EFFECTS OF KADUNA REFINERY AND PETROCHEMICAL COMPANY (KRPC) EFFLUENT ON ROMI RIVER WATER QUALITY KADUNA STATE NIGERIA.

BY

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SEPTEMBER, 2019.

DECLARATION

I hereby declare that this dissertation has been written by me and it is a report of my research work. it has not been presented in any previous application for the award of Master of Science Degree. All quotations are indicated sources of information specifically acknowledged by means of references,

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CERTIFICATION

This dissertation entitled: "**Effect of Kaduna Refinery and Petrochemical Company (KRPC) Effluent on Romi River Water Quality Kaduna State Nigeria**'' meets the regulations governing the award of Master of Science in Department of Geography, Faculty of Environmental Sciences of Nassarawa State University Keffi, Nigeria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

To God Almighty for His faithfulness, My husband Ali Abel Ikese, Children, My parents, Mr and Dr. Mrs Anyanya.

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ABSTRACT

The study examined the effects of Kaduna refinery effluent on water quality of River Romi Kaduna state. The study was conducted within three (3) months and aimed at assessing the effect of KRPC on River ROMI. The study covered a distance of 20Km from the point of effluent discharge from the Kaduna Refining Petrochemical Company to the point of outflow into the River Romi. They were four sampling points and three samples were collected from of the four points.. The results of the analysis were used to investigate the impact (s) of the effluent from the Refinery on the River Romi, in the host Community of Kaduna Refining and Petrochemical Company (KRPC). Physical characterizing parameters that were considered in the investigation include: the physical and Chemical Properties which are measured in terms physical and chemical properties. Biological Chemical oxygen demand (BOD),170pp 160pp, PH7.45 and 6.72 temperature 34^0C and 32^0C, Turbidity 39.71 NTU and 11.74NTU, , and Heavy Metals among other key analyses. The results obtained were used to determine the level of impact of these parameters in the effluent water whether in the rating of either being high, or low or within permissible limit if, when compared with Compliance limit stipulated by NESREA and World Health organization (WHO) and; thereby endangering aquatic life in the river: subjecting its domestic use to high risk by inhabitants of Romi, the host Community. The environment and the farmlands located at the discharge point were also preview considering the attendant impact of refinery effluent water in an environment. Student T-test and ANOVA was used to determine the extent of Impact on the River Romi. The recommendations and action plans are aimed at addressing the issues/problems noted in the disposal of the effluent from the refinery, following the need for operations of the Refinery should be closely monitored with greater enforcement of Guidelines and Policies as stipulated by Government Environmental Agencies. The recommendation(s) call for enforcement of Government Guidelines, Policies and Agency responsible for periodic monitoring of the operations of the Refinery.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Water is life! Without it there can be no life. Governments all over the globe make effort to provide water both in quantity and quality to their citizens. This involves harnessing surface water resources. All people, irrespective of their stage of development and social or economic conditions, have the right to have access to drinking water in quantities and of quality equal to their basic needs (Mar del Plata, 1977).

Water bodies are under serious threat by natural and anthropogenic activities around the globe. Increase and changes in environmental pressure threaten surface water quality and complicate the assessment of its present and future spatial distribution (Vissers et *al.,* 2005). Pollution of freshwater bodies such as rivers, streams, lakes and ponds is mostly experienced as result of industrial discharge, municipal waste disposal and surface runoff (Akaniwor et *al.*, 2007).

Inadequate supply of potable water coupled with pollution of surface water have made individuals especially in Nigeria resort to various means of gaining access to and managing their own water supply. Among such means are construction of hand-dug wells and harvesting of rain water. Every aspect of agriculture requires tire adequate and timely supply of water to succeed. Surface water has sustained agriculture in some desertregions of the world and in Nigeria through tube wells and boreholes. The pattern and level of life development depends, to a great extent on the quality, quantity and rate of water supply to the species. Civilizations have flourished with the development of reliable water supplies and have collapsed as the supply of water failed (Fetters 1972, Troften, 1973).

Surface water offers the most abundant source of water to man. It is the cheapest and the most constant in quality and quantity. Because it is not visible on the surface and the misinformation about surface water, many people undervalue the importance of surface water in sustaining water supply needs.

Surface water exists all through in Nigeria. Experience has shown that the most important organs of the human body are not visible on our exterior skin. For example, the blood, and the heart that pumps it are not visible yet they are very important. The prominent situation in which greater emphasis is placed on groundwater rather than surface water can be likened to a woman using costly soap and detergent to kill genus on her body without caring for the infections in the blood which have caused the very same skindisease.

The money, time and emphasis given to ground water development in Nigeria at the expense of surface water development have not been justified in terms of meeting water needs. A study of water supply for irrigation, domestic purposes and hydro-electric power generation in 1993 showed that 63 large dams and 99 small dams had been constructed (JICA, 1993; FAO, 2005). According to Olasehinde (2010), out of these, 31 large dams and 45 small dams were used to irrigate 418,620 hectares and 45,880 hectares of land respectively. Twenty six (26) large dams and 53 small dams were used to supply water to 5,718,500 people and 2,298,300 people respectively. Six large dams were used to supply 4,978 MW of hydro-electricity and one small dams used to supply 16MW. The huge amount used ineffectively in these projects could have been complemented with a conjunctive development of groundwater sources which would have produced better results (Olasehinde, 1983; 2003; Olasehinde and Awojobi, 2004).

Water is a liquid that at ambient conditions co-exists on earth in various states. (Stanley, 2007). Water covers 70.9% of the earth's surface and is a vital substance in all organisms. On earth it is found mostly in oceans and other large water bodies with 1.6% of water below ground in aquifers and 0.00% in the air as vapor, clouds (formed of solid and liquid water particles suspected in air) and precipitation. (Bath. M. 1974) Oceans hold 97% of surface water, glaciers and polar ice caps 2.4% and other land surface water such as rivers, lakes and ponds 0.6%. Avery small amount of earth's water is contained within biological bodies and manufactured products. (Gleick, 2001).

The water on earth moves continuously through a cycle of evaporation or transpiration(Evapo-transpiration), precipitation, and run-off usually reaching the sea and overland(Olasehinde, 2010). The evaporation and transpiration contributes to the precipitationoverland. Clean drinking water is essential to human and other forms of life. The accessto safe drinking water has improved steadily and substantially over past decades in almost every part of the world. There is a clear connection between access to safe water and GOP (Olasehine, 2010). However, some observations made by observers estimated that by 2005 more than half of the world population will be facing water-based vulnerability.

A recent report (November, 2009) suggests that by 2003, in some developing regions of the world. Water demand will exceed the supply by 50%. Water plays an important role in the world economy; it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. Approximately 70% of freshwater is consumed by agriculture.

1.2 Statement of Research Problem

Romi settlement is one of the fast growing towns in Kaduna State due to the presence of Kaduna Refinery located in the area. Population growth coupled with increasing developmental activities has widened the gap between demand and supply of potable water both in quantity and quality. The rapid population growth has overwhelmed the capacity of the area to provide the most basic service of providing potable water to all the inhabitants at the new areas of settlement. Quality of the water together with its ecological integrity has raised concerns due to indiscriminate disposal of oil spill and waste into the Romi River. Both the normal operation of oil drills and production platforms and accidents associated with this exercise deposits varying amounts of crude into the water. It is interesting to note that about 50% of the cases of water contamination related to oil field activities are salt or hydrocarbons in nature. Individuals who do not have access to the water supplied by Kaduna Water Company (KWC) depend on the Romi River about 10km from the refinery for their source of water. Various observations such as change of the color of water in the River have made some of the settlers decided to abandon Romi midstream whilst others heavily depend on them for drinking and other domestic purposes. There are latrines, and septic tanks sited few meters away from the river. The river unlike treated piped water are not monitored for pollution indicators even though bulk of the population relies on them for their daily needs. The major reason of this research is to examine the influence of effluent disposal from the refinery activitiesinto the Romi River within the location of KRPC. Romi River serves as the source oftheir water intake, therefore the research is to analyze the extent of water pollution and look at possible solutions.

1.3 Research Questions

Since the effluents disposal can be harmful to both the people and their environs with the following research questions.The study therefore sought to assess the water quality of River Romi in the area in respect to their physical and chemical properties of Kaduna Refinery effluent.

i. What are the physical and chemical properties of Kaduna refinery effluent?

ii. What are the physical and chemical properties of water in River Romi?

iii. How does the concentrations of the physical and chemical properties of the Kaduna Refinery affect water quality of River Romi?

iv. What is the suitability of the water of River Romi for domestic use

1.4 Aim and Objectives of the Study

The aim of this study is to assess the effect of effluent from Kaduna Refinery on water quality in Romi River for domestic use.

The specific objectives were to:

i. Determine the physical and chemical properties of Kaduna Refinery effluent;

ii. Determine the physical and chemical properties of water in River Romi.

iii. To determine the effect of the physical and chemical properties of effluent of Kaduna Refinery with that of River Romi.

iv. To determine the suitability of the water of River Romi for domestic use.

1.5 Significance of the Study

Water sustains life of every living organism including humans as such quality water devoid of contaminants is required to maintain good health. Infectious diseases caused by pathogenic bacteria, viruses, and protozoa or by parasites are the most common and wide spread health risk associated with drinking water (WHO, 1993). If sustainable development is to mean anything, such development must be based on an appropriate understanding of the environment i.e. an environment where knowledge of water resources is basic to virtually all endeavours (UMO/UNESCO, 1991). A larger population of Romi settlement is outside the grid of treated water supplied by the water treatment plant and as such depend on River Romi for drinking and for other domestic activities. It is therefore important that citizens, policy makers and stakeholders in the water sector are informed about the quality of water accessible to the populace in this study area. The research data will provide significant and credible scientific basis for decision makers, planners, non-governmental organizations, the public sector to cost effectively deal with issues relating water quality in terms of natural and human influence on water quality and its impact on human health and aquatic ecosystem. Besides, the findings may also assist advising government on policy regarding regulation and monitoring of surface water quality for domestic and commercial activities in the country. The study will also give insight into the negative impact of anthropogenic activities on water bodies.

1.6 Scope and Limitations of the Study

This study is covering the area surrounding the Kaduna refinery starting from the KadunaRefinery effluent to River Romi. Kaduna refinery, Nigerian’s third refinery with a crudecapacity of 100,000 barrels per stream day is located at Kaduna South, 30 kilometerssouth of Kaduna city on an area of more than 2.89 square kilometers. Water are Sampledfrom Kaduna Refinery effluent and River Romi then taken to the laboratory for assessment.

The limitation of the study included the unavailability of various materials at the university library and the huge problem regarding accessibility to data at the Kaduna Refinery which cannot be over emphasized.

CHAPTER TWO

CONCEPTUAL FRAME WORKANDLITERATURE REVIE

2.1 Conceptual Frame Work

There has been the need for the management and protection of surface water due to its advantage over surface water. Among the earliest studies in the literature of contaminant hydrogeology are those of salt intrusion (Bear, 1999).

2.1.1 Concepts of surface water and its Importance

A geophysical study of the area will be undertaken as well as an assessment of surface water quality in the project area. River existing, in the study area in particular is classified into two; River Romi effluent point of discharge and natural flowing River Romi.

People have different concepts about surface water:

Some people think that the potential for harvesting surface water potential is equal everywhere. This is due to ignorance and can be easily refuted due to the fact that the earth has differing geologies. The geology of every given area differs.

Some people think that surface water is purified because there is purifying abilities of every water table on ground (Segun, 2006).

Some people think that surface water can never be compared to ground water because it is easier for ground water to be treated and it is cheaper than surface water while some people think groundwater is sustainable and lasts longer (Oteze and Olugboye, 2008).

2.1.2 Community use of Surface water

Surface water is an important part of the environment; it flows into rivers and wetlands often sustaining them during the summer months or in drought. People rely on surface water as their key source of water particularly during times of drought. They pump surface water for lots of reasons. For example, the provision of drinking water for morethan 1000 households in NNPC. It is used for irrigation and the stock to support the industry. An efficient operatingsurface water saves money, surface water as sustainable development serves as reservoir during dry season when there is no more rain water.

It is well acknowledge that settlements which overtime becomes villages, towns, cities and mega cities are located or situated close to a convenient and stable water sources/body such as lakes, rivers, streams, waterfalls, and groundwater medium drilled borehole. Water plays a vital and important role in a community's life. It is used for:

- Washing, Bathing and Laundry
- For cleaning windows, walls and floors
- For drinking
- For heating and air conditioning
- For irrigation practices or Agriculture
- For producing hydraulic and stream power
- For protecting life and property against fire
- For removing offensive and potentially dangerous waste from households and industries.
- In order for these to be effective, water must be adequately available in large quantities and quality and also easily accessible (Roddick, 2004).

LITERATURE REVIEW

2.2 Surface water

Water supplies fall into two basic categories; surface water and groundwater. Surfacewater is the water that exists in streams, rivers, lakes and wetlands. When rain falls on theground or snow melts, much of this precipitation drains in ravines, streams and creeks.

Gradually, these smaller waterways join together and form rivers (Encarta, 2009).

Surface water remains a significant source of water. It may be readily available and easilyabstracted but is typically polluted (Barrell, 2000). In some sparsely populated areas,streams, lakes, and ponds are subject to substantial faecal pollution (Hofdes, 1986; Petts, 11 1994) due to poor sewage disposal. The water running across the surface of the ground is designated surface water. It picks up many substances such as micro-organisms, organic matter and minerals as it flows. It is rich in nutrients and therefore, become a perfect medium for the growth of all type of micro-organisms (McKinney, 1962). Karikari and Bosque-Hmanilton (2004) maintained that good quality surface water is essential in maintaining and ensuring the multiple use of it.

2.2.1 Sources of contamination

Contamination is used for situations where a substance is present in the environment but not causing any obvious harm. Low levels of infectious microorganisms are present throughout our environment and only occasionally cause illness in healthy people .Drinking water that is contaminated is only one of the many possible sources of infectious microorganisms. Water, both groundwater and surface water each has a unique set of contaminants. Surface water contains most bacteria and other microorganisms. Due to the interconnectivity of groundwater and surface water, these contaminants may be shared between the two sources (History of Water Filters (HWF), 2010). Contaminants that may be in untreated water include microorganisms such as viruses and bacteria; inorganic contaminants such as salt and metals; organic chemical contaminants from industrial processes and petroleum use; pesticides and herbicides; and radioactivecontaminants.

Surface water and other drinking water sources can be contaminated by storm water runoff from roadways, farms and livestock operations, discharges from sewage treatment plants, or septic system discharges. Craun et *al.* (1989). In the opinion of Blank waardt (1984) most serious source of pollution is contamination by human and animal waste from latrines, septic tanks, and farm manure, resulting in increased level of microorganisms including pathogens. However, the most hazardous gross faecal contamination is most commonly associated with latrines sited too close to the well (Brush, 1979). Indeed the threat of harmful contaminants in drinking water can no longer be reasonably ignored.

The correlation between contaminated drinking water and many significant diseases and health problems is far too strong to discount (History of water filters.com, 2010).

2.2.3 Drinking water standard

Most bacteria in the coliform group do not cause disease, but the greater their number the likelihood that disease-causing bacteria may be present. Since coliform bacteria usually persist in water longer than most disease-causing organisms, the absence of coliform bacteria leads to the assumption that the water supply is micro-biologically safe to drink. Therefore, the drinking water standard requires that no coliform bacteria be present in drinking water. Faecal coliform and *E. coli* bacteria should be totally absent from drinking water. The recommended permissible limits of bacteriological impurity of public health service standard are follows:

1. The water supply is to be obtained from a source free from pollution, adequately protected by natural agencies against the effects of population.
2. The water is to be clear, colorless, odorless and pleasant to taste, and is not to contain an excessive substances or of any of the chemicals used in the treatment processes.
3. The bacteriological requirement is more restrictive. Not more than 10% of all 10ml portions examined are permitted to show presence of *E.coli* group organisms.
4. Maximum permissible concentrations of water sample are established for heavy metals or, other substances having deleterious, physiological effects are not allowed in water supply system.
5. Water supply system should be free from sanitary defects and health hazards and shall be maintained at all times in a proper sanitary condition (Zoeteman, 1980).

In situation where these standards are not met, vulnerability of the water user to water related diseases are high.

2.4 Water quality

Water is a vital part of both our environment and our body systems. It covers nearly three quarters of the earth’s surface and makes up between 60 and 70% of the human body matter. It is an essential component of nearly everything we eat and drink.

Water quality can be thought of as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics (USGS, 2010). It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose (Wikipedia-the free encyclopaedia, 2011).

The term water quality has also been explained to mean the physical, chemical, biological and aesthetic properties of water which determine its fitness for a variety of uses and for protecting the health and integrity of aquatic ecosystems (DWAF, 1996).The parameters for water quality are determined by the intended use, such as domestic use, industrial, irrigation, fishery etc. Water quality depends on the local geology and ecosystem, as well as human uses such as sewage dispersion, industrial pollution, and use of water bodies as a heat sink,and over-use (which may lower the level of the water).

2.2.5 Physical parameters of water quality

Measurement of the physical attribute of a stream can serve as indicators of some form of pollution. For example changes in pH may indicate the presence of certain effluents, while changes in turbidity may indicate dredging in the area (Kortatsi, 2007). Other commonly physical characteristics of a stream include temperature, colour, and total dissolved solids. Svobodova et *al.*, (1993) added that alteration of waters physical chemistry includes acidity, conductivity, temperature, and eutrophication.

2.2.6 pH

Water pH is the most commonly measured attribute of water. The concentration of hydrogen ion (H+) activity in a solution determines the pH. Thus, it is a measure of the acidity or alkalinity of a solution. pH is measured on a scale of 0 to 14. Acidic water has pH values less than 7. Basic water has value likewise greater than 7, with 14 being the most basic. The pH of most streams ranges from neutral (6.5) to slightly basic (8.5). If a stream water has a pH less than 5.5, it may be too acidic for fish to survive in, while stream water with pH greater than 8.5 may be too basic (WHO, 2004). Water with high or extremely high or low pH is deadly as it has been established that pH below 4 or above 10 will kill most fish and very few animals can tolerate water with a pH of 3 or above 11 (Mensner et *al.*, 2010).

The ideal pH level of drinking water should be between 6 and 8.5. Water with pH less than 6.5 could be acidic, soft and corrosive. Acidic water could contain metal ions such as iron, manganese, copper, lead, and zinc (Freedrinkingwater.com).pH of water determines the solubility (amount that can be dissolve in water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.) Michand (1991). No health-based guide is proposed for pH, although eye irritation and exacerbation of skin disorders have been associated with pH values greater the 11 (WHO, 2004).

2.2.7 Turbidity

Water that is highly colored or has an objectionable taste may be regarded by consumers as unsafe and may be rejected for drinking purposes (Anon, 1993). Turbidity is the amount of particulate matter suspended in water. It measures the scattering effect that suspended solids have on light. It is widely agreed that the higher the intensity of scattered light, the higher the turbidity. Clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton and microscopic organisms make water opaque. Different particles have significantly different effects on perceived turbidity. The particulate matter suspended making drinking water turbid could either be organic or inorganic, or both (Boxall et *al.*, 2003).

Turbidity is used to indicate water quality and filtration effectiveness (e.g. whether disease causing organisms are present). Higher turbidity levels are often associated with higher levels of disease causing microorganisms such as virus, parasites and some bacteria. These organisms cause symptoms such nausea, cramps, diarrhoea, and associated headaches (USEPA, 2009). According to the WHO (2011), although the turbidity is not necessarily a threat to health, it is an important indicator of the presence of the possible presence of contaminants that would be of concern for health, especially from inadequately treated or unfiltered surface water.

2.8 Conductivity

Conductivity is the ability of water to any electrical charges. It indicates the presence of ions in the water. Conductivity relates to the amount of dissolved substances in water, but it, however, does not give an indication of which mineral is present. Changes in conductivity over time may indicate changing water quality. With regards to acceptable results, there is no health standard. A normal conductivity value is roughly twice the hardness in unsoften water. Conductivity source may be natural or human-made dissolved substances. The presence of inorganic compounds makes water exhibit high conductivity (Ntengwe, 2006). For typically unpolluted stream, the average conductivity value is approximately 350pS/cm (Koning and Roos, 1999). The presence of inorganic dissolved solids such as chlorides, nitrate, and phosphate anions or sodium, magnesium, calcium and aluminum cat ions affect conductivity. Temperature on the other hand affects the conductance of water as the warmer the water, the higher the conductivity. For this reason, conductivity is reported as conductivity at 250C.

A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; oil spill would however lower the conductivity (APHA, 1992).

Industrial pollution or urban runoff (water running of streets, building, and parking lot may results high conductance reading. Conductivity in streams and rivers is affected by the geology of the area through which the water flows. Streams that run through granite bedrock will have lower conductivity, and those that flow through limestone and clay soils will have higher conductivity values. Extended dry periods and low flow conditions also contribute to higher specific conductance readings (www.lcra.org/water/quality/crwn/indicators .html).

2.2.9 Chemical Parameters

2.2.10.1 Total Dissolved Solids (TDS)

Dissolve solids refer to any minerals, salts, metals, cat ion, or anions in water. Total dissolve solids comprise inorganic salts (principally calcium, magnesium, potassium, sodium, carbonates, chlorides and sulphates) and some small amount of organic matter that are dissolved in water (USEPA, 1997). TDS in drinking water originate from natural sources, sewage, urban runoff, industrial waste water, and chemical used in the water treatment process and the nature of the piping or hardware used to convey the water. There is no primary drinking water standard for TDS but the secondary standard for TDS is 500mg/L (USEPA, 1997).

Elevated TDS can result in water having a bitter or salty taste, encrustations, and films of precipitates on fixtures, corrosion of fixtures, and reduced efficiency of water filter and equipment (Oram, 2011). High TDS interfere with the taste of foods and beverages, and makes them less desirable to consumers (Freedrinkingwater.com).

2.2.10.1 Nitrates

Nitrogen is typically present in surface water in three forms; ammonia (NH3), nitrate (NO3-) and nitrite (NO22-). Nitrate comes into water supplies through the nitrogen cycle rather than through dissolved minerals. Other secondary sources of nitrogen compounds include fertilizers, manure and urine from feedlots and pastures, sewage, and landfills(ODNR, 2011).

Increasing nitrate levels in water resources are a potential source of severe environmentalstress to aquatic organisms, because nitrate is known to be toxic to crustaceans (Muir et *al.,* 1990), insects (Camargo and Ward, 1992), amphibians (Baker and Waights 1993; 1994) and fish (Tomass and Carnicheal, 1986). Nitrates are especially toxic to children less than six months of age. The condition known as “blue baby syndrome” (methemoglobinemia) may occur (Spalding and Exner 1993; ODNR, 2011). Water moving down through soil after rainfall or irrigation carries dissolved nitrate with it water. In this way, nitrate enters the water supplies of many home-owners wells or spring (Jennings eta/., 1996).

Water quality standards for human consumption have been set at ten milligrams of nitrate-nitrogen per liter or water (lOmg/L NO3-N) (Jennings et a/., 1997). This level of nitrate-nitrogen is equivalent to 45mg/L of nitrate (NO3-)

Pregnant women may be less able to tolerate nitrate, and nitrate in the milk of nursing mothers may affect infants directly. These persons should not consume water containing more than lOppm nitrate directly added to food products, or beverages especially in baby formula (DEQ, 2011). High nitrate level in surface water contribute to algae blooms and may result in elevated levels of disinfection by-product in treated drinking water which is linked to increased cancer and reproductive health risk in humans as well as liver, kidney and central nervous system problems (Stewart, 201.1).

2.2.11 Effects of some metals in water

Problems associated with chemical constituents of drinking water arise primarily from their ability to cause adverse health effect after prolong periods of exposure. Of particular concern are contaminants that have cumulative toxic properties, such as heavy metals (Anon, 1993).

Metals are inorganic substances that occur naturally in geological formations. Somemetals are essential for life and are naturally available in our food and water. In addition to metals essential for life, drinking water may contain metals which cause chronic or acute poisoning (Pedersen, 1997). Consumption of heavy metals is linked to many serious health concerns (Benham et *al*,.2011). Severe effects include reduced growth and development, cancer, organ damage, nervous system damage and in extreme cases, death.

Contaminations of our water resources by poisonous metal occur largely due to human activities such as industrial processes, agricultural activities, and discarding of wastes in landfills (Pedersen, 1997). Heavy metals such as lead and copper for example most commonly leached into water supplies through corrosion of household plumbing fixtures, pipes, fittings, and solder. However, many heavy metals enter the water supply dissolvesrocks or soil from runoff due to environmental contamination.

2.2.11.1 Lead

The most ubiquitous of toxic metals in drinking water is lead. Lead can leach from waterpipes and soldered joints which deliver water to our tap especially in older homes. The toxic effect of lead can lead to nerve and brain damage. Children are specifically sensitive. Exposure to lead has been shown to be associated with wide range of effects, including neurological and behavioural effects, mortality (mainly due to cardiovascular disease), impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes, delayed sexual maturation and impaired dental health (WHO, 2011).

Lead is generally immobile in soil and accumulates in the upper layers (Pate et *al.,* 2006).

The primary rout of entry into surface waters include surface erosion of lead contaminated soils, airborne drift of fine dust, and contamination of other sources of discharge into surface waters such as cooling water steam or wastewater treatment plant effluents (Illinois Environmental Protection Agency (lEPA), 2007). The solubility of lead increases as the pH is reduced below 8 as there is substantial decrease in the equilibrium concentration (Anon, 1993). The USEPA maximum control level (MCE) for lead is 0.005mg/L in water (Pedersen, 1997).

2.2.11.2 Iron

One of the most troublesome elements in water supplies is iron. It makes up at least 5% of the earth’s crust and it is one of the earth’s most plentiful resources (IDPH, 1999). It is found in natural fresh waters at levels ranging from 0.5 to 50mg/l exposure to theatmosphere, however, the ferrous iron oxidizes to ferric iron, given an objectionablereddish-brown colour to the water.

The combination of naturally occurring organic material and iron can be found in shallowwells and surface water. This type of iron is usually yellow or brown but may be colorless (IDPH, 1999). Iron is not hazardous to health but it is considered a secondary or aesthetic contaminant as it stains laundry and plumbing fixtures at levels above 0.3mg/L. It is essential for good health and also helps in oxygen transport in the blood (Nartey et *al.,* 2005).

2.2.11.3 Arsenic

Arsenic is widely distributed throughout the earth's crust and is used commercially, primarily in alloying agents. It is introduced into water through the dissolution of minerals and ore, from industrial effluents, and atmospheric deposition. Concentrations in groundwater in some areas are sometimes elevated as a result of erosion from natural sources. Besides, Blaylock (2006) maintains that environmental arsenic is still produced as a result of various mining, industrial and manufacturing operations. Contamination of surface water by arsenic poses significant health risk to humans and animals that depend on such water resources. Arsenic is known carcinogen and mutagen (Smedley et, *al.*, 1995). It is an immune system depressant and contributes to skin, bladder and other cancers (WHO, 2004). With the view to reducing the concentration of this carcinogenic contaminant in drinking water, a provisional guideline value for arsenic in drinking water of O.Olmg/L is established (WHO, 2004).

CHAPTER THREE

THE STUDY AREA AND RESEARCH METHODOLOGY

3.1 The Study Area

3.1.1 Location and Extent

AngwanRomi is a settlement in Chikun Local Government Area of Kaduna State, Nigeria. It is locate at latitude 10° 25' 48" north of the equator and longitude 7° 25' 12" east of the Greenwich Meridian. Romi is located in Kaduna State at the Southern end of high plains of Central Northern Nigeria. (Udo, 2006). Romi River is a body of running water moving to a lower level in a channel on land.

3.1.2 Geology and Relief

The Kaduna State geology is broadly subdivided into the sedimentary rock and the basement complex area. The geology of Kaduna is made up of metamorphic rocks which in parts are highly weathered.

The bedrock of Kaduna is predominantly metamorphic rocks of the Nigerian basement complex which consists of biotic, gneisses and older granites. In the Southern-east comer, younger granites and batholiths are evident and it is where the refinery is located. Deep chemical weathering and fluvial erosion, influenced by the bioclimatic nature of the environment have developed the characteristic high undulating plains with sub-clued interfluves (Mortimore, 1999).

3.1.3 Climate

Kaduna experiences atypical tropical continental climate with distinct seasonal regimes oscillating between cool to hot dry and humid to wet. These two seasons reflect the influences of tropical continental and equatorial maritime air masses that sweep over the entire country. When compared with winter, the summer average much more rainfall. "!lie average annual temperature in Kaduna is 25°c. About 1211 mm of precipitation falls annually. The driest month is January, there is 0 mm of precipitation, August the precipitation reaches its peak with an average of 284with an average temperature $£ 28.6°C, April is the warmest month at 23.3°C on average.

The effluent from the refinery is discharged to nearby River Romi of the refinery, which has an ever increasing population of about 60,000 (Nigeria, 2006 Census Figure)

3.2 Research Methodology

This chapter explains the methods employed in obtaining information on assessing River Romi water quality and as well as methods of data analysis.

3.2.1 Source of Data

i. Primary Source of data: This involved the collection of water samples from the field.

ii. Secondary Sources of data: This included data collected from previous published records of government ministries (WHO standard, KEPA Standard and FEPA Standard) and some term papers and journals.

5.2.2 Sampling Procedures

Water samples three each (3) were collected from Kaduna Refinery, River Romi-Upstream (natural flowing river), River Romi-Midstream (before and entry point of effluent disposal), River Romi-Down (recovery and the Healing point). Triplicate samples were taken from each site/point of the river at an interval of morning, afternoon and evening period of about 2km each. Triplicate samples were also taken from the respective River. A total of 27 samples were taken each time. In all, a total of 81 samples from the river and were taken for the analysis in this study. Water samples were collected in the morning between the hours of 03:00 GMT and 06:00 GMT. Sterile bottles were used to collect samples for physical and chemical analysis. Sample containers and lids were rinsed with some of the sampled water except for microbiological analysis and then

filled to the rim leaving an air space of at least 2.5cm to ensure homogenize sample for

, laboratory analysis and the lids were carefully tightened or sealed. They were then

labelled and immediately placed in a cold ice chest at temperature of 4 C to prevent possible alteration of parameters and also to ensure that micro-organisms remain viable though dormant. Samples were then transported to laboratory for analysis. All the physical and chemical properties were done at the Kaduna Refinery Laboratory KRPC,

3,2.3 Laboratory Method of Analysis

The methodology employed in analysing samples collected for this study varied according to the parameters. However standard laboratory methods were used to determine both the physical and chemical properties of water covered by this study. ^

The objective of the assessment is to determine the quality of water. There are numbers of quality indicating parameters and these can be grouped into Physical, Chemical and Biochemical assessment in the course of this project.

Physical Parameters include $_{P}$H, Turbidity, Temperature and Conductivity

- Biochemical parameters include Biochemical, Oxygen Demand (BOD)
- Chemical Parameters include Ions analysis
- Hardness of water

3.2.4 Determination of pH

The pH model The Yokogawa model PH 82 was used. The pH meter was calibrated by immersing the electrode in two buffer solutions of pH4.Gl And 7.00 prepared from capsules of BDH buffer. The pH meter was adjusted to the standard buffers (4.01 and 7). The water sample was placed in a beaker and the electrode was rinsed with distilled water and lowered into the sample in the beaker and the pH meter was allowed to stabilize and the pH of the sample read.

3.2.5 Determination of Electrical conductivity (EC)

The conductivity was measured using Hanna instrument model HI 9032 microcomputer conductivity meter. The conductivity meter was calibrated by immersing the electrode in a reference buffer of 12,880µS/cm. The water sample was put in a beaker and the electrode rinsed with distilled water and lowered into the sample in the beaker. The conductivity in µS/cm of the sample was displayed on the screen and the result was recorded.

3.2.6 Determination of Total dissolve solid (TDS)

Total dissolve solids (TDS) were measured using Hanna instrument model HI 9032 rnicrocomputer conductivity meter. The conductivity meter was calibrated by immersing the electrode in a reference buffer of 12,S80µS/cm. The water sample was put in a beaker and the electrode rinsed with distilled water and lowered into the sample in the beaker and was measured by selecting the Total Dissolve Solid key while the electrode remained in the water sample used to measure the conductivity, and the IDS value in mg/L displayed on the screen was recorded.

3.2.7 Determination of Turbidity

The turbidity values were taken using a Cybercan 1R TB 100 Turbidi meter. The Turbidity was calibrated with the 1000 NTU, 100 NTU, 10 NTU and 0.02 NTU calibration standards. The cuvette was rinsed three times with the sample to be tested.

The light shield cap was replaced and all outside surfaces were cleaned and made dry. The cuvette was pushed firmly into the optical well and index to the lowest reading. The NTU values were measured by pressing and releasing the arrow button and the value was recorded after the display has stopped flashing

3.2.8 Determination of heavy metals (iron, lead and arsenic)

An aliquot of 5ml of concentrated nitric acid was added to 50ml of sample collected in a 100ml beaker. The mixture was heated slowly to evaporate to a lower volume of 20ml. Five milliliter of concentrated nitric acid (HNO3) was again added to the 20ml and heating continued for 10 more minutes. A final 5ml of nitric acid was used to rinse the sides of the beaker. The solution was poured into a 50ml volumetric flask and topped with distilled water to the mark. A blank solution was similarly prepared to serve as control for analyses.

Heavy metal analyses were performed on Atomic Absorption Spectrophotometer (Unicam 969) using acetylene gas as a fuel and air as oxidizer. Calibration curves were prepared separately for all the metals by running suitable concentrations of the standard solutions. The digested samples were aspirated in the ruel rich air-acetylene flame and the

concentrations of metal were determined from the calibration curves. Average values of three replicates were taken for each determination.

The blank absorbance was taken before the testing of the samples.

3.2.9 3.2.9 Determination of Nitrate Concentration

Using Data logging spectro-photometer Dr. 2010 by HACH. Nitrate from the sample aliquot was reduced to nitrite and the resulting nitrite was then determined by a

diazonium reaction to form reddish dye. Unique zinc-based Nitratest Powder and Nitratest Tablet were used in the reduction stage to aid rapid flocculation. The nitrite resulting from the reduction stage was determined by reaction with sulphanilic acid in the presence of N-(l-naphthyl) ethylene diamine to form a reddish dye. The intensity of colour produced in the test is proportional to the nitrate concentration and was measured using the data logging spectro-photometer Dr. 2010 by HACH.

3.2.10 Statistical analysis

T-Test was used to analyse the t-distribution and degree of freedom to determine whether the sample mean differ. Its used to compare three or more variables using analysis of variance (ANOVA)

4.3 Discussion of Findings

Each of the sample figures obtained from the laboratory analysis table 1 in Appendix i. was compared with the World Health Organization's (WHO) maximum permissive level for domestic use. This enables the determination of the variation between the quality of the Kaduna Refinery, Romi Midstream, Romi Upstream and Romi Downstream and confirms if it is or if it is not suitable for domestic use.

It is observed from the laboratory analysis results that the Kaduna Refinery has a normal $_{P}$H ,AIkalinity Methyl (M), Calcium hardness, Conductivity, Nitrate, Sulphate, and Total hardness of water but Temperature of the water is below WHO standard. The mean pH of the water collected from the sampling sites of the river ranged from 6.33 to 7.44 indicating a balance between acid and alkalinity (Appendix. 1). This signifies that the level is not totally within the WHO recommended guideline standard for drinking water (6.5 to 8.5) (WHO, 2014). There were no significant differences in the observed pH range at Kaduna Refinery and Romi Upstream and Down site of the river. The pH of the river will thus not affect the health of its users for domestic purposes and that of aquatic life. However, the observed mean pH recorded in the at RomiMidstream ranged from 5.43 to 5.19(Appendix 1). It exhibited acidic characteristics. The values in all the samples from the Midstream were below the FEPA-Nigeria and WHO recommended pH range of 6.5 to 8.5. The low pH values might have come from the source of the water. This is unacceptable for domestic use. Acidic or low pH of drinking water is usually a result of natural geological conditions at the site, possibly compounded by acid rain

(www.watersystemscouncil.org). Acidic water may be soft and corrosive and could contain metal ions. It could leach metals from pipes and fixtures such as copper, lead, and zinc. It could also damage metal pipes and cause aesthetic problems such as metallic or sour taste, laundry staining, or blue-green stains in sinks and drains. Low pH exposure may cause hair fibres to swell in sensitive individuals, gastrointestinal irritation may occur just as high pH results in similar effects (pH in drinking -water @ www.who.int/water sanitation_health/dwq/chemicals) Corrosion of metals and aggression of cement concrete is likely at low pH. The low pH of the River Romi water may, therefore affect constructional works in the locality, and could be the cause of cracks and decay of the cement lining in the wells.

But the samples at the same time have a high value for turbidity, BOD, Magnesium Hardness, Turbidity, Phosphate, which is above the WHO Standard for quality drinking water and is therefore not acceptable. Higher turbidity levels are often associated with disease causing organisms such as virus, parasites and some bacteria which cause symptoms such as nausea, cramps, diarrhoea, and associated headaches (USEPA, 2009).

Turbidity The mean turbidity recorded from the Kaduna Refinery and Romi river varied between 147±11.18 to 44.79.±7.28 NTU at sample site respectively (Appendix 1). The values were far beyond the background limit of between 0- 10NTU (Nephelometric turbidity unit). USEPA (2011) has indicated that at no time can turbidity go above 5NTU based under surface water treatment rule. There was significant difference ($p<0.05$) between sampling site. The elevated level at sample 1 site could be due to the high inflow of waste water from the Kaduna Refinery into the river. Dead decaying organic matter from improper disposal of domestic waste along theriver banks has also contributed to increase the level.

The value decreased value partly because of self- purification of the river as it flows downwards. Site B and C did not show any significant difference during the sampling period. Ordinarily, finely divided organic and inorganic matters, like clay, silt, plankton and microscopic organisms make water opaque. Higher turbidity levels are often associated with disease causing organisms such as virus, parasites and some bacteria which cause symptoms such as nausea, cramps, diarrhoea, and associated headaches (USEPA, 2009). Turbidity can have negative impact on consumer acceptability of water as a result of visible cloudiness. Consumption of turbid water does not have any direct health effects. High turbidity implies a high concentration of suspended particles.

These particles can shield bacteria and other micro-organisms from disinfection properties of treatment chemicals, for example chlorine, resulting in ineffective disinfection ((physical and Organoleptic Parameters @www.wqms,co.za/ infopa.ges/211). It is therefore important that the water from the river be filtered before it is used for domestic purposes.

Consumption of heavy metals is linked to many serious health concern (Benham et «/.,2011). Severe effects may include reduced growth and development, cancer, organ damage, nervous system damage and in extreme cases, death. These metals are present in varying concentrations

depending on prevailing factors such as temperature, pH, hardness and standing time of the

water. Among the river studied, the concentration of both arsenic (As) and lead (Pb) were below limit of detection (<0.01mgL-l) (Appendix i-table 1). The maximum control level of these metals given by FEPA-Nigeria and WHO (2014) in domestic water is O.OlmgL-1. Lead exposureis shown to be associated with wide range of effects including neurological and behavioural defects, mortality (mainly due to cardiovascular disease), impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes, delay sexual maturation and impaired dental health (WHO, 2014). Arsenic is however a known carcinogen and mutagen (Smedley et *a/.*, 1995). The International Programme on Chemical Safety (JPCS) has indicated that long-term exposure to arsenic is casually related to increased risks of cancer in the skin, lungs, bladder and kidney, as well as other skin changes such as hyperkeratosis an pigmentation changes (WHO, 2014). Using the source waters for drinking and other domestic purposes can be said to be safe and nontoxic to the health of the people as the level of arsenic and lead, if any were below detection limit (<0.01 mgL-1).

Table 1 in Appendix I. is observed from the laboratory analysis results put forward that some of

the samples are having normal Alkalinity methyl (M), Calcium Hardness, Conductivity, Nitrate, Sulphate and Total Hardness which is within the range of the WHO standard. But at the same time the samples have high value for Ammonium Nitrate, BOD, Nitrate, Sulphate and Turbidity which passes the level of the WHO standard and is therefore not accepted for domestic use with normal Temperature and pH.

From the experiments, the effect of the operations by the Kaduna refinery to the River Romi quality is evident and in the following years it will surely escalate negatively. Although the effect of the refinery's activities is greater on the River RomiDownstream,Upstream water than theRiver Romi Midstream water, the ions found on the River Romi Upstream, and Downstream water can also be the result of Anthrpogenic activities such as application of fertilizers such as phosphorous (phosphate) Nitrate and also of the physical parameters. Other secondary sources of nitrogen compounds include fertilizer, manure, sewage, and landfills (ODNR, 2011). Increasing nitrate levels in water resources are a potential source of severe environmental stress to aquatic organisms, because nitrate is known to be toxic to insects, amphibians and fish (Tomass and Carnicheal, 1986). Nitrates are especially toxic to children less than six months of age. The condition called "blue baby syndrome" (methemoglobinemia) may occur. Pregnant women may be less able to tolerate, and nitrate in the milk of nursing mothers may affect infants directly. These persons should not consume water containing more than l0ppm nitrate added directly to food products of beverages especially in baby formula (DEQ, 2011).High nitrate level.

in surface water contribute to algae blooms and may result in elevated levels of disinfection byproduct in treated drinking water which is linked to increased cancer and reproductive health risk in humans as well as liver, kidney and central nervous system problems (Stewart, 2011). Though the nitrate level in the river was far below WHO/FEPA-Nigeria standard limit and using it for drinking purposes may not be Avorrying to the health of the users, it would be more advisable to use the well water for drinking and preparing food especially for infants and pregnant women because nitrate was not detected in the wells studied and therefore would have no negative impact on their health.

The River Romi Upstream, and Downstream water was unable to meet up with the WHO standards. This shows that the quality of the River Romi Upstream Midstream and Downstream water is very poor and is not safe for domestic use. The importance of oxygen in water makes it essential to be able to measure the amount of oxygen required to oxidize impurities in the water, most of the oxygen demand use due to the oxidation of organic matter by microorganisms, but inorganic reducing agents e.g., hydrogen sulphide also consume oxygen. These various parameters are used to assess the oxygen demand of a sample. These are biochemical oxygen demand (BOD). Hardness is the sum total of Mg and Cal in a given solution. In the water the salt occur naturally by the properties of the refinery activities and soil.

The quality of River Romi assessed is very poor and therefore not suitable for drinking based on

the findings. Apart from the contribution of the the refinery's activities there is a lot of human activities that affect the quality of the River Romi water, activities such as the application of

fertilizers on the soil percolate and filter downwards. The same goes for the River Romi down water. Very few ions passed the WHO standard and this is not suitable for domestic use based on the result of the experiment I carried out.

From the result presented in Appendix I, table 1 compares some of the parameters with the effluent specification of the WHO Standard for petroleum refineries. It is quite obvious that these parameters are averagely higher than the stipulated specifications and this is as a result of more chemicals introduced into the refinery system which produces more contaminants that causes pollution to our water resources which is vital to human and ecological survival.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Findings

After the treatment of liquid effluent from the refinery, it is then discharged into the River Romi Down close to the Refinery which happen to be the point of effluent disposal after treatment. The refinery After discharges about 3.600m^3 per day of effluent into this river (Romi Down) which is used for Domestics, consumption and farming by the local inhabitants of the area.

The analysis was carried out in the water quality section of the chemical laboratory of the refinery in one phase. It was earned out in the month of May.

Due to the Turnaround Maintenance (TAM) of the refinery, this month (May) was chosen because of the high production expected during the period after which the exercise will have been undertaken. There will be no production in the refinery during the period in the month (May) and as a result, no effluent is expected to be discharged.

The sample River Romi water was assessed with reference to the effluent parameters to determine the quality changes in the River Romi water. From the result present in Appendix I, table 1 compared the refinery effluent specifications with the standard of the WHO. It is therefore obvious that the Kaduna refinery has impact on the River Romi and also anthropogenic activities. Hydrocarbons present in the water are averagely higher than the stipulated. specifications which mean the water quality is very poor and therefore not suitable for and domestic use.

5.2 Conclusion

In general, the quality evaluation of River Romi located near the KRPC Refinery Kaduna reveals that 89% of the sampled water not suitable for domestic use. This is not acceptable by the world health organization (WHO) standards on reliability and suitability as far as its consumption is concerned.

The results showed variations in the parameters studied. ANOVA showed a Significantdifference ($P < 0.05$) in parameters between kaduna Refinery and River Romi. Fromthe T-testtable indicate that the parameters have a significant effect on the RiverRomi.thusF =10.4,df(3) P< 0.05(in Table 4.2.6 page 58).The variations in the studied parameters are influenced by location of the Refinery activities, time of sampling and other human activities such as laundry, rearing of animals, fishing and other agricultural inputs from the irrigation carried out around the settlement. It is therefore important that water quality monitoring is carried out periodically to ensure the healthy growth of the citizenry. Activities that can introduce pollutants into water bodies should be discouraged as the pollutants have the ability to get into the food chains causing detrimental effects on the consumers. Conclusively Kaduna Refinery has an impact on the River Romi and also the human activities too we then say it's not suitable for domestic use.

It is a matter of fact that the oil industry has brought economic prosperity to our country Nigeria,but it also true that it has also brought a complex mix of environmental pollution surface water Underground tanks. contamination is an epitome of environmental degradation, including loss of land and aquatic resources in Nigeria. Improper disposal of untreated industrial wastes (hydrocarbons) has resulted in the pollution of water, evident by the colored odious unwholesome surface waters which cause respiratory diseases, kills aquatic life and renders recreational and economical amenities and activities unworkable. A significant amount of the population still relies on River Romi water for drinking, washing, fishing, irrigation and swimming. Industries also need water to run their various processes.

From the above results and discussion it becomes an indisputable fact to say that the water in, River Romi has been contaminated by effluent discharge from the refinery, because there is difference of concentration of the pollutants at the up stream, point of entry and down stream, despite the fact that the refinery has a waste water treatment plant, the waste released into the river from the refinery contaminates the water. Many of the parameters measured are still higher than the acceptable limit set by National Standard Nigeria and World Health Organization, it was found that these pollutants present in the river reduce the effects of solar energy absorption, resulting in a lower rate of photosynthesis and slows down natural water purification processes and the long effect of this is environmental degradation. Kaduna Environmental Protection Authority (KEPA) should ensure that Kaduna refinery complies with Federal Environmental Protection Agency and National Standard Drinking Water Quality guidelines of industrial effluent discharge.

RECOMMENDATION

(a) It is mandatory for all industries which generate treatable waste to treat it according to FEPA

set standards before discharging it into the environment.

(b) It is mandatory for new industries and for any expansion work in existing industries to

Prepare and submit environmental impact assessment (ETA) to FEPA. For review and approval before the new project or expansion is embarked upon.

Records of all disposal (liquid) treatment and disposal must be remitted to the nearest community within twenty-four hours.

(c) Industries should draw up a contingency plan to deal with accidental spillage of hazardous

wastes and should report such incidence promptly to the nearest FEPA's office.

The operations of the Refinery should be closely monitored with greater enforcement of

Guidelines and Policies as stipulated by Government Environmental Agencies

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Water is life! Without it there can be no life. Governments all over the globe make effort to provide water both in quantity and quality to their citizens. This involves harnessing surface water resources. All people, irrespective of their stage of development and social or economic conditions, have the right to have access to drinking water in quantities and of quality equal to their basic needs (Mar del Plata, 1977).

Water bodies are under serious threat by natural and anthropogenic activities around the globe. Increase and changes in environmental pressure threaten surface water quality and complicate the assessment of its present and future spatial distribution (Vissers et al., 2005). Pollution of freshwater bodies such as rivers, streams, lakes and ponds is mostly experienced as result of industrial discharge, municipal waste disposal and surface runoff (Akaniwor et al., 2007).

Inadequate supply of potable water coupled with pollution of surface water have made individuals especially in Nigeria resort to various means of gaining access to and managing their own water supply. Among such means are construction of hand-dug wells and harvesting of rain water. Every aspect of agriculture requires tire adequate and timely supply of water to succeed. Surface water has sustained agriculture in some desert regions of the world and in Nigeria through tube wells and boreholes. The pattern and level of life development depends, to a great extent on the quality, quantity and rate of water supply to the species. Civilizations have flourished with the development of reliable water supplies and have collapsed as the supply of water failed (Fetters 1972, Troften, 1973).

Surface water offers the most abundant source of water to man. It is the cheapest and the most constant in quality and quantity. Because it is not visible on the surface and the misinformation about surface water, many people undervalue the importance of surface water in sustaining water supply needs.

Surface water exists all through in Nigeria. Experience has shown that the most important organs of the human body are not visible on our exterior skin. For example, the blood, and the heart that pumps it are not visible yet they are very important. The prominent situation in which greater emphasis is placed on groundwater rather than surface water can be likened to a woman using costly soap and detergent to kill genus on her body without caring for the infections in the blood which have caused the very same skin disease.

The money, time and emphasis given to ground water development in Nigeria at the expense of surface water development have not been justified in terms of meeting water needs. A study of water supply for irrigation, domestic purposes and hydro-electric power generation in 1993 showed that 63 large dams and 99 small dams had been constructed (JICA, 1993; FAO, 2005). According to Olasehinde (2010), out of these, 31 large dams and 45 small dams were used to irrigate 418,620 hectares and 45,880 hectares of land respectively. Twenty six (26) large dams and 53 small dams were used to supply water to 5,718,500 people and 2,298,300 people respectively. Six large dams were used to supply 4,978 MW of hydro-electricity and one small dams used to supply 16MW. The huge amount used ineffectively in these projects could have been complemented with a conjunctive development of groundwater sources which would have produced better results (Olasehinde, 1983; 2003; Olasehinde and Awojobi, 2004).

Water is a liquid that at ambient conditions co-exists on earth in various states. (Stanley, 2007). Water covers 70.9% of the earth’s surface and is a vital substance in all organisms. On earth it is found mostly in oceans and other large water bodies with 1.6% of water below ground in aquifers and 0.00% in the air as vapor, clouds (formed of solid and liquid water particles suspected in air) and precipitation. (Bath. M. 1974) Oceans hold 97% of surface water, glaciers and polar ice caps 2.4% and other land surface water such as rivers, lakes and ponds 0.6%. Avery small amount of earth’s water is contained within biological bodies and manufactured products. (Gleick, 2001).

The water on earth moves continuously through a cycle of evaporation or transpiration (Evapo-transpiration), precipitation, and run-off usually reaching the sea and overland (Olasehinde, 2010). The evaporation and transpiration contributes to the precipitation overland. Clean drinking water is essential to human and other forms of life. The access to safe drinking water has improved steadily and substantially over past decades in almost every part of the world. There is a clear connection between access to safe water and GOP (Olasehine, 2010). However, some observations made by observers estimated that by 2005 more than half of the world population will be facing water-based vulnerability.

A recent report (November, 2009) suggests that by 2003, in some developing regions of the world. Water demand will exceed the supply by 50%. Water plays an important role in the world economy; it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. Approximately 70% of freshwater is consumed by agriculture.

1.2 Statement of Problem

Romi settlement is one of the fast growing towns in Kaduna State due to the presence of Kaduna Refinery located in the area. Population growth coupled with increasing developmental activities has widened the gap between demand and supply of potable water both in quantity and quality. The rapid population growth has overwhelmed the capacity of the area to provide the most basic service of providing potable water to all the inhabitants at the new areas of settlement. Quality of the water together with its ecological integrity has raised concerns due to indiscriminate disposal of oil spill and waste into the Romi River. Both the normal operation of oil drills and production platforms and accidents associated with this exercise deposits varying amounts of crude into the water. It is interesting to note that about 50% of the cases of water contamination related to oil field activities are salt or hydrocarbons in nature. Individuals who do not have access to the water supplied by Kaduna Water Company (KWC) depend on the Romi River about 10km from the refinery for their source of water. Various observations such as change of the color of water in the River have made some of the settlers decided to abandon Romi midstream whilst others heavily depend on it for drinking and other domestic purposes. There are latrines, and septic tanks sited few meters away from the river. The river unlike treated piped water are not monitored for pollution indicators even though bulk of the population relies on them for their daily needs. The major reason of this research is to examine the influence of effluent disposal from the refinery activities into the Romi River within the location of KRPC. Romi River serves as the source of their water intake, therefore the research is to analyze the extent of water pollution and look at possible solutions.

1.3 Research Questions

Since the effluents disposal can be harmful to both the people and their environs with the following research questions. The study therefore sought to assess the water quality of River Romi in the area in respect to their physical and chemical properties of Kaduna Refinery effluent.

i. What are the physical and chemical properties of Kaduna refinery effluent?

ii. What are the physical and chemical properties of water in River Romi?

iii. How suitable water Romi river for domestic use?

iv. How the quality of drinking water be improved in the area.

1.4 Aim and Objectives of the Study

The aim of this study is to assess the effect of effluent from Kaduna Refinery on water quality in Romi River for domestic use.

The specific objectives were to:

i. Determine the concentration of physical and chemical properties of effluent (Waste) discharge into River Romi;

ii. Determine the physical and chemical properties of water in the River Romi

iii To determine the suitability of the water in River Romi for domestic use.

iv. to proffer solution for improving drinking water quality in the area.

1.5 Significance of the Study

Water sustains life of every living organism including humans as such quality water devoid of contaminants is required to maintain good health. Infectious diseases caused by pathogenic bacteria, viruses, and protozoa or by parasites are the most common and wide spread health risk associated with drinking water (WHO, 1993). If sustainable development is to mean anything, such development must be based on an appropriate understanding of the environment i.e. an environment where knowledge of water resources is basic to virtually all endeavours (UMO/UNESCO, 1991). A larger population of Romi settlement is outside the grid of treated water supplied by the water treatment plant and as such depend on River Romi for drinking and for other domestic activities. It is therefore important that citizens, policy makers and stakeholders in the water sector are informed about the quality of water accessible to the populace in this study area. The research data will provide significant and credible scientific basis for decision makers, planners, non-governmental organizations, the public sector to cost effectively deal with issues relating water quality in terms of natural and human influence on water quality and its impact on human health and aquatic ecosystem. Besides, the findings may also assist advising government on policy regarding regulation and monitoring of surface water quality for domestic and commercial activities in the country. The study will also give insight into the negative impact of anthropogenic activities on water bodies.

1.6 Scope of the Study

This study is covering the area surrounding the Kaduna refinery starting from the Kaduna Refinery effluent to River Romi. Kaduna refinery, Nigerian’s third refinery with a crude capacity of 100,000 barrels per stream day is located at Kaduna South, 30 kilometers south of Kaduna city on an area of more than 2.89 square kilometers. Water are Sampled from Kaduna Refinery effluent and River Romi then taken to the laboratory for assessment.

The limitation of the study included the unavailability of various materials at the university library and the huge problem regarding accessibility to data at the Kaduna Refinery which cannot be over emphasized.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Framework

There has been the need for the management and protection of surface water due to its advantage over surface water. Among the earliest studies in the literature of contaminant hydrogeology are those of salt intrusion (Bear, 1999).

Some people think that the potential for harvesting surface water potential is equal everywhere. This is due to ignorance and can be easily refuted due to the fact that the earth has differing geologies. The geology of every given area differs. Some people think that surface water is purified because there is purifying abilities of every water table on ground (Segun, 2006). Some people think that surface water can never be compared to ground water because it is easier for ground water to be treated and it is cheaper than surface water while some people think groundwater is sustainable and lasts longer (Oteze and Olugboye, 2008).

2.1.2 Community use of Surface water

Surface water is an important part of the environment; it flows into rivers and wetlands often sustaining them during the summer months or in drought. People rely on surface water as their key source of water particularly during times of drought. They pump surface water for lots of reasons. For example, the provision of drinking water for more than 1000 households in NNPC. It is used for irrigation and the stock to support the industry. An efficient operating surface water saves money, surface water as sustainable development serves as reservoir during dry season when there is no more rain water.

It is well acknowledge that settlements which overtime becomes villages, towns, cities and mega cities are located or situated close to a convenient and stable water sources/body such as lakes, rivers, streams, waterfalls, and groundwater medium drilled borehole. Water plays a vital and important role in a community's life. It is used for:

- Washing, Bathing and Laundry
- For cleaning windows, walls and floors

- For drinking
- For heating and air conditioning
- For irrigation practices or Agriculture
- For producing hydraulic and stream power
- For protecting life and property against fire
- For removing offensive and potentially dangerous waste from households and industries.
- In order for these to be effective, water must be adequately available in large quantities and quality and also easily accessible (Roddick, 2004).

2.2 Surface water

Water supplies fall into two basic categories; surface water and groundwater. Surface water is the water that exists in streams, rivers, lakes and wetlands. When rain falls on the ground or snow melts, much of this precipitation drains in ravines, streams and creeks.

Gradually, these smaller waterways join together and form rivers (Encarta, 2009).

Surface water remains a significant source of water. It may be readily available and easily abstracted but is typically polluted (Barrell, 2000). In some sparsely populated areas, streams, lakes, and ponds are subject to substantial faecal pollution (Hofdes, 1986; Petts, 11 1994) due to poor sewage disposal. The water running across the surface of the ground is designated surface water. It picks up many substances such as micro-organisms, organic matter and minerals as it flows. It is rich in nutrients and therefore, become a perfect medium for the growth of all type of micro-organisms (McKinney, 1962). Karikari and Bosque-Hmanilton (2004) maintained that good quality surface water is essential in maintaining and ensuring the multiple use of it.

2.2.1 Sources of Contamination of Surface Water

Contamination is used for situations where a substance is present in the environment but not causing any obvious harm. Low levels of infectious microorganisms are present throughout our environment and only occasionally cause illness in healthy people .Drinking water that is contaminated is only one of the many possible sources of infectious microorganisms. Water, both groundwater and surface water each has a unique set of contaminants. Surface water contains most bacteria and other microorganisms. Due to the interconnectivity of groundwater and surface water, these contaminants may be shared between the two sources (History of Water Filters (HWF), 2010). Contaminants that may be in untreated water include microorganisms such as viruses and bacteria; inorganic contaminants such as salt and metals; organic chemical contaminants from industrial processes and petroleum use; pesticides and herbicides; and radioactive contaminants.

Surface water and other drinking water sources can be contaminated by storm water runoff from roadways, farms and livestock operations, discharges from sewage treatment plants, or septic system discharges. (Craun et al, 1989). In the opinion of (Waardt 1984) most serious source of pollution is contamination by human and animal waste from latrines, septic tanks, and farm manure, resulting in increased level of microorganisms including pathogens. However, the most hazardous gross faecal contamination is most commonly associated with latrines sited too close to the well (Brush, 1979). Indeed the threat of harmful contaminants in drinking water can no longer be reasonably ignored. The correlation between contaminated drinking water and many significant diseases and health problems is far too strong to discount (History of water filters.com, 2010).

2.2.2 Drinking water standard

Most bacteria in the coliform group do not cause disease, but the greater their number the likelihood that disease-causing bacteria may be present. Since coliform bacteria usually persist in water longer than most disease-causing organisms, the absence of coliform bacteria leads to the assumption that the water supply is micro-biologically safe to drink. Therefore, the drinking water standard requires that no coliform bacteria be present in drinking water. Faecal coliform and E. coli bacteria should be totally absent from drinking water. The recommended permissible limits of bacteriological impurity of public health service standard are follows:

1. The water supply is to be obtained from a source free from pollution, adequately protected by natural agencies against the effects of population.

2. The water is to be clear, colorless, odorless and pleasant to taste, and is not to contain an excessive substances or of any of the chemicals used in the treatment processes.

3. The bacteriological requirement is more restrictive. Not more than 10% of all 10ml portions examined are permitted to show presence of E.coli group organisms.

4. Maximum permissible concentrations of water sample are established for heavy metals or, other substances having deleterious, physiological effects are not allowed in water supply system.

5. Water supply system should be free from sanitary defects and health hazards and shall be maintained at all times in a proper sanitary condition (Zoeteman, 1980).

In situation where these standards are not met, vulnerability of the water user to water related diseases are high.

2.3 Water quality

Water is a vital part of both our environment and our body systems. It covers nearly three quarters of the earth's surface and makes up between 60 and 70% of the human body matter. It is an essential component of nearly everything we eat and drink.

Water quality can be thought of as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics (USGS, 2010). It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose (Wikipedia-the free encyclopaedia, 2011).

The term water quality has also been explained to mean the physical, chemical, biological and aesthetic properties of water which determine its fitness for a variety of uses and for protecting the health and integrity of aquatic ecosystems (DWAF, 1996).The parameters for water quality are determined by the intended use, such as domestic use, industrial, irrigation, fishery etc. Water quality depends on the local geology and ecosystem, as well as human uses such as sewage dispersion, industrial pollution, and use of water bodies as a heat sink, and over-use (which may lower the level of the water).

2.3.1 Physical parameters of water quality

Measurement of the physical attribute of a stream can serve as indicators of some form of pollution. For example changes in pH may indicate the presence of certain effluents, while changes in turbidity may indicate dredging in the area (Kortatsi, 2007). Other commonly physical characteristics of a stream include temperature, colour, and total dissolved solids. Svobodova et al., (1993) added that alteration of waters physical chemistry includes acidity, conductivity, temperature, and eutrophication.

2.3.1.1 P^H

Water P^H is the most commonly measured attribute of water. The concentration of hydrogen ion (H+) activity in a solution determines the pH. Thus, it is a measure of the acidity or alkalinity of a solution. pH is measured on a scale of 0 to 14. Acidic water has pH values less than 7. Basic water has value likewise greater than 7, with 14 being the most basic. The pH of most streams ranges from neutral (6.5) to slightly basic (8.5). If a stream water has a pH less than 5.5, it may be too acidic for fish to survive in, while stream water with pH greater than 8.5 may be too basic (WHO, 2004). Water with high or extremely high or low pH is deadly as it has been established that pH below 4 or above 10 will kill most fish and very few animals can tolerate water with a pH of 3 or above 11 (Mensner et al., 2010).

The ideal pH level of drinking water should be between 6 and 8.5. Water with pH less than 6.5 could be acidic, soft and corrosive. Acidic water could contain metal ions such as iron, manganese, copper, lead, and zinc (Freedrinkingwater.com).pH of water determines the solubility (amount that can be dissolve in water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.) Michand (1991). No health-based guide is proposed for pH, although eye irritation and exacerbation of skin disorders have been associated with pH values greater the 11 (WHO, 2004).

2.3.1.2 Turbidity

Water that is highly colored or has an objectionable taste may be regarded by consumers as unsafe and may be rejected for drinking purposes (Anon, 1993). Turbidity is the amount of particulate matter suspended in water. It measures the scattering effect that suspended solids have on light. It is widely agreed that the higher the intensity of scattered light, the higher the turbidity. Clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton and microscopic organisms make water opaque. Different particles have significantly different effects on perceived turbidity. The particulate matter suspended making drinking water turbid could either be organic or inorganic, or both (Boxall et al., 2003).

Turbidity is used to indicate water quality and filtration effectiveness (e.g. whether disease causing organisms are present). Higher turbidity levels are often associated with higher levels of disease causing microorganisms such as virus, parasites and some bacteria. These organisms cause symptoms such nausea, cramps, diarrhoea, and associated headaches (USEPA, 2009). According to the WHO (2011), although the turbidity is not necessarily a threat to health, it is an important indicator of the presence of the possible presence of contaminants that would be of concern for health, especially from inadequately treated or unfiltered surface water.

2.3.1.3 Conductivity

Conductivity is the ability of water to any electrical charges. It indicates the presence of ions in the water. Conductivity relates to the amount of dissolved substances in water, but it, however, does not give an indication of which mineral is present. Changes in conductivity over time may indicate changing water quality. With regards to acceptable results, there is no health standard. A normal conductivity value is roughly twice the hardness in unsoften water. Conductivity source may be natural or human-made dissolved substances. The presence of inorganic compounds makes water exhibit high conductivity (Ntengwe, 2006). For typically unpolluted stream, the average conductivity value is approximately 350pS/cm (Koning and Roos, 1999). The presence of inorganic dissolved solids such as chlorides, nitrate, and phosphate anions or sodium, magnesium, calcium and aluminum cat ions affect conductivity. Temperature on the other hand affects the conductance of water as the warmer the water, the higher the conductivity. For this reason, conductivity is reported as conductivity at 250C. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; oil spill would however lower the conductivity (APHA, 1992). Industrial pollution or urban runoff (water running of streets, building, and parking lot may results high conductance reading. Conductivity in streams and rivers is affected by the geology of the area through which the water flows. Streams that run through granite bedrock will have lower conductivity, and those that flow through limestone and clay soils will have higher conductivity values. Extended dry periods and low flow conditions also contribute to higher specific conductance readings (www.lcra.org/water/quality/crwn/indicators .html).

2.3.2 Chemical Parameters

2.3.2.1 Total Dissolved Solids (TDS)

Dissolve solids refer to any minerals, salts, metals, cat ion, or anions in water. Total dissolve solids comprise inorganic salts (principally calcium, magnesium, potassium, sodium, carbonates, chlorides and sulphates) and some small amount of organic matter that are dissolved in water (USEPA, 1997). TDS in drinking water originate from natural sources, sewage, urban runoff, industrial waste water, and chemical used in the water treatment process and the nature of the piping or hardware used to convey the water. There is no primary drinking water standard for TDS but the secondary standard for TDS is 500mg/L (USEPA, 1997). Elevated TDS can result in water having a bitter or salty taste, encrustations, and films of precipitates on fixtures, corrosion of fixtures, and reduced efficiency of water filter and equipment (Oram, 2011). High TDS interfere with the taste of foods and beverages, and makes them less desirable to consumers (Freedrinkingwater.com).

2.3.2.2 Nitrates

Nitrogen is typically present in surface water in three forms; ammonia (NH3), nitrate (NO3-) and nitrite (NO22-). Nitrate comes into water supplies through the nitrogen cycle rather than through dissolved minerals. Other secondary sources of nitrogen compounds include fertilizers, manure and urine from feedlots and pastures, sewage, and landfills (ODNR, 2011).

Increasing nitrate levels in water resources are a potential source of severe environmental stress to aquatic organisms, because nitrate is known to be toxic to crustaceans (Muir et al., 1990), insects (Camargo and Ward, 1992), amphibians (Baker and Waights 1993; 1994) and fish (Tomass and Carnicheal, 1986). Nitrates are especially toxic to children less than six months of age. The condition known as “blue baby syndrome” (methemoglobinemia) may occur (Spalding and Exner 1993; ODNR, 2011). Water moving down through soil after rainfall or irrigation carries dissolved nitrate with it water. In this way, nitrate enters the water supplies of many home-owners wells or spring (Jennings eta/., 1996). Water quality standards for human consumption have been set at ten milligrams of nitrate-nitrogen per liter or water (lOmg/L NO3-N) (Jennings et al 1997). This level of nitrate-nitrogen is equivalent to 45mg/L of nitrate (NO3-) Pregnant women may be less able to tolerate nitrate, and nitrate in the milk of nursing mothers may affect infants directly. These persons should not consume water containing more than lOppm nitrate directly added to food products, or beverages especially in baby formula (DEQ, 2011). High nitrate level in surface water contribute to algae blooms and may result in elevated levels of disinfection by-product in treated drinking water which is linked to increased cancer and reproductive health risk in humans as well as liver, kidney and central nervous system problems (Stewart, 2011).

2.4 Effects of some metals in water

Problems associated with chemical constituents of drinking water arise primarily from their ability to cause adverse health effect after prolong periods of exposure. Of particular concern are contaminants that have cumulative toxic properties, such as heavy metals (Anon, 1993). Metals are inorganic substances that occur naturally in geological formations. Some metals are essential for life and are naturally available in our food and water. In addition to metals essential for life, drinking water may contain metals which cause chronic or acute poisoning (Pedersen, 1997). Consumption of heavy metals is linked to many serious health concerns (Benham et al,2011). Severe effects include reduced growth and development, cancer, organ damage, nervous system damage and in extreme cases, death.

Contaminations of our water resources by poisonous metal occur largely due to human activities such as industrial processes, agricultural activities, and discarding of wastes in landfills (Pedersen, 1997). Heavy metals such as lead and copper for example most commonly leached into water supplies through corrosion of household plumbing fixtures, pipes, fittings, and solder. However, many heavy metals enter the water supply dissolves rocks or soil from run off due to environmental contamination.

2.3.2.3 Lead

The most ubiquitous of toxic metals in drinking water is lead. Lead can leach from water pipes and soldered joints which deliver water to our tap especially in older homes. The toxic effect of lead can lead to nerve and brain damage. Children are specifically sensitive.

Exposure to lead has been shown to be associated with wide range of effects, including neurological and behavioural effects, mortality (mainly due to cardiovascular disease), impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes, delayed sexual maturation and impaired dental health (WHO, 2011). Lead is generally immobile in soil and accumulates in the upper layers (Pate et al., 2006). The primary rout of entry into surface waters include surface erosion of lead contaminated soils, airborne drift of fine dust, and contamination of other sources of discharge into surface waters such as cooling water steam or wastewater treatment plant effluents (Illinois Environmental Protection Agency (lEPA), 2007). The solubility of lead increases as the pH is reduced below 8 as there is substantial decrease in the equilibrium concentration (Anon, 1993). The USEPA maximum control level (MCE) for lead is 0.005mg/L in water (Pedersen, 1997).

2.3.2.4 Iron

One of the most troublesome elements in water supplies is iron. It makes up at least 5% of the earth's crust and it is one of the earth's most plentiful resources (IDPH, 1999). It is found in natural fresh waters at levels ranging from 0.5 to 50mg/l exposure to the atmosphere, however, the ferrous iron oxidizes to ferric iron, given an objectionable reddish-brown colour to the water. The combination of naturally occurring organic material and iron can be found in shallow wells and surface water. This type of iron is usually yellow or brown but may be colorless (IDPH, 1999). Iron is not hazardous to health but it is considered a secondary or aesthetic contaminant as it stains laundry and plumbing fixtures at levels above 0.3mg/L. It is essential for good health and also helps in oxygen transport in the blood (Nartey et al., 2005).

2.3.2.5 Arsenic

Arsenic is widely distributed throughout the earth's crust and is used commercially, primarily in alloying agents. It is introduced into water through the dissolution of minerals and ore, from industrial effluents, and atmospheric deposition. Concentrations in groundwater in some areas are sometimes elevated as a result of erosion from natural sources. Besides, Blaylock (2006) maintains that environmental arsenic is still produced as a result of various mining, industrial and manufacturing operations. Contamination of surface water by arsenic poses significant health risk to humans and animals that depend on such water resources. Arsenic is known carcinogen and mutagen (Smedley et, al., 1995). It is an immune system depressant and contributes to skin, bladder and other cancers (WHO, 2004). With the view to reducing the concentration of this carcinogenic contaminant in drinking water, a provisional guideline value for arsenic in drinking water of O.Olmg/L is established (WHO, 2004).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 The Study Area

3.1.1 Location

The study covers some part Romi River, which is a tributary of Kaduna River which drains the southern part of Kaduna metropolis. It is located between Latitudes 10º 18' to10˚ 30'N and Longitudes 7˚ 15' to7˚ 45' E of the Greenwich meridian (Figure 3.1). Romi River follows a course of about16.4km and the area is situated on a relatively low plain liable to flooding (BLSK, 2010). The location of the Kaduna Refinery is shown on figure 3.1 while the portion

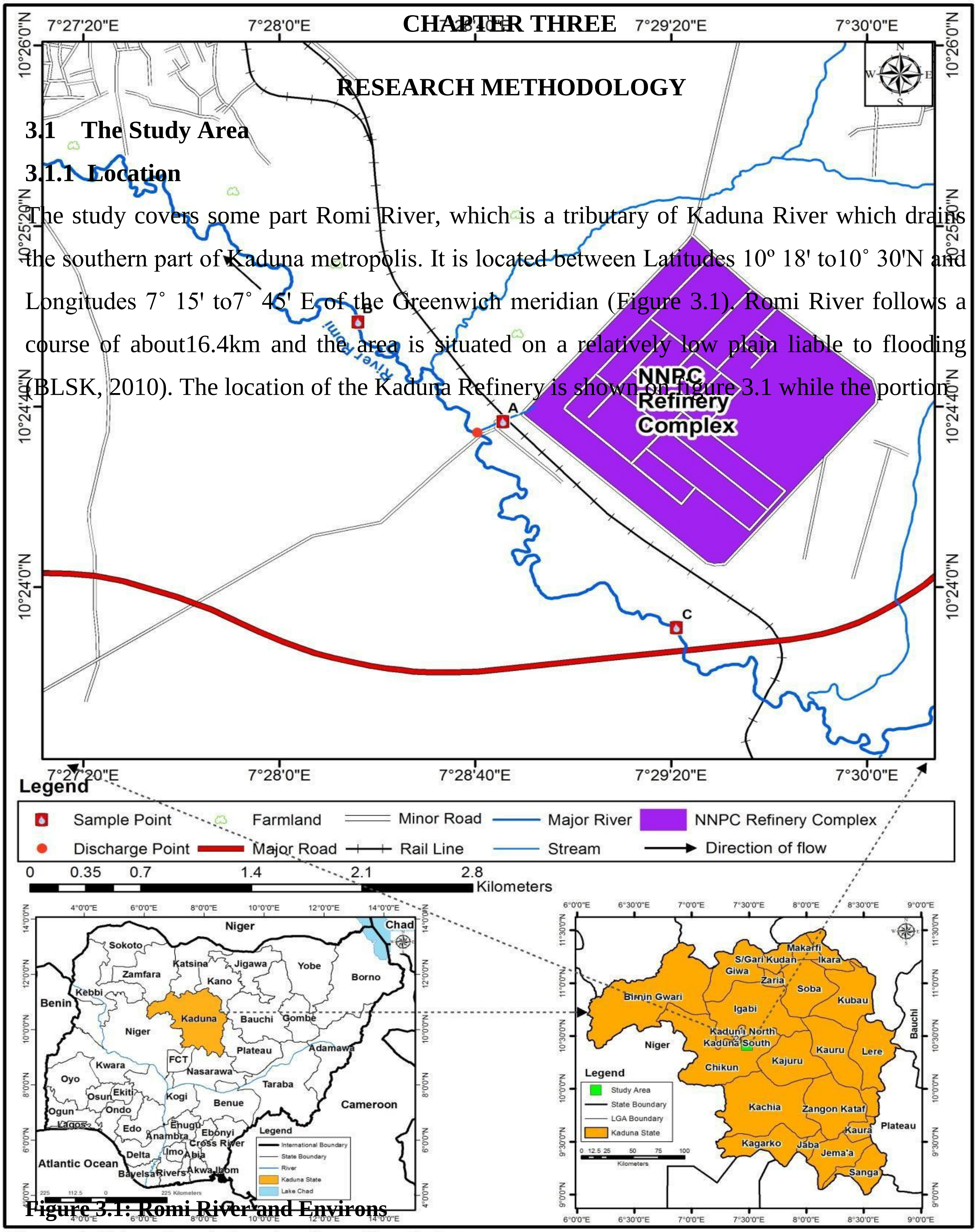

Figure 3.1: Romi River and Environs

Source: geography department, Kogi state University, Anyigba, 2019

Figure 3.2: Romi River Showing Sampling Points

Source: Geography Department, Kogi State University, Anyigba, 2019

3.1.2 Drainage, Geology, and Relief

Romi area drained by river Romi that originate from Kujama Hill at elevation 847meters above sea level (locak and Partners 1987). The river is a tributary of river Kaduna located east of Kaduna town. The river transverses Romi village crosses Kaduna-Abuja road and eventually discharges into the river Kaduna at Garko. The river flows throughout the year but its volume reduces during the dry season and increase in volume during the rainy season. The river at Rido receives effluent from the Kaduna Refinary and Petrochemical Company.

The Kaduna State geology is broadly subdivided into the sedimentary rock and the basement complex area. The geology of Kaduna is made up of metamorphic rocks which in parts are highly weathered.

The bedrock of Kaduna is predominantly metamorphic rocks of the Nigerian basement complex which consists of biotic, gneisses and older granites. In the Southern-east comer, younger granites and batholiths are evident and it is where the refinery is located. Deep chemical weathering and fluvial erosion, influenced by the bioclimatic nature of theenvironment have developed the characteristic high undulating plains with sub-clued interfluves (Mortimore, 1999).

3.1.3 Climate

Kaduna experiences atypical tropical continental climate with distinct seasonal regimes oscillating between cool to hot dry and humid to wet. These two seasons reflect the influences of tropical continental and equatorial maritime air masses that sweep over the entire country. When compared with winter, the summer average much more rainfall. "!lie average annual temperature in Kaduna is 25°c. About 1211 mm of precipitation falls annually. The driest month is January, there is 0 mm of precipitation, August the precipitation reaches its peak with an average of 284with an average temperature 28.6°C, April is the warmest month at 23.3°C on average.

The effluent from the refinery is discharged to nearby River Romi of the refinery, which has an ever increasing population of about 60,000 (Nigeria, 2006 Census Figure)

3.2 Research Methodology

This chapter explains the methods employed in obtaining information on assessing River Romi water quality and as well as methods of data analysis

3.2.1 Reconnaissance Survey of the Study Area

In preparation for this study, a reconnaissance survey was undertaken to the study area. The objectives were to obtain relevant information on the study area, seek for co-operation of key stakeholders in particular residents of Rido and Romi community and to obtain a general overview of the study area in order to choose the appropriate methodology to be adopted.

3.2.2 Types of Data

i. Concentration level of pollutants at both Upstream and Downstream.

ii. Physico-chemical and biological parameters.

iii. Data on socio-economic activities like swimming, farming, fishing etc.

iv. Field observation and photograph.

3.2.3 Sources of Data

Data was collected from both primary and secondary sources. The primary sources include results derived from the laboratory analysis of water quality of the water samples taken from Kaduna Refinery, upstream, the refinery effluents discharge point and downstream of Romi River. Other sources for this study include interview survey and field observations, the interview survey was employed in order to identify the socio-economic activities carried out on/along river such as fishing, swimming, irrigation, etc. The main target group are the fishermen and close-by residence communities. The field observation concerns the physical characteristic of the river like colour, odour etc.

Secondary sources included data collected through the review of relevant literatures from document and materials such as journals, proceeding of seminars, textbooks and other research findings. Also documents containing Kaduna Refinery waste management plan and Environmental Audit have been used for this study.

3.2.4 Sampling Technique and Sample Size Sampling Procedures

Water samples were collected from three (3) points along the Romi River around the Kaduna Refinery, River Romi-Upstream (natural flowing river before the effluent dispoal), River Romi-Midstream (entry point of effluent disposal), River Romi-Down (recovery and the Healing point). Triplicate samples were taken from each (sampling point) of the river in of 9am in the morning and 4pm in the evening period. Triplicate samples were also taken from the respective River and Kaduna Refinery . A total of 57 samples were taken each sampling points for the laboratory analysis. In all, a total of 228 samples from the Kaduna refinery area along the river . The water samples were collected in the morning at about 9:00am before the plant operation and discharge into the river and 4:00pm after the discharge twice a month for the duration of three months in order to observe any variation. Each sampling point was 5 Km away from each other which is within 20 Km of the river length as indicated in Figure 3.2.

Sterile bottles were used to collect samples for physical and chemical analysis. Sample containers and lids were rinsed with some of the sampled water except for microbiological analysis and then filled to the rim leaving an air space of at least 2.5cm to ensure homogenize sample for, laboratory analysis and the lids were carefully tightened or sealed. They were then labeled and immediately placed in a cold ice chest at temperature of 4 °C to prevent possible alteration of parameters and also to ensure that micro-organisms remain viable though dormant. Samples were then transported to laboratory for analysis. All the physical and chemical properties were done at the Kaduna Environmental Protection Authority (KEPA). The construction of the sample frame was done to ascertain a good representation of the sampled villages in the study area. This was made possible through the reconnaissance survey. Two communities were purposefully selected from five villages that are located along the Romi River namely; Rido and Romi. This selection was based on purposive sampling technique and because of their proximity to the pollution affected area and the human activities taking place along the Romi River. Majority of the sampled population were farmers who use Romi River for irrigation, fishing, animals watering, bathing or other related domestic uses.

The entire human population of the study area (communities) whose source of livelihood depends largely on the Romi River is 1,800 (NPC, 2006). Thus, 327 respondents were selected for the administration of questionnaires out of the entire population. The 327 sample size was obtained through the application of Yamani's sample size selection formula for a finite population (Uzoagulu, 1998). The formula is given thus:

$$S = \frac{\quad}{1+N(e)^2} \quad - (1)$$

Where S= sample size

N= finite population of the study area

e= Error margin or level of significance (0.05)

1= constant

The second formula was used to determine the proportion of questionnaire to the two communities, (see Table 3.1)

Where n= Population of the community

N= Total population of selected communities.

The selected communities and number of respondents are as given in table 3.1:

Table 3.1: Sampled Communities and number of Respondents

Table 3.1: Sampled Communities and number of Respondents

S/NO	Selected communities	Sample frame	Proportion of sampled Population

1	Rido	980	178
2	Romi	820	149
	Total	1, 800	327

3.3 Method of Data Analysis

Objective i: Determine the concentration of physical and chemical properties of effluent along Romi River

In achieving objective one, the physico-chemical analysis was conducted by collecting water samples in sterilized bottles using the grab method and each bottle was labelled for clear identification and to avoid mixing up the samples.

The samples collected were analyzed in the laboratory of Kaduna Environmental Protection Authority (KEPA) within one hour in order to avoid unpredictable changes in the sample (WHO, 1971; WHO, 1976; USEPA, 1992). Two techniques were also employed in the analysis of the data which are Gravimetric and Volumetric because they are the most standard methods that are capable of giving the most desired precision (DPR 2008) . This was done for water both Kaduna refineries, before the point of discharge, at discharge point and after the point of discharge samples. The analysis includes the physico-chemical test analysis such as pH, temperature, total dissolved solid (TDS), biological oxygen demand (BOD), Nitrate, Turbidity, Electrical conductivity. This is because pH according to FEPA is a good indicator of pollution effect on water (FEPA, 2002). Also according to World Bank (1998), Odour, colour and TDS are pointers to pollution in surface water while the bacteriological test analysis which include the (BOD), and, which affect the aquatic ecosystem by creating oxygen deficit and determine water purity. Other parameters analyzed are Lead (Pb), etc, these are common heavy metals present in waste waters from petrochemical industries (KRPC Environmental Audit Report, 2010).

Objective ii: Compare the concentration of pollutants in the water with the acceptable limits of WHO 2006 and NESREA 2007 standard: In achieving objective (ii), the results of the concentration of pollutants analyzed in the laboratory were presented in table 4.4 against WHO 2006 and NESREA 2007 permissible standard. This was used in comparing what was observed in the laboratory and WHO/NESREA standard.

Objective iii: To determine the suitability River Romi for domestic use to achieve objective (iii), structured questionnaire was issued out to 100 respondents from Rido and Romi communities using purposive sampling. The variables that were investigated are those that can be used to determine the pollution effects on human activities such as farming, fishing, swimming, and other related domestic uses. The questionnaire was structured in such a way that it sought out information on the respondent personal data, effect of the effluent on farming, fishing, swimming and other domestic uses. The sample questionnaire is attached at appendix II. Also simple descriptive statistics was used to analyse the socio-economic data. The results were presented in percentages to show the effluent effects on farming, fishing, swimming, cooking and drinking.

3, 3.1 Laboratory Method of Analysis

The methodology employed in analyzing samples collected for this study varied. According to the parameters. However standard laboratory methods were used to determine both the physical and chemical properties of water covered by this study. The objective of the assessment is to determine the quality of water. There are numbers of quality indicating parameters and these can be grouped into Physical, Chemical and Biochemical assessment in the course of this project.

Physical Parameters include PH, Turbidity, Temperature and Conductivity

- Biochemical parameters include Biochemical, Oxygen Demand (BOD)
- Chemical Parameters include Ions analysis
- Hardness of water

3.3.2 Determination of pH

The pH model The Yokogawa model PH 82 was used. The pH meter was calibrated by immersing the electrode in two buffer solutions of pH4.Gl And 7.00 prepared from capsules of BDH buffer. The pH meter was adjusted to the standard buffers (4.01 and 7). The water sample was placed in a beaker and the electrode was rinsed with distilled water and lowered into the sample in the beaker and the pH meter was allowed to stabilize and the pH of the sample read.

3.3.3 Determination of Electrical conductivity (EC)

The conductivity was measured using Hanna instrument model HI 9032 microcomputer conductivity meter. The conductivity meter was calibrated by immersing the electrode in a reference buffer of 12,880µS/cm. The water sample was put in a beaker and the electrode rinsed with distilled water and lowered into the sample in the beaker. The conductivity in µS/cm of the sample was displayed on the screen and the result was recorded.

3.3.4 Determination of Total dissolve solid (TDS)

Total dissolve solids (TDS) were measured using Hanna instrument model HI 9032 rnicro computer conductivity meter. The conductivity meter was calibrated by immersing the electrode in a reference buffer of 12,S80µS/cm. The water sample was put in a beaker and the electrode rinsed with distilled water and lowered into the sample in the beakerand was measured by selecting the Total Dissolve Solid key while the electrode remained in the water sample used to measure the conductivity, and the IDS value in mg/L displayed on the screen was recorded.

3.3.5 Determination of Turbidity

The turbidity values were taken using a Cybercan 1R TB 100 Turbidimeter. The Turbidity was calibrated with the 1000 NTU, 100 NTU, 10 NTU and 0.02 NTU calibration standards. The cuvette was rinsed three times with the sample to be tested. The light shield cap was replaced and all outside surfaces were cleaned and made dry. The cuvette was pushed firmly into the optical well and index to the lowest reading. The NTU values were measured by pressing and releasing the arrow button and the value was recorded after the display has stopped flashing

3.3.6 Determination of heavy metals (iron, lead and arsenic)

An aliquot of 5ml of concentrated nitric acid was added to 50ml of sample collected in a 100ml beaker. The mixture was heated slowly to evaporate to a lower volume of 20ml. Five milliliter of concentrated nitric acid (HNO3) was again added to the 20ml and heating continued for 10 more minutes. A final 5ml of nitric acid was used to rinse the sides of the beaker. The solution was poured into a 50ml volumetric flask and topped with distilled water to the mark. A blank solution was similarly prepared to serve as control for analyses. Heavy metal analyses were performed on Atomic Absorption Spectrophotometer (Unicam 969) using acetylene gas as a fuel and air as oxidizer. Calibration curves were prepared separately for all the metals by running suitable concentrations of the standard solutions. The digested samples were aspirated in the ruel rich air-acetylene flame and the concentrations of metal were determined from the calibration curves. Average values of three replicates were taken for each determination. The blank absorbance was taken before the testing of the samples. 3.2.9

3.3.7 Determination of Nitrate Concentration

Using Data logging spectro-photometer Dr. 2010 by HACH. Nitrate from the sample aliquot was reduced to nitrite and the resulting nitrite was then determined by a diazonium reaction to form reddish dye. Unique zinc-based Nitratest Powder and Nitrate Tablet were used in the reduction stage to aid rapid flocculation. The nitrite resulting from the reduction stage was determined by reaction with sulphanilic acid in the presence of N-(l-naphthyl) ethylene diamine to form a reddish dye. The intensity of colour produced in the test is proportional to the nitrate concentration and was measured using the data logging spectro-photometer Dr. 2010 by HACH.

3.3.8 Statistical analysis

T-Test was used to analyse the t-distribution and degree of freedom to determine whether the sample mean differ. Its used to compare three or more variables using analysis of variance (ANOVA) T-test was used to determine the level of concentration of the parameter tested. ANOVA was used to know the level of concentration of the temporal and spatial distribution along the River Romi.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.1 Concentration of Physical and Chemical Properties of effluent Along River Romi

The result of the laboratory analysis of Kaduna refinery and petrochemical company effluent at the three sampling points are presented in Table 4.1.

Table 4.1: Mean Value of Parameters Kaduna refinery, before, after and at the Point of Discharge.

Parameters	Point of collecting Water Sample			
	kaduna refinery5km	Upstream5	Point of Discharge5km	Downstream5km
pH (no unit)	5.54	7.45	5.33	6.72
Temperature(^oC)	38	34	37	34
Conductivity µm/cm	250	187	290	187
Turbidity (NTU)	147	39.1	44.79	11.9
Total dissolve solid (TDS)	180	160	160	120
Sulphate (SO^4 mg/l)	50	-10	2	-2
Ammonium (NH4 mg/l)	0.89	0.13	0.20	0.14
Biochemical Oxygen Demand (mg/l)	170.70	160.71	170.70	160.71
Arsenic(mg\l)	0.001	0.001	0.001	0.001
Sulphide (mg/l)	0.007	Nil	0.005	Nil
Total hardness (Calca^3)	38	18	30	18
Nitrate (N mg/l)	2.3	0.4	1.2	0.4
Iron(Fe mg/l)	0.29	0.3	0.25	0.2
Calcium hardness (Cu mg/l)	42	24	28	12
Magnesium hardness (mg/l)	62	12	18	10
Lead (Pb mg/l)	0.001	0.001	0.001	0.001
Alkalinity P (mg/l)	Nil	Nil	Nil	Nil
Alkalinity M (mg/l)	160	56	160	22
Phosphate (mg/l)	3.2	1.0	3.2	0.1

From table 4.1,the analysis conducted on pH of the water samples at Kaduna refinery was 5.54, discharge point was 5.56 while before and after the point of discharge was found to be 7.45 and 6.72 respectively. These results shows that pH before the point of discharge is neutral while pH after the point of discharge is slightly acidic. When this result was compared with previous studies of Lekwotet al (2012) which pH value was reported to be3.5 at discharge point, 5.0 downstream and 6.9upstream which is acidic in nature the reason for this slight decrease in the pH value may be due to seasonal variations which affect the dilution of the River. Usually the volume of water in rivers decrease during dry season and increase during rainy season which is the period this study was carried out. But the results of pH after the point of discharge for this research concur with the findings of Lekwotet al (2012) both values increases after the point of discharge this implies that pH is on the increase in Romi River.

Temperature: Temperature of water sample before and after the point of discharge was found to be 34ºC each, 38ºC at Kaduna refinery and 37ºC at discharge point. This implies that temperature of Romi River is tolerable and when compared with the studies of Lekwotet al (2012) which reported surface temperature of 38ºC at discharge point, 36ºC upstream and downstream which can be attributed to the location of the study area however the result showed tolerable temperatures which means that temperature remain within the same range despite the three years interval.

Electrical Conductivity: The result of electrical conductivity (EC) at Kaduna Refinery was 83.7 µm/cm before the point of discharge was 80.7µm/cm, 96.1µm/cm at discharge point and EC after the point of discharge was 80.1µm/cm these values are lower in terms of EC. Although previous study by Lekwotet al (2012) reported EC to be 250µm/cm upstream300µm/cm at discharge point 260µm/cm downstream which shows higher value in wet season than dry season as a result of urban runoff which introduce high load of suspended matter into the water system. In the same vein, Romi River is still polluted.

4.1.1 Magnesium hardness: The result of the analysis for magnesium at the Kaduna refinery was 62mg/l, before the point of discharge is 12mg/l and after the point of discharge is 10mg/l and 18mg/l at discharge point, this result shows a sharp increase in magnesium hardness concentration from the upstream to downstream. The reason for this sharp increase in magnesium hardness could be due to accumulation of organic solid particles. These results shows similarity with the results of previous studies carried out by USEPA (2011) .

4.1.2 Total dissolve solid: TDS result was observed to be 180mg/l at the Kaduna refinery , 120mg/l before the point of discharge and 120mg/l after the point of discharge and 160mg/l at discharge point. These values are normal but previous studies conducted by Lekwotet al (2012) whose studies observed a lower value of TDS concentration although below what is obtained by this research yet higher with 150mg/l upstream, 195mg/l at discharge point, 180mg/l downstream, the present increase could be as a result of the chemicals constituents of the petroleum industry waste water this means that there is gradual increase of TDS in Romi River.

4.1.3 Turbidity: The turbidity result of the water sample at the Kaduna Refinery was 147NTU before the point of discharge was 39.1NTU, at discharge point 44.79NTU and after the point of discharge is 11NTU which is very high at all sampling points due to effluents in the water while previous studies by Abui (2012) reveals that turbidity of the same river is 17.1NTU at upstream and downstream which is higher than what was obtained by this study. This could be due to decrease in volume of water in Romi River.

4.1.4 Calcium hardness: Calcuim hardness of the water sample was observed to be 42mg/l at the Kaduna refinery, 24mg/l before the point of discharge, 12mg/l after the point of discharge and 28mg/l at the point of discharge this is low due it is in agreement with USEPA (2012) shows that the River is still polluted base on the study conducted.

4.1.5 Biologichemical Oxygen Demand: BOD measured at the kaduna Refinery 170.32pp before the point of discharge was 170.52pp at discharge point 170.32 pp ,160.52pp after the point of discharged. These values are relatively high. However when compared to the findings of Lekwotet al (2012) with BOD 15mg/l which is high and it may be due to high content of biodegradable organic pollutant in effluent before the point of discharge or the reason may also be due to vegetation cover and presence of decaying plant in the river. It therefore means that BOD in Romi River has drastically reduced after three years.

4.1.6 Total hardness: total hardness measured at the kaduna refinery was 38mg/l, before the point of discharge was 18mg/land after the point of discharge 18mg/l and at the point of discharge is 30mg/l which is low and it may be as a result of both industrial effluent discharges and surface runoff from fertilizer application into the river. Though similar studies by Abui (2012) have also reported high levels of in Romi River ranging between 50mg/l to120mg/l upstream and downstream respectively and might be due to particulates from the industry.

4.1.7 Sulphate : Sulphate result of the water sample at the Kaduna Refinery was under range before the point of discharge is-2 mg/l and after the point of discharge is -50mg/l the presence of these sulphate may be due to effluents from the industry but is within the allowable limit while that is discharge point iis -50mg/l which is tolerable. Previous studies by lekwotet al (2012) indicate similar values in Romi River both studies concur with each other.

4.1.8 Sulphide: Sulphide concentration measured at the Kaduna refinery was 0.007mg/l Romi River before and after the point of discharge is nil and 0.005mg/l at this level sulphide is high at Romi River. this could be as a result of operational activities in the refinery and sewage into the river however this result did not agree with the report of previous studies carried out by Lekwot et al (2012).

4.1.9 Nitrate (NO3): The concentration of NO3measured in water samples at Kaduna refinery 2.3 mg/l before the point of discharge is 0.2mg/l, at discharge point is0.42mg/land after the point of discharge is 0.7mg/l these results indicated low concentration of NO3before the point of discharge but relatively high after the point of discharge which may be as a result of eutrophication by Nitrogenous fertilizer due to farming activities along the Riverbank. Also when these results is compared with the report of Abui (2012) who observed a concentration ofNO30.9mg/l the values obtained are relatively low and Lekwotet al (2012) with 62 mg/l average quantity in water. It is obvious that the value of Nitrate in Romi River is increasing gradually irrespective of the low values.

4.1.10 Iron: The concentrations of iron measured before and after the point of discharge are0.93mg/l and 0.27mg/l while at discharge point is 1.2mg/l respectively, these values are low. The reason for low concentration of iron could be as a result of oxidation reaction of different compound in the River, however Romi River is not polluted with Iron concentrations.

4.1.11 Arsenic : The result obtained for Arsenic shows concentration of 0.001 mg/l at the Kaduna refinery, before the point of discharged and 0.001mg/l after the point of discharge and 0.001mg/l at discharge point which shows low increase of arsenic concentration in the River. This shows a low value which may be as a result of natural purification in the River previous study by Butu (2012) also indicate low values of arsenic in Galma Dam both studies shows similar result of low copper concentration.

4.1.12 Lead: The results obtained for lead measured in water samples at the Kaduna Refinery was 0.001 mg/l, before the point of discharge is 0.001mg/l, at discharge point 0.001mg/l and after the point of discharge is 0.001 which is low because of emission from the refining activities in the study area where petroleum products contain lead substances are been drained into the river. Previous studies by Lekwotetal (2012) observed 0.11 mg/l average quantity of lead in Romi River while Butu (2012) also observed high concentration of lead in the Gama dam. This means that the level of lead slightly increase which implies that Romi River is still polluted three years after.

4.1.13 Ammonium : Ammonium Concentration at the Kaduna refinery was 0.89mg/l before the point of discharge is 0.13mg/l and after the point of discharged is 0.14 mg/l and at discharge point is 0.20mg/l this result indicated a high concentration which may be due to high operation activities. Also impurities in fertilizers, sewages, pesticides and manure are likely to have contributed to high increase ammonium in the river. Previous research by USEPA(2011).

4.1.14 Alkalinity Methyl: Alkalinity M was observed to be 160mg/l at discharge point, 52mg/l before the point of discharge and 160mg/l at the Kaduna refinery, 22mg/l after the point of discharge, these values are low and might affect the pH USEPA (201) indicates that Alkalinity M was not detected at all sampling sites which means that is normal in Romi River.

4.1.15 Alkalinity P: Alkalinity P was observed to be at discharge point, nil before the point of discharge, nil after the point of discharge and nil at the Kaduna refinery, these indicates that it is normal in Romi River.

There is an increase in most of the parameters analyzed in this research work and this has potential health consequences on human and the environment at large. Objective two deals with the considerable variation in the physiochemical parameters of the water at the sample point.

4.2 Determine the spatial distribution of the physical and chemical properties of effluent of the River Romi

Results of the statistical test of variation using Anova in quality of water before and after the point of discharge are presented in Table 4.2, the samples in the four sites were compared and the results reveal that many of the parameters measured vary using Anova.

Table 4.2: Spatial Distribution of Physical And Chemical Properties Of Effluent of the River Romi

Parameters	KD Refinery	Upstream	Mid Stream	Down Stream	F (ANOVA)	P value

pH	7.0433±0.61906	7.0433±0.61906	5.3333±0.12662	7.0433±0.61906	7.525	0.010*
Temperature	29.733±3.9260	27.400±3.9850	25.433±0.3055	27.400±3.9850	0.785	0.535
Conductivity	310.800±395.9497	310.800±395.9497	69.967±44.8319	310.800±395.9497	0.368	0.778
Turbidity	65.9633±71.61492	65.9633±71.61492	21.2700±20.49062	65.9633±71.61492	0.379	0.771
Sulphate	13.33±32.146	13.33±32.146	-0.33±2.082	13.33±32.146	0.181	0.907
Nitrate	1.067±1.0693	1.067±1.0693	0.233±0.0577	1.067±1.0693	0.607	0.629
Ammonium	0.6500±0.44193	0.6500±0.44193	0.1167±0.02309	0.1800±0.03464	2.586	0.126
Phosphate	9.067±11.3143	9.067±11.3143	5.767±5.4262	2.067±1.8475	0.462	0.717
Sulphide	0.0040±0.00361	0.004000±0.00361	0.000000±0.00000	0.003000±0.00265	1.303	0.339
Total Hardness	58.67±39.311	58.67±39.311	26.67±7.572	58.67±39.311	0.655	0.602
Calcium hardness	30.00±10.392	30.00±10.392	15.33±11.372	30.00±10.392	1.424	0.306
Magnesium hardness	28.67±28.937	28.67±28.937	11.33±7.024	14.00±4.000	0.597	0.635
Alkalinity M	94.00±57.236	94.00±57.236	34.67±18.583	80.67±34.196	1.179	0.377
Lead	0.00100±0.00	0.00100±0.00	0.00100±0.00	0.00100±0.00	.	.
Arsenic	0.00100±0.00	0.00100±0.00	0.00100±0.00	0.00100±0.000	.	.
Iron	1.3133±1.76381	1.3133±1.76381	0.2967±0.00577	0.2967±0.00577	0.664	0.597
Total dissolve	186.67±7.638	161.00±11.533	174.33±5.132	149.00±1.732	14.471	0.001*
BOD	170.3467±0.30022	170.52±0.000	160.1533±0.13279	170.1733±0.300	1576.314	0.000*

Table 4.2 Result shows There was a statistically significant difference of the water samples in the four sites (P<0.05). The degree of significant difference was tested statistically the result of pH values in Romi River indicates that there is difference between the midstream with 5.333±0.12662 and 7.0433±0.619062 downstream with significant level of P<0.010.While the statistical test employing Anova was used and temperature values also indicated that there is no significant difference between the the kaduna refinery with 29.733.±3.2926016, and

27.400±3.980 upstream, 25.433±0.3055 midstream and downstream 27.400±3.9850 of Romi River with significant level P > 0.535 and the electric conductivity value indicated that there is a significant difference between the kaduna refinery with 310.800±395.94927, upstream 310.800±395.9497, Midstream 69.9633±44.8319 and downstream value 310.800±395.9497 of Romi River with significant level P < 0.778.The statistical test was carried out and it confirm that value for total sulphate 13.33±32.146kaduna refinery, 13.33±32.146 upstream, midstream -0.3.±2.082.and 13.33±32.146 downstream of Romi River shows no significant difference with P < 0.907 level of significant. The statistical test value for total dissolved solid the result shows a significant difference between the kaduna refinery 186.67±7.638, upstream 16100±11.533, Midstream 174.33±5.132 and 149.00±1.732 downstream with P <0.001 level of significant. The results for turbidity at Romi River with 65.9633±71.61469 kaduna refinery,65.9633±71.61492 upstream and Midstream 21.2700±20.49062and 65.9633±71.61492 downstream show no significant difference between the upstream and downstream at P < 0.771 level of significant.

Similarly, the test was employed to test the level of significant values for BOD indicate a significant difference between the kadunarefinery170.3467±0.30022, 170.3467±0.30022 Upstream, Midstream 160.1533±0.13279 and downstream 170.3467±0.30022 of Romi River at P < 0.000 level of significant, Calcium indicate no significant difference between the Kaduna refinery, 30.00± 0.10.392 upstream, 30.00±0.10.392 with Midstream 15.33±11.375,30.00±0.10.392 downstream at P < 0.306 level of significant. Sulphide indicate no a significant difference between the kaduna refinery 0.0040±0.00.361,.0040±0.00.361 upstream .00000±0.0000 Midstream and 0.0040±0.00.265 downstream of Romi River at P < 0.339 level of significant. The value for the total hardness in Romi River also indicates no significant different between the kaduna refinery 58.67±39.311, 58.67±39.311 upstream Midstream 26.67±7.572 and 58.67±39.311 downstream with significant level P > 0.602 also the statistical test values for Nitrate (NO3) kaduna refinery 1.067±1.0693,1.067±1.0693upstream, Midstream 0.233±0.0577 and downstream 1.067±1.0693 of Romi River at significant level of P< 0.629 also the value of ammonium indicates no significant difference between the Kaduna refinery 0.6500±0.44193, 0.6500±0.44193 upstream, Midstream 0.1167±0.02309 and 0.1800±0.03464 downstream with P < 0.126 level of significant in Romi River while Butu (2002) observed that there is no significant difference in the level of concentration of Ammonium in the lower and upper region of the Dam. The statistical test for phospate indicates no significant difference between the Kaduna refinery 9.067±11.3143, 9.067±11.3143 upstream, midstream 5.767±5.4262, and downstream 2.067±1.8475 with $P < 0.717$ level of significant in Romi River when compared with Butu (2002) stated that there is significant difference in level of concentration between the upper and lower region of Galma Dam.

Furthermore, iron (Fe) indicate no significant difference between the Kaduna refinery 1.3133±1.76361, 1.3133±1.76361 upstream, Midstream 0.2967±0.00577 and 0.2967±0.00577 downstream with $P < 0.0597$ level of significant in Romi River while Butu (2002) observed that there is no significant difference in the level of concentration of Ammonium in the lower and upper region of the Dam. The statistical test for arsenic and Lead indicates no significant difference between the kaduna refinery 0.00100±00, 0.00100±00 upstream, midstream , and downstream 0.00100±00, with P value level of significant in Romi River when compared with Butu (2002) stated that there is significant difference in level of concentration between the upper and lower region of Galma Dam.

The statistical test for phospate indicates no significant difference between the Kaduna refinery 9.067±11.3143, 9.067±11.3143 upstream, midstream 5.767±5.4262, and downstream 2.067±1.8475 with $P < 0.717$ level of significant in Romi River when compared with Butu (2002) stated that there is significant difference in level of concentration between the upper and lower region of Galma Dam.. As observed from the results of the statistical test pH, Total Dissolve Solid and Biochemical Oxygen Demand values indicates that there is significant difference between the kaduna refinery, upstream, midstream and downstream concentration in Romi River which may be due to dilution as a result of 10 kilometre distance between the two sections whereas Temperature, conductivity, and Lead results shows that there is no significant difference between the two sections despite the distance of 10 kilometre. Some of the metals discussed in this study are release through the effluents discharge by KRPC in the study area. Chemical element like Iron and arsenic are embedded in the geological formations and when this rocks undergo complete weathering, the element are release into the environment from where they are wash into the River. Lead are used in electric and electronic equipment and are release into refuse dump and drainage system from where they decay and are release into the general environment and finally into the

River.Lekwot et al dictated high concentration of heavy metals in Romi River three years later this research work also shows a gradual increase of effluents in the River.

4.3 THE TEMPORAL DISTRIBUTION OF THE PHYSICAL AND CHEMICAL PROPERTIES FO EFFLUENCT IN THE STUDY AREA

The physiochemical properties of the sampled water at the dry season and wet season of the effluent discharge point are presented in

Table 4.3 Seasonal Distribution of Physical and Chemical Properties in Dry and Wet Season

Parameters	**Dry season**	**Raining Season**	**T-test**	**Pvalue**

PH	6.4550±0.86683	6.9375±1.00500	0.749	0.407
Temperature	27.775±3.5005	26.925±3.3994	0.400	0.698
Conductivity	332.550±361.3190	86.675±5.9500	1.764	0.214
Turbidity	77.0825±58.75850	10.2050±1.95000	4.933	0.051
Sulphate	15.13±29.216	-0.50±1.000	1.089	0.321
Nitrate	1.113±0.9891	0.350±0.1000	2.254	0.164
Ammonium	0.5300±0.40263	0.1375±0.00500	3.620	0.086
Phosphate	7.863±8.7995	3.750±5.5000	0.713	0.418
Sulphide	0.004125±0.0027484	0.0000±0.00000	8.582	0.015*
Total Hardness	59.50±37.428	33.00±2.000	1.907	0.197
Calcium	29.00±12.604	21.00±6.000	1.399	0.264
Magnesium	25.00±23.176	12.00±4.000	1.183	0.302
Alkalinity M	86.50±52.718	54.50±19.000	1.330	0.276
Lead	0.00100±0.000000	0.00100±0.000000	.	.
Arsenic	0.00100±0.000000	0.00100±0.000000	.	.
Iron	1.0613±1.41265	0.2925±0.00500	1.128	0.313
Total dissolve	166.50±17.550	170.25±14.637	0.134	0.722
BOD	167.8825±4.72663	167.6300±5.09257	0.007	0.934

4.3.1 pH: There was no statistically significant difference in the level of pH in the dry and raining seasons ($p=0.407$) however, the pH level in the raining season was higher.

4.3.2 Temperature: The temperature in the dry season was higher than the raining season, but the difference was not statistically significant ($p=0.698$)

4.3.3 Conductivity: The conductivity level in dry season was higher than the raining season however, the difference was not statistically significant.

4.3.4 Turbidity: The turbidity level in dry season was higher than in the raining season, and the difference was statistically significant ($p=0.05$)

4.3.5 Nitrate: There was no statistically significant difference between the levels of nitrate in the dry season and raining season. The Nitrate level in the dry season was higher than in the raining season.

4.3.6 Ammonium: The ammonium level in dry season was higher than in the raining season but the difference was not statistically significant (P=0.086)

4.3.7 Phosphate: There was no statistically significant difference in the phosphate levels in the dry and raining seasons. However, the phosphate level in the dry season was higher than in the raining season.

4.3. 8 Sulphide: The sulphide level in the dry season was significantly higher than in the raining season (p=0.015)

4.3.9 Total Hardness (TH): There was no statistically significant difference in the TH level between dry and raining seasons (p=0.197). However, TH level in dry season is higher than in the raining season.

4.3.10 Calcium: The calcium level in the dry season was higher than in the raining season, but the difference was statistically significant (p=0.264)

4.3.11 Magnesium: The magnesium level in the dry season is higher than in the raining season, but the difference is not statistically different (P>0.0)

4.3.12 Alkalinity M: The level of alkalinity level in dry season was higher than in the raining season, however the difference was not statistically significant (p>0.05)

4.3.13 Iron: The iron level in dry season was higher than in the raining season, but there was no statistically significant difference between the two seasons (p>0.05)

4.3 14 Total dissolve Solid: There was no statistically significant difference in the level of TD in dry and raining seasons, however, TD level in the raining season were higher in the raining season than in the dry season.

4.3.15 BOD: The level of BOD in the dry season and in the raining season were almost at the same level, and there was no statistically significant difference in their levels.

From the table 4.3 the measured parameters show no significant difference for the season ($P>0.05$). However, levels of many of the parameters were higher in dry season than in the wet season due to high operation which can lead to increase in the deposition of the effluents .the level of parameters are lower in the season due to rainfall that causes dilution of the River. Usually the volume of water in rivers decrease during dry season and increases during rainy season.The table 4.3 shows that all the value measured for both season has no significant effect on the River Romi, but the results also indicate that Sulphide has a significant difference with p.value 0.015. However the implication is that high level of sulphide is present and contaminates the River Romi.

4.4 Concentrations of Physiochemical parameters in Comparison with WHO/NESREA Standards for Domestic Use

The Physiochemical properties of the sampled water at 5km upstream and downstream of the effluent discharge point are presented in table 4.4. Mean Values of Physico-chemical Parameters compared with WHO/NESREA.

Table 4.4: Determination And Suitability Of Water Of River Romi For Domestic Use.

Parameters	**Mean**	**WHO permissive level**	**NESREA**	

PH	6.61	6.5 -8.5	6.5-8.5	NOT PERMISSABLE
Temperature(^oC)	33.158	30	30	NOT PERMISSABLE
Conductivity (µm/cm)	250.592	1000	240	NOT PERMISSABLE
Turbidity(NTU)	-	-	-	-
sulphate(mg/l)	54.7900	10	10	NOT PERMISSABLE
Nitrate	9.92	250	500	PERMISABLE
Ammonium(mg/l)	.858	50	0.20	NOT PERMISSABLE
Phosphate(mg/l)	.3992	0.20	0.2	NOT PERMISSABLE
Sulphide H²S(mg/l)	6.492	0.2	0.2	NOT PERMISSABLE
TotalHardness(mg/l)	.002750	0.5	150	PERMISABLE
Calcium(mg/l)	50.67	150	50	PERMISSABLE
Mangnesium(mg/l)	26.33	75	0.05	PERMISSALE
AlkalinityM	20.67	0.05	200	NOT PERMISSABLE
Lead(mg/l)	75.83	200	0.01	PERMISSABLE
Arsenic (mg/l)	.00100	0.01	0.01	PERMISSABLE
Iron (mg/l)	.00100	0.01	0.02	PERMISSABLE
Total dissolve solid	.8050	0.3	2000	PERMISSABLE
(mg/l)	167.75	1000	-	PERMISSABLE
BOD	167.7983	80pp		-

The Results from table 4.4 was compared with the World Health Organization's (WHO) maximum permissive level for domestic use. This enables the determination of the variation between the quality of the Kaduna Refinery, Romi Midstream, Romi Upstream and Romi Downstream and confirms if it is or if it is not suitable for domestic use.The parameters analyzed in table 4.4 are good indicators of pollutants that affect surface water quality to a large extent (Gbenga 2007). Among the physical parameters measured was the mean of pH which was found to be 6.61 pH values are within WHO/NESREA standard while at effluent discharge point fell short of the standard. Mosley et al (2004) reported that water is hard with pH>8.5, similarly, Lekwotet al (2012) in their study observed that pH deviates in Romi River from the acceptable limit of 6.5upstream, the upstream shows high acidity with the highest pH 5.33 at effluent discharge point due to the effluents discharged (table 4.1)

It is observed from the laboratory analysis results that the Kaduna Refinery has a normal PH ,AIkalinity Methyl (M), Calcium hardness, Conductivity, Nitrate, Sulphate, and Total hardness of water but Temperature of the water is below WHO standard. The mean pH of the water collected from the sampling sites of the river ranged from 5.33 to 7.44 indicating a balance between acid and alkalinity (table . 1).. The pH of the river will thus not affect the health of its users for domestic purposes and that of aquatic life. However, the observed mean pH recorded in the at Romi Midstream ranged from 5.33 to 5.19(table 4.1). It exhibited acidic characteristics. The values in all the samples from the Midstream were below the NESREA-Nigeria and WHO recommended pH range of 6.5 to 8.5. The low pH values might have come from the source of the water. Acidic or low pH of drinking water is usually a result of natural geological conditions at the site, possibly compounded by acid rain(www.watersystemscouncil.org). Acidic water may be soft and corrosive and could contain metal ions. It could leach metals from pipes and fixtures such as copper, lead, and zinc. It could also damage metal pipes and cause aesthetic problems such as metallic or sour taste, laundry staining, or blue-green stains in sinks and drains. Low pH exposure may cause hair fibres to swell in sensitive individuals, gastrointestinal irritation may occur just as high pH results in similar effects (pH in drinking -water @ www.who.int/water sanitation health/dwq/chemicals) Corrosion of metals and aggression of cement concrete is likely at low pH. The low pH of the River Romi water may, therefore affect constructional works in the locality, and could be the cause of cracks and decay of the cement lining in the wells.

But the samples at the same time have a high value for turbidity, BOD, Magnesium Hardness, Turbidity, Phosphate, which is above the WHO Standard for quality drinking water and is therefore not acceptable. Higher turbidity levels are often associated with disease causing organisms such as virus, parasites and some bacteria which cause symptoms such as nausea, cramps, diarrhoea, and associated headaches (USEPA, 2009).

Turbidity The mean turbidity recorded from the Kaduna Refinery and Romi river varied between 147±11.1 to 44.79 NTU at sample site respectively (table 4.1). The values were far beyond the background limit of between 0- 10NTU (Nephelometric turbidity unit). USEPA (2011) has indicated that at no time can turbidity go above 5NTU based under surface water treatment rule. There was significant difference ($p<0.05$) between sampling site. The elevated level at sample 1 site could be due to the high inflow of waste water from the Kaduna Refinery into the river. Dead decaying organic matter from improper disposal of domestic waste along theriver banks has also contributed to increase the level.

The temperature of the water sample was found to be 34oC upstream, 37oC at effluent discharge point and 34 downstream. This shows an increase in temperature downstream, the sharp increase in the temperature at the effluent discharge point may be as a result of heat from cooling since the water is being used to cool the machineries during the refining operations. Therefore the temperature can be said to have exceeded the NESREA 2007 and WHO 2006 standard limits of 30oC. This result varies slightly with the findings of lekwotet al (2012) who reported that the mean of temperature is 34oC while at 35oC upstream, 34oC at discharge point and 36oC downstream of Romi River (table 4.1).

The analysis conducted on Electrical Conductivity (EC) of the water sample indicates that the EC value was 39.1µm/cm upstream and 39.1µm/cm downstream with a sharp increase of 147µm/cm at effluent discharge point. This indicates that EC is high at effluent discharge point and but did not the NESREA 2007 and WHO 2006 maximum limits of 1000µm/cm. This result vary with the values reported in Lekwotet al (2012) who reported EC 250 µm/cm upstream, downstream 240 µm/cm and 300 µm/cm at the discharge point.

The result for total dissolved solid was observed to be high at 195mg/l at Kaduna refinery, upstream, 160mg/l downstream and 170mg/l at effluent discharge point. The results show higher values compared to 20mg/l NESREA 2007 and WHO 2006 standard of 50mg/l. however the concentration of TDS as compared to previous study by Lekwotet al (2012) reported that TDS is quite high with upstream 300mg/l, discharge point 400mg/l and downstream 250mg/l.

The turbidity results of the water sample analysis Kaduna refinery 39.11 NTU upstream is 11NTU, 39NTU downstream, and 44NTU effluent discharge point .It is higher than the permissible limit of 5NTU this could be attributed to high concentration of effluents. All values are above the WHO/ NESREA standard. It was also observed that the water in Romi River has a sharp chocking smell especially downstream.The result for the biological oxygen demand (BOD) upstream is 170pp, downstream 170pp and 160pp at effluent discharge point. This is in conformity with the permissible standard of 80pp of the NESREA 2007 and WHO 2006. Okechuku, (2009), stated that the presence of organic parameters in the surface water serves as measures for pollution dictation. Lekwotet al (2012) measured 2500-3000mg/l in Romi River which is ten times the strength of domestic water.

Metals such as nitrate (NO3) , iron (Fe) lead (Pb), arsenic (As) and create oxygen deficit and also determine water purity. They are pointers to water pollution in surface water (Abui, 2012). The results shows that nitrate concentration is (NO3) 0.2mg/l upstream, 0.7mg/l downstream and 0.42mg/l at effluent discharge point, these values are low and decrease both at upstream and downstream of Romi River and after the effluent discharge point. When compared with previous study by Abui (2012), it was observed that the nitrate was very low at both dry and rainy season upstream with 0.7mg/l and 0.9mg/l, at discharge point 0.3mg/l and 0.4mg/l while downstream 0.8mg/l and0.9mg/l which is lower than WHO 2006/NESREA 2007 permissible limits.

Iron (Fe) concentration upstream 0.23mg/l, 0.29mg/l downstream and at discharge point is 0.2mg/l the result shows it is lower than NESREA 2007 and WHO 2006 standard. From previous study by Abui (2012) it was observed that iron concentration in both dry and rainy season is normal with 0.4mg/l and 0.3mg/l upstream, 0.2mg/l for both seasons at discharge point, 2.3mg/l downstream at both seasons because of the difference in sampling period of the study. It is low at upstream and downstream but increases downstream above the permissible limit.

The parameters when compared with NESREA and WHO some of the results are above the maximum permissible standard which may cause environmental degradation and reduce the effect of solar energy absorption while others are below the permissible standard which may not affect human and aquatic life but over time will have great impact on both lives and acquatic lives.The parameters when compared with NESREA and WHO some of the results are above the maximum permissible standard which may cause environmental degradation and reduce the effect of solar energy absorption while others are below the permissible standard which may not affect human and aquatic life.

4.5Effectsof the Effluents in Romi River for Human Activities

4.5.1Age Distribution of Respondents

The age distribution of respondents is presented in table 4.4

Table 4.5:Age Distribution of Respondents

Farmer Age (years)	Number of Respondents	Percentage (%)
15 – 25	65	19.87
26 – 45	71	21.71
46 – 65	191	58.41
Total	327	100%

The mean age of the respondents was 44.1 years in the age group 26 – 45 years (table 4.3). The respondents in the age bracket of 15 – 25 years constituted 19.87% and that of 26 – 45 years constituted 21.71%, while the age group of 46 – 60 years made up of 58.41%. The respondents within the age of 26 – 45 years were energetic and very active for farming. These falls within the age range of 15 – 64 years defined by FAO as economically productive. Consequently, the age of a farmer determine the type of farm operation he or she could undertake. The young farmers could embark on more demanding farm operation such as land tilling and tree felling than older farmers. While the aged engaged in less energy demanding tasks as planting, land clearing, thinning and harvesting.

Table 4.6Level of Education of Respondents

Level of Education	Number of Respondents	Percentage (%)
No Formal Education	57	17.43
Primary Education	73	22.32
Secondary Education	185	56.57
Tertiary Education	12	3.67

Total	327	100%

The highest level of education of respondents is given in table 4.5, it is seen that 56.57% of the respondents had secondary education, while 22.32% had primary education. About 17.43% of the respondents did not attend any formal educational institution while about 3% had post-secondary education. These results suggest that about 82.49% had one form of formal education or the other while 17.43% did not go to school at all. Therefore it is obvious that the educated respondents had really gone into farming and might have little knowledge on the effects of the effluent discharged by the refinery into their farmlands.

4.6.2 Location of Farmlands of Respondents

The location of farmlands of respondents is presented in table 4.7

Table 4.7: Location of Farmland of the Respondents

Farm Location	Number of Respondents	Percentage (%)
River Bank	213	65.1
Upland	114	34.9
Total	327	100(%)

From the survey of farm locations along the River Romi (Table 4.6), about 65.1% of the respondents have their farmlands located along the river bank and 34.9% of the respondents have their farmlands located at the uplands. And according to FAO the location of farmlands determines the types of the crops grown, also it helps in comparing the fertility of the river bank farmlands and that of the upland farms. Therefore it is obvious why majority of the respondents have their farmlands located at the river bank

4.4.3 Respondents Experience in Farming

The farming experience of respondents is given in table 4.7.

Table 4.8: Farming Experience of the Respondents

Farming Experience (years)	Number of Respondents	Percentage (%)
1 – 5	41	12.54
6 – 10	73	22.32
11 – 20	69	21.10
21 – 30	37	11.31
31 years and above	107	32.72
Total	327	100%

The results on table 4.6 show that 32.72% of the respondents have been farming their land for at least over 30 years. This followed by 22.32% who have 6 – 10 years of farming experience of their land. The next is 21.10% of the respondent who have been farming on their lands for 11 – 20 years. This result suggests that at least 30 years constitutes the majority of the farming experience in the area. Therefore it could be said that farmers in the study area are experienced in the farming process as they have been able to explain the situation of the Romi area before and after the establishing of the refinery.

4.8.1 Effects of the Effluent on Domestic Water Use

The results of the analysis of the effects of the effluent on domestic water use such as farming, fishing, swimming/bathing, cooking and drinking were presented in percentage in Figure 4.1

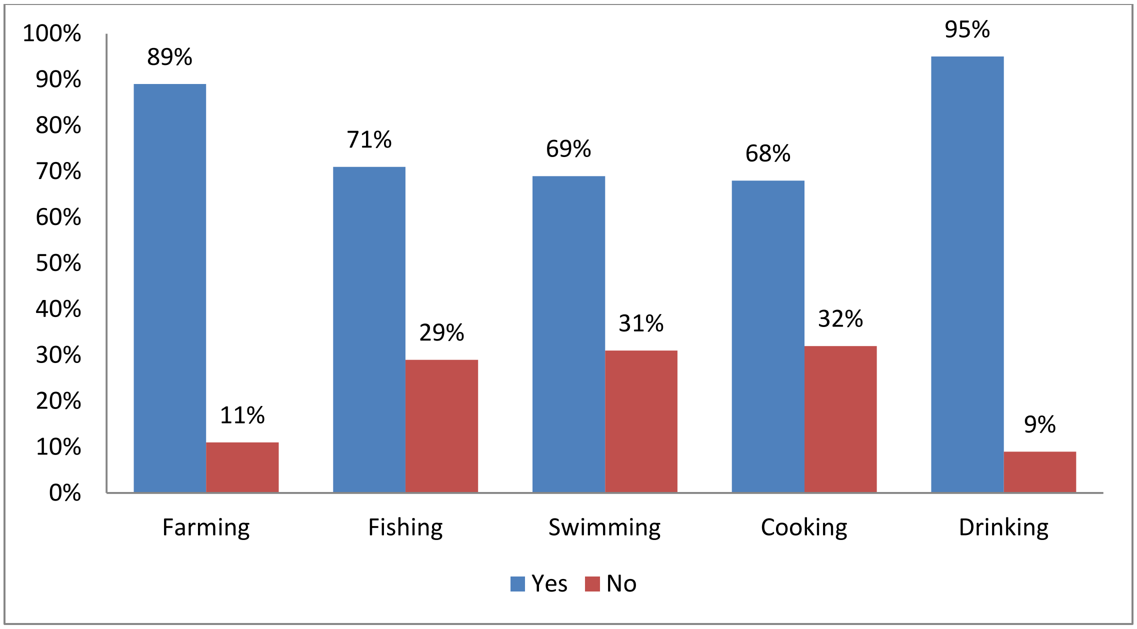

Figure 4.1: Effect of the Effluent on Farming, Fishing, Swimming, Cooking and Drinking

The results show that 89% of the respondent affirmed that the pollution of the river has negative effect on their farming activities while 11% said the pollution of the river do not affect their farms because they do not depend on river Romi for farming activities. 71% of the respondents agree that the pollution of the river affected their fishing activities while 29% of the respondent said it does not because they do not engage in fishing activities. 69% of the respondent unanimously agrees that the pollution of the river has affected their swimming and bathing activities while 31% of the respondent said it doesn‘t because they do not swim or bath in river Romi. 68% of the respondent confirmed that the pollution of the river has affected their cooking activities and they no longer use water from the river to cook food while 32% of the respondent said no because they use water from hand dug well for cooking activities. Almost 91% of the respondent unanimously confirms that the pollution of River Romi has negatively affected their sources of water and they cannot depend on the river for drinking while 9% of the respondent said no they do not source water from river Romi. Therefore it can be said that effluent discharges in river Romi affect negatively the socio-economic activities of the nearby communities.

4.8.2 The Effect of Effluent on the Domestic uses (swimming, bathing, cooking, drinking, and livestock watering)

During the interview the host communities accused the refinery for polluting the source of their water on which they depend to a large extent for their livelihood in particular drinking, cooking, washing, bathing and livestock watering. The host communities complained further that they have been losing their livestock through drinking the polluted water from the river Romi.

In addition the researcher observed that the effects of the effluent is so severe that majority of the inhabitants are compelled to abandon their traditional occupation for other activities such as petty trading or labouring in construction sites. Some farmers interviewed expressed their intention to migrate to other places to continue with their traditional farming.

The researcher further observed from the information gathered that the respondent‘s attributed their health problems to the odour and smell from the effluent. Though this facts could not be established here because it is out of the scope for this research, however this suggest further studies which may aim to determine the effect of the effluent on health status of the host communities.

4.9 Discussion of Findings

Each of the sample figures obtained from the laboratory analysis The value decreased value partly because of self- purification of the river as it flows downwards. Site B and D did not show any significant difference during the sampling period. Ordinarily, finely divided organic and inorganic matters, like clay, silt, plankton and microscopic organisms make water opaque. Higher turbidity levels are often associated with disease causing organisms such as virus, parasites and some bacteria which cause symptoms such as nausea, cramps, diarrhoea, and associated headaches (USEPA, 2009). Turbidity can have negative impact on consumer acceptability of water as a result of visible cloudiness. Consumption of turbid water does not have any direct health effects. High turbidity implies a high concentration of suspended particles. These particles can shield bacteria and other micro-organisms from disinfection properties of treatment chemicals, for example chlorine, resulting in ineffective disinfection ((physical and Organoleptic Parameters @www.wqms,co.za/ infopa.ges/211). It is therefore important that the water from the river be filtered before it is used for domestic purposes.

Consumption of heavy metals is linked to many serious health concern (Benham et «/.,2011). Severe effects may include reduced growth and development, cancer, organ damage, nervous system damage and in extreme cases, death. These metals are present in varying concentrations depending on prevailing factors such as temperature, pH, hardness and standing time of the water. Among the river studied, the concentration of both arsenic (As) and lead (Pb) were below limit of detection (<0.01mgL-l) (Appendix i-table 1). The maximum control level of these metals given by FEPA-Nigeria and WHO (2014) in domestic water is O.OlmgL-1. Lead exposures shown to be associated with wide range of effects including neurological and behavioral defects, mortality (mainly due to cardiovascular disease), impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes, delay sexual maturation and impaired dental health (WHO, 2014). Arsenic is however a known carcinogen and mutagen (Smedley et *a/.*, 1995). The International Program on Chemical Safety (JPCS) has indicated that long-term exposure to arsenic is casually related to increased risks of cancer in the skin, lungs, bladder and kidney, as well as other skin changes such as hyperkeratosis an pigmentation changes (WHO, 2014). Using the source waters for drinking and other domestic purposes can be said to be safe and nontoxic to the health of the people as the level of arsenic and lead, if any were below detection limit (<0.01 mgL-1).

Table 4.4 is observed from the laboratory analysis results put forward that some of the samples are having normal Alkalinity methyl (M), Calcium Hardness, Conductivity, Nitrate, Sulphate and Total Hardness which is within the range of the WHO standard. But at the same time the samples have high value for Ammonium Nitrate, BOD, Nitrate, Sulphide and Turbidity which passes the level of the WHO standard and is therefore not accepted for domestic use with normal Temperature and $_P$H. From the experiments, the effect of the operations by the Kaduna refinery to the River Romi quality is evident and in the following years it will surely escalate negatively. Although the effect of the refinery's activities is greater on the River Romi Down stream,Upstream water than the River Romi Midstream water, the ions found on the River Romi Upstream, and Downstream water can also be the result of Anthrpogenic activities such as application of fertilizers such as phosphorous (phosphate) Nitrate and also of the physical parameters. Other secondary sources of nitrogen compounds include fertilizer, manure, sewage, and landfills (ODNR, 2011).

Increasing nitrate levels in water resources are a potential source of severe environmental stress to aquatic organisms, because nitrate is known to be toxic to insects, amphibians and fish (Tomass and Carnicheal, 1986). Nitrates are especially toxic to children less than six months of age. The condition called "blue baby syndrome" (methemoglobinemia) may occur. Pregnant women may be less able to tolerate, and nitrate in the milk of nursing mothers may affect infants directly. These persons should not consume water containing more than l0ppm nitrate added directly to food products of beverages especially in baby formula (DEQ, 2011).High nitrate level in surface water contribute to algae blooms and may result in elevated levels of disinfection byproduct in treated drinking water which is linked to increased cancer and reproductive health risk in humans as well as liver, kidney and central nervous system problems (Stewart, 2011). Though the nitrate level in the river was far below WHO/FEPA-Nigeria standard limit and using it for drinking purposes may not be Avorrying to the health of the users, it would be more advisable to use the well water for drinking and preparing food especially for infants and pregnant women because nitrate was not detected in the wells studied and therefore would have no negative impact on their health.

The River Romi Upstream, and Downstream water was unable to meet up with the WHO standards. This shows that the quality of the River Romi Upstream Midstream and Downstream water is very poor and is not safe for domestic use importance of oxygen in water makes it essential to be able to measure the amount of oxygen required to oxidize impurities in the water, most of the oxygen demand use due to the oxidation of organic matter by microorganisms, but inorganic reducing agents e.g., hydrogen sulphide also consume oxygen. These various parameters are used to assess the oxygen demand of a sample. These are biochemical oxygen demand (BOD). Hardness is the sum total of Mg and Cal in a given solution. In the water the salt occur naturally by the properties of the refinery activities and soil. The quality of River Romi assessed is very poor and therefore not suitable for drinking based on the findings. Apart from the contribution of the the refinery's activities there is a lot of human activities that affect the quality of the River Romi water, activities such as the application of fertilizers on the soil percolate and filter downwards. The same goes for the River Romi down water. Very few ions passed the WHO standard and this is not suitable for domestic use based on the result of the experiment I carried out.

From the result presented in Appendix I, table 1 compares some of the parameters with the effluent specification of the WHO Standard for petroleum refineries. It is quite obvious that these parameters are averagely higher than the stipulated specifications and this is as a result of more chemicals introduced into the refinery system which produces more contaminants that causes pollution to our water resources which is vital to human and ecological survival.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

After the treatment of liquid effluent from the refinery, it is then discharged into the River Romi Down close to the Refinery which happen to be the point of effluent disposal after treatment. The refinery After discharges about 3.600m3 per day of effluent into this river (Romi Down) which is used for Domestics, consumption and farming by the local inhabitants of the area. The analysis was carried out in the water quality section of the chemical laboratory of the Kaduna environmental protection authority (KEPA). It was carryout during the Turnaround Maintenance (TAM) of the refinery because of the high production expected during the period after which the exercise will have been undertaken. There will be no production in the refinery during the period in the month April, May and June.

The sample Kaduna refinery and River Romi water was assessed with reference to the effluent parameters to determine the quality changes in the River Romi water. From the result present in table 4. 3 compared the refinery effluent specifications with the standard of the WHO/NESREA. It is therefore obvious that the Kaduna refinery has impact on the River Romi and also anthropogenic activities. Hydrocarbons present in the water are averagely higher than the stipulated. specifications which mean the water quality is very poor and therefore not suitable for and domestic use. the study considered the physico-chemical properties of water Kaduna refinery upstream, downstream and at discharge point of effluents. Heavy metals are compared with NESREA and WHO standard. It also analyzed questionnaire results on effluents discharge effects on human activities.

The study found out that river Romi has become contaminated by the KRPC effluent discharge into it over time. The results also shows that many of the physico-chemical parameters measured were above NESREA (2007) and WHO (2006) stipulated standards for most sampling points like Electrical Conductivity with values 83.7 µm/cm at Kaduna refinery,70.1µm/cm upstream,96.1µm/cm at discharge point and 76.1µm/cm downstream, also Total Dissolve Solid with values 150mg/l upstream, 195mg/l at discharge point and 147mg/l downstream, while Lead with values 0.001mg/l upstream, 0.001mg/l at discharge point and 0.001mg/l downstream With the result obtained, the effects may destabilize the balance of the ecosystem and the river cannot be relied upon for various human activities. There is difference (variation) of concentration of the pollutants between the Kaduna refinery upstream, effluent discharge point and downstream. Despite the fact that the refinery has a wastewater treatment plant, the waste released into the river from the refinery contaminates the water. The average age of the respondents was 44.1 years in the age group 26 - 45 years. The respondents in the age bracket of 15 - 25 years constituted 19.87% and 26 - 45 years constituted 21.71%, while the age group of 46 - 60 years constituted 58.41%.The levels of education of the respondents were as follows; 56.57% had secondary education, 22.32% had primary education and 17.43% of the respondents did not attend any formal educational institution while about 3% of the respondents had post-secondary education. It is obvious that majority of the farmers in the study area have secondary school certificate which shows that they are not well trained.

Location of the farmlands of the respondents revealed that 65.1% of the respondents have their farmlands located along the river bank and 34.9% of the respondents have their farmlands located at the uplands. The results show that 32.72% of the respondents have been farming their land for at least 30 years, 22.32% have 6 - 10 years of farming experience of their land and 21.10% of the respondents have been farming their lands for 11 - 20 years and at least 30 years constitutes the majority of the farming experience in the area. This proofs that most of the farmers in the study area have been farming for a very long time.

5.2 Conclusion

In general, the quality evaluation of River Romi located near the KRPC Refinery Kaduna reveals that 89% of the sampled water not suitable for domestic use. This is not acceptable by the world health organization (WHO) standards on reliability and suitability as far as its consumption is concerned. The results showed variations in the parameters studied. ANOVA showed a Significant difference ($P < 0.05$) in parameters between kaduna Refinery and River Romi. From the T-test table indicate that the parameters have a significant effect on the River Romi.thus Sulphide = 0.015 $P< 0.05$(in Table 4.3).The variations in the studied parameters are influenced by location of the Refinery activities, time of sampling and other human activities such as laundry, rearing of animals, fishing and other agricultural inputs from the irrigation carried out around the settlement. It is therefore important that water quality monitoring is carried out periodically to ensure the healthy growth of the citizenry. Activities that can introduce pollutants into water bodies should be discouraged as the pollutants have the ability to get into the food chains causing detrimental effects on the consumers. Conclusively Kaduna Refinery has an impact on the River Romi and also the human activities too we then say it's not suitable for domestic use.

From the above results and discussion it becomes an indisputable fact to say that the water in, River Romi has been contaminated by effluent discharge from the refinery, because there is difference of concentration of the pollutants at the Kaduna refinery up stream, point of entry and downstream, despite the fact that the refinery has a waste water treatment plant, the waste released into the river from the refinery contaminates the water. Many of the parameters measured are still higher than the acceptable limit set by National Standard Nigeria and World Health Organization, it was found that these pollutants present in the river reduce the effects of solar energy absorption, resulting in a lower rate of photosynthesis and slows down natural water purification processes and the long effect of this is environmental degradation. Kaduna Environmental Protection Authority (KEPA) should ensure that Kaduna refinery complies with Federal Environmental Protection Agency and National Standard Drinking Water Quality guidelines of industrial effluent discharge.

The study analyzed water samples from River Romi, It was observed that River Romi has been contaminated by the effluents discharged from the refinery. results show that despite the 5km distance which would have enhanced rapid purification many of the parameters measured were high above the permissible limits set by NESREA and WHO for instance temperature with value 34oC for upstream and downstream and37oC at discharge point instead of 30oC by both NESREA and WHO, also turbidity with value 147NTU Kaduna refinery 11.1NTU upstream, at discharge point and 44.79NTU downstream instead of 10NTU by both NESREA and WHO. The result indicated that all samples collected at the collection points Kaduna refinery upstream, downstream and at discharge point varies in pollutants concentration, especially with the downstream of the river being more polluted than the upstream. Also the effluent discharge point show high levels of pollutants for physico-chemical parameters and heavy metals emanating from the effluents discharged by the refinery in particular, pH,TDS, Turbidity,

BOD, Nitrate, Iron, Lead. The results from the administered questionnaires reveal that the farmers have been experiencing decline crop outputs from their farmlands despite the application of fertilizer and the farmers attribute it to the polluted nature of water from river Romi. The inhabitant of the area accuses the refinery of polluting the source of the water upon which they depend on for drinking and other domestic purposes. The farmers believe that the effluent discharge is responsible for the reduction and death of fishes in the river, and diseases in the study area. Therefore the effluent discharges in River Romi affect negatively the socio-economic activities of the nearby communities which conform with the study of Lekwotet al (2012) in River Romi.

5.3 Recommendations

In order to meet the requirements of NESREA and WHO regulatory guidelines and standards it is recommended that KRPC implements the following recommendations;

Kaduna Environmental Protection Authority (KEPA) should ensure that Kaduna Refinery complies with Federal Environmental Protection Agency and National Standard Drinking Water Quality guidelines of industrial effluent discharge.

The waste water treatment plant of KRPC should be rehabilitated and the clean water retention pond cleared so that waste water should be pre-treated before discharging into the river.

Efforts should be made by KRPC to ensure that the effluent quality meets standards, since it is used for irrigating farms during the dry season agriculture, in order to avoid bioaccumulation of toxic pollutants in the agricultural products. Romi River effluents should be sampled weekly or at regular interval and the result of the effluents quality should be reported in newspapers.

Proper orientation should be given to farmers and communities in the study area on the effect of chemical inputs on water quality.

(a). It is mandatory for all industries which generate treatable waste to treat it according to FEPA

set standards before discharging it into the environment.

(b). It is mandatory for new industries and for any expansion work in existing industries to Prepare and submit environmental impact assessment (ETA) to FEPA. For review and approval before the new project or expansion is embarked upon. Records of all disposal (liquid) treatment and disposal must be remitted to the nearest community within twenty-four hours.

(c) Industries should draw up a contingency plan to deal with accidental spillage of hazardous wastes and should report such incidence promptly to the nearest FEPA's office.

(d) The operations of the Refinery should be closely monitored with greater enforcement of Guidelines and Policies as stipulated by Government Environmental Agencies

5.4 Contribution to Knowledge

The study has contributed to knowledge as follows:

All most the physiochemical parameters of the River Romi were within the WHO limits excluding factors such as temperature ranging along 32.0°C and turbidity within 147mg/L. During this ground breaking research, we made previously unknown information to all those who wished to have a deeper understanding of man's relationship with aquatic bodies. We discovered that the refinery pollutes the River Romi, the major source of water for the host community. The host community depend on this River for portable water for drinking,cooking,washing,irrigation and livestock watering. The host complained further that they have been loosing their livestock through drinking and the plants are withering not yielding as it should as a result of the pollution from refinery effluent. Visibly the point of effluent which is the mid stream is mouldy and no living organism was sighted in the water and also the plants are not growing properly. In addition it was observed that the effects of the pollution is so severe that the majority of the inhabitants are compelled to abandon their traditional occupation for other activities. These information were not made known to people not until now, a lot of people are not even aware that River Romi is used by the host community (Romi and Rido) without any form of purification, hence it is unsafe for use and this was proven from effluent analysis carried out at the KEPA laboratory as a result of the refinery effluent disposal into River Romi.

5.5 limitations to the study

The research Effects of Kaduna Refinery And Petrochemical Company effluent on River Romi Water Quality Kaduna State Nigeria was largely dependent on cooperation from the host community who happened to be mostly illiterate. The research was further hindered by the fact that they were no previous detailed research conducted on the River this made collation of information extremely cumbersome and tasking as there were no past precedents. There were also financial limitations that did not allow the research to be conducted optimally. Time was another major factor, as the research was subject to human and natural variables.

5.6 Suggestion for further study

Detailed research should be carried out on the suitability of the River Romi for domestic use, taking into consideration the physical and chemical parameters along with heavy metals to determine the adverse effect of this aquatic body. The research should also cover well being of the aquatic organisms. Sustainable Development Goals (SDG) should also be carried for the host community to enlighten them about the River Romi and equipping them with the knowledge on treatment of water for domestic Use.

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APPENDIX II

NASARAWA STATE UNIVERSITY, KEFFI

FACULTY OF SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY

RESEARCH QUESTIONS FOR ROMI/RIDO COMMUNITY

This questionnaire is designed to obtain information for a research study titled: The Effect of Kaduna Refinery Effluents on Water Quality of Romi River, Kaduna State. Please fill in or tick where appropriate.

1. Name of community or village…………………………………………………..
2. Age ………………………………………………………………………………
3. Educational status: (a) primary school (b) secondary school (c) ND/NCE (d) HND/B SC (e) PGD/MSC. (f) No formal education
4. Occupation (a) Civil servant (b) Farmer (c) Trader (d) Herdsman (e) Others

6. How long have you been farming (a) 1-5yrs [ ] (b) 6-10yrs [ ] (c) 11-15yrs [ ] (d) 16-20yrs [ ] (e) 21yrs and above [ ]

7. Where is the location of your farmlands upland [ ] river bank [ ] others................

8. How would you assess your crop output

9. Do you use Romi river for irrigation [ ] fishing [ ] bathing/Swimming [ ] cooking [ ] drinking [ ]

10. (a) Do you notice any absence or decline in species? Yes [ ] No [ ]

(b) lf there is any absence or decline in the species, population and length, then what is the Problem (a) oily nature of the water [ ] (b) reduction of water volume [ ] (c) others [ ]

11. Have these changes affected your yield (a) Yes [ ] (b) No [ ]

12. Have people or animals died as a result of drinking water from river Romi?
Yes [ ] No [ ]

13. Have you noticed or heard of someone that contacted disease due to bathing or swimming in Romi river Yes [ ] No [ ]

APPENDIX III

COMPARISON OF DIFFERENT MEASURED PARAMETERS IN THE FOUR STUDIED SITES

	KD Refinery	Mid Stream	Upstream	Down Stream	F (ANOVA)	Pvalue
PH	7.0433±0.61906	5.3333±0.12662	7.0433±0.61906	7.0433±0.61906	7.525	0.010 *
Temperature	29.733±3.9260	25.433±0.3055	27.400±3.9850	27.400±3.9850	0.785	0.535
Conductivity	310.800±395.9497	69.967±44.8319	310.800±395.9497	310.800±395.9497	0.368	0.778
Turbidity	65.9633±71.61492	21.2700±20.49062	65.9633±71.61492	65.9633±71.61492	0.379	0.771
Sulphate	13.33±32.146	-0.33±2.082	13.33±32.146	13.33±32.146	0.181	0.907
Nitrate	1.067±1.0693	0.233±0.0577	1.067±1.0693	1.067±1.0693	0.607	0.629
Ammonium	0.6500±0.44193	0.1167±0.02309	0.6500±0.44193	0.1800±0.03464	2.586	0.126
Phosphate	9.067±11.3143	5.767±5.4262	9.067±11.3143	2.067±1.8475	0.462	0.717
Sulphide	0.0040±0.00361	0.000±0.000	0.0040±0.00361	0.0030±0.00265	1.303	0.339
Total Hardness	58.67±39.311	26.67±7.572	58.67±39.311	58.67±39.311	0.655	0.602
Calcium	30.00±10.392	15.33±11.372	30.00±10.392	30.00±10.392	1.424	0.306
Magnesium	28.67±28.937	11.33±7.024	28.67±28.937	14.00±4.000	0.597	0.635

Alkalinity M	94.00±57.236	34.67±18.583	94.00±57.236	80.67±34.196	1.179	0.377
Lead	0.00100±0.00	0.00100±0.00	0.00100±0.00	0.00100±0.00	.	.
Arsenic	0.00100±0.00	0.00100±0.00	0.00100±0.00	0.00100±0.000	.	.
Iron	1.3133±1.76381	0.2967±0.00577	1.3133±1.76381	0.2967±0.00577	0.664	0.597
Total dissolve	186.67±7.638	174.33±5.132	161.00±11.533	149.00±1.732	14.471	0.001 *
BOD	170.35±0.30	160.15±0.13	170.52±0.00	170.173±0.30	1576.314	0.000 *

*Statistically significant

PH: There was a statistically significant difference in the pH of the water samples in the four sites (P<0.05). The PH of the water sample from Mid Stream (5.33)was statistically lower to those of the other sites.

Temperature: No statistically significant differences was not shown in the Temperature of water sample in the four sites, however Kaduna Refinery (29.73) had the highest temperature of water sample.

Conductivity: The result of electrical conductivity (EC) showed no statistically significant difference (P>0.05) in the four studied sites, but Mid Stream level of electrical conductivity was the lowest of the four sites.

Turbidity: The turbidity levels of the four sites did not exhibited statistical difference(p>0.05) However, mid stream turbidity level was the lowest of the four sites.

Sulphate: There was no statistical significant difference in the sulphate levels in the four sites(P>0.05)

Nitrate: The nitrate of the Mid stream site was the lowest of the four sites, but the difference was not statistically significant when compared with other sites (p>0.05).

Ammonium: The ammonium levels in the KD refinery and that of the upstream were higher than that of the Mid stream and down stream but their was no statistically significant difference in the mean levels (P>0.05)

Phosphate: The phosphate level of the down stream was the lowest of the four studied sites, however there was no statistically significant difference in the phosphate level in the four sites (P=0.717).

Sulphide: The sulphide level of KD refinery and upstream were higher than the other two sites, but there was no statistically significant difference in the sulphide levels in the four sites.

Total Hardness: There was no statistically significant difference in the measured total hardness in the four studied sites (P=0.602)

Calcium: The calcium level of Mid stream was the lowest of the four sites, however, there was no statistically significant difference in the calcium level of the four sites (p=0.306).

Magnesium: There was no statistically significant difference in the magnesium levels in the four sites (p=0.635) The magnesium level of mid stream was the lowest of the four sites.

Alkalinity M: The level alkalinity of KD refinery and upstream were the highest of the four sites, but there was no statistically significant difference in the level of alkalinity in the four sites (p>0.05).

Iron: The iron level in the mid stream and down stream were the lowest of the four studied sites, and there was no statistically significant difference in the iron levels in the four sites (p>0.05)

Total dissolve: There was a statistically significant difference in the Total dissolve solid (TDS) results observed in the four sites (P<0.05). The TD level of KD refinery was the highest of the four sites.

BOD: Biological Oxygen Demand **(**BOD) measured in the four sites showed there was a statistically significant difference (P<0.05). The BOD level of mid stream was the lowest of the four sites.

SEASONAL COMPARISON OF DIFFERENT MEASURED PARAMETERS

	Dry season	Raining Season	T-test	Pvalue
PH	6.4550±0.86683	6.9375±1.00500	0.749	0.407
Temperature	27.775±3.5005	26.925±3.3994	0.400	0.698
Conductivity	332.550±361.3190	86.675±5.9500	1.764	0.214
Turbidity	77.0825±58.75850	10.2050±1.95000	4.933	0.050
Sulphate	15.13±29.216	-0.50±1.000	1.089	0.321
Nitrate	1.113±0.9891	0.350±0.1000	2.254	0.164
Ammonium	0.5300±0.40263	0.1375±0.00500	3.620	0.086
Phosphate	7.863±8.7995	3.750±5.5000	0.713	0.418
Sulphide	0.004125±0.0027484	0.0000±0.00000	8.582	0.015*
Total Hardness	59.50±37.428	33.00±2.000	1.907	0.197
Calcium	29.00±12.604	21.00±6.000	1.399	0.264
Magnesium	25.00±23.176	12.00±4.000	1.183	0.302
Alkalinity M	86.50±52.718	54.50±19.000	1.330	0.276
Lead	0.00100±0.000000	0.00100±0.000000	.	.
Arsenic	0.00100±0.000000	0.00100±0.000000	.	.
Iron	1.0613±1.41265	0.2925±0.00500	1.128	0.313
Total dissolve	166.50±17.550	170.25±14.637	0.134	0.722
BOD	167.8825±4.72663	167.6300±5.09257	0.007	0.934

*Statistically significant

PH: There was no statistically significant difference in the level of PH in the dry and raining seasons (p=0.407) however, the PH level in the raining season was higher.

Temperature: The temperature in the dry season was higher than the raining season, but the difference was not statistically significant (p=0.698)

Conductivity: The conductivity level in dry season was higher than the raining season however, the difference was not statistically significant.

Turbidity: The turbidity level in dry season was higher than in the raining season, and the difference was statistically significant (p=0.05)

Nitrate: There was no statistically significant difference between the levels of nitrate in the dry season and raining season. The Nitrate level in the dry season was higher than in the raining season.

Ammonium: The ammonium level in dry season was higher than in the raining season but the difference was not statistically significant (P=0.086)

Phosphate: There was no statistically significant difference in the phosphate levels in the dry and raining seasons. However, the phosphate level in the dry season was higher than in the raining season.

Sulphide: The sulphide level in the dry season was significantly higher than in the raining season (p=0.015)

Total Hardness (TH): There was no statistically significant difference in the TH level between dry and raining seasons (p=0.197). However, TH level in dry season is higher than in the raining season.

Calcium: The calcium level in the dry season was higher than in the raining season, but the difference was statistically significant (p=0.264)

Magnesium: The magnesium level in the dry season is higher than in the raining season, but the difference is not statistically different (P>0.0)

Alkalinity M: The level of alkalinity level in dry season was higher than in the raining season, however the difference was not statistically significant (p>0.05)

Iron: The iron level in dry season was higher than in the raining season, but there was no statistically significant difference between the two seasons (p>0.05)

Total dissolve: There was no statistically significant difference in the level of TD in dry and raining seasons, however, TD level in the raining season were higher in the raining season than in the dry season.

BOD: The level of BOD in the dry season and in the raining season were almost at the same level, and there was no statistically significant difference in their levels.