | 24.0 | 23.8 | 23.8 | 8.0 | 9.40 | 9.40 | 8.60 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | 0.50 | BDL | 2.01 | 2.50 | 2.80 | 2.40 | 2.10 | 2.00 |
| NO2 (mg/l as NO3) | BDL | 0.07 | 0.05 | 0.04 | 0.01 | BDL | 0.01 | BDL |
| NH3 (mg/l) | 0.56 | 0.29 | 0.24 | 0.22 | BDL | 0.19 | 0.15 | 0.12 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 26.8 | 22.1 | 20.6 | 20.2 | 11.5 | 10.2 | 10.1 | 9.60 |
| 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: 70 43‘ 58” N, 60 44 ‘37’’ E

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER |
| PARAMETERS  pH | 8.20 | 7.10 | 7.40 | 7.30 | 7.20 | 7.50 | 8.20 | 8.30 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | 4.80 | 4.81 | 4.80 | 4.80 | 4.81 | 4.70 | 4.60 | 4.20 |
| Mg2+(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 CaCO3) | 13.0 | 12.0 | 11.8 | 11.7 | 12.0 | 11.8 | 11.5 | 11.1 |
| MgH (as mg /l CaCO3) | 105 | 84.0 | 80.2 | 68.7 | 16.0 | 15.2 | 15.3 | 15.3 |

T Alkalinity (as mg/l CaCO3)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 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- NO3)

3

(mg/l as

0.70 BDL 0.65 0.50 2.40 2.10 1.82 1.70

NO2 (mg/l as NO3)

BDL 0.05 0.04 0.01 0.02 0.01 0.01 BDL

NH3 (mg/l) 1.20 0.40 0.45 0.05 BDL 0.64 0.70 0.82

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 38.4 | 20.0 | 19.8 | 19.6 | 12.1 | 11.8 | 11.5 | 10.8 |
| 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: 70 43 ‘58” N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 4.70 | 4.81 | 4.78 | 4.80 | 4.81 | 4.70 | 4.65 | 4.50 |
| Mg2+(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 CaCO3) | 10.0 | 12.0 | 23.7 | 29.5 | 12.0 | 12.2 | 12.4 | 12.2 |
| MgH (as mg /l CaCO3) | 124 | 72.0 | 60.0 | 54.0 | 16.0 | 15.6 | 15.2 | 15.0 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | 50.0 | BDL | BDL | 1.00 | 1.30 | 1.27 | 1.25 | 1.20 |
| NO2 (mg/l as NO3) | BDL | 0.06 | 0.04 | 0.04 | 0.02 | 0.01 | 0.01 | BDL |
| NH3 (mg/l) | 1.30 | 1.10 | 1.15 | 1.19 | BDL | 1.20 | 1.26 | 1.30 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 34.4 | 19.7 | 19.5 | 19.0 | 7.45 | 7.30 | 7.20 | 7.15 |
| 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: 70 43 ‘26N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 6.50 | 6.47 | 6.44 | 6.43 | 6.41 | 6.30 | 6.20 | 619 |
| Mg2+(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 CaCO3) | 12.0 | 16.0 | 16.0 | 15.8 | 16.0 | 15.7 | 15.5 | 15.1 |
| MgH (as mg /l CaCO3) | 111 | 44.0 | 38..0 | 34.2 | 10.0 | 9.60 | 9.60 | 9.70 |
| T Alkalinity (as mg/l 22.0 | | 22.5 | 23.0 | 25.0 | 31.5 | 28.7 | 28.5 | 27.8 |
| CaCO3) |  |  |  |  |  |  |  |  |
| 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- (mg/l as NO )  3 3 | 0.40 | BDL | 0.35 | 0.30 | BDL | 0.28 | 0.30 | 0.27 |
| NO2 (mg/l as NO3) | BDL | 0.06 | 0.40 | 0.03 | 0.01 | 0.01 | BDL | 0.01 |
| NH3 (mg/l) | 1.25 | BDL | 1.40 | 1.45 | BDL | 1.50 | 1.52 | 1.58 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 25.6 | 25.7 | 24.8 | 24.5 | 8.82 | 7.50 | 7.20 | 700 |
| 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: 70 43 ‘48”N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 6.84 | 6.41 | 6.30 | 6.32 | 7.21 | 7.20 | 6.80 | 6.65 |
| Mg2+(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 CaCO3) | 13.0 | 16.0 | 15.0 | 17.5 | 18.0 | 17.8 | 17.5 | 17.4 |
| MgH (as mg /l CaCO3) | 78.0 | 80.0 | 83.0 | 81.3 | 4.00 | 4.00 | 2.90 | 3.0 |
| T Alkalinity (as mg/l 17.0 | | 30.0 | 29.8 | 29.5 | 28.4 | 28.2 | 27.8 | 27.5 |
| CaCO3) |  |  |  |  |  |  |  |  |
| 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- (mg/l as NO )  3 3 | BDL | BDL | BDL | 1.80 | 1.80 | 1.75 | 1.62 | 1.50 |
| NO2 (mg/l as NO3) | BDL | 0.06 | 0.04 | 0.02 | 0.01 | 0.01 | BDL | BDL |
| NH3 (mg/l) | 0.96 | BDL | 1.20 | 1.52 | BDL | 1.60 | 1.70 | 1.87 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 13.2 | 25.2 | 24.0 | 23.5 | 20.0 | 19.2 | 8.4 | 18.2 |
| 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: 70 46 ‘10”N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 6.20 | 6.41 | 6.40 | 6.30 | 6.41 | 6.20 | 6.10 | 6.00 |
| Mg2+(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 CaCO3) | 10.0 | 16.0 | 16.2 | 16.3 | 16.0 | 15.8 | 15.5 | 15.0 |
| MgH (as mg /l CaCO3) | 76.0 | 44.0 | 38.8 | 24.5 | 6.00 | 6.00 | 5.20 | 5.50 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | BDL | BDL | 0.80 | 0.70 | 0.65 | 0.50 |
| NO2 (mg/l as NO3) | BDL | 0.06 | 0.05 | 0.05 | 0.01 | 0.01 | BDL | 0.01 |
| NH3 (mg/l) | 0.87 | 0.04 | 0.60 | 0.80 | BDL | 01.00 | 1.50 | 1.55 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 11.6 | 26. | 20.8 | 20.5 | 11.3 | 11.0 | 10.8 | 10.5 |
| 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: 70 46 ‘45”N, 60 44 ‘18’’E

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER |
| PARAMETERS |  |  |  |  |  |  |  |  |
| pH | 7.90 | 7.40 | 7.50 | 7.40 | 7. 60 | 7. 70 | 7.80 | 7.90 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | 4.90 | 4.81 | 4.80 | 4. 78 | 5.61 | 5.60 | 5.45 | 5.20 |
| Mg2+(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 CaCO3) | 11.0 | 12.0 | 13.5 | 13.3 | 14.0 | 13.5 | 13.2 | 12.8 |
| MgH (as mg /l CaCO3) | 89.0 | 60.0 | 36.5 | 35.3 | 12.0 | 12.5 | 12.3 | 12.4 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | 2.01 | 1.89 | 1.20 | 1.18 | 1.15 | 1.00 |
| NO2 (mg/l as NO3) | 0.02 | 0.04 | BDL | BDL | 0.02 | 0.01 | 0.01 | 0.01 |
| NH3 (mg/l) | 0.98 | BDL | 1.00 | 1.10 | BDL | 1.12 | 1.15 | 1.70 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 20.8 | 20. 7 | 20.0 | 20.2 | 9.61 | 9.50 | 9.20 | 9.10 |
| 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: 70 47’ 52’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 6.20 | 6.41 | 6.40 | 6.30 | 6.41 | 6.20 | 6.10 | 6.00 |
| Mg2+(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 CaCO3) | 10.0 | 16.0 | 16.2 | 16.3 | 16.0 | 15.8 | 15.5 | 15.0 |
| MgH (as mg /l CaCO3) | 76.0 | 44.0 | 38.8 | 24.5 | 6.00 | 6.00 | 5.20 | 5.50 |

T Alkalinity (as mg/l CaCO3)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 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- (mg/l as NO )  3 3 | BDL | BDL | BDL | BDL | 0.80 | 0.70 | 0.65 | 0.50 |
| NO2 (mg/l as NO3) | BDL | 0.06 | 0.05 | 0.05 | 0.01 | 0.01 | BDL | 0.01 |
| NH3 (mg/l) | 0.87 | 0.40 | 0.60 | 0.80 | BDL | 01.00 | 1.50 | 1.55 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 11.6 | 26.7 | 20.8 | 20.5 | 11.3 | 11.0 | 10.8 | 10.5 |
| 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: 70 48’ 36’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 4.90 | 4.81 | 4.80 | 4.78 | 5.61 | 5.60 | 5.45 | 5.20 |
| Mg2+(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 CaCO3) | 11.0 | 12.0 | 13.5 | 13.2 | 14.0 | 13.5 | 13.2 | 12.8 |
| MgH (as mg /l CaCO3) | 89.0 | 60.0 | 36.5 | 35.3 | 12.0 | 12.5 | 12.3 | 12.4 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | 2.01 | 1.89 | 1.20 | 1.18 | 1.15 | 1.00 |
| NO2 (mg/l as NO3) | 0.02 | 0.04 | BDL | BDL | 0.02 | 0.01 | 0.01 | 0.01 |
| NH3 (mg/l) | 0.98 | BDL | 1.00 | 1.10 | BDL | 1.12 | 1.15 | 1.70 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 20.8 | 20.7 | 20.5 | 20.2 | 9.61 | 9.50 | 9.20 | 9.10 |
| 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: 70 49’ 2’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 6.20 | 6.41 | 6.40 | 6.38 | 6.41 | 6.38 | 6.35 | 6.30 |
| Mg2+(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 CaCO3) | 10.0 | 16.0 | 15.8 | 15.9 | 16.0 | 15.9 | 15.7 | 15.5 |
| MgH (as mg /l CaCO3) | 23.0 | 160 | 159 | 154 | 8.00 | 6.10 | 6.10 | 5.10 |

T Alkalinity (as mg/l CaCO3)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 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- (mg/l as NO )  3 3 | BDL | BDL | 3.50 | 3.6 | 3.20 | 3.15 | 3.10 | 2.80 |
| NO2 (mg/l as NO3) | 0.08 | 0.04 | BDL | BDL | 0.04 | 0.03 | 0.02 | 0.01 |
| NH3 (mg/l) | 0.89 | 1.96 | 2.50 | 2.60 | BDL | 2.80 | 2.95 | 3.20 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 26.6 | 36.2 | 20.8 | 20.5 | 6.00 | 6.00 | 5.48 | 5.20 |
| 0.13 | 0.73 | 0.58 | 0.48 | 0.19 | 0.16 | 0.14 | 0.10 |

**TABLE 26:**Physico-Chemical and Microbial Analyses Results in Water (2014) Location: 70 49’ 47’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 6.80 | 6.41 | 5.40 | 5.10 | 4.81 | 4.50 | 4.48 | 4.20 |
| Mg2+(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 CaCO3) | 9.0 | 16.0 | 15.8 | 13.4 | 12.0 | 10.9 | 10.5 | 10.2 |
| MgH (as mg /l CaCO3) | 132 | 8.00 | 10.2 | 13.6 | 16.0 | 16.1 | 16.0 | 15.2 |

**T Alkalinity (as mg/l CaCO3)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 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- (mg/l as NO )  3 3 | BDL | BDL | 2.90 | 2.81 | 2.50 | 2.48 | 2.45 | 2.40 |
| NO2 (mg/l as NO3) | 0.04 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | BDL |
| NH3 (mg/l) | 0.67 | 7.15 | 0.95 | 0.80 | 0.72 | 1.58 | 1.69 | 1.70 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 25.2 | 26.9 | 26.5 | 26.1 | 7.10 | 7.00 | 6.53 | 6.40 |
| 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:70 49’ 57” N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 4.80 | 4.81 | 4.75 | 4.70 | 5.61 | 5.10 | 4.80 | 4.30 |
| Mg2+(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 CaCO3) | 8.00 | 12.0 | 10.4 | 9.60 | 14.0 | 13.2 | 0.3 | 9.60 |
| MgH (as mg /l CaCO3) | 104 | 84.0 | 70.1 | 41.0 | 6.00 | 6.80 | 8.30 | 8.00 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | 5.20 | 4.10 | 2.30 | 2.10 | 1.98 | 1.80 |
| NO2 (mg/l as NO3) | 0.08 | BDL | 0.05 | 0.04 | BDL | 0.04 | 0.03 | 0.02 |
| NH3 (mg/l) | 1.31 | BDL | 1.28 | 1.20 | 0.64 | 0.60 | 0.57 | 0.52 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 19.7 | 39.4 | 30.3 | 20.7 | 4.38 | 4.20 | 4.10 | 3.70 |
| 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: 70 50’ 14” N, 60

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. (0C) | 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 |
| Ca2+(mg/l) | 6.50 | 6.41 | 6.20 | 6.10 | 5.61 | 5.40 | 4.30 | 3.80 |
| Mg2+(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 CaCO3) | 10.0 | 16.0 | 15.8 | 15.0 | 14.0 | 13.8 | 12.2 | 10.8 |
| MgH (as mg /l CaCO3) | 109 | 56.0 | 45.0 | 35.5 | 8.00 | 7.80 | 8.40 | 9.00 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | 3.80 | 3.90 | 3.60 | 3.40 | 2.10 | 2.10 | 2.00 | 1.94 |
| NO2 (mg/l as NO3) | 0.02 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.10 | 0.01 |
| NH3 (mg/l) | 1.32 | 0.36 | 0.32 | 0.30 | 0.53 | 0.60 | 0.70 | 0.91 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 21.6 | 25.4 | 24.8 | 23.5 | 8.46 | 8.20 | 7.80 | 7.50 |
| 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: 70 50’ 42’’N, 60 45’ 6’’ E

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PARAMETERS: | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPEMBER | OCTOBER |
| pH | 7.60 | 7.50 | 7.60 | 7.80 | 8.00 | 8.10 | 8.00 | 7.90 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | 4.84 | 4.81 | 4.50 | 4.40 | 8.02 | 8.00 | 7.60 | 5.60 |
| Mg2+(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 CaCO3) | 9.0 | 12.0 | 12.8 | 13.5 | 20.0 | 21.3 | 21.8 | 22.4 |
| MgH (as mg /l CaCO3) | 123 | 12.0 | 11.1 | 10.6 | 8.00 | 8.40 | 8.60 | 12.8 |

**T Alkalinity (as mg/l CaCO3)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 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- (mg/l as NO )  3 3 | 2.5 | BDL | 1.30 | 1.40 | 1.70 | 1.65 | 1.60 | 1.54 |
| NO2 (mg/l as NO3) | 0.03 | BDL | 0.03 | 0.04 | 0.04 | 0.03 | 0.02 | 0.01 |
| NH3 (mg/l) | 1.28 | 1.02 | 0.98 | 0.90 | 0.97 | 0.98 | 1.10 | 1.20 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 28.3 | 12.1 | 11.40 | 10.8 | 6.39 | 6.20 | 6.00 | 5.89 |
| 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: 70 50’ 53’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 4.68 | 4.81 | 4.76 | 4.70 | 7.21 | 7.20 | 7.10 | 7.00 |
| Mg2+(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 CaCO3) | 14.0 | 12.0 | 11.2 | 10.4 | 18.0 | 17.8 | 17.6 | 17.2 |
| MgH (as mg /l CaCO3) | 122 | 60.0 | 59.8 | 58.0 | 8.00 | 8.00 | 8.00 | 8.00 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | 4.60 | BDL | 4.30 | 4.10 | 2.30 | 2.10 | 1.96 | 1.87 |
| NO2 (mg/l as NO3) | 0.05 | BDL | 0.07 | 0.08 | 0.03 | 0.03 | BDL | 0.01 |
| NH3 (mg/l) | 1.27 | 1.05 | 1.00 | 0.95 | 0.67 | 0.87 | 0.96 | 0.98 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 12.5 | 10.1 | 9.80 | 9.50 | BDL | 6.50 | 6.20 | 6.10 |
| 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: 70 51’ 13’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 4.90 | 4.81 | 4.76 | 4.72 | 6.41 | 6.30 | 6.20 | 6.00 |
| Mg2+(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 CaCO3) | 14.0 | 12.0 | 11.0 | 10.2 | 16.0 | 15.3 | 14.2 | 13.5 |
| MgH (as mg /l CaCO3) | 122 | 48.0 | 49.0 | 43.2 | 6.00 | 5.50 | 5.40 | 5.70 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | 4.60 | 1.80 | 1.90 | 1.96 | 2.50 | 2.40 | 2.30 | 2.10 |
| NO2 (mg/l as NO3) | 0.05 | BDL | 0.06 | 0.07 | 0.02 | 0.02 | 0.01 | 0.01 |
| NH3 (mg/l) | 1.27 | 1.23 | 1.24 | 1.30 | 0.84 | 0.90 | 0.92 | 0.95 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 12.5 | 13.6 | 13.5 | 12.7 | BDL | 5.60 | 5.40 | 5.20 |
| 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: 70 51’ 29’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 3.40 | 3.21 | 3.18 | 3.16 | 5.61 | 5.40 | 5.20 | 5.10 |
| Mg2+(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 CaCO3) | 15.0 | 8.00 | 7.60 | 7.00 | 14.0 | 13.8 | 12.9 | 12.5 |
| MgH (as mg /l CaCO3) | 81.0 | 76.0 | 63.0 | 57.0 | 4.00 | 4.20 | 4.90 | 3.90 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | 3.00 | BDL | 2.80 | 2.10 | 4.30 | 4.20 | 4.18 | 4.00 |
| NO2 (mg/l as NO3) | 0.03 | BDL | 0.02 | 0.01 | 0.01 | 0.01 | BDL | 0.01 |
| NH3 (mg/l) | 0.54 | 1.34 | 1.40 | 1.45 | 1.76 | 1.80 | 1.86 | 1.90 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 13.8 | 21.9 | 20.1 | 19.5 | BDL | 18.6 | 18.2 | 18.0 |
| 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: 70 51’ 50’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 4.90 | 4.18 | 4.70 | 4.78 | 4.81 | 4.20 | 3.80 | 3.50 |
| Mg2+(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 CaCO3) | 17.0 | 12.0 | 11.7 | 11.1 | 12.0 | 11.8 | 11.6 | 10.2 |
| MgH (as mg /l CaCO3) | 87.0 | 36.0 | 35.9 | 35.7 | 6.00 | 6.10 | 6.00 | 7.00 |
| T Alkalinity (as mg/l 24.5 | | 22.5 | 22.2 | 22.1 | 22.1 | 22.0 | 21.9 | 21.5 |
| CaCO3) |  |  |  |  |  |  |  |  |
| 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- (mg/l as NO )  3 3 | BDL | 0.30 | 0.28 | 0.25 | 3.20 | 2.86 | 2.70 | 2.20 |
| NO2 (mg/l as NO3) | 0.04 | BDL | 0.03 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 |
| NH3 (mg/l) | 0.65 | 1.20 | 1.30 | 1.38 | 1.13 | 1.50 | 1.55 | 1.58 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 21.8 | 25.0 | 24.8 | 24.6 | 0.48 | 0.45 | 0.40 | 0.38 |
| 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: 70 52’ 25’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 3.80 | 3.21 | 3.18 | 3.15 | 5.61 | 5.20 | 5.00 | 4.80 |
| Mg2+(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 CaCO3) | 13.0 | 8.0 | 10.8 | 11.5 | 14.0 | 13.2 | 12.0 | 11.4 |
| MgH (as mg /l CaCO3) | 78.0 | 52.0 | 40.0 | 39.0 | 6.00 | 6.80 | 6.40 | 7.20 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | 0.5 | 0.8 | 3.50 | 3.10 | 2.80 | 1.95 |
| NO2 (mg/l as NO3) | 0.02 | BDL | 0.03 | 0.01 | 0.01 | BDL | 0.01 | 0.01 |
| NH3 (mg/l) | BDL | 0.87 | 0.98 | 0.90 | 1.30 | 1.35 | 1.40 | 1.42 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 15.2 | 20.1 | 19.1 | 18.2 | BDL | 16.2 | 15.5 | 14.5 |
| 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: 70 53’ 10’’N, 60 45’ 20’’ E

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PARAMETERS: | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPEMBER | OCTOBER |
| pH | 8.20 | 7.30 | 7.40 | 8.00 | 7.70 | 7.80 | 7.60 | 8.20 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | 4.40 | 3.21 | 3.19 | 3.15 | 6.41 | 6.39 | 6.30 | 6.00 |
| Mg2+(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 CaCO3) | 12.0 | 8.00 | 8.00 | 7.50 | 16.0 | 15.40 | 14.8 | 14.5 |
| MgH (as mg /l CaCO3) | 105 | 52.0 | 52.00 | 50.7 | 4.00 | 4.10 | 3.80 | 3.70 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | 1.80 | 1.85 | 2.10 | 2.05 | 1.82 | 1.80 |
| NO2 (mg/l as NO3) | 0.02 | BDL | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 |
| NH3 (mg/l) | 0.21 | 1.21 | 1.25 | 1.85 | 2.47 | 2.50 | 2.53 | 2.55 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 17.6 | 35.1 | 34.6 | 34.2 | 13.3 | 12.8 | 12.5 | 12.2 |
| 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: 70 53’ 23’’N, 60

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. (0C) | 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 |
| Ca2+(mg/l) | 3.60 | 3.21 | 3.20 | 3.10 | 4.81 | 4.70 | 4.68 | 4.65 |
| Mg2+(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 CaCO3) | 14.0 | 8.00 | 8.00 | 7.50 | 12.0 | 11.9 | 11.5 | 10.8 |
| MgH (as mg /l CaCO3) | 122 | 52.0 | 48.7 | 48.3 | 10.0 | 9.60 | 9.10 | 9.70 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | 2.50 | 2.60 | 3.70 | 3.60 | 3.40 | 3.10 |
| NO2 (mg/l as NO3) | 0.04 | BDL | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | BDL |
| NH3 (mg/l) | 0.24 | 0.80 | 0.90 | 0.98 | 0.63 | 0.60 | 0.58 | 0.46 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 19.8 | 20.2 | 20.0 | 18.6 | BDL | 16.5 | 15.8 | 15.0 |
| 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: 70 53’ 56’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 7.20 | 6.41 | 6.20 | 6.10 | 8.02 | 8.00 | 7.65 | 7.50 |
| Mg2+(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 CaCO3) | 14.0 | 16.0 | 14.0 | 12.8 | 20.0 | 18.5 | 17.6 | 15.2 |
| MgH (as mg /l CaCO3) | 79.0 | 84.0 | 86.0 | 86.2 | 6.00 | 6.60 | 7.20 | 8.70 |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | 4.20 | 4.00 | 3.70 | 3.60 | 3.40 | 3.10 |
| NO2 (mg/l as NO3) | 0.03 | BDL | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 |
| NH3 (mg/l) | 0.54 | 0.24 | 0.35 | 0.38 | 0.63 | 0.65 | 0.70 | 0.76 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 36.7 | 12.5 | 12.5 | 11.2 | BDL | 10.8 | 9.60 | 9.20 |
| 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: 70 54’ 27’’N, 60 45’ 4’’ E

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPEMBER | OCTOBER |
| PARAMETERS: |  |  |  |  |  |  |  |  |
| pH | 7.50 | 7.30 | 7.50 | 7.60 | 7.60 | 7.60 | 7.80 | 8.10 |
| TEMP. (0C) | 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 |
| Ca2+(mg/l) | 5.00 | 4.81 | 4.50 | 4.00 | 2.40 | 2.10 | 2.00 | 1.89 |
| Mg2+(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 CaCO3) | 14.0 | 12.0 | 11.6 | 10.4 | 6.00 | 5.60 | 5.40 | 5.20 |
| MgH (as mg /l | 86.0 | 48.0 | 46.6 | 47.3 | 16.0 | 16.2 | 15.8 | 15.7 |
| CaCO3) |  |  |  |  |  |  |  |  |
| T Alkalinity (as mg/l CaCO3) | 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- (mg/l as NO )  3 3 | BDL | BDL | 1.50 | 1.49 | 1.40 | 1.20 | 1.18 | 1.16 |
| NO2 (mg/l as NO3) | 0.02 | BDL | 0.05 | 0.03 | 0.02 | 0.1 | 0.01 | BDL |
| NH3 (mg/l) | 1.23 | 0.22 | 0.25 | 0.30 | 0.52 | 0.64 | 0.68 | 0.70 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 24.8 | 15.2 | 14.8 | 14.6 | BDL | 12.0 | 11.8 | 10.5 |
| 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: 70 54’ 53’’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 5.00 | 2.00 | 2.10 | 3.87 | 2.70 | 2.60 | 2.20 | 2.00 |
| Mg2+(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 CaCO3) | 87.0 | 32.0 | 30.8 | 30.5 | 20.0 | 19.3 | 18.6 | 17.5 |
| MgH (as mg /l CaCO3) | 12.0 | 12.0 | 11.0 | 9.86 | 14.0 | 13.4 | 13.0 | 12.8 |
| T Alkalinity (as mg/l CaCO3) | 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 NO3) | 1.04 | 0.64 | 0.54 | 0.48 | BDL | 0.36 | 0.24 | 0.20 |
| NO2 (mg/l as NO3) | BDL | BDL | 3.00 | 2.84 | 2.50 | 2.30 | 2.00 | 2.00 |
| NH3 (mg/l) | 0.04 | BDL | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1.95 | 1.31 | 1.30 | 1.30 | 0.56 | 0.60 | 0.78 | 0.80 |
| 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: 70 55’

31’N, 60 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. (0C) | 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 |
| Ca2+(mg/l) | 7.20 | 6.41 | 5.80 | 5.50 | 6.41 | 6.30 | 6.20 | 5.40 |
| Mg2+(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 CaCO3) | 16.0 | 16.0 | 15.8 | 15.5 | 16.0 | 15.8 | 15.2 | 14.8 |
| MgH (as mg /l CaCO3) | 94.0 | 32.0 | 29.2 | 26.5 | 6.00 | 5.00 | 4.90 | 5.00 |
| T Alkalinity (as mg/l CaCO3) | 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 NO3) | BDL | BDL | 3.50 | 3.50 | 3.40 | 3.20 | 3.10 | 3.00 |
| NO2 (mg/l as NO3) | 0.05 | BDL | 0.05 | 0.04 | 0.01 | 0.01 | 0.01 | 0.01 |
| NH3 (mg/l) | 0.28 | 0.54 | 0.52 | 0.50 | 1.11 | 1.20 | 1.25 | 1.35 |

SO42-(mg/l) PO43- (mg/l)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 26.7 | 17.8 | 16.9 | 15.8 | 8.19 | 8.10 | 8.00 | 7.50 |
| 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** |  |
| W1 | ND | 0.10 | ND | ND | ND | 0.31 | 0.06 | 0.08 | 0.00 |  |
| W2 | ND | 0.21 | ND | 0.01 | ND | 0.11 | 0.03 | 0.00 | 0.00 |  |
| W3 | ND | 0.21 | 0.10 | ND | 0.01 | 0.13 | 0.06 | 0.00 | 0.00 |  |
| W4 | ND | 0.01 | ND | ND | ND | 0.12 | 0.02 | 0.00 | 0.00 |  |
| W5 | ND | 0.09 | 0.10 | ND | ND | 0.18 | 0.06 | 0.00 | 0.00 |  |
| W6 | ND | 0.12 | ND | ND | ND | 0.14 | 0.05 | 0.06 | 0.00 |  |
| W7 | ND | 0.12 | ND | ND | ND | 0.09 | 0.05 | 0.00 | 0.00 |  |
| W8 | ND | 0.18 | ND | ND | ND | 0.16 | 0.04 | 0.00 | 0.00 |  |
| W9 | ND | 0.07 | 0.10 | ND | ND | 0.09 | 0.06 | 0.00 | 0.00 |  |
| W10 | ND | 0.11 | 0.10 | ND | ND | 0.13 | 0.06 | 0.02 | 0.00 |  |
| W11 | ND | 0.10 | ND | ND | ND | 0.12 | 0.06 | 0.02 | 0.00 |  |
| W12 | ND | 0.17 | ND | ND | 0.01 | 0.15 | 0.00 | 0.00 | 0.00 |  |
| W13 | ND | 0.14 | ND | 0.01 | ND | 0.18 | 0.09 | 0.07 | 0.00 |  |
| W14 | ND | 0.10 | ND | ND | ND | 0.10 | 0.05 | 0.00 | 0.00 |  |
| W15 | ND | 0.18 | 0.10 | 0.01 | 0.01 | 0.21 | 0.09 | 0.00 | 0.00 |  |
| W16 | ND | 0.10 | ND | ND | ND | 0.09 | 0.06 | 0.00 | 0.00 |  |
| W17 | ND | 0.07 | ND | 0.01 | ND | 0.08 | 0.01 | 0.00 | 0.00 |  |
| W18 | ND | 0.08 | ND | 0.01 | 0.01 | 0.12 | 0.03 | 0.00 | 0.00 |  |
| W19 | ND | 0.11 | ND | 0.01 | ND | 0.19 | 0.05 | 0.00 | 0.00 |  |
| W20 | ND | 0.13 | ND | ND | ND | 0.11 | 0.04 | 0.00 | 0.00 |  |
| W21 | ND | 0.19 | ND | ND | ND | 0.18 | 0.03 | 0.00 | 0.00 |  |
| W22 | ND | 0.06 | 0.10 | 0.01 | ND | 0.11 | 0.02 | 0.00 | 0.00 |  |
| W23 | ND | 0.09 | ND | ND | ND | 0.16 | 0.03 | 0.00 | 0.00 |  |
| W24 | ND | 0.29 | 0.10 | ND | ND | 0.13 | 0.00 | 0.00 | 0.00 |  |
| W25 | ND | 0.18 | ND | ND | ND | 0.18 | 0.09 | 0.02 | 0.00 |  |
| W26 | ND | 0.13 | ND | 0.01 | ND | 0.09 | 0.00 | 0.00 | 0.00 |  |
| W27 | ND | 0.30 | 0.10 | ND | ND | 0.36 | 0.09 | 0.07 | 0.00 |  |
| W28 | ND | 0.16 | ND | ND | ND | 0.12 | 0.04 | 0.00 | 0.00 |  |
| W29 | ND | 021 | 0.01 | ND | ND | 0.17 | 0.01 | 0.00 | 0.00 |  |
| W30 | ND | 0.20 | ND | ND | ND | 0.30 | 0.07 | 0.00 | 0.00 |  |
| W31 | ND | 0.14 | 0.01 | ND | ND | 0.23 | 0.09 | 0.00 | 0.00 |  |
| W32 | ND | 0.25 | ND | ND | ND | 0.27 | 0.08 | 0.00 | 0.00 |  |
| W33 | ND | 0.30 | ND | ND | ND | 0.56 | 0.04 | 0.00 | 0.00 |  |
| W34 | ND | 0.14 | ND | 0.01 | ND | 0.34 | 0.00 | 0.00 | 0.00 |  |
| W35 | ND | 0.20 | 0.10 | 0.01 | ND | 0.40 | 0.04 | 0.00 | 0.00 |  |
| W36 | ND | 0.13 | 0.10 | 0.01 | ND | 0.15 | 0.07 | 0.00 | 0.00 |  |
| W37 | ND | 0.05 | 0.10 | ND | ND | 0.06 | 0.07 | 0.00 | 0.00 |  |
| W38 | ND | 0.22 | ND | ND | ND | 0.26 | 0.08 | 0.04 | 0.00 |  |
| W39 | ND | 0.12 | ND | ND | 0.01 | 0.10 | 0.05 | 0.00 | 0.00 |  |
| W40 | 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** |  |
| W1 | 0.01 | 0.19 | ND | ND | ND | 0.10 | 0.01 | 0.01 | 0.00 |  |
| W2 | ND | 0.21 | ND | 0.01 | ND | 0.13 | 0.02 | 0.00 | 0.00 |  |
| W3 | 0.01 | 0.17 | ND | 0.01 | ND | 0.05 | 0.00 | 0.00 | 0.00 |  |
| W4 | ND | 0.31 | ND | ND | ND | 0.19 | 0.01 | 0.00 | 0.00 |  |
| W5 | ND | 0.19 | 0.10 | ND | ND | 0.11 | 0.01 | 0.00 | 0.00 |  |
| W6 | ND | 0.21 | ND | ND | ND | 0.08 | 0.01 | 0.06 | 0.00 |  |
| W7 | ND | 0.20 | ND | 0.02 | ND | 0.05 | 0.00 | 0.00 | 0.00 |  |
| W8 | ND | 0.16 | 0.10 | 0.01 | ND | 0.08 | 0.00 | 0.00 | 0.00 |  |
| W9 | ND | 0.23 | ND | ND | ND | 0.12 | 0.04 | 0.00 | 0.00 |  |
| W10 | ND | 0.18 | ND | ND | ND | 0.04 | 0.01 | 0.00 | 0.00 |  |
| W11 | ND | 0.13 | 0.10 | ND | ND | 0.06 | 0.02 | 0.00 | 0.00 |  |
| W12 | ND | 0.18 | 0.10 | ND | ND | 0.08 | 0.01 | 0.00 | 0.00 |  |
| W13 | ND | 0.13 | ND | 0.01 | ND | 0.04 | 0.00 | 0.00 | 0.00 |  |
| W14 | ND | 0.20 | 0.10 | 0.01 | ND | 0.17 | 0.00 | 0.02 | 0.00 |  |
| W15 | ND | 0.18 | ND | ND | ND | 0.03 | 0.00 | 0.03 | 0.00 |  |
| W16 | ND | 0.12 | ND | 0.01 | ND | 0.07 | 0.00 | 0.00 | 0.00 |  |
| W17 | ND | 0.14 | 0.01 | ND | ND | 0.02 | 0.00 | 0.00 | 0.00 |  |
| W18 | ND | 0.11 | ND | ND | ND | 0.05 | 0.03 | 0.00 | 0.00 |  |
| W19 | ND | 0.14 | ND | 0.01 | 0.01 | 0.26 | 0.01 | 0.01 | 0.00 |  |
| W20 | ND | 0.17 | ND | 0.01 | ND | 0.08 | 0.02 | 0.00 | 0.00 |  |
| W21 | ND | 0.26 | ND | ND | ND | 0.20 | 0.02 | 0.00 | 0.00 |  |
| W22 | ND | 0.19 | ND | ND | ND | 0.09 | 0.04 | 0.00 | 0.00 |  |
| W23 | ND | 0.17 | ND | 0.01 | ND | 0.15 | 0.01 | 0.00 | 0.00 |  |
| W24 | ND | 0.28 | ND | ND | ND | 0.17 | 0.08 | 0.10 | 0.00 |  |
| W25 | ND | 0.17 | ND | ND | ND | 0.09 | 0.04 | 0.00 | 0.00 |  |
| W26 | 0.02 | 0.12 | 0.10 | 0.01 | 0.01 | 0.10 | 0.01 | 0.00 | 0.00 |  |
| W27 | ND | 0.27 | ND | ND | ND | 0.12 | 0.03 | 0.00 | 0.00 |  |
| W28 | ND | 0.51 | 0.10 | 0.01 | ND | 0.13 | 0.04 | 0.00 | 0.00 |  |
| W29 | ND | 0.13 | ND | ND | ND | 0.08 | 0.08 | 0.00 | 0.00 |  |
| W30 | ND | 0.20 | ND | ND | ND | 0.12 | 0.03 | 0.00 | 0.00 |  |
| W31 | ND | 0.24 | 0.01 | 0.01 | ND | 0.14 | 0.09 | 0.00 | 0.00 |  |
| W32 | ND | 0.34 | ND | ND | ND | 0.25 | 0.03 | 0.00 | 0.00 |  |
| W33 | ND | 0.37 | 0.01 | ND | ND | 0.24 | 0.02 | 0.00 | 0.00 |  |
| W34 | ND | 0.19 | ND | ND | ND | 0.18 | 0.04 | 0.00 | 0.00 |  |
| W35 | ND | 0.28 | ND | ND | ND | 0.10 | 0.05 | 0.00 | 0.00 |  |
| W36 | ND | 0.22 | ND | ND | ND | 0.06 | 0.02 | 0.00 | 0.00 |  |
| W37 | ND | 0.14 | 0.10 | ND | ND | 0.02 | 0.03 | 0.10 | 0.00 |  |
| W38 | ND | 0.11 | ND | ND | 0.01 | 0.09 | 0.03 | 0.07 | 0.00 |  |
| W39 | ND | 0.30 | ND | ND | ND | 0.27 | 0.07 | 0.03 | 0.00 |  |
| W40 | 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** |
| S1 | 0.42 | 130 | 5.20 | 2.82 | 0.02 | 1.40 | 1.52 | 0.03 | 0.02 |
| S2 | 0.42 | 25.0 | 2.86 | 0.81 | 0.16 | 1.38 | 0.81 | 0.02 | 0.02 |
| S3 | 0.25 | 28.7 | 1.00 | 1.00 | 0.19 | 7.80 | 0.92 | 0.90 | 0.01 |
| S4 | 0.20 | 22.2 | 0.86 | 0.98 | 0.20 | 32.7 | 1.10 | 0.02 | 0.02 |
| S5 | 0.28 | 17.5 | 0.42 | 0.69 | 0.20 | 13.5 | 0.98 | 0.15 | 0.01 |
| S6 | 0.38 | 26.4 | 3.20 | 0.67 | 0.32 | 23.8 | 0.73 | 3.00 | 0.02 |
| S7 | 0.15 | 28.3 | 1.00 | 0.92 | 0.20 | 6.20 | 0.62 | 1.50 | 0.02 |
| S8 | 0.22 | 20.0 | 0.92 | 0.54 | 0.09 | 21.9 | 0.78 | 2.30 | 0.02 |
| S9 | 0.30 | 22.7 | 3.20 | 0.98 | 0.04 | 2.60 | 0.52 | 1.25 | 0.00 |
| S10 | 0.10 | 48.6 | 1.20 | 0.80 | 0.08 | 3.03 | 0.82 | 1.50 | 0.02 |
| S11 | 0.20 | 21.0 | 3.20 | 0.82 | 0.04 | 12.8 | 0.52 | 1.00 | 0.03 |
| S12 | 0.25 | 22.6 | 1.10 | 0.52 | 0.04 | 25.2 | 1.30 | 0.08 | 0.02 |
| S13 | 0.30 | 20.7 | 5.20 | 4.20 | 0.08 | 27.6 | 8.20 | 1.82 | 0.01 |
| S14 | 0.17 | 152 | 4.20 | 5.00 | 0.50 | 24.8 | 0.16 | 1.92 | 0.02 |
| S15 | 0.42 | 163 | 9.40 | 3.01 | 0.52 | 33.8 | 0.62 | 1.97 | 0.01 |
| S16 | 0.45 | 109 | 5.20 | 2.20 | 0.06 | 5.60 | 0.48 | 1.82 | 0.01 |
| S17 | 0.16 | 49.6 | 2.86 | 3.00 | 0.30 | 2.40 | 0.42 | 1.00 | 0.01 |
| S18 | 0.32 | 120 | 4.78 | 1.00 | 0.34 | 2.20 | 0.52 | 1.00 | 0.00 |
| S19 | 0.21 | 20.6 | 0.40 | 1.02 | 0.05 | 8.7 | 0.63 | 0.98 | 0.02 |
| S20 | 0.32 | 22.2 | 3.00 | 1.10 | 0.42 | 3.20 | 1.00 | 1.50 | 0.02 |
| S21 | 0.10 | 21.3 | 2.86 | 2.00 | 0.43 | 26.2 | 0.82 | 1.86 | 0.03 |
| S22 | 0.28 | 75.6 | 2.90 | 1.12 | 0.08 | 22.6 | 0.52 | 3.30 | 0.02 |
| S23 | 0.30 | 19.3 | 5.60 | 4.00 | 0.09 | 18.7 | 0.57 | 2.20 | 0.01 |
| S24 | 0.31 | 100. | 6.02 | 2.00 | 0.32 | 32.1 | 1.00 | 2.50 | 0.02 |
| S25 | 0.35 | 80.6 | 2.06 | 0.62 | 0.28 | 16.2 | 0.51 | 0.80 | 0.01 |
| S26 | 0.18 | 23.7 | 0.86 | 0.35 | 0.07 | 17.7 | 0.56 | 1.93 | 0.02 |
| S27 | 0.97 | 20.6 | 0.67 | 2.00 | 0.08 | 4.10 | 2.00 | 1.63 | 0.01 |
| S28 | 0.10 | 42.5 | 2.80 | 0.93 | 0.09 | 4.70 | 0.87 | 1.52 | 0.01 |
| S29 | 0.12 | 26.2 | 1.30 | 0.72 | 0.35 | 3.02 | 1.72 | 1.82 | 0.01 |
| S30 | 0.10 | 24.6 | 1.92 | 0.82 | 0.08 | 35.8 | 0.92 | 1.72 | 0.02 |
| S31 | 0.31 | 152 | 7.20 | 7.30 | 0.80 | 37.6 | 3.10 | 1.86 | 0.01 |
| S32 | 0.30 | 142 | 7.20 | 1.40 | 0.80 | 15.0 | 0.80 | 0.02 | 0.01 |
| S33 | 0.10 | 37.3 | 0.10 | 0.90 | 0.09 | 22.6 | 0.30 | 0.02 | 0.01 |
| S34 | 0.08 | 19.6 | 0.13 | 0.80 | 0.10 | 35.1 | 0.56 | 0.02 | 0.01 |
| S35 | 0.30 | 90.0 | 3.10 | 3.20 | 0.50 | 15.4 | 0.62 | 0.01 | 0.02 |
| S36 | 0.08 | 98.0 | 3.00 | 4.20 | 0.10 | 7.40 | 0.67 | 0.02 | 0.01 |
| S37 | 0.28 | 15.4 | 0.96 | 1.00 | 0.48 | 22.6 | 0.38 | 0.02 | 0.01 |
| S38 | 0.30 | 25.6 | 2.96 | 1.00 | 0.10 | 2.90 | 0.45 | 0.03 | 0.01 |
| S39 | 0.10 | 100 | 2.44 | 2.96 | 0.10 | 20.6 | 2.10 | 0.02 | 0.01 |
| S40 | 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** |
| S1 | 0.30 | 119 | 4.60 | 2.60 | 0.01 | 1.32 | 1.40 | 0.02 | 0.01 |
| S2 | 0.10 | 20.2 | 2.40 | 0.60 | 0.10 | 1.20 | 0.62 | 0.01 | 0.00 |
| S3 | 0.15 | 26.3 | 0.82 | 0.75 | 0.10 | 7.50 | 0.80 | 0.80 | 0.01 |
| S4 | 0.10 | 20.1 | 0.71 | 0.68 | 0.10 | 31.6 | 0.92 | 0.01 | 0.00 |
| S5 | 0.23 | 15.2 | 0.38 | 0.28 | 0.10 | 12.2 | 0.55 | 0.10 | 0.00 |
| S6 | 0.21 | 24.8 | 2.51 | 0.52 | 0.24 | 22.1 | 0.68 | 2.50 | 0.02 |
| S7 | 0.12 | 27.3 | 0.62 | 0.74 | 0.10 | 5.20 | 0.20 | 1.00 | 0.01 |
| S8 | 0.11 | 18.2 | 0.52 | 0.42 | 0.02 | 20.8 | 0.61 | 2.15 | 0.01 |
| S9 | ND | 20.5 | 2.87 | 0.90 | 0.01 | 1.87 | 0.43 | 1.12 | 0.01 |
| S10 | ND | 45.3 | 0.69 | 0.85 | 0.02 | 2.93 | 0.67 | 1.00 | 0.00 |
| S11 | 0.10 | 19.1 | 2.52 | 0.43 | 0.01 | 11.2 | 0.46 | 0.80 | 0.00 |
| S12 | 0.15 | 20.8 | 0.63 | 0.76 | 0.01 | 23.0 | 1.00 | 0.04 | 0.00 |
| S13 | 0.10 | 18.5 | 4.47 | 0.47 | 0.02 | 26.1 | 7.30 | 1.60 | 0.00 |
| S14 | 0.13 | 148 | 4.30 | 3.82 | 0.25 | 22.6 | 0.12 | 1.65 | 0.00 |
| S15 | 0.38 | 150 | 8.20 | 4.92 | 0.43 | 32.3 | 0.56 | 1.70 | 0.00 |
| S16 | 0.22 | 90.2 | 4.10 | 2.72 | 0.02 | 4.50 | 0.39 | 1.50 | 0.00 |
| S17 | 0.13 | 48.2 | 2.40 | 1.83 | 0.26 | 2.10 | 0.20 | 0.90 | 0.00 |
| S18 | 0.21 | 110 | 4.32 | 2.60 | 0.28 | 1.84 | 0.30 | 0.95 | 0.01 |
| S19 | 0.10 | 18.0 | 0.10 | 0.92 | 0.02 | 16.3 | 0.42 | 0.86 | 0.01 |
| S20 | 0.21 | 20.1 | 2.60 | 0.84 | 0.29 | 2.75 | 0.79 | 1.20 | 0.01 |
| S21 | 0.08 | 20.2 | 2.54 | 0.72 | 0.30 | 24.2 | 0.45 | 2.60 | 0.01 |
| S22 | 0.24 | 70.3 | 2.65 | 1.62 | 0.04 | 20.4 | 0.38 | 1.86 | 0.00 |
| S23 | 0.23 | 18.2 | 4.82 | 0.86 | 0.05 | 15.10 | 0.46 | 2.10 | 0.00 |
| S24 | 0.24 | 96.7 | 4.93 | 3.52 | 0.23 | 31.6 | 0.86 | 0.60 | 0.00 |
| S25 | 0.23 | 76.5 | 6.42 | 1.89 | 0.22 | 14.6 | 0.42 | 0.40 | 0.00 |
| S26 | 0.07 | 22.3 | 0.85 | 0.49 | 0.02 | 16.4 | 0.51 | 1.32 | 0.00 |
| S27 | 0.87 | 18.5 | 0.69 | 0.28 | 0.04 | 3.62 | 1.86 | 1.40 | 0.00 |
| S28 | 0.05 | 38.2 | 2.43 | 1.67 | 0.03 | 3.64 | 0.76 | 1.32 | 0.00 |
| S29 | 0.06 | 24.2 | 0.50 | 0.82 | 0.26 | 2.86 | 0.92 | 1.40 | 0.01 |
| S30 | 0.07 | 22.6 | 0.42 | 0.63 | 0.02 | 34.6 | 0.50 | 1.35 | 0.01 |
| S31 | 0.26 | 14.6 | 2.63 | 6.10 | 0.65 | 36.2 | 2.10 | 1.45 | 0.00 |
| S32 | 0.23 | 136 | 6.52 | 1.20 | 0.50 | 12.70 | 0.60 | 0.01 | 0.00 |
| S33 | 0.07 | 35.4 | 0.09 | 0.50 | 0.03 | 21.4 | 0.20 | 0.01 | 0.01 |
| S34 | 0.06 | 18.2 | 0.08 | 0.25 | 0.08 | 33.2 | 0.41 | 0.01 | 0.00 |
| S35 | 0.28 | 81.0 | 2.10 | 2.80 | 0.42 | 12.3 | 0.48 | 0.01 | 0.00 |
| S36 | 0.04 | 95.0 | 2.30 | 3.60 | 0.06 | 6.82 | 0.52 | 0.01 | 0.00 |
| S37 | 0.22 | 12.3 | 0.84 | 0.82 | 0.31 | 21.4 | 0.23 | 0.01 | 0.00 |
| S38 | 0.24 | 24.5 | 2.11 | 0.95 | 0.05 | 1.50 | 0.34 | 0.00 | 0.01 |
| S39 | 0.03 | 89.2 | 2.32 | 2.30 | 0.06 | 19.3 | 1.82 | 0.01 | 0.01 |
| S40 | 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** |  |
| S1 | 0.20 | 109 | 4.00 | 2.40 | ND | 1.20 | 1.35 | 0.00 | 0.00 |  |
| S2 | ND | 16.2 | 2.00 | 0.20 | ND | 1.00 | 0.20 | 0.00 | 0.00 |  |
| S3 | ND | 24.8 | ND | 0.40 | ND | 7.30 | 0.30 | 0.50 | 0.00 |  |
| S4 | ND | 18.2 | ND | 0.60 | ND | 30.5 | 0.70 | 0.00 | 0.00 |  |
| S5 | ND | 13.2 | ND | 0.20 | ND | 11.0 | 0.35 | 0.09 | 0.00 |  |
| S6 | 0.20 | 23.2 | 2.00 | 0.40 | 0.20 | 20.5 | 0.56 | 2.10 | 0.00 |  |
| S7 | ND | 26.2 | ND | 0.60 | ND | 4.20 | 0.16 | 0.90 | 0.00 |  |
| S8 | ND | 15.6 | ND | 0.40 | ND | 20.2 | 0.54 | 2.10 | 0.00 |  |
| S9 | ND | 19.2 | 2.00 | 0.80 | ND | 1.20 | 0.32 | 0.95 | 0.00 |  |
| S10 | ND | 44.2 | ND | 0.60 | ND | 2.80 | 0.35 | 0.70 | 0.00 |  |
| S11 | ND | 18.2 | ND | 0.40 | ND | 10.5 | 0.32 | 0.10 | 0.00 |  |
| S12 | ND | 19.0 | 2.00 | 0.60 | ND | 20.8 | 0.71 | 0.00 | 0.00 |  |
| S13 | ND | 16.4 | ND | 0.40 | ND | 25.6 | 6.20 | 1.20 | 0.00 |  |
| S14 | ND | 146 | 4.00 | 3.20 | 0.20 | 20.5 | 0.08 | 1.40 | 0.00 |  |
| S15 | 0.40 | 146 | 8.00 | 4.60 | 0.40 | 30.1 | 0.50 | 1.50 | 0.00 |  |
| S16 | 0.20 | 81.8 | 4.00 | 2.40 | ND | 3.10 | 0.32 | 1.20 | 0.00 |  |
| S17 | ND | 45.8 | 2.00 | 1.00 | 0.20 | 1.20 | 0.16 | 0.80 | 0.00 |  |
| S18 | 0.20 | 105. | 4.00 | 2.40 | 0.20 | 1.30 | 0.28 | 1.00 | 0.00 |  |
| S19 | ND | 15.0 | ND | 0.60 | ND | 15.2 | 0.31 | 0.72 | 0.00 |  |
| S20 | 0.20 | 18.0 | 2.00 | 0.40 | 0.20 | 2.50 | 0.71 | 0.91 | 0.00 |  |
| S21 | ND | 18.0 | 2.00 | 0.40 | 0.20 | 22.6 | 0.35 | 2.50 | 0.00 |  |
| S22 | 0.20 | 69.2 | 2.00 | 1.40 | ND | 19.6 | 0.33 | 1.00 | 0.00 |  |
| S23 | 0.20 | 17.2 | 4.00 | 0.40 | ND | 14.8 | 0.32 | 1.10 | 0.00 |  |
| S24 | 0.20 | 92.4 | 4.00 | 3.00 | 0.20 | 30.7 | 0.72 | 0.00 | 0.00 |  |
| S25 | 0.20 | 63.8 | 6.00 | 1.60 | 0.20 | 13.5 | 0.20 | 0.00 | 0.00 |  |
| S26 | ND | 21.0 | ND | 0.40 | ND | 15.3 | 0.31 | 1.00 | 0.00 |  |
| S27 | 0.80 | 16.4 | ND | 0.20 | ND | 2.50 | 1.52 | 1.12 | 0.00 |  |
| S28 | ND | 36.8 | 2.00 | 1.00 | ND | 3.40 | 0.40 | 1.22 | 0.00 |  |
| S29 | ND | 23.6 | ND | 0.60 | 0.20 | 2.50 | 0.80 | 1.35 | 0.00 |  |
| S30 | ND | 21.6 | ND | 0.40 | ND | 32.6 | 0.43 | 1.20 | 0.00 |  |
| S31 | 0.20 | 147 | 2.00 | 5.20 | 0.40 | 32.2 | 1.00 | 2.00 | 0.00 |  |
| S32 | 0.20 | 136 | 6.00 | 1.80 | 0.20 | 12.5 | 0.40 | 0.00 | 0.00 |  |
| S33 | ND | 31.6 | ND | 0.40 | ND | 20.5 | 0.18 | 0.00 | 0.00 |  |
| S34 | ND | 16.2 | ND | 0.20 | ND | 30.6 | 0.38 | 0.00 | 0.00 |  |
| S35 | 0.20 | 79.4 | 2.00 | 2.40 | 0.20 | 10.6 | 0.35 | 0.00 | 0.00 |  |
| S36 | ND | 92.0 | 2.00 | 3.40 | ND | 6.20 | 0.45 | 0.00 | 0.00 |  |
| S37 | 0.20 | 11.6 | ND | 0.40 | 0.20 | 20.5 | 0.17 | 0.00 | 0.00 |  |
| S38 | 0.20 | 22.2 | 2.00 | 0.60 | ND | 1.20 | 0.18 | 0.00 | 0.00 |  |
| S39 | ND | 86.2 | 2.00 | 1.80 | ND | 1.50 | 1.42 | 0.00 | 0.00 |  |
| S40 | 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** |  |
| S1 | 0.40 | 110 | 4.51 | 2.70 | 0.20 | 1.30 | 1.86 | 0.02 | 0.00 |  |
| S2 | 0.20 | 18.2 | 2.82 | 0.40 | 0.20 | 1.12 | 0.60 | 0.04 | 0.00 |  |
| S3 | 0.20 | 26.2 | 2.51 | 0.60 | 0.20 | 7.50 | 0.80 | 0.08 | 0.00 |  |
| S4 | 0.20 | 20.1 | 0.40 | 0.92 | 0.20 | 31.2 | 1.00 | 0.20 | 0.00 |  |
| S5 | 0.20 | 14.6 | 0.31 | 0.32 | 0.25 | 11.9 | 0.40 | 0.10 | 0.00 |  |
| S6 | 0.30 | 24.8 | 2.20 | 0.45 | 0.20 | 20.8 | 0.72 | 2.62 | 0.00 |  |
| S7 | 0.20 | 28.2 | 0.20 | 0.78 | 0.20 | 4.52 | 0.23 | 1.00 | 0.00 |  |
| S8 | 0.20 | 18.7 | 0.20 | 0.62 | 0.20 | 21.1 | 0.82 | 2.30 | 0.00 |  |
| S9 | 0.10 | 20.7 | 2.11 | 1.10 | 0.20 | 2.50 | 0.51 | 1.20 | 0.00 |  |
| S10 | 0.10 | 45.6 | 0.20 | 0.82 | 0.18 | 3.10 | 0.62 | 1.10 | 0.00 |  |
| S11 | 0.10 | 19.7 | 0.30 | 0.75 | 0.19 | 11.2 | 0.73 | 0.40 | 0.00 |  |
| S12 | 0.20 | 21.2 | 2.24 | 0.93 | 0.16 | 20.9 | 0.92 | 0.20 | 0.00 |  |
| S13 | 0.20 | 18.1 | 0.24 | 0.55 | 0.20 | 26.7 | 7.10 | 1.40 | 0.00 |  |
| S14 | 0.20 | 148 | 4.10 | 3.80 | 0.25 | 21.6 | 0.12 | 1.80 | 0.00 |  |
| S15 | 0.50 | 151 | 8.21 | 4.72 | 0.48 | 30.8 | 0.81 | 2.00 | 0.00 |  |
| S16 | 0.40 | 90.6 | 4.30 | 2.75 | 0.21 | 2.82 | 0.51 | 1.70 | 0.00 |  |
| S17 | 0.20 | 48.2 | 2.10 | 1.32 | 0.28 | 1.71 | 0.34 | 1.10 | 0.00 |  |
| S18 | 0.30 | 106 | 4.21 | 2.86 | 0.32 | 1.42 | 0.40 | 1.20 | 0.00 |  |
| S19 | 0.20 | 18.1 | 0.30 | 0.91 | 0.20 | 15.8 | 0.41 | 1.00 | 0.00 |  |
| S20 | 0.30 | 20.2 | 2.21 | 0.83 | 0.31 | 2.70 | 0.86 | 2.72 | 0.00 |  |
| S21 | 0.10 | 70.3 | 2.18 | 0.82 | 0.32 | 22.8 | 0.43 | 1.30 | 0.00 |  |
| S22 | 0.25 | 18.6 | 2.20 | 1.61 | 0.20 | 20.1 | 0.48 | 1.20 | 0.00 |  |
| S23 | 0.28 | 93.8 | 4.26 | 0.48 | 0.22 | 22.3 | 0.52 | 0.40 | 0.00 |  |
| S24 | 0.22 | 64.2 | 4.18 | 3.20 | 0.26 | 15.1 | 1.20 | 0.20 | 0.00 |  |
| S25 | 0.23 | 24.8 | 6.30 | 1.80 | 0.27 | 40.3 | 1.00 | 1.20 | 0.00 |  |
| S26 | 0.18 | 18.2 | 0.21 | 0.95 | 0.22 | 16.6 | 0.41 | 1.32 | 0.00 |  |
| S27 | 0.87 | 38.1 | 0.24 | 0.72 | 0.20 | 2.86 | 1.85 | 1.42 | 0.00 |  |
| S28 | 0.20 | 25.0 | 2.26 | 1.33 | 0.20 | 3.72 | 0.73 | 1.63 | 0.00 |  |
| S29 | 0.20 | 27.7 | 0.45 | 0.80 | 0.31 | 2.72 | 0.97 | 1.53 | 0.00 |  |
| S30 | 0.20 | 24.8 | 0.31 | 0.71 | 0.20 | 33.7 | 0.85 | 1.42 | 0.00 |  |
| S31 | 0.24 | 150 | 2.32 | 5.93 | 0.62 | 35.3 | 1.50 | 2.80 | 0.00 |  |
| S32 | 0.32 | 140 | 6.30 | 1.92 | 0.40 | 15.2 | 0.80 | 0.20 | 0.00 |  |
| S33 | 0.04 | 33.8 | 2.10 | 0.62 | 0.20 | 26.3 | 0.25 | 0.20 | 0.00 |  |
| S34 | 0.08 | 18.2 | 2.50 | 0.40 | 0.20 | 33.2 | 0.52 | 0.20 | 0.00 |  |
| S35 | 0.40 | 80.2 | 2.72 | 2.60 | 0.40 | 15.8 | 0.62 | 0.40 | 0.00 |  |
| S36 | 0.20 | 100 | 1.20 | 3.84 | 0.20 | 7.30 | 0.71 | 0.20 | 0.00 |  |
| S37 | 0.60 | 15.3 | 2.63 | 0.72 | 0.40 | 25.1 | 0.20 | 0.20 | 0.00 |  |
| S38 | 0.47 | 23.6 | 2.84 | 0.82 | 0.20 | 1.80 | 0.24 | 0.40 | 0.00 |  |
| S39 | 0.20 | 90.3 | 2.90 | 7.10 | 0.20 | 2.10 | 1.83 | 0.30 | 0.00 |  |
| S40 | 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** |
| S1 | 0.35 | 90.8 | 4.38 | 2.50 | 0.18 | 1.22 | 1.50 | 0.01 | 0.01 |
| S2 | 0.16 | 17.6 | 2.10 | 0.30 | 0.15 | 1.00 | 0.30 | 0.02 | 0.00 |
| S3 | 0.17 | 25.5 | 2.12 | 0.52 | 0.10 | 6.80 | 0.40 | 0.06 | 0.00 |
| S4 | 0.16 | 19.3 | 0.29 | 0.81 | 0.12 | 30.6 | 0.80 | 0.18 | 0.01 |
| S5 | 0.18 | 14.0 | 0.10 | 0.28 | 0.20 | 11.0 | 0.20 | 0.09 | 0.00 |
| S6 | 0.26 | 23.2 | 2.10 | 0.41 | 0.16 | 19.1 | 0.58 | 2.40 | 0.01 |
| S7 | 0.19 | 24.1 | 0.10 | 0.69 | 0.14 | 3.80 | 0.18 | 0.80 | 0.00 |
| S8 | 0.09 | 15.3 | 0.12 | 0.58 | 0.17 | 20.8 | 0.74 | 2.00 | 0.00 |
| S9 | 0.08 | 18.4 | 2.00 | 0.96 | 0.10 | 1.90 | 0.48 | 1.00 | 0.00 |
| S10 | 0.10 | 42.3 | 0.10 | 0.76 | 0.10 | 2.90 | 0.53 | 1.00 | 0.00 |
| S11 | 0.09 | 18.2 | 0.22 | 0.71 | 0.16 | 10.0 | 0.68 | 0.28 | 0.01 |
| S12 | 0.18 | 20.1 | 2.20 | 0.92 | 0.12 | 18.8 | 0.76 | 0.15 | 0.00 |
| S13 | 0.17 | 15.3 | 0.20 | 0.53 | 0.15 | 25.1 | 0.81 | 1.32 | 0.00 |
| S14 | 0.16 | 12.0 | 3.80 | 3.28 | 0.20 | 20.1 | 6.50 | 1.35 | 0.00 |
| S15 | 0.45 | 148 | 7.40 | 4.23 | 0.32 | 28.2 | 0.09 | 1.65 | 0.01 |
| S16 | 0.37 | 60.8 | 3.20 | 1.86 | 0.18 | 3.10 | 0.60 | 1.62 | 0.00 |
| S17 | 0.18 | 41.2 | 1.80 | 1.30 | 0.26 | 0.90 | 0.38 | 1.00 | 0.00 |
| S18 | 0.29 | 105 | 4.00 | 2.63 | 0.25 | 1.10 | 0.21 | 1.02 | 0.00 |
| S19 | 0.18 | 17.0 | 0.21 | 0.52 | 0.16 | 14.6 | 0.36 | 0.80 | 0.01 |
| S20 | 0.25 | 19.3 | 2.10 | 0.61 | 0.20 | 2.10 | 0.35 | 2.12 | 0.00 |
| S21 | 0.08 | 68.2 | 2.00 | 0.71 | 0.22 | 20.8 | 0.76 | 1.10 | 0.00 |
| S22 | 0.23 | 17.4 | 2.10 | 0.92 | 0.16 | 18.5 | 0.34 | 1.00 | 0.00 |
| S23 | 0.25 | 90.2 | 2.00 | 0.41 | 0.19 | 20.2 | 0.33 | 0.30 | 0.00 |
| S24 | 0.20 | 61.3 | 3.88 | 3.00 | 0.22 | 14.6 | 0.40 | 0.12 | 0.00 |
| S25 | 0.20 | 21.4 | 4.00 | 1.20 | 0.24 | 36.4 | 0.96 | 1.00 | 0.01 |
| S26 | 0.15 | 17.1 | 5.78 | 0.73 | 0.21 | 15.3 | 0.92 | 1.11 | 0.00 |
| S27 | 0.63 | 32.5 | 0.10 | 0.64 | 0.18 | 1.80 | 0.31 | 1.25 | 0.00 |
| S28 | 0.16 | 24.1 | 0.20 | 1.28 | 0.16 | 2.96 | 0.66 | 1.36 | 0.00 |
| S29 | 0.18 | 26.8 | 2.11 | 0.76 | 0.23 | 2.10 | 0.85 | 1.48 | 0.00 |
| S30 | 0.19 | 23.4 | 0.32 | 0.62 | 0.15 | 30.6 | 0.56 | 1.20 | 0.00 |
| S31 | 0.20 | 140 | 0.28 | 4.86 | 0.49 | 34.8 | 1.38 | 1.92 | 0.00 |
| S32 | 0.30 | 129 | 6.10 | 1.22 | 0.35 | 14.8 | 0.60 | 0.16 | 0.00 |
| S33 | 0.02 | 17.0 | 1.82 | 0.41 | 0.18 | 25.2 | 0.20 | 0.15 | 0.01 |
| S34 | 0.06 | 78.2 | 2.10 | 0.23 | 0.30 | 80.3 | 0.48 | 0.17 | 0.01 |
| S35 | 0.35 | 80.5 | 2.40 | 2.10 | 0.10 | 15.2 | 0.58 | 0.29 | 0.00 |
| S36 | 0.20 | 13.2 | 1.00 | 2.36 | 0.30 | 6.80 | 0.63 | 0.19 | 0.01 |
| S37 | 0.52 | 20.3 | 2.10 | 0.50 | 0.12 | 22.4 | 0.17 | 0.16 | 0.01 |
| S38 | 0.42 | 75.6 | 2.25 | 0.65 | 0.15 | 0.96 | 0.21 | 0.30 | 0.00 |
| S39 | 0.17 | 73.8 | 2.40 | 2.30 | 0.10 | 1.80 | 1.20 | 0.25 | 0.01 |
| S40 | 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** |
| S1 | ND | 16.2 | 2.00 | 0.60 | ND | 1.60 | 1.40 | 0.00 | 0.00 |
| S2 | ND | 16.8 | ND | 0.20 | ND | 1.20 | 0.20 | 0.00 | 0.00 |
| S3 | ND | 48.0 | 2.00 | 0.60 | ND | 8.40 | 0..40 | 0.60 | 0.00 |
| S4 | 0.80 | 582 | 10.0 | 5.60 | 0.80 | 35.8 | 0.80 | 0.00 | 0.00 |
| S5 | 0.20 | 75.6 | 4.00 | 1.60 | ND | 1.2 | 0.40 | 0.00 | 0.00 |
| S6 | 0.20 | 110 | 6.00 | 2.60 | 1.20 | 23.6 | 0.60 | 2.00 | 0.00 |
| S7 | ND | 18.8 | 2.00 | 0.40 | ND | 5.60 | 0.20 | 1.00 | 0.00 |
| S8 | 0.20 | 134 | 6.00 | 4.00 | 0.20 | 26.2 | 0.60 | 2.20 | 0.00 |
| S9 | 0.20 | 18.8 | 2.00 | 0.40 | 0.20 | 1.60 | 0.40 | 0.00 | 0.00 |
| S10 | ND | 17.2 | ND | 0.20 | ND | 3.60 | 0.40 | 0.80 | 0.00 |
| S11 | ND | 73.6 | 4.00 | 2.40 | ND | 16.2 | 0.40 | 0.00 | 0.00 |
| S12 | 1.20 | 133 | 8.00 | 4.60 | 0.60 | 31.4 | 0.80 | 0.00 | 0.00 |
| S13 | 0.20 | 114 | 2.00 | 3.60 | 0.20 | 27.8 | 6.00 | 1.40 | 0.00 |
| S14 | 0.20 | 110 | 6.00 | 2.40 | 0.20 | 22.6 | 0.00 | 1.80 | 0.00 |
| S15 | 0.20 | 111 | 6.00 | 3.40 | 0.60 | 35.0 | 0.60 | 1.80 | 0.00 |
| S16 | ND | 20.2 | 2.00 | 0.40 | ND | 3.20 | 0.40 | 1.40 | 0.00 |
| S17 | 0.20 | 17.2 | 4.00 | 0.40 | 0.40 | 1.40 | 0.20 | 0.00 | 0.00 |
| S18 | 0.20 | 20.0 | 2.00 | 0.40 | 0.20 | 1.60 | 0.40 | 0.00 | 0.00 |
| S19 | ND | 29.0 | 2.00 | 1.00 | ND | 20.2 | 0.40 | 0.00 | 0.00 |
| S20 | ND | 16.2 | ND | 0.60 | ND | 3.40 | 0-.80 | 0.00 | 0.00 |
| S21 | 0.20 | 125 | 6.00 | 3.00 | 0.40 | 25.8 | 0.40 | 2.80 | 0.00 |
| S22 | 2.60 | 107 | 10.0 | 3.00 | 1.60 | 20.8 | 0.40 | 1.40 | 0.00 |
| S23 | 0.20 | 42.4 | 2.00 | 1.00 | 0.40 | 19.3 | 0.40 | 1.60 | 0.00 |
| S24 | 0.40 | 90.0 | 4.00 | 2.80 | 0.20 | 36.0 | 0.40 | 0.00 | 0.00 |
| S25 | 0.40 | 62.0 | 2.00 | 2.00 | 0.20 | 15.2 | 0.40 | 0.00 | 0.00 |
| S26 | 0.20 | 88.6 | 6.00 | 3.00 | 0.20 | 19.4 | 0.80 | 0.00 | 0.00 |
| S27 | 0.20 | 18.4 | 2.00 | 0.60 | ND | 3.20 | 0.20 | 0.00 | 0.00 |
| S28 | 0.20 | 22.0 | 2.00 | 0.80 | ND | 5.00 | 0.40 | 0.60 | 0.00 |
| S29 | ND | 15.4 | 2.00 | 0.40 | ND | 3.20 | 1.60 | 0.00 | 0.00 |
| S30 | 0.20 | 139 | 2.00 | 4.20 | 2.80 | 35.8 | 0.60 | 3.40 | 0.00 |
| S31 | 3.60 | 470 | 12.0 | 5.40 | 1.60 | 34.6 | 1.00 | 0.00 | 0.00 |
| S32 | 0.40 | 72.4 | 4.00 | 4.00 | 3.00 | 13.8 | 0.60 | 0.00 | 0.00 |
| S33 | 0.40 | 15.2 | 6.00 | 6.00 | 3.40 | 23.2 | 0.20 | 0.00 | 0.00 |
| S34 | 0.20 | 68.2 | 6.00 | 6.00 | 2.60 | 38.8 | 0.40 | 0.00 | 0.00 |
| S35 | 0.20 | 75.0 | 4.00 | 4.00 | 3.00 | 13.6 | 0.40 | 0.00 | 0.00 |
| S36 | 0.20 | 60.2 | 6.00 | 6.00 | 0.60 | 7.60 | 0.60 | 0.00 | 0.00 |
| S37 | 0.20 | 140 | 4.00 | 4.00 | 5.00 | 22.8 | 0.20 | 0.00 | 0.00 |
| S38 | ND | 13.6 | ND | ND | 0.18 | 1.40 | 0.20 | 0.00 | 0.00 |
| S39 | 0.20 | 10.6 | 2.00 | 2.00 | 0.40 | 1.80 | 1.60 | 0.00 | 0.00 |
| S40 | 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** |
| S1 | 1.10 | 16.8 | 3.10 | 0.80 | 1.10 | 1.80 | 1.85 | 1.10 | 0.00 |
| S2 | 1.10 | 18.2 | 1.20 | 1.30 | 1.10 | 0.40 | 0.50 | 0.60 | 0.00 |
| S3 | 1.10 | 50.2 | 2.84 | 0.82 | 1.00 | 9.60 | 0.87 | 0.80 | 0.00 |
| S4 | 1.20 | 78.6 | 10.8 | 7.00 | 1.00 | 38.2 | 0.87 | 1.00 | 0.00 |
| S5 | 1.20 | 120 | 6.70 | 2.00 | 0.80 | 12.5 | 0.48 | 2.20 | 0.00 |
| S6 | 0.30 | 118 | 7.00 | 2.85 | 1.80 | 24.3 | 0.80 | 2.50 | 0.00 |
| S7 | 0.21 | 20.1 | 2.40 | 0.60 | 1.10 | 7.70 | 0.50 | 1.20 | 0.00 |
| S8 | 0.40 | 140 | 7.10 | 7.00 | 1.20 | 27.1 | 0.80 | 2.80 | 0.00 |
| S9 | 0.60 | 19.8 | 3.40 | 0.40 | ND | 4.10 | 0.60 | 1.20 | 0.00 |
| S10 | 1.00 | 18.4 | 1.00 | 0.80 | 1.12 | 4.00 | 0.60 | 0.87 | 0.00 |
| S11 | 0.80 | 74.0 | 5.10 | 3.10 | 1.00 | 18.2 | 0.70 | 0.80 | 0.00 |
| S12 | 1.25 | 140 | 10.0 | 6.20 | 0.80 | 33.2 | 0.87 | 1.00 | 0.00 |
| S13 | 0.40 | 116 | 2.60 | 4.40 | 0.31 | 28.2 | 7.10 | 1.80 | 0.00 |
| S14 | 0.50 | 120 | 8.50 | 2.62 | 0.40 | 23.4 | 1.00 | 1.90 | 0.00 |
| S15 | 0.40 | 112 | 7.00 | 3.60 | 0.82 | 35.7 | 0.72 | 2.00 | 0.00 |
| S16 | 1.00 | 25.2 | 2.60 | 0.70 | 1.00 | 3.80 | 0.61 | 1.82 | 0.00 |
| S17 | 0.40 | 18.2 | 6.30 | 0.70 | 0.62 | 1.80 | 0.35 | 1.00 | 0.00 |
| S18 | 0.25 | 23.1 | 2.60 | 0.70 | 0.50 | 1.80 | 0.60 | 0.80 | 0.00 |
| S19 | 0.86 | 30.6 | 2.40 | 1.60 | 0.80 | 21.2 | 0.45 | 1.00 | 0.00 |
| S20 | 1.00 | 17.5 | ND | 0.80 | 1.00 | 3.85 | 0.87 | 0.00 | 0.00 |
| S21 | 0.38 | 130 | 7.00 | 4.30 | 0.60 | 26.7 | 0.80 | 3.0 | 0.00 |
| S22 | 2.80 | 110 | 11.2 | 4.20 | 1.70 | 22.4 | 0.60 | 1.80 | 0.00 |
| S23 | 0.32 | 45.0 | 2.20 | 1.20 | 0.60 | 21.2 | 0.60 | 1.80 | 0.00 |
| S24 | 0.52 | 100 | 6.10 | 3.10 | 0.25 | 37.2 | 0.60 | 0.80 | 0.00 |
| S25 | 0.80 | 70.2 | 3.10 | 3.00 | 0.32 | 18.2 | 0.60 | 1.00 | 0.00 |
| S26 | 0.31 | 92.0 | 6.80 | 3.20 | 0.80 | 21.1 | 1.00 | 0.70 | 0.00 |
| S27 | 0.35 | 20.2 | 3.10 | 0.80 | 0.75 | 4.10 | 0.60 | 0.60 | 0.00 |
| S28 | 0.42 | 23.1 | 3.10 | 0.90 | 0.60 | 6.20 | 0.60 | 0.80 | 0.00 |
| S29 | 0.45 | 16.2 | 3.20 | 0.60 | 0.40 | 3.60 | 1.80 | 0.60 | 0.00 |
| S30 | 0.30 | 142 | 2.80 | 4.80 | 3.32 | 38.2 | 0.80 | 4.10 | 0.00 |
| S31 | 3.80 | 480 | 13.8 | 6.20 | 1.80 | 35.2 | 1.10 | 0.40 | 0.00 |
| S32 | 0.60 | 75.2 | 4.20 | 3.10 | 0.70 | 15.2 | 0.80 | 0.80 | 0.00 |
| S33 | 0.60 | 16.2 | 7.20 | 3.80 | 0.80 | 24.1 | 0.40 | 0.60 | 0.00 |
| S34 | 0.50 | 69.0 | 6.80 | 3.10 | 0.40 | 39.2 | 0.50 | 0.20 | 0.00 |
| S35 | 0.31 | 78.0 | 4.32 | 3.81 | 0.71 | 13.6 | 0.60 | 0.00 | 0.00 |
| S36 | 0.35 | 60.8 | 7.00 | 0.80 | 0.60 | 7.80 | 0.86 | 0.20 | 0.00 |
| S37 | 0.32 | 148 | 5.62 | 5.20 | 0.35 | 25.1 | 0.35 | 0.40 | 0.00 |
| S38 | 0.40 | 14.8 | 0.20 | 0.32 | 0.40 | 1.80 | 0.40 | 0.60 | 0.00 |
| S39 | 0.32 | 11.8 | 2.80 | 0.46 | 0.41 | 2.30 | 2.10 | 0.00 | 0.00 |
| S40 | 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** |
| S1 | 1.20 | 17.3 | 3.60 | 1.20 | 1.30 | 2.21 | 2.00 | 2.34 | 0.01 |
| S2 | 1.25 | 20.4 | 1.80 | 1.60 | 1.50 | 1.62 | 1.00 | 1.72 | 0.01 |
| S3 | 1.35 | 52.1 | 2.90 | 2.00 | 1.60 | 10.1 | 1.80 | 1.23 | 0.01 |
| S4 | 1.40 | 79.8 | 11.8 | 7.92 | 1.82 | 40.3 | 1.20 | 2.20 | 0.01 |
| S5 | 1.20 | 130 | 7.90 | 2.60 | 1.20 | 13.2 | 0.85 | 2.80 | ND |
| S6 | 0.80 | 120 | 8.42 | 2.90 | 2.00 | 8.10 | 0.70 | 2.92 | ND |
| S7 | 0.72 | 27.2 | 2.50 | 1.20 | 1.32 | 8.00 | 0.80 | 1.35 | 0.01 |
| S8 | 0.84 | 148 | 7.60 | 7.60 | 1.53 | 28.2 | 0.93 | 2.96 | 0.02 |
| S9 | 1.20 | 21.6 | 3.45 | 0.80 | 1.00 | 4.80 | 0.75 | 1.42 | 0.01 |
| S10 | 1.40 | 20.3 | 1.30 | 1.20 | 1.43 | 4.92 | 0.78 | 0.93 | 0.01 |
| S11 | 1.20 | 75.2 | 5.20 | 3.60 | 1.35 | 18.7 | 0.87 | 0.95 | 0.02 |
| S12 | 1.50 | 143 | 10.50 | 6.92 | 1.10 | 35.5 | 0.96 | 1.20 | 0.01 |
| S13 | 0.80 | 120 | 2.80 | 4.80 | 0.89 | 28.9 | 7.86 | 2.10 | ND |
| S14 | 0.92 | 123 | 9.20 | 2.91 | 0.80 | 23.7 | 1.43 | 2.00 | ND |
| S15 | 0.65 | 115 | 7.30 | 4.10 | 0.90 | 36.3 | 0.74 | 2.31 | ND |
| S16 | 1.32 | 27.2 | 2.80 | 1.20 | 1.36 | 3.98 | 0.70 | 1.96 | ND |
| S17 | 0.72 | 19.1 | 7.20 | 1.31 | 1.01 | 2.10 | 0.62 | 1.32 | ND |
| S18 | 0.50 | 24.2 | 2.80 | 1.20 | 0.75 | 2.15 | 0.73 | 0.92 | 0.02 |
| S19 | 1.22 | 33.7 | 2.80 | 1.81 | 0.96 | 22.6 | 0.52 | 1.25 | 0.01 |
| S20 | 1.42 | 20.2 | 1.20 | 1.00 | 1.52 | 4.00 | 0.90 | 1.00 | ND |
| S21 | 0.85 | 138 | 8.20 | 4.86 | 0.93 | 27.2 | 1.10 | 3.12 | ND |
| S22 | 4.32 | 49.2 | 11.5 | 4.87 | 1.83 | 23.7 | 0.86 | 2.10 | 0.01 |
| S23 | 0.95 | 120 | 2.80 | 1.57 | 0.95 | 22.7 | 0.92 | 2.23 | 0.01 |
| S24 | 0.82 | 80.3 | 6.92 | 3.81 | 0.49 | 38.9 | 0.95 | 0.97 | 0.01 |
| S25 | 1.10 | 78.2 | 4.20 | 3.42 | 0.63 | 20.1 | 0.96 | 1.50 | 0.02 |
| S26 | 0.63 | 110 | 7.10 | 3.51 | 0.94 | 21.9 | 1.20 | 0.96 | 0.02 |
| S27 | 0.86 | 26.3 | 3.85 | 1.10 | 1.10 | 5.10 | 0.76 | 0.98 | 0.02 |
| S28 | 0.69 | 24.4 | 3.90 | 1.23 | 0.83 | 6.70 | 0.75 | 0.89 | 0.02 |
| S29 | 0.70 | 17.5 | 3.60 | 0.89 | 0.72 | 3.92 | 2.10 | 0.87 | 0.01 |
| S30 | 0.65 | 145 | 3.10 | 4.93 | 3.97 | 39.5 | 0.96 | 4.35 | 0.01 |
| S31 | 4.30 | 482 | 14.1 | 7.12 | 2.10 | 36.4 | 1.50 | 0.63 | 0.01 |
| S32 | 0.86 | 75.9 | 4.30 | 3.50 | 0.79 | 15.8 | 1.10 | 1.86 | 0.02 |
| S33 | 0.92 | 18.5 | 7.92 | 4.20 | 0.93 | 24.9 | 0.86 | 1.10 | 0.04 |
| S34 | 0.72 | 70.6 | 6.95 | 3.60 | 0.68 | 40.1 | 0.93 | 0.40 | 0.01 |
| S35 | 0.63 | 80.3 | 5.20 | 4.42 | 0.85 | 14.8 | 0.87 | 1.20 | 0.02 |
| S36 | 0.54 | 69.5 | 7.60 | 1.10 | 0.69 | 8.90 | 1.21 | 0.90 | 0.01 |
| S37 | 0.62 | 150 | 6.10 | 6.20 | 0.42 | 26.2 | 0.67 | 0.80 | 0.01 |
| S38 | 0.82 | 15.8 | 0.62 | 0.84 | 0.72 | 1.92 | 0.73 | 1.00 | 0.02 |
| S39 | 0.74 | 13.7 | 3.10 | 0.73 | 0.84 | 2.56 | 3.10 | 1.10 | 0.03 |
| S40 | 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**

c

Dry season Dry season concentration oncentration of heavy s of heavy

metals in metals in

water sediments

Correlation

Coefficient

1.000

.848

Dry season

concentration of heavy metals in water

Sig. (2-tailed)

.

.004

N

9

9

Spearman's rho

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 Wet season concentrations concentrations of

of heavy heavy metals in

metals in water sediments

Correlation

Coefficient

1.000

.803

Wet season

concentrations of heavy metals in water

Sig. (2-tailed)

.

.009

N

9

9

Spearman's rho

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 Wet season concentration concentration of heavy s of heavy

metals in metals in

water water

Correlation

Coefficient

1.000

.936

Dry season concentration of heavy

metals in water

Sig. (2-tailed)

.

.000

N

9

9

Spearman's rho

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

c

Dry season Wet season oncentration concentration s of heavy s of heavy metals in metals in

sediments sediments

Correlation

Coefficient

1.000

1.000

Dry season concentrations of heavy

metals in sediments

Sig. (2-tailed)

.

0.000

N

9

9

Spearman's rho

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**

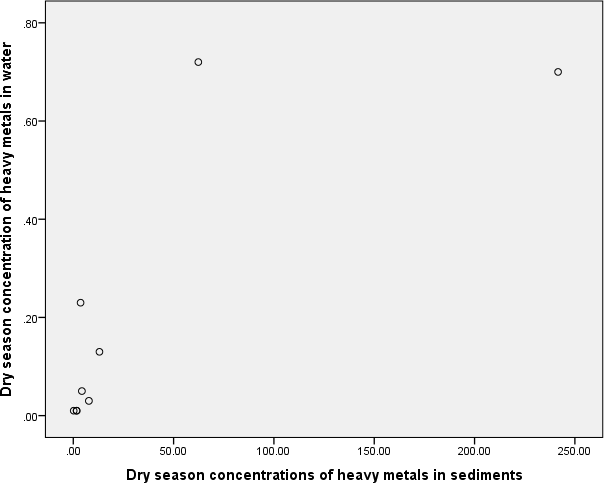


Fig 1:scatter plot of dry season concentration of heavy metal in water Vs in sediment

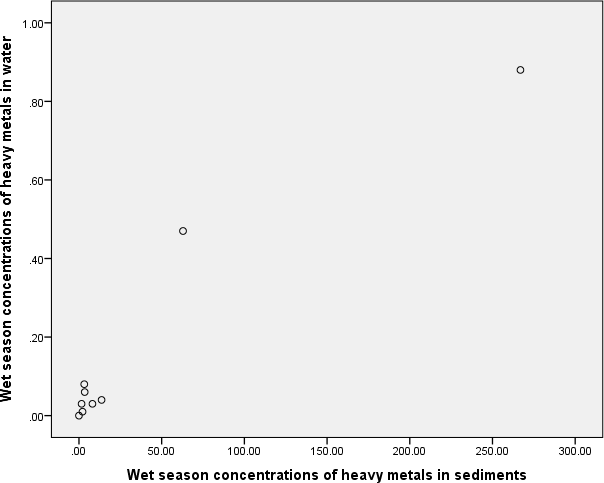


Fig 2:scatter plot of wet seasons concentration of heavy metal in water Vs in sediment

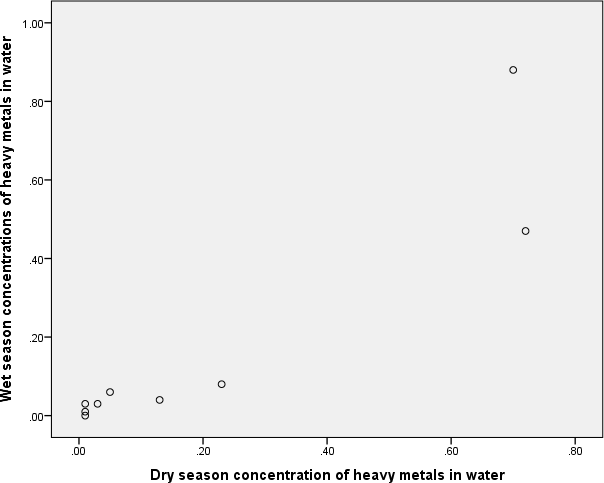


Fig 3: Scatter plot of wet season concentration of heavy metal in water Vs dry season concentration in water

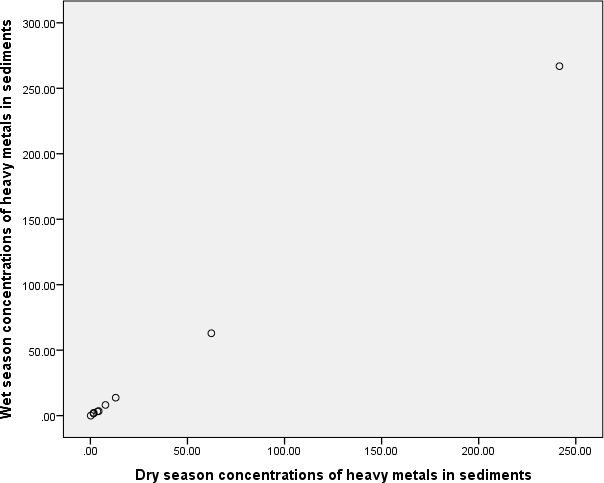


Fig 3:Scatter plot of wet season concentration of heavy metal in sedimentVs dry season concentration in sediments.

#### 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 |
|  | |  |  |
|  | Pearson Correlation | 1 | .988\*\* |
| concentrations of heavy metals in Tilapia from lokoja | Sig. (2-tailed) |  | .000 |
|  | N | 9 | s9 |
|  | Pearson Correlation | .988\*\* | 1 |
| concentrations of heavy metals in catfish from lokoja | 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 |
| Pearson Correlation | 1 | .999\*\* |
| concentrations of heavy metals Sig. (2-tailed) in Tilapia from itobe |  | .000 |
| N | 9 | 9 |
| Pearson Correlation | .999\*\* | 1 |
| Concentration of heavy metals Sig. (2-tailed) in catfish from itobe | .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 |
| Pearson Correlation | 1 | .975\*\* |
| concentrations of heavy Sig. (2-tailed) |  | .000 |
| N | 9 | 9 |
| Pearson Correlation | .975\*\* | 1 |
| Concentration of heavy Sig. (2-tailed) | .000 |  |
| N | 9 | 9 |

metals in catfish from lokoja

metals in catfish from itobe

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

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

Concentration of heavy metals in catfish from idah

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

1

9

\*

0

9

f

|  |  |  |
| --- | --- | --- |
|  | concentrations o heavy metals in catfish from lokoja | Concentration of heavy metals in catfish from idah |
| Pearson Correlation |  | .999\*\* |
| concentrations of heavy metals Sig. (2-tailed) in catfish from lokoja |  | .000 |
| N |  | 9 |
| Pearson Correlation | .999\* | 1 |
| Concentration of heavy metals Sig. (2-tailed) in catfish from idah | .00 |  |
| N |  | 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 |
| Pearson Correlation | 1 | | .996\*\* |
| concentrations of heavy Sig. (2-tailed) metals in Tilapia from itobe |  | | .000 |
| N | 9 | | 9 |
| Pearson Correlation | .996\*\* | | 1 |
| Concentration of heavy Sig. (2-tailed) metals in Tilapia from Idah | .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 |
|  | |  |  |
|  | Pearson Correlation | 1 | .969\*\* |
| Concentration of heavy  metals in catfish from itobe | Sig. (2-tailed) |  | .000 |
|  | N | 9 | 9 |
|  | Pearson Correlation | .969\*\* | 1 |
| Concentration of heavy  metals in catfish from idah | 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

|  |  |  |
| --- | --- | --- |
| Correlation Coefficient | 1.000 | .848 |
| Sig. (2-tailed) | . | .004 |
| N | 9 | 9 |
| Correlation Coefficient  Sig. (2-tailed) | .848\*\*  .004 | 1.000\*\* |
| N | 9 | 9 |

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

Dry season Dry season concentration of concentrations heavy metals in of heavy metals

water in sediments

Dry season concentration of

heavy metals in water

Spearman's rho

Dry season concentrations of

heavy metals in sediments

#### Table 71: Wet season concentration in water and sediment

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

c

Dry season Wet season oncentration concentration of heavy s of heavy

metals in metals in

water water

Correlation Coefficient

1.000

.936

Dry season concentration of heavy metals in water

Sig. (2-tailed)

.

.000

N 9

Spearman's rho

Correlation Coefficient

.936\*\*

9

1.000\*\*

Wet season concentrations of heavy metals in water

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

heavy metals in sediments

of heavy metals in sediments

\*\*. 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 Dry season concentration of concentrations heavy metals in of heavy metals

water in sediments

Dry season concentration of heavy metals in water

Spearman's rho

Dry season concentrations of heavy metals in sediments

|  |  |  |
| --- | --- | --- |
| Correlation Coefficient | 1.000 | .848 |
| Sig. (2-tailed) | . | .004 |
| N | 9 | 9 |
| 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  Wet season concentrations of heavy metals in sediments | Correlation Coefficient Sig. (2-tailed)  N  Correlation Coefficient Sig. (2-tailed)  N | 1.000 | | | .803 |
| . | | | .009 |
| 9 | | | 9 |
| .803\*\* | | | 1.000\*\* |
| .009 | | |  |
| 9 | | | 9 |
|  |  |  |

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

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

c

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

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

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

|  |  |  |
| --- | --- | --- |
| Correlation Coefficient | 1.000 | 1.000 |
| Sig. (2-tailed) | . | 0.000 |
| N | 9 | 9 |
| Correlation Coefficient | 1.000\* | 1.000\*\* |
| Sig. (2-tailed) | 0.000. |  |
| N | 9 | 9 |

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

\*

Dry season Wet season concentrations concentrations of heavy metals of heavy metals in sediments in sediments

Dry season concentrations of heavy metals in sediments

Spearman's rho

Wet season concentrations of heavy metals in sediments

#### APPENDIX XXV

**SCATTER PLOTS OF THE CONCENTRATION OF METALS IN FISH SAMPLES**

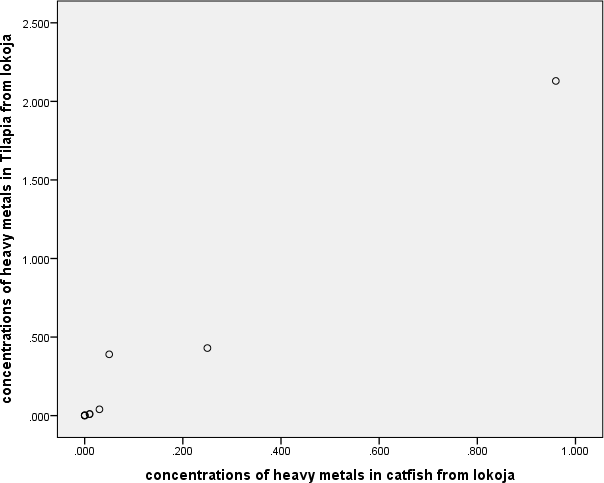


Fig. 1: Metals in Tilapia VS metals in catfish from lokoja

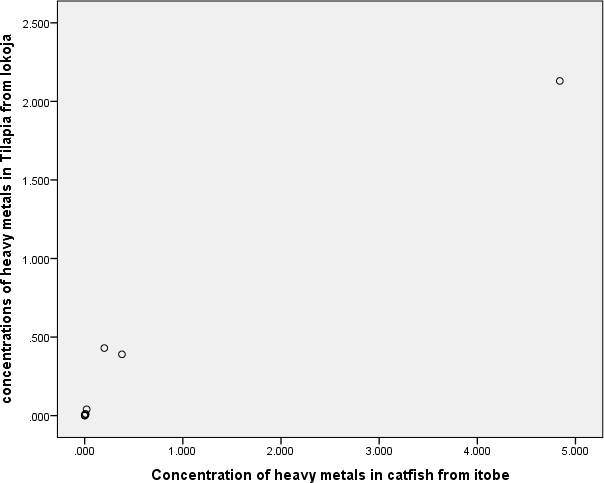


Fig. 2: metals in tilapia from Lokoja VS metals in Catfish from Itobe

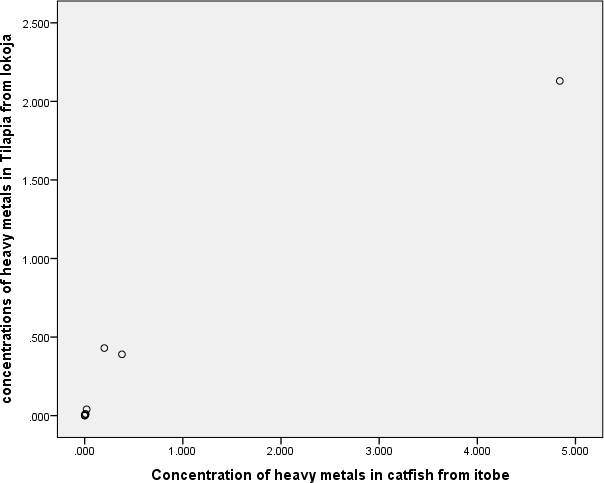
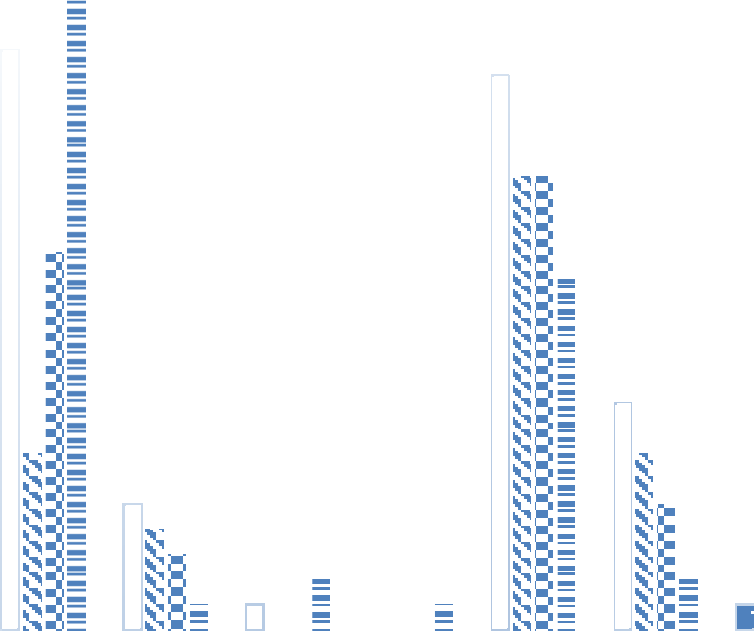


Fig. 3: Metals in Tilapia from Lokoja VS Metals in Catfish from Itobe

0.3

mg/L

0.25



0.2

0.15

0.1

0.05

0

Cr Mn Pb Co Ni Fe Zn Cu Cd

March April May Oct.

Metals

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



100

90

80

70

60

50

40

30

20

10

0

Cr

Mn

Pb

Co

Ni

Fe

Zn

Cu

Cd

June

July

August

Sept.

Metals

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



100

90

80

70

60

50

40

30

20

10

0

Cr

Mn

Pb

Co

Ni

Fe

Zn

Cu

Cd

June

July

August

Sept.

### Metals

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



90

80

70

60

50

40

30

20

10

0

Cr

Mn

Pb

Co

Ni

Fe

Zn

Cu

Cd

March April May Oct.

### Metals

Fig4.4:

Barchart representation of dry season concentration of metals in sediments of River Niger