

**EFFECTS OF KADUNA REFINERY EFFLUENT ON THE WATER QUALITY OF
ROMI RIVER, KADUNA STATE, NIGERIA**

BY

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(M.Sc. ENVIRONMENTAL MANAGEMENT)**

**A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE
STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE AWARD OF A MASTER DEGREE IN
ENVIRONMENTAL MANAGEMENT**

**DEPARTMENT OF GEOGRAPHY,
FACULTY OF SCIENCE,
AHMADU BELLO UNIVERSITY,
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JANUARY, 2016

DECLARATION

I declare that the work in this Thesis entitled “**Effect of Kaduna Refinery Effluentson Water Quality of Romi River, Kaduna State, Nigeria**” has been carried out by me in the Department of Geography. The information derived from the literature has been duly acknowledged in the text ad a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

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Signature

Date

CERTIFICATION

This entitled dissertation EFFECTS OF KADUNA REFINERY EFFLUENT ON THE WATER QUALITY OF ROMI RIVER, KADUNA STATE, NIGERIA by Laraba Susan ISHAYA meets the regulations governing the award of the degree of Master of Science in Environmental Management of the Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This research work is dedicated to my beloved husband late Dr Danladi Bardidawi Mshelia
'the best husband a woman will always want, Continue to rest with the lord till I come.

ACKNOWLEDGEMENTS

To God be the Glory! For indeed, everything that has a beginning has an end, therefore not to acknowledge the assistance I received from all those whom I have consulted and who have contributed in one way or the other towards making this research a reality would be impossible. I can say that I have at all times been helped by others who without their goodwill and interest, this research would not have been possible.

I like to start by expressing my unquantified gratitude and sincere appreciation to Professor E.O. Iguisi, Chairman of the Supervisory Committee. In spite of his tight schedules, he was able to find time to go through even the minutes of details in this work. For this, I have learnt a great deal. I also owe Dr B.A. Sawa a Member of the Supervisory team, a depth of gratitude for his numerous contributions and constructive criticism through proposal to the final report. The numerous relevant materials obtained from them cannot be forgotten. I also appreciate the encouragements given by Dr B.A. Akpu, Dr Y.Y. Obadaki, Dr R.O. Yusuf to mention a few.

I also appreciate the support and assistance rendered in a various ways by members of staff of Geography Department, the librarian Mallam Lawal and Mr Ezekiel.

I also wish to extend my gratitude to some members of staff of Kaduna State Environmental Protection Authority (KEPA) who lent me the instrument I used in collecting data for this research. I must sincerely thank Mr. Musa Kulausa Hena for his effort in the data collection. I must also mention Mathew Habila, Gamalia Steven, my colleagues and friends in Geography Department A.B.U., Zaria, whom I always consulted over issues that puzzled me and unfaithfully came to my aid, may God crown your efforts with success.

I owe a debt of gratitude to all members of my family for their support, help, encouragement and prayers. Also my sincere appreciation and gratitude to my In-laws Mr & Mrs B. Mshelia, Dr K. Mshelbwala, Dr & Mrs P. Mshelbwala, Engr. & Dr Mrs I. Mshelia for their understanding, prayers, support and encouragement, I love you people.

I am eternally grateful to my late husband. We started together right from the inception of this topic till the Lord Jesus called you home. You've been there always.

Finally, it would be ungrateful to forget any but it would be impossible to remember all, so to those whose names did not appear, it is not an act of discrimination. For those who take time in reading this research work, may Almighty God bless you.

ABSTRACT

The study examined the effects of Kaduna refinery effluents on water quality of River Romi Kaduna State. The study was conducted within three (3) months and aimed at assessing the effect of KRPC effluent on water quality of the river before, after and at the point of discharge, effect on farming, swimming and fishing activities. A structured questionnaire was designed to source information from farmers and the physico-chemical parameters and heavy metals were analysed using Atomic Absorption Spectrophotometer. The before and after the point of discharge mean values for pH 7.45 and 6.72, Temperature 34°C and 34°C, TSS 68mg/l and 96.0mg/l, TDS 300mg/l and 324mg/l, Turbidity 12NTU and 16 NTU, Colour is light brown, Oil and grease 2.7mg/l and 4.7mg/l, BOD 3.45mg/l and 4.37mg/l, COD 45mg/l and 66mg/l, DO 6.7mg/l and 6.4mg/l, NO₃ 0.2mg/l and 0.7mg/l, Cu 0.2mg/l and 0.36mg/l, Fe 0.93mg/l and 0.2mg/l, Zn 0.27mg/l and 0.36mg/l, Pb 0.221mg/l and 0.228mg/l, Cd 0.022mg/l and 0.024mg/l, As 0.045mg/l and Cr 0.22mg/l and 0.21mg/l were estimated. The laboratory results were compared with the permissible limit allowed by NESREA and WHO and the result reveals that pH, Oil and grease are within the standard at upstream and downstream but deviates at discharge point while Temperature, EC, TSS, TDS, Turbidity, COD, Pb, Cd and Cr at all the three sampling sites are above NESREA and WHO standard. DO, NO₃, Fe, Cu, and Zn values are within the permissible limits also Colour is light brown at upstream, downstream and at discharge point. Statistical techniques were employed in the analysis of the data collected from the respondents to determine the effect of the effluents and the results revealed that River Romi has become contaminated by the effluents discharged. It was observed that the farmers have been experiencing reduction and loss of fish production. The solution proffered includes rehabilitation and cleaning of effluent water retention pond so that effluents water should be treated before discharge. KEPA and NESREA should ensure compliance with national standard for drinking water quality guidelines.

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CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Water is a natural resource of fundamental importance; supports all forms of life and creates jobs and wealth, tourism, recreation and fisheries (Ntengwe, 2005). Without water life as it exists on our planet is impossible (Asthana and Asthana, 2001). Water is an important geomorphic agent playing a significant role in weathering the most important energy regulator in the heat budget of the earth (Ayoade, 1988). Freshwater therefore, is a renewable resource, yet the world's supply of clean, freshwater is steadily decreasing. Water demand already exceeds supply in many parts of the world, and as world population continues to rise at an unprecedented rate, many more areas are expected to experience this imbalance in the near future (Wikipedia, 2008). The demand for freshwater has increased with the ever increasing population in the world. About half of the people that live in developing countries do not have access to safe drinking water and 73% have no sanitation and some of their wastes eventually contaminate their drinking water supply leading to a high level of suffering (Vivian, Bashiru, and Adamu, 2012).

According to the World Commission on Water for the 21st century, more than half of the world's major rivers are so depleted and polluted that they endanger human health and poison surrounding ecosystems. When wastewater finds its way into any water body, it pollutes the water. Water pollution is primarily associated with domestic and industrial waste. Both types of waste-water pose threats to water quality which may be classified into health hazards and sanitary nuisances. Each day some 25,000 people are said to die

from their everyday use of contaminated water, and many millions more suffer from frequent and devastating water borne illnesses (WHO, 2004).

Water pollution occurs when unwanted materials with potentials to threaten human and other natural systems find their way into rivers, lakes, wells, streams, boreholes or even reserved fresh water in homes and industries. These pollutants include pathogens, silt and suspended solid particles such as soils, sewage materials, disposed foods, cosmetics, automobile emissions, construction debris and eroded banks from rivers and other waterways. Some of these pollutants are decomposed by the action of micro-organisms through oxidation and other processes.

Throughout the world, the provision of water to meet human use standard are essential requirements. Unfortunately, the process of analysing and monitoring water supply can be costly and time consuming. ELE International Ltd (1991), defined water quality by physical, chemical, and organic parameters while the United State Environmental Protection Agency (2004) attest that water standards are the foundation of water quality based control programme mandated by the Clean Water Act Version of November 27, 2002.

The coastal residential environment in any industrial effluent site is always under considerable stress due to the prevailing harsh environmental conditions, especially high temperature and salinity, restricted benthic fauna diversity and overall development of a fragile intertidal ecosystem. The fauna inhabiting the intertidal zone is most likely dominated by a few species probably living at their limit of tolerance. Organic pollution is always evident and the pollution is made worse by land-based sources such as the occasional discharge of raw sewage

through stormwater outlets, and industrial effluents from refineries, oil terminals, and petrochemical plants. Fish production from inland water resources (rivers, lakes and streams) is under threat from pollution, habitat alteration and degradation, changes in river flows and over-exploitation (Gupta, 2006). These effluents from industries have a great deal of influence on the pollution of the water body. The effluent can alter the physical, chemical and biological nature of the receiving water body.

Increased industrial activities have led to pollution stress on surface waters both from industrial, agricultural and domestic sources. Wastes entering these water bodies are both in solid and liquid forms, and mostly derived from industrial, agricultural and domestic activities. As a result, water bodies which are major receptacles of treated and untreated or partially treated industrial wastes have become highly polluted. The resultant effects of this on public health and the environment are usually great in magnitude. (Reza, Jain and Singh, 2010).

Over the last years, in many African countries, a considerable population growth has taken place, accompanied by a steep increase in urbanization, industrial and agricultural land use, which has led to a tremendous increase in discharge of a wide diversity of pollutants to receiving water bodies and has caused undesirable effects on the different components of the aquatic environment and on fisheries. As a result, there is growing appreciation nationally, regionally, and globally, that the management and utilization of natural resources need to be improved and that the amount of waste and pollution generated by human activity need to be reduced on a large scale. (Saad, El-Rayis and Ahdy, 1984; Osibanjo, Daso and Gbadebo, 2011).

The sources of water pollution vary and involve almost every significant human activity. These include mostly the dumping of domestic wastes, sewage, agricultural wastes and industrial effluents into water bodies. However, industries are the major sources of pollution in all environments. Based on the type of industry, various levels of pollutants can be discharged into the environment directly or indirectly through public sewer lines. Wastewater from industries include employees' sanitary waste, processed wastes from manufacturing, washed waters and relatively uncontaminated water from heating and cooling operations (Glyn and Gary 1996).

High levels of pollutants in river water systems causes an increase in Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), toxic metals such as Cyanide (Cn), Cadmium (Cd) Chromium (Cr), Nitrate (NO_3) lead (Pb) and fecal coliform hence makes such water unsuitable for drinking, irrigation farming and aquatic life. Industrial wastewaters possess biochemical oxygen demand (BOD) from biodegradable wastes such as those from human sewage, pulp and paper industries, slaughterhouses, tanneries and chemical industry. Others include those from plating shops and textiles, which may be toxic and require on-site physico-chemical pre-treatment before discharge into municipal sewage system.

(Emongor, Kealotswe, Koorapetse, Sankwase, and Keikanetswe, 2005; Phiri, Mumba, Moyo, and Kadewa, 2005; Otokunefor and Obiukwu, 2005).

Industrial effluents are characterized by their high turbidity, electrical conductivity and Chemical Oxygen Demand (COD). By

characteristics, one of the prominent quality indices of concern in the water sources of Nigeria as a developing nation is the microbial quality. According to WHO (1968), in developing countries, the incidence of typhoid fever, bacillary dysentery, amoebiasis, infectious hepatitis and other enteric infections that may be transmitted by water is often 10 to more than 100 times compared with the advanced countries.

According to Wotton (1992), material pollution of rivers is caused by toxic pollutants (heavy metals, phenols, insecticides etc) that have direct adverse effect on aquatic biota and by pollutants that indirectly affect aquatic biota like human and animal waste which are not toxic but due to bacterial action on them, dissolved oxygen is used up which harms aquatic biota. In many places both surface and groundwater is fouled with industrial, agricultural, and municipal wastes. Industrial water pollution also leads to severe economic and social consequences such as the destruction of fish life by poisonous substances or excess organic loads that reduce the Dissolved Oxygen (DO) in the water to critical level or impair with the chemical content of the water so that it cannot be used for agricultural purposes, or render the water unsafe for recreational activities like swimming. Individuals affected by these results include fishermen who may lose their source of livelihood.

The Kaduna Refinery and Petrochemical Company of Kaduna also known as Kaduna Refinery is the major factory that drains its wastes into the Romi River. The petroleum refining industry is primarily engaged in the manufacturing of fuel, lubricants and petrochemical intermediates, using petroleum as a principal input material (Austin, 2010).

1.2 STATEMENT OF THE RESEARCH PROBLEM

Industrial effluent contamination of natural water bodies has emerged as a major challenge in developing and densely populated countries like Nigeria. In this regard, the river systems are the primary means for disposal of waste, especially the effluent from industries that are located closer to the river. As such, the estuaries and inland water bodies, which are the major sources of drinking water in Nigeria are often contaminated by the activities of the adjoining populations and industrial establishments.

In Nigeria today, the provision of water for domestic and other uses in rural and urban centres is one of the most intractable problems. Also, one of the most critical problems of developing countries is improper management of vast amount of wastes generated by various anthropogenic activities. More challenging is the disposal of these wastes into the ambient environment. Water bodies especially freshwater reservoirs are the most affected. This has often rendered these natural resources unsuitable for both primary and secondary usage (Nsiah-Gyabaah, 2003).

Effluent discharge practices in Nigeria are still very crude and thus possess danger to the society especially in the industrialized part of cities. The National Environmental Standard and Regulatory Enforcement Agency (NESREA) established to check these environmental abuses has had little impact on pollution control in our cities. Population explosion, haphazard rapid urbanization, industrial and technological expansion, energy utilization and waste generation from domestic and industrial sources have

rendered many water resources unwholesome and hazardous to man and other living resources. Water pollution is now a significant global problem (Ezeronye and Amogu, 1998).

Kaduna refinery comprises of numerous operations and as a result, many pollutants are generated which are toxic to the environment. These pollutants (effluents) are supposed to be broken down into non-toxic forms before they are disposed into the environment (land, air and water). When a river is used for the discharge of waste or when it receives drainage from agricultural land, its water quality may register a change because a river has only a limited capacity to absorb waste (UNESCO and WHO, 1978; Austin, 2010).

In Nigeria today research indicates that, majority of the common freshwater sources are polluted, resulting in serious outbreak of diseases. Several studies by Umeh, Amali and Umeh, 2004; Jaji, Bamgbose, Odukoya and Arowolo, 2007; Olaoye and Onilude, 2009; Yusuf and Shuaibu, 2009; Garba, Hamza and Galadima, 2010) on different aspects of water quality and pollution in different parts of Nigeria have revealed various levels of negative impacts of anthropogenic activities on the environment. For example, a study by Umeh, Amali and Umeh (2004) showed that 48% of the people in Katsina-Ala Local Government area of Benue state are affected by urinary schistosomiasis, due to increase in water pollution index. Some previous investigations indicate that 19% of the whole Nigerian population is affected with urinary schistosomiasis, some communities having up to 50% incidence. This has raised serious concerns by the World Health Organization, in an attempt to improve cultural and socio-economic standards of people in the tropical region.

Jaji, Bamgbose, Odukoya and Arowolo(2007) examined the water quality of Ogun River, in which industrial effluent from Lagos and Abeokuta is discharged. It was reported that the level of turbidity, oil and grease, faecal coliform and iron were very high in all the sampling sites.

Furthermore, Israel, Both, Umere, Mkpem and Ebong (2008) also observed the ineffectiveness of water purification system and remarked that waste waters may become seriously dangerous, leading to the accumulation of toxic products in the receiving water bodies with potentially serious consequences on the ecosystem.

In another study, Olaye and Onilude (2009) documented varying levels of microbial contaminations in drinking water from western parts of the country. Total bacteria and coliform counts were found to be between 2.86-4.45 and ≤ 1.62 log cfu/ml respectively. In addition to microbial infections, heavy metal poisoning through drinking water have also been documented. Similarly, Garba, Hamza and Galadima (2010) reported a mean Arsenic concentration of 0.34 mg/l in drinking water from hand dug wells, boreholes and taps of Karaye Local Government area, Kano state. The arsenic levels are of serious concern to regulatory agencies because they far exceed the upper band (0.01 mg/l) recommended by WHO.

Yusuf and Shuaibu (2009) also studied the effect of wastes discharge on the quality of Samaru stream, in Zaria. Using Standard analytical methods in investigating the parameters, they observed that among all the parameters investigated only colour levels were observed to be above the maximum permitted level as specified by the Nigerian Standard for Drinking Water.

While the studies cited above have been conducted to analyse the different aspects of water quality, none of these studies, to the best of the researcher's knowledge, has investigated how industrial discharge affects the water quality of Romi River and the economic activities of the area. The focus of this study therefore is to assess the effects of industrial effluents discharge on the water quality of Romi River and the economic activities of Romi communities in Chikun Local Government Area of Kaduna state.

Specific questions that the study seeks to address are:

- i. What is the nature of effluent discharged by the refinery into the Romi River?
- ii. What are the effects of this wastewater on the human activities (swimming, fishing and domestic uses)?

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of the study is to assess the effects of the discharged effluent from Kaduna refinery on the water quality of Romi River. The stated aim are to be achieved through the following set objectives:

- i. assess the level of pollution of Romi River before and after the point of discharge of the effluent in terms of physicochemical parameters such as pH, BOD, COD, DO, TDS, TSS, NO₃, Fe, Cu, Zn, Pb, Cd and Cr in the study area.
- ii. compare the concentration of pollutants in the water with the acceptable limits of WHO(2006) and NESREA(2007) standard.
- iii. examine the effect of the effluents on some selected human activities in the study area.

1.4 SCOPE OF THE STUDY

The study focuses on the effect of Kaduna Refinery effluent discharge on water quality of Romi River through a tributary into the main Romi River. The study will assess the pollution status of the River Romi through the analysis of water samples before, after and at the point of discharge of the effluents. The research will only focus on evaluation of the effect of those water quality indicators discharged from the KRPC on the quality of water in River Romi and its effect on the people of Romi communities. The major water quality parameters to be investigated in this study include Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Colour, Odour, pH, Oil and grease, Nitrate, Iron Copper, Zinc, Lead, Cadmium, Arsenic, and Chromium at 5 km distance upstream and 5km distance downstream from the discharge point over a period of 90 days (April-june) for data collection.

1.5 JUSTIFICATION OF THE STUDY

The roles of rivers as medium of disposal and source of water for swimming, fishing, farming, domestic and industrial purpose, makes it necessary that they should be protected from any form of contamination. River Romi serves as a sink for industrial and domestic waste. Downstream, the river is used for irrigation, sand mining, laundry, swimming and livestock watering during the dry season. With all the waste discharged into the river, the water quality has progressively been deteriorating, posing health hazards and may affect the socio-economic activities of the users. When consumed or used, the water can have an adverse effect on the community or on the user. This justifies the need for water quality

evaluation of water bodies such as streams, river and lakes in order to identify the source region of the pollutants and to determine the true nature and quality of the water body.

Furthermore, heavy metals in the environment may accumulate unnoticed to toxic levels. Despite the relatively low level of industrialization in Africa, there is high potential for heavy metal accumulation in water. The challenges posed by heavy metals on human health are issues that need robust studies. A precise knowledge of toxic concentrations and physico-chemical properties provide a basis for careful water management, which will limit, as far as possible, the negative impact of toxic waste on the ecosystem.

CHAPTER TWO: CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 INTRODUCTION

This section deals with the various concepts and theoretical frameworks which were used to form the basis for this research work. Also relevant literatures were reviewed which provide suitable information for this study.

2.2 CONCEPTUAL FRAMEWORK

With growing concern for environmental protection, which has rapidly developed on a worldwide scale, the management and disposal of residues from industrial operations have assumed a critical role in the society. This is particularly important in the developing countries, many of which are undergoing rapid growth in their economies. Since the industrial sector is frequently the major element in such growth, the early consideration of the total environment as one entity will permit the coordinated management and protection of the air, water and land resources affected by such development (Sani, 2004).

The United States Environmental Protection Agency (USEPA, 2004), estimates that one out of every three kilometres of the stream in most developing countries are contaminated to some extent. Our rivers were not always in such deplorable condition, but primarily in the interest of our industrial-technological and economic growth, we have allowed our cities and industries to impinge heavily on human and aquatic habitat.

Water quality has become a subject of concern to every nation of the world, since without water life cannot exist (Adamu 2003), this is why it has been a subject of study in the world (Porter, 1973; Ademorati, 1983). Also Andrew (2004) emphasized that despite the fact that

water is in vast quantity, useful water is not readily available and is not sufficient to meet the demand of the people.

2.3 LITERATURE REVIEW

Demand for water supply is increasing especially due to population explosion. According to the Population Action International, another three billion people will be added to the planet within the next five decades and the demand for water has tripled between 1950 and 1990, and is expected to double in 35 years that is by the year 2015 (Soutari, 2003).

Apart from the shortage in quantity, the available fresh water is facing a serious challenge on quality. The quality of surface water is a factor of two variables that is natural and artificial impurities. Natural impurities can be through acidification of rainwater by carbon dioxide, surface runoff, and windblown dust etc while artificial is due to human activities such as domestic, industrial and agricultural discharge of toxic and other unwanted materials into the surface water thereby polluting the water and making it harmful for use.

The contamination of freshwaters with wide range of pollutants has become a matter of concern over the last few decades (Dirilgen, 2001; Vutukuru, 2005). The problem can be attributed to the process of rapid urbanization and industrial development over the last decades and these have been a subject of environmental concern. Rivers worldwide serve as recipient of great quantities of waste discharged by agricultural, industrial and domestic activities (Mimosa, 2007). Farvar and Milton (2009) edited the proceedings of the conference on: careless technology: which held at Geneva and commented that the advancements in present century technological development have not been met with desirable environmental

considerations. Consequently the element of nature especially soil, water, air, plant and animals are being degraded at an alarming rate.

The water quality of a river is influenced by many factors including atmospheric chemistry, the underlying geology, climate change and anthropogenic activities. Human activities such as the discharge of industrial and domestic effluents, the use of agricultural chemicals, land use and cover changes are the major factors that affect surface water quality (Peters and Meybeck, 2000; Buck, Niyogi and Tournsend, 2004; Alam, Elahiand Alkam,2006; Zhang *et al.*, 2007; Hem, 1995; Feller, 2007; Hussain, Ahmed and Abdurrahman, 2008; Raymond, Oh, Turner and Broussand, 2008).

Freshwater contaminants come from both organic and inorganic sources. Among the inorganic contaminants of river water, heavy metals are getting importance for their non-degradable nature and often accumulate through trophic level causing a deleterious biological effect (Jain, 1978). Heavy metals are regarded as serious pollutants of aquatic ecosystems, because of their persistence (Armitage, Bomes and Vincent 2007), toxicity, and ability to be incorporated into food chains (Forster and Wittman, 1983).

Recently, water quality monitoring has become a matter of concern in stream and river systems affected by careless disposal of urban effluents. Run-off, atmospheric deposition and domestic and industrial effluent discharges are the major sources of aquatic pollution (Wasswa, 1997; Linnik and Zubenko, 2000;Lwanga, Kansiime, Denny and Scullion, 2003; Lomniczi, Boemo and Musso, 2007).

Bunker (2005) in his study in Brazil, noted the persistent pollutants and observed that the ocean is the ultimate sink in which they accumulate. He noted further that some of these pollutants

are leached in the soil or carried to sea by rivers or directly into the ocean as domestic and industrial wastes. Some are dumped in the sea from shipboards or as direct consequence of ship operation and the atmosphere transport some over a great distance from the source before sedimentation on land or water.

The risk of acquiring a waterborne infection increases with the level of contamination by chemicals and pathogenic microorganisms. However, the relationship is not necessarily a simple one and depends very much on factors such as infectious dose and host susceptibility. Pollution reaches its most serious proportions in the urban-industrial centres of the more developed countries. In poor countries of the world more than 80% polluted water has been used for irrigation purpose in industrial urban and semi urban areas. Industry, clustered in urban and semi-urban areas surrounded by densely populated, low-income localities, continues to pollute the environment with impurity (European Public Health Alliance, 2009).

Okonkwo and Mothiba (2005) conducted a trace metal analysis of the surface waters from River Dzindi, Madanzhe and Mvudi in Thohoyandou, South Africa using a Varian Spectra AA 220 Atomic Absorption Spectrophotometer (AAS). The results show a seasonal variation in the concentrations of Cd, Cu, Pb and Zn. The concentration values for the wet season are generally higher than that of the dry season. This they attributed to runoff from land into the rivers during the wet season. It was also observed that the Pb concentrations in water samples from all the rivers were significantly higher than the values for the other metals in both wet and dry seasons. These high levels shown by Pb, they reported may be attributed to the deposition of Pb particulates on the roads next to the rivers especially during precipitation. The high concentrations of Pb in Madanzhe and Mvudi Rivers may also have been influenced by the effluents from the nearby sewage treatment plant and a waste dumping site. Also the

agricultural activities around the rivers may have contributed to the observed high levels of Pb and Cd levels, since these metals can occur as impurities in fertilizers and in metal-based pesticides and compost manure.

Sekabira, Oryemoriga, Basamba, Mutumba and Kakudidi(2010) have recently investigated the heavy metals concentration and contamination of the Nakivubo channelized stream water in Kampala, Uganda. The results revealed that the concentration of Pb, Cu and Mn have exceeded the WHO (2008) standard for drinking water in most of the sites and NEMA, (2006) maximum permissible limit of discharge of waste water into the environment (100µm/L).

In addition, water resources management studies and water quality in particular has been one of the areas that draw attention. Igusi (1999) reported the presence of heavy metals in the Kubani River with very significant concentration levels. Butu (2002) in his study on variation in concentration of selected heavy metals in the lower and upper regions of the GalmaDam, Zaria, reported the presence of heavy metals in high concentration within the Galma Dam.

2.4 NATURE OF TOXIC WASTE

Toxic waste is any waste that possess chemical characteristic, which has the potentials to poison human or the environment. It is usually in the form of sludge or effluent and originates from industrial activities.

An estimated 30-40 million metric tons of hazardous wastes, exclusive radioactive waste are generated each year in the world. This amount represents almost 15% of all industrial wastes and includes a very diverse array of substances. One in four of the metals in common use

such as lead, mercury and zinc are considered hazardous (Environmental Protection Agency 2002). Waste generated from factories varies as much as their raw materials and products. And to identify the types of toxic waste generated, it will be important to classify them according to the line of industrial production (Moran, Clayton, Lebhoocke and Fenton 1980).

2.5 PETROCHEMICALS

2.5.1 Laboratory process unit of KRPC

The Plant is not in full operation as per its initial installed capacity but a number of observations were made by Midland Consultancy (2013). The Alkylation unit still contains the Hydrofluoric acid and the area is not treated as if it still contains this hazardous acid. The safety sign indicating the presence of this acid is not in place. Barricade discouraging unauthorized staff entering into the unit is not in place. Most of the hazards associated with the area are still present. The radiation signs are also not in place. In the HDS, and the Compressor house most of the Hydrogen Sulphide detector have been removed from where they were installed. A good number of them are lying on the ground.

2.5.2 Waste water treatment unit (wwt) of KRPC

In both the Refinery plants and Laboratory the WWT plants are not working. In the refinery, the clean water retention pond is contaminated with oil and littered with sachets of pure water and yet oil continues to escape from the outfall. Efforts are being made by the Pollution Control Unit of Health Safety and Environment Department to control the oil escape through the installation of oil absorbent booms.

2.5.3 Solid waste sources of KRPC

In the process of KRPC operations solid waste is generated. These wastes are in the form of;

- i. sludge from waste water treatment plant,
- ii. office waste
- iii. spent catalysts/chemicals
- iv. kitchen/domestic waste
- v. Medical waste
- vi. construction waste
- vii. Maintenance repairs waste
- viii. Manufacturing Waste.

There are several ways available for treating these wastes. But in KRPC except the sale of scrap metals among these wastes, most of these wastes are dumped in area W. There is no organized or planned method of disposing these solid wastes.

2.5.4 Solid wastes dump site at area W of KRPC

Hospital (Medical) waste in KRPC is not treated as hazardous waste and it is equally dumped at Area W in conjunction with the domestic waste generated. The spent catalyst which is also hazardous is stored in an area in the laboratory plant and the drums containing these are overgrown with weeds. The spent batteries used by KRPC which contain toxic materials like Acids and Lead were also dumped in Area W haphazardly. This method of solid waste disposal carried out by KRPC is clearly the cheapest method of waste disposal but it is the most polluting.

By statutory requirement KRPC is supposed to keep a comprehensive list of chemical wastes by toxicity categories but this is not done. Therefore, KRPC is not complying with waste management regulations S 1.15 (1991).

2.6 EFFECTS OF WATER POLLUTION ON HUMAN HEALTH AND AQUATIC ORGANISMS

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at high concentrations. Heavy metals are natural components of the earth's crust. They cannot be degraded or destroyed by nature. To some extent they enter our bodies via food, drinking water and air. The effects of these heavy metals on the surrounding ecosystems cannot be over emphasized. The environmental consequences of marine pollution include creating a harsh environment which adversely affects activities of marine micro flora as well as fish and other marine lives (Obire and Amusan, 2003).

According to Mosley, Sarabject and Aaibersberg (2004), water with a pH > 8.5 indicates that the water is hard. Most metals become more water soluble and more toxic with increase in acidity. The principle long-term effects of low level exposure to cadmium are chronic obstructive pulmonary disease and emphysema and chronic renal tubular disease. Ingestion of high concentration of cadmium leads to nausea, vomiting, and abdominal pain. About three quarters of cadmium is used in batteries (especially Ni-Cd batteries) and most of the remaining quarter is used mainly for pigments, coatings and plating, and as stabilizers for plastics (Wallace, 2000).

According to Perry, Green and Maloney (2007), nitrogen, phosphorus, or both may cause aquatic biological productivity to increase, resulting in low dissolved oxygen and eutrophication of lakes, rivers, estuaries, and marine waters. Besides adding to nutrient-content of the water, addition of some forms of nitrogen and phosphorus will increase biological oxygen demand (BOD) and chemical oxygen demand (COD) (Mahdiah and Amirhossein, 2009). Increased nitrogen levels adversely affect cold-water fish more than they do warm water fish. The study carried out by Barnes, Meyer and Freeman (1998) on sedimentation and Georgia's fishes revealed that nitrogen concentrations of 0.5 mg/litre are toxic to rainbow trout.

In humans, it was well known that high concentration of heavy metals in food or drink can provoke serious health hazards. For example, elevated copper and manganese levels in drinking water may have a neurotoxin potential and can produce mental diseases such as Alzheimers and Manganism (Dieter, Bayer and Multhaup 2005). In 1956, cases of Minimata disease were reported in Japan. The disease affects the brain, causing insanity and leading to death, as a result of pollution of water by industrial effluents containing methyl-mercury. Also, the Itai-Itai disease caused by cadmium poisoning originated in a prefecture factory in Japan. This disease damages the joints, softens the bones and causes the body to shrink and the affected person dies painful death. One time or the other, there were cases of outbreak of mercury poisoning in Iraq and Nigeria when a number of people ate bread made from wheat which had been treated with alkyl-mercury as a fungicide. High levels of manganese in drinking water have also been shown to affect intellectual functions in 10-year-old children in Araihasar, Bangladesh (Wasseman, Liu, Parvez, Ahsan and Heavy 2006).

Other metals such as Zinc can also cause demyelinating diseases in humans (Zatta, Zucchini, Van ransbarg and Taylor2003). Aluminium in drinking water has been associated with the development of dementia-type syndromes and postulated as one of the etiological agents of Alzheimers disease (Kawahara, 2005). High levels of Cu in drinking water have also been associated with different pathologies in humans. For example in London, there were several reports on specified liver complaints in infant patients who were found to live in areas served by public drinking water supplies that contained high Cu concentrations (Fewtrell, Kay, Jones, Baker and Mowat 1996). Acute gastrointestinal effects, which include nausea, vomiting and diarrhoea, maybe observed in some individuals at Cu concentrations in drinking water above 3mg/l (WHO, 1993). Acute effects of lead are inattention; hallucinations, delusions, poor memory, and irritability are symptoms of acute intoxication. Lead absorption in children may affect their development and also results in bone stores of lead. It is associated with behavioural effects, nephropathy, and plumbism.

Another most hazardous trace metal found in drinking water is arsenic because it's both toxic and carcinogenic. Long-time intake of arsenic may give rise to skin lesion at concentrations of 50mg/l (WHO, 2001). Arsenic was also reported to cause cancers of the skin, lung, bladder, and other internal organs along with numerous non-cancer diseases (Tsai, Wang and Ko 1999; Ritter, Solomon, Sibley, Hall, Keen, Mattu and Linton 2002).

2.7 GUIDELINES FOR DRINKING WATER QUALITY

The World Health Organization (WHO) International Standards for drinking water have been among one of the most widely recognized and utilized WHO's publications. International

water quality standards started in 1958 when WHO published its first International drinking water standard (Goodman, 1980). But quite before then several standards were published in the United State, they include; USPH (1914, 1925, 1946) drinking water standards. On the contrary, the UK had none until the development of the 1958's WHO standard and subsequently in 1961 WHO aimed at providing upgraded standards to industrialized countries in Europe, besides the international standards. In 1975 the European Economic Community published its first drinking water standards for its member countries and the UK inclusive (Goodman, 1980). From there onward several other publications come from time to time, they include the revised editions of the WHO standards such as WHO (1993 and 2005) and EPA (2003) standard among others.

UNESCO (1983) and EPA (2003) classified the chemical and physical characteristics of water into four namely organoleptic-those rapidly observable by any untrained observer and pose little or no health threat also included are natural physicochemical parameter: normal characteristics with no health significant but indicate evidence of stability of water undesirable parameter-those directly harmful in high concentration and toxic parameters-those with adverse toxic effect to man. The WHO standards follow these classifications.

2.8 STATUTORY PROVISIONS

The Petroleum Refining processes and the production of petrochemical products involve a complex combination of interdependent operations. In the processes of these operations a complex array of gaseous, liquid and solid effluents were discharged. The discharges must be disposed off under controlled conditions to avoid environmental damages. To avoid

this environmental damage a number of regulations, guidelines and standards were put in place for the industry. The major objective of this is to regulate, and control the industries.

In Nigeria, the petroleum Act of 1969 generally empowers these laws. It was the first enabling Act for environmental control in Nigeria, to ensure full compliance with the laws provided by the Petroleum Act (1969); the Department of Petroleum Resources (DPR) was instituted by Decree No. 33 of 1977 to monitor the operations of Petroleum Industries. To ensure adherence to the law, DPR issued Environmental Guidelines and Standards for the Oil Industry in Nigeria (1992).

Another body involved in the regulating of the industry is Federal Environmental Protection Agency through Decree No. 58 of 1988. Presently FEPA has been scrapped and in its place the Federal Ministry of Environment was instituted in 1999. To enable the measurement of their performance, the Federal Ministry of Environment and DPR have instruments in place which industries are required to comply with, and there are:

2.9 NATIONAL EFFLUENT LIMITATION REGULATION S1.8 OF 1991

This makes it mandatory for industrial facilities to install anti-pollution equipment, makes provision for effluent treatment and prescribes maximum limits of effluent parameters allowed for contravention.

2.9.1 Pollution abatement in industries and facilitates generating waste S1.9 of 1991

Among other things, this imposes restrictions on the release of toxic substances and stipulates the requirements for the monitoring of pollution, to ensure that permissible limits are not

exceeded. While unusual and accidental discharges, contingency plans, generators ability and strategies for waste reduction and the safety of workers are put in place.

2.9.2 Waste management regulations S.1.15 of 1991

This regulates the collection, transportation, treatment and disposal of solid and hazardous wastes from municipal and industrial sources and gives the comprehensive list of chemical wastes by toxicity categories.

2.9.3 National environmental standards and regulations enforcement agency (NESREA) 2009

NESREA in 2009 came up with its own National Environmental Standards and Regulations. Most of the requirements are not different from what is in the FEPA and DPR Guidelines and Standards.

2.10 PREVIOUS STUDIES ON EFFLUENT DISCHARGE

Industrial pollution has been and will continue to be a major factor causing degradation of the environment around us, affecting the water we use, the air we breathe and the soil we live on. But of these, pollution of water is arguably the most serious threat to human welfare (Bhagirath and Reddy, 2002).

Chhonkar, Datta and Pathak (2000) studied the impact of industrial effluents on soil health and agriculture in New Delhi India using standard analytical method. The result shows a high organic load of 50,000mg/L Biological Oxygen Demand (BOD) and 95,000mg/L Chemical Oxygen Demand (COD) recorded in spent wash, whereas the post-methanation effluents had

considerably lower organic load of 5,000mg/L (BOD) and 25,000mg/L (COD). The result also revealed that the spent wash contain 1,000mg/L nitrogen, 40mg/L phosphorus, 11,000mg/L potassium and 1,500mg/L Sulphate with 15dsm-1 electrical conductivity (EC) and 4.5 pH. The nutrient concentration and electrical conductivity decreases while pH increased in post methanation effluents as compared to those in spent wash. It contain 300mg/L nitrogen, 20mg/L phosphorus, 6,000mg/L potassium and 900mg/L Sulphate with 8.5 dsm-1 electrical conductivity and 5.9 pH.

Paul (2011) carried out a research on industrial effluents on water quality of receiving streams in Nakawa-Ntinda Uganda using AAS in analysing the parameters. The research revealed that the effluents from industries have a big impact on the water quality of the receiving streams and there is general increase in some of the parameters analyzed downstream as opposed to up stream. Although the value in some cases were lower than the maximum allowable limit by National Emergency Management Authority (1999).

Similarly, Chikogu, Adamu and Lekwot (2012) examine the public health effect of effluents discharge of Kaduna refinery into Romi river and the results revealed that the (DO) content of the water upstream is normal, at discharge points 9.8mg/L and downstream, it decreased further while the BOD and COD do not conform with the maximum acceptable limit of WHO as 10mg/L and 40mg/L are the respective acceptable limits. Upstream value shows 15mg/L and 42mg/L for BOD and COD. It also shows that BOD is very high downstream which is supposed to be lower but the result indicate 100mg/L which is ten times higher than national standard acceptable limit.

Lawal and Sigh (1981) carried out research on analytical studies of waste water effluents of some Tanneries in Kano and Sokoto State, for possible environmental pollution. The results shows some degree of environmental pollution caused through discharge of effluents into streams, sewers and on land.

Also Yabagi (1989) studied the nature and sources of urban sediments and their relationship to water quality in River Kaduna. The study revealed that metal pollution for river Kaduna water was due to uncontrolled effluent waste discharge from industries within the metropolis. The result also indicates that heavy metal like iron, cobalt, lead, cadmium, mercury and arsenic occur in this river with a very high concentration which is above the standard recommended by WHO for drinking water and also varied in concentration from one source (industry) to another.

Further still, Gorinderajalu(2003) examine the impact of industrial effluents on human health in three (3) different health camps in India on different dates and he was able to identify the symptoms of water borne diseases. Health problems such as skin allergy 31.65%, respiratory 22.56%, infections general allergy 13.13%, gastritis 9.43%, ulcer 7.07%, joint pain 10.44% and 5.72% and other ailments were scanned among the villagers and it was medically accepted that water had significant influence on these diseases.

Mathuthu, Mwanga and Simoro (1997) investigate the impact assessment of industrial and sewage effluent on water quality of Marimba River. He opined that most of the rivers in these areas of the developing world are the end points of effluents discharged from industries considering the stream in Nkawa-Ntinda industrial effluent, the water quality of the stream has been tremendously affected as a result of industrial activities. These streams drains part of

Naguru hills, Kyamboga, Gbenda and feeds into Kinawataka wetland and then finally into the Lake Victoria.

LVEMP (2002) in a study carried out by the management of industrial and municipal and urban run-off component of lake victoria environmental management project indicates that most factory in Uganda do not have effluent treatment plants, even were they are existing, most industrial wastes water treatment plants are poorly designed and constructed.

Mosley, Serabject and Aaibersberg (2004) conducted a research on water quality monitoring which indicates that the water is hard with a $P^H > 8.5$ and that most metals become more water soluble and more toxic with increase in acidity. Toxicity of cyanide and sulphides also increase with a decrease in P^H (increase in acidity). The content of toxic forms of ammonia to the un toxic forms also depends on the P^H dynamics.

Lekwot, Blamah and Ezemokwe (2012) examine the socio-economic impact of Kaduna Refinery and Petrochemical Company (KRPC) on Rido Area of Kaduna metropolis and the result revealed that air and water pollution is the common environmental problem in the area. Gaseous pollutants and prevalence of typhoid fever is high the study area accounting for 48%, Malaria accounting for 33% then cough accounting for 19%. Children and youth in the study population are the most affected which is not good for the future of the area. It has led to the increase in commercial activities as this has created employment for those in the informal sector, also the area was originally homogenous community with a common culture has been altered by the infiltration of migrants from other cultural background due to the presence of the refinery in the study area.

Abui (2012) conducted a research on the environmental effect of KRPC effluents discharge on Romi area. He opined that the result of organic parameters of the water samples along the river in dry and rainy season for BOD are 4mg/l and 18mg/l, COD 12mg/l and 45mg/l, Oil and grease 0.03 and 4.6 and phenol Nil in both season etc this reveals that the level of pollution is severe in the dry season than rainy season while the result of hydrocarbon like Toluene, Xylene and Benzene were lower than the maximum value stipulated by FEPA of 0.05mg/kg. For soil samples bulk density deviates from FEPA standard, the average value obtained is 1.8mg/ms also micro nutrients ranges from 12.73-22.45mg/100g Cd and Zn 26.78-44.98mg/100g, Ca content 1.35-1.96mg/100g, Mg 1.02-1.42mg/100g and K (potassium) 0.2-0.19mg/100g in Romi area.

CHAPTER THREE: STUDY AREA AND METHODOLOGY

3.1 INTRODUCTION

This section deals with the background of the study area and methodology used for this study. The study area is Kaduna refinery, Rido and River Romi located in parts of ChikunLG that form part of the Kaduna metropolis, Nigeria. Also highlighted are the major environmental features, as well as industrial, economic activities and other general land use and human settings that are relevant to this study. The methodology adopted for this study is organized in three parts:

- i. Types and sources of data collected
- ii. Methods of data collection
- iii. Methods of data analysis

3.2 STUDY AREA

3.2.1 Location

The study covers some part River Romi, which is a tributary of Kaduna River which drains the southern part of Kaduna metropolis. It is located between Latitudes $10^{\circ} 18'$ to $10^{\circ} 30'$ N and Longitudes $7^{\circ} 15'$ to $7^{\circ} 45'$ E of the Greenwich meridian (Figure 3.1). Romi River follows a course of about 16.4km and the area is situated on a relatively low plain liable to flooding (BLSK, 2010).

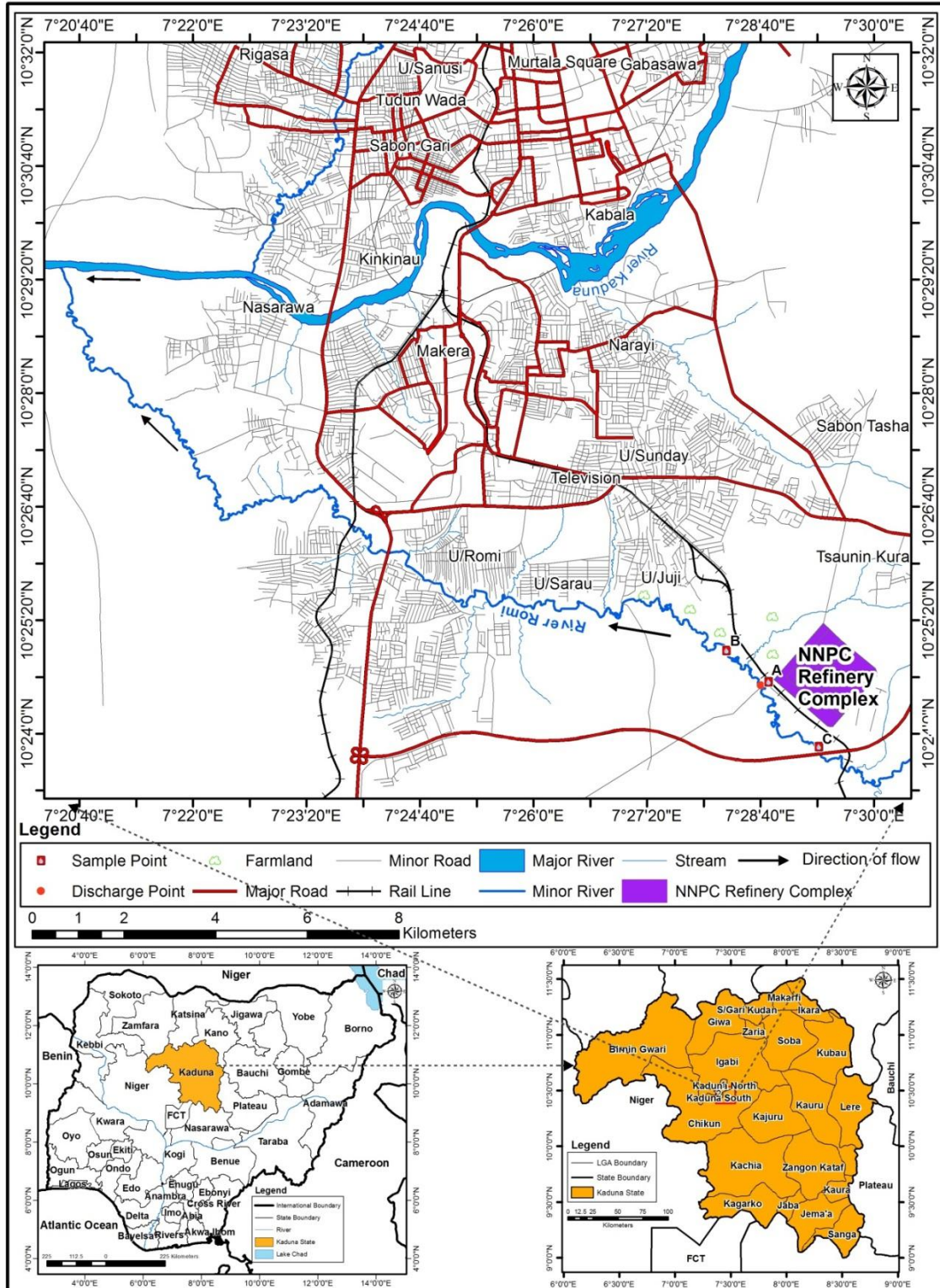


Figure 3.1: River Romi and Environs

Source: Adapted and Modified from Google Maps/Field Work, 2014

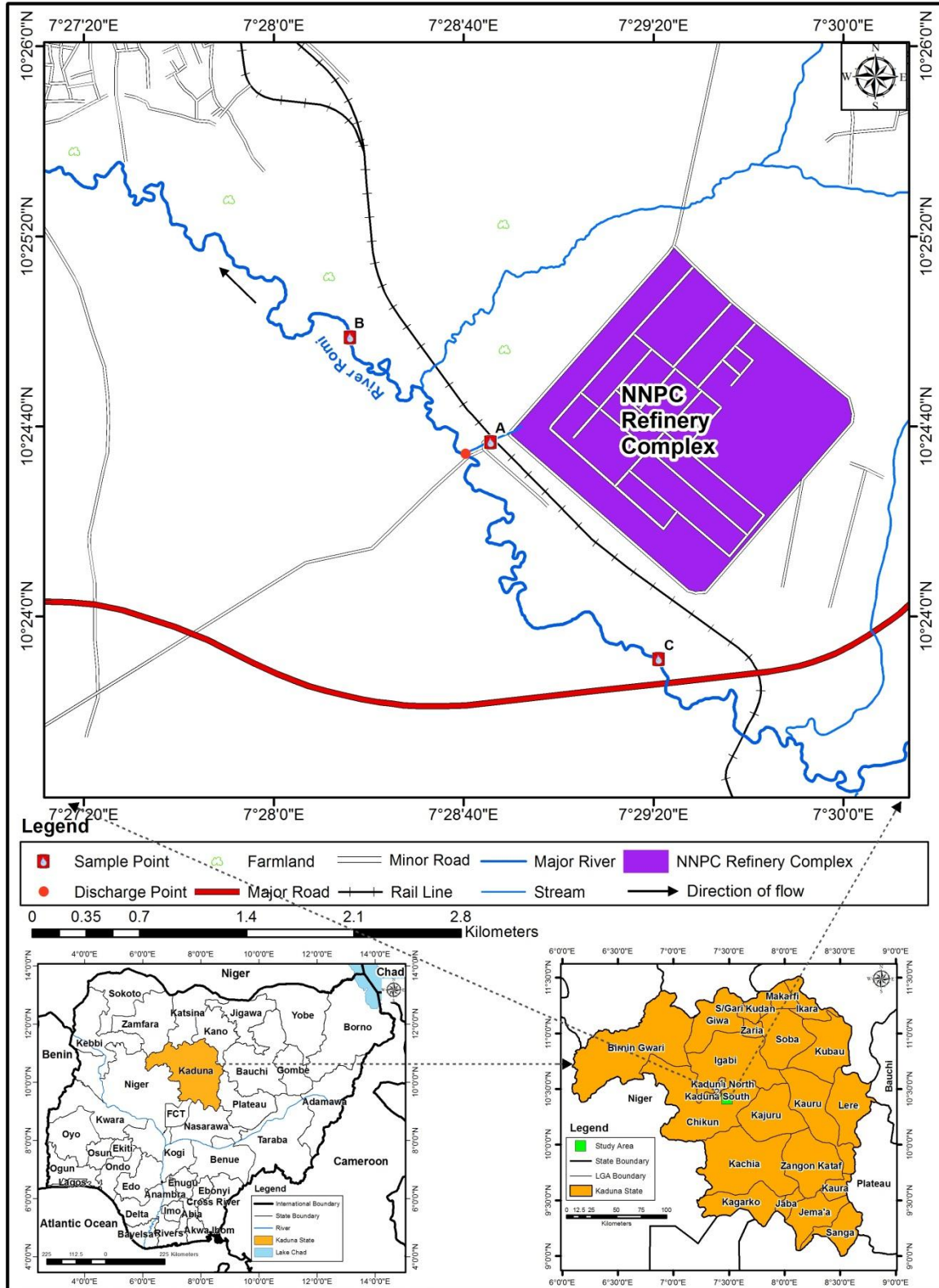


Figure 3.2: River Romi Showing Sampling Points

Source: Adapted and Modified from Google Maps/Field Work, 2014

3.2.2 Climate

The climate of the area lies within the tropical wet and dry climatic zone (Aw); characterized by strong seasonality in rainfall and temperature distributions (Koppen, 1928). Seasonality in climatic condition is caused by the oscillation of the two air masses, the Maritime Tropical air mass (mT) and the Tropical Continental air mass (cT) with contrasting rainfall and temperature characteristics. When the Maritime Tropical is prevailing, the study area experience a rainy season, while the Continental Tropical ushers in the dry season with its cold, dry and dusty air which occasionally limits visibility and reduces solar radiation. The rainy season is short and followed by five to seven months dry season (Iguisi, 1996).

3.2.3 Soils

The soil of the study area fall within the tropical ferruginous soils, the top soil is coarse sandy loamy to clay loamy (Adetola, 1990). The soil has lost its fertility such that no crop can grow successfully without the use of artificial fertilizer. The area was initially characterized by over 80% agricultural land-use. However owing to the petroleum industry, the land-use pattern is fast changing.

The soils are typically red-brown to red-yellow tropical ferruginous soils derived from the regolith of the Basement complex. In some places these soils are covered by a layer of Aeolian drift materials. Soils in the upland are rich in red clay and sand but poor in organic matter. While soils within the flood plains are rich in kaolinitic clay and organic matter and are referred to as Fadama soils (Iguisi, 1996).

3.2.4 Vegetation

Kaduna metropolis is located within the Guinea savannah vegetation zone of Nigeria; therefore it has a savannah grassland type of vegetation. The natural vegetation of this zone consists of scattered trees interspersed with tall grasses. However human activities associated with urbanization have seriously modified the vegetation to the extent that now, trees are most often found only as ornamental ones, comprising mostly of exotic species such as Eucalyptus and economic trees such guava, mango, sheer butter trees (*Viteletriaparadoxa*), *Isoberialiadoka*, *Parkiabiglobosa*, silk cotton tree (*ceibapentadra*) and a variety of flowers with an average height of about 6m-10m. Other less frequent shrub species are *Dachrostachys specie*, *Termalina specie*, *Vitexpiliostima*, the area consists of vegetal cover made up of scattered trees predominantly grasses (Folorunsho, 2004; Usman, 2012).

3.2.5 Drainage, Relief and Geology

Romi area is drained by the River Romi that originates from the Kujama hill at elevation of 847 meters above sea level (Lock and Partners1987). 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 atGarko. The river flows throughout the year but its volume reduces during the dry season and increases in volume during the rainy season. The river at Rido receives effluent from the Kaduna Refinery and Petrochemical Company.

The general relief of the study area is undulating plains, with areas along the flood plains of the river being lower than those on the upland sections and occasional rock outcrops in some

part of the city. Eastern part of the city which is mostly bounded by the River Kaduna has a mean elevation of about 550m above sea level. The north-western part of the city is comparatively higher with a mean elevation of about 620m above sea level. The relief is to the largest extent controlled by the geology, that is, areas more resistant to denudation are higher than those that are susceptible (Iguisi, 1996). It is note-worthy that in parts of the metropolis; there are outcrops of hard resistant of granitic rocks. This is as a result of weathering through the age of previously existing Pre-Cambrian rocks. These rocks have been exposed to agents of erosion through these ages and the erosive activities bring out crops of rocks forming inselbergs and some huge rocky land as that of Tudun Wada and Malali (Lauretta, 2009).

The area is underlain by rock of basement complex consisting of biotite gneiss and older granites. These rocks have been subjected to weathering to produce fairly deep regolith which has been subjected to lateralization. There is also the occurrence of hardened lateriterocks of the basement complex of different locations within the metropolis and at the different section of the Kaduna River (Iguisi, 1996).

3.2.6 Population and Human Activities

The 2006 census estimated the population of the study area (Romi and Rido) to be about 1,800 people. The people of Romi area are predominantly farmers. The settlements are dispersed along Romi River and this enables each household to cultivate as much land as possible.

3.3 METHODOLOGY

3.3.1 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.

3.3.2 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.

3.3.3 Sources of Data

Both primary and secondary data have been sourced for this study

3.3.3.1 Primary source of data

The primary sources include results derived from the laboratory analysis of water quality of the water samples taken from 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.

3.3.3.2 Secondary source of data

This involved sourcing of information 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.

3.3.4 Sampling Technique and Sample Size

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 River Romi 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 River Romi. Majority of the sampled population were farmers who use River Romi for irrigation, fishing, animals watering, bathing or other related domestic uses.

The physico-chemical and bacteriological 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 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. The water samples were collected from the River at three sampled points. First

sample was collected at upstream before the discharge point of the refinery effluent, the second sample was collected at discharge point and the third sample was collected at the downstream after the discharge point. Each sampling point was 5 Km away from each other which is within 10 Km of the river length as indicated in Figure 3.1.

The entire human population of the study area (communities) whose source of livelihood depends largely on the River Romi 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:

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

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 1.1)

$$\frac{n \times 327}{N} \text{----- (2)}$$

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

S/NO	Selected communities	Sample frame	Proportion of sampled Population
1	Rido	980	178
2	Romi	820	149
	Total	1, 800	327

3.3.5 Techniques of Data Analysis

Objective i: Assess the Level of Pollution of River Romi.

In achieving objective one, the physico-chemical and bacteriological 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 analysed 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). The gravimetric technique was used for TDS while the volumetric technique was used to analyse BOD, COD while the Atomic Absorption Spectrophotometer (AAS) was used for the analysis of N, Cd, Pb, and Cr. The AAS analysis was carried out using AAS spectrophotometer: model: DR 2010-Spect at Kaduna Environmental Protection Authority (KEPA) laboratory. This was done for water both before the point of discharge, at discharge point and after the point of discharge samples.

This analysis includes the physico-chemical test analysis such as pH, temperature, colour, total dissolved solid (TDS), biological oxygen demand (BOD), dissolved oxygen (DO),

chemical oxygen demand (COD), total suspended solid (TSS) 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), (DO) and (COD), which affect the aquatic ecosystem by creating oxygen deficit and also determine water purity. COD also shows the oxidation of water which serves as a measure for pollution dictation. Other parameters analysed are Cadmium (Cd), Lead (Pb), Chromium (Cr) etc, these are common heavy metals present in waste waters from petrochemical industries (KRPC Environmental Audit Report, 2010).



Plate 3.1: Water Sample Collection at 5km Downstream



Plate 3.2: Water Sample Collection at 5 km Upstream

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 analysed in the laboratory were presented in table 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: Examine the effect of the effluent on human activities such as fishing, swimming (bathing) farming and other domestic uses.

To achieve objective (iii), structured questionnaire was issued out to 327 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 socioeconomic data. The results were presented in percentages to show the effluent effects on farming, fishing, swimming, cooking and drinking.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents the results which are discussed sequentially. First the concentration of the physico-chemical parameters of the effluents at distance of 5km each upstream and 5km downstream of the discharge point then followed by effluents concentrations measured at the discharge point. The results for the socio-economic data were also discussed.

4.2 THE LEVEL OF POLLUTION OF ROMI RIVER

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 before, after and at the Point of Discharge.

Parameters	Point of collecting Water Sample		
	Upstream 5km	Point of Discharge	Downstream 5km
pH	7.45	5.56	6.72
Temperature(°C)	34	37	34
Conductivity $\mu\text{m}/\text{cm}$	248	290	263
Total suspended solids (TSS)	68	420	96
Total dissolve solid (TDS)	300	495	324
Turbidity (NTU)	12	18	16
Colour	Light Brown	Light Brown	Light Brown
Biochemical Oxygen Demanding (mg/l)	3.45	8.5	4.37
Chemical Oxygen Demand(mg\l)	45	128	66
Oil and grease	2.7	17.2	4.7
Dissolved Oxygen (mg/l)	6.7	4.6	6.4
Nitrite (NO ₃)	0.25	0.42	0.7
Iron(Fe)	0.93	1.2	0.2
Copper (Cu)	0.25	0.98	0.36
Zinc (Zn)	0.27	0.42	0.36
Lead (Pb)	0.22	0.388	0.228
Cadmium (Cd)	0.022	0.031	0.024
Chromium (Cr)	0.22	0.38	0.21

Source: Author's Analysis (2014)

pH: The analysis conducted on pH of the water samples at 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 show 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 Lekwot *et al* (2012) which pH value was reported to be 3.5 at discharge point, 5.0 downstream and 6.9 upstream 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 decreases during dry season and increases 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 Lekwot *et al* (2012) both values increase 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 34°C each and 37°C at discharge point. This implies that temperature of Romi River is tolerable and when compared with the studies of Lekwot *et al* (2012) which reported surface temperature of 38°C at discharge point, 36°C upstream and downstream which can be attributed to the location of the study area however the result showed tolerable temperatures which means that temperature remains within the same range despite the three years interval.

Electrical Conductivity: The result of electrical conductivity (EC) before the point of discharge was 248 µm/cm, 290 µm/cm at discharge point and EC after the point of discharge was 263 µm/cm these values are high in terms of EC. Although previous study by Lekwot *et al* (2012) reported EC to be 250 µm/cm upstream 300 µm/cm at discharge point 260 µm/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, River Romi is still polluted.

Total suspended solid: The result of the analysis for TSS before the point of discharge is 68mg/l and TSS after the point of discharge is 96mg/l and 420mg/l at discharge point, this result shows a sharp increase in TSS concentration from the upstream to downstream. The reason for this sharp increase in TSS could be due to accumulation of organic solid particles. These results shows similarity with the results of previous studies carried out by Lekwot *et al* (2012) and Abui (2012) who also reported high increase in TSS from upstream to downstream.

Total dissolve solid: TDS result was observed to be 300mg/l before the point of discharge and 324mg/l after the point of discharge and 495mg/l at discharge point. These values are quite high but previous studies conducted by Lekwot *et al* (2012) whose studies observed a lower value of TDS concentration although below what is obtained by this research yet lower 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.

Turbidity: The turbidity result of the water sample before the point of discharge was 12NTU, at discharge point 18NTU and after the point of discharge is 16NTU 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.

Colour: Colour of the water sample was observed to be light brown in appearance before the point of discharge and also after the point of discharge this might have originated from decomposition of organic matter and it is in agreement with Abui (2012) also observed brown colour in the same Romi River water, the colour shows that the River is still polluted base on the study conducted.

Biological Oxygen Demand: BOD measured before the point of discharge was 3.43mg/l, at discharge point 8.4mg/l and 4.37mg/l after the point of discharged. These values are relatively low, the reason may likely be due to dilution effect and natural purification system along the River. However when compared to the findings of Lekwot *et 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.

Chemical oxygen demand: COD measured before the point of discharge was 45mg/l and after the point of discharge 66mg/l which is high while COD measured at the point of discharge is 128mg/l this is quite high and it may be as a result of industrial effluent discharges into the river. Though similar studies by Abui (2012) and Lekwot *et al* (2013) have also reported high levels of COD in Romi River ranging between 50mg/l to 120mg/l upstream and downstream respectively and might be due to particulates from the industry.

Oil and grease: The oil and grease result of the water sample before the point of discharge is 2.70 mg/l and after the point of discharge is 4.7mg/l the presence of these oil and grease may be due to effluents from the industry but is within the allowable limit while at discharge point

is 17.2mg/l which is intolerable. Previous studies by Lekwot *et al* (2012) indicate similar values as 4.0mg/l in Romi River both studies concur with each other.

Dissolved oxygen: DO concentration measured in Romi River before and after the point of discharge is 6.70 mg/l and 6.4mg/l at this level DO is almost normal at Romi River this could be as a result of inflow of fresh water into the river however this result did not agree with the report of previous studies carried out by Lekwot *et al* (2012) who reported DO concentration as 9.8mg/l upstream, 2mg/l at discharge point and 6mg/l downstream. Both studies shows the same trend of DO value reducing down the River.

Nitrate (NO₃): The concentration of NO₃ measured in water samples before the point of discharge is 0.2mg/l, at discharge point is 0.42mg/l and after the point of discharge is 0.7mg/l these results indicated low concentration of NO₃ before 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 of NO₃ 0.9mg/l the values obtained are relatively low and Lekwot *et 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.

Iron: The concentrations of iron measured before and after the point of discharge are 0.93mg/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.

Copper: The result obtained for Copper shows concentration of 0.25 mg/l before the point of discharged and 0.3mg/l after the point of discharge and 0.98mg/l at discharge point which shows a steady increase of copper 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 copper in Galma Dam both studies shows similar result of low copper concentration.

Zinc: The concentration of zinc observed in water samples before and after the point of discharged is 0.27mg/l and 0.34mg/l respectively and 0.42mg/l at discharge point. These results indicated low values which are far below the allowable range. The reason for this low values may be due to dilution of refinery effluent discharged into the Romi River with eroded soil materials due to intensive cultivation.

Lead: The results obtained for lead measured in water samples before the point of discharge is 0.22mg/l, at discharge point 0.38mg/l and after the point of discharge is 0.23 which is high 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 Lekwot *et al*(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.

Cadmium: Cadmium Concentration before the point of discharge is 0.022mg/l and after the point of discharged is 0.020 mg/l and at discharge point is 0.042mg/l this result indicated a high concentration which may be due to lubricating oil which is a major source of cadmium. Also impurities in fertilizers, pesticides and manure are likely to have contributed to

high increase of cadmium in the river. Previous research by Lekwot *et al*(2012) observed 0.003mg/l and 0.013mg/l upstream and downstream whereas Butu (2012) observed high cadmium concentration in the Dam. Comparing previous studies with this work, it is obvious that cadmium is at an increase.

Chromium: Chromium was observed to be 0.38mg/l at discharge point, 0.2mg/l before the point of discharge and 0.21mg/l after the point of discharge, these values are high and it maybe due to chromium electroplated materials used in petroleum refining process while Abui (2012) indicates that chromium was not detected at all sampling sites which means that chromium too is on the increase in Romi River.

There is an increase in most of the parameters analysed in this research work and this has potential health consequences on human and the environment at large, this is the considerable difference between the results obtained by this research work.

4.2.3 Difference between the Two Sections

Results of the statistical test of difference in quality of water before and after the point of discharge are presented in Table 4.2, the samples in the two sites were compared and the results reveal that many of the parameters measured varies.

Table 4.2: Mean Values of Parameters Concentration Measured Across Sampling Points

Parameter	Point of collecting water sample			P-value
	Upstream 5km	Downstream 5km	T-value	
pH	7.45	6.72	5.49	0.001
Temperature(°C)	34.67	34.50	0.143	0.89
Conductivity $\mu\text{m/cm}$	248.33	263.67	2.56	0.02
Total suspended Solids (TSS)	68.83	96.00	6.13	0.001
Total dissolve Solid (TDS)	300.17	324.33	4.44	0.001
Turbidity (NTU)	12.83	16.50	3.77	0.004
Biochemical Oxygen Demand (mg/l)	3.43	4.37	6.36	0.001
Chemical Oxygen Demand (mg/l)	45.17	66.50	16.80	0.001
Dissolved Oxygen (mg/l)	6.70	6.43	1.87	0.09
Colour	Light Brown	Light Brown	Light Brown	NA
Oil and grease	2.70	4.75	11.01	0.001
Nitrate (NO_3)	0.25	0.72	9.28	0.001
Iron(Fe)	0.93	0.27	59.34	0.001
Copper (Cu)	0.25	0.36	9.84	0.001
Zinc (Zn)	0.27	0.36	12.21	0.001
Lead (Pb)	0.22	0.22	0.45	0.66
Cadmium (Cd)	0.22	0.03	05.12	0.001
Chromium (Cr)	0.22	0.21	7.55	0.001

Source: Author's Analysis (2014). N=6: Values are express as mean \pm SD with significant difference at $P < 0.05$

The degree of significant difference was tested statistically the result of P^H values in Romi River indicates that there is difference between the upstream with MD7.45SD \pm 0.26 and MD6.72SD \pm 0.20 downstream with significant level of $P < 0.001$. While the statistical test employing t-test was used and temperature values also indicated that there is no significant difference between the upstream with MD34.67SD \pm 2.16 and MD34.50SD \pm 1.87 downstream of Romi River with significant level $P > 0.89$ and the electric conductivity value indicated that there is a significant difference between the upstream with MD248.33SD \pm 9.18 and downstream value MD263.67SD \pm 11.43 of Romi River with significant level $P < 0.02$. The statistical test was carried out and it confirm that value for total suspended solid MD68.83SD \pm 4.96 upstream and MD96.00SD \pm 9.65 downstream of Romi River shows a

significant difference with $P < 0.001$ level of significant. The statistical test value for total dissolved solid the result shows a significant difference between the upstream $MD300.17SD \pm 10.3$ and $MD324.33SD \pm 8.45$ downstream with $P < 0.001$ level of significant. The results for turbidity at Romi River with $MD12.83SD \pm 1.47$ upstream and $MD16.50SD \pm 1.87$ downstream show a significant difference between the upstream and downstream at $P < 0.004$ level of significant.

Similarly, the t-test was employed to test the level of significant values for BOD indicate a significant difference between the upstream $MD3.43SD \pm 0.29$ and downstream $MD4.37SD \pm 0.21$ of Romi River at $P < 0.001$ level of significant, likewise COD indicate a significant difference between the upstream with $MD45.17SD \pm 2.48$ and $MD66.50SD \pm 1.87$ downstream at $P < 0.001$ level of significant. Oil/Grease indicates a significant difference between the upstream $MD2.70SD \pm 0.29$ and $MD4.75SD \pm 0.35$ downstream of Romi River at $P < 0.001$ level of significant. The value for the dissolved oxygen in Romi River also indicates no significant different between the upstream $MD6.70SD \pm 0.24$ and downstream $MD6.43SD \pm 0.26$ with significant level $P > 0.09$ also the statistical test values for Nitrate (NO_3) upstream $MD0.25SD \pm 0.04$ and downstream $MD0.72SD \pm 0.12$ of Romi River at significant level of $P < 0.001$ also the value of Iron (Fe) indicates a high significant difference between the upstream $MD0.93SD \pm 0.03$ and downstream $MD0.27SD \pm 0.07$ with $P < 0.001$ level of significant in Romi River while Butu (2002) observed that there is no significant difference in the level of concentration of iron in the lower and upper region of the Dam. The statistical test for Copper (Cu) indicates a high significant difference between the upstream $MD0.23SD \pm 0.03$ and downstream $MD0.36SD \pm 0.02$ with $P < 0.001$ 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, Zinc (Zn) indicate a high significant difference between the upstream with $MD0.27SD\pm0.02$ and $MD0.36SD\pm0.01$ downstream of Romi River with $P < 0.001$ level of significant compared to Butu (2002) find out that there is no significant difference in level of concentration of zinc between the lower and upper region of the Dam. For lead (Pb) the values indicate no significant different between the upstream $MD0.22SD\pm0.01$ and downstream $MD0.22SD\pm0.01$ of Romi River at significant level $P > 0.66$ while Butu (2002) conclude that there is no significant difference between the level of concentration of lead in the lower and upper region of Galma Dam while statistical tests for Cadmium (Cd) indicate a high significant difference between the upstream with $MD0.02SD\pm0.001$ and downstream $MD0.03SD\pm0.001$ with $P < 0.001$ level of significant in Romi River while Butu (2002) stated that there is no significant difference between the upper and lower region of the Dam. The value for Chromium (Cr) in Romi River indicates a high significant difference between the upstream $MD0.02SD\pm0.01$ and downstream $MD0.21SD\pm0.02$ with $P < 0.001$ level of significant compared to Butu (2002) in his study observed that there is no significant difference between the lower and upper region of Galma Dam.

As observed from the results of the statistical test pH, Electrical Conductivity, Total Suspended Solid, Total Dissolve Solid, Turbidity, Biological Oxygen Demand, Chemical Oxygen Demand, Oil and Grease, Nitrate, Zinc, Iron, Copper, Cadmium and Chromium values indicates that there is significant difference between the upstream 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, Dissolved Oxygen 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 released through the effluents discharged by KRPC in the study area. Chemical elements like Iron and Zinc are embedded in the geological formations and when these rocks undergo complete weathering, the elements are released into the environment from where they are washed into the River. Copper and Lead are used in electric and electronic equipment and are released into refuse dumps and drainage systems from where they decay and are released into the general environment and finally into the River. Chromium and Cadmium are used for electroplating of materials and can readily be dissociated under favourable climatic conditions and are released into the environment and finally drained into the River. Lekwot et al. dictated high concentrations of heavy metals in Romi River three years later; this research work also shows a gradual increase of effluents in the River.

4.3 OBSERVED CONCENTRATIONS COMPARED WITH WHO/NESREA STANDARD

The physico-chemical properties of the sampled water at 5 km upstream and downstream of the effluent discharge point are presented in table 4.3.

Table 4.3: Mean Values of Physico-chemical Parameters Measured Across Sampling Point

Parameters	Point of collecting water sample		Maximum permissible limits		
	Upstream	Point of Discharge	Downstream	NESREA	WHO
	5km		5km		
pH	7.45	5.56	6.72	6.5-8.5	6.5-8.5
Temperature(°C)	34	37	34	30	30
Conductivity $\mu\text{m/cm}$	248	290	263	240	250
Total suspended solids (TSS)	68	420	96	30	30
Total dissolve solid (TDS)	300	495	324	200	250
Turbidity (NTU)	12	18	16	5	5
Colour	Light Brown	Light Brown	Light Brown	NA	NA
Biochemical Oxygen Demanding (mg/l)	3.45	8.5	4.37	10	10
Chemical Oxygen Demand(mg/l)	45	128	66	40	40
Oil and grease	2.7	17.2	4.7	10	
Dissolved Oxygen (mg/l)	6.7	4.6	6.4	10	10
Nitrate (NO_3)	0.2	0.42	0.7	44	50
Iron (Fe)	0.93	1.2	0.2	20	20
Copper (CU)	0.25	0.98	0.36	1.0	2.0
Zinc (Zn)	0.27	0.42	0.36	1.0	1.0
Lead (Pb)	0.221	0.388	0.228	0.01	0.001
Cadmium (Cd)	0.022	0.031	0.024	0.003	0.005
Chromium (Cr)	0.22	0.38	0.21	0.1	0.05

Source: Author's Analysis (2014).

NA= Not Available

The parameters analysed in table 4.3 are good indicators of pollutants that affect surface water quality to a large extent (Gbenga 2007). Among the physical parameters measured was the pH which was found to be 7.45 upstream which is partial neutral in nature, 5.56 at the effluent discharge points which is acidic and 6.72 downstream which is also slightly acidic, upstream and downstream pH values are within WHO/NESREA standard while at effluent discharge point fell short of the standard. Mosley etal (2004) reported that water is hard with $\text{P}^{\text{H}} > 8.5$, similarly, Lekwot etal (2012) in their study observed that P^{H} deviates in Romi River from the acceptable limit of 6.5 downstream, the upstream shows high acidity with the highest pH 3.5 at effluent discharge point due to the effluents discharged.

The temperature of the water sample which was found to be 34°C upstream, 37°C 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 30°C. This result varies slightly with the findings of Lekwot et al (2012) who reported that temperature is 35°C upstream, 38°C at discharge point and 36°C downstream of Romi River.

The analysis conducted on Electrical Conductivity (EC) of the water sample indicates that the EC value was 248µm/cm upstream and 263µm/cm downstream with a sharp increase of 290 µm/cm at effluent discharge point. This indicates that EC is high at effluent discharge point and has exceeded the NESREA 2007 and WHO 2006 maximum limits of 250 µm/cm, when this result is compared with the values reported in Lekwot et al (2012) in their findings reported that EC 250 µm/cm upstream, downstream 240 µm/cm and 300 µm/cm discharge point.

Regarding the total suspended solid (TSS), the results obtained do not conform to the permissible limits of 30mg/l as stipulated by NESREA 2007 and WHO 2006. There is a rise from 68mg/l upstream to 96mg/l downstream and a sharp increase to 420mg/l at effluent discharge point. The high TSS content could have originated from the organic solids. Dix (2001) observed that small suspended solids particles make water turbid while previous research by Lekwot et al (2012) shows that TSS remain high at all sample points in river Romi as against the permissible limits of 30mg/l, with upstream value of 40mg/l, discharge point 100mg/l and downstream 70mg/l value recorded.

The result for total dissolved solid was observed to be high at 300mg/l at upstream, 324mg/l downstream and 495mg/l at effluent discharge point. The results show higher values compared to 200mg/l NESREA 2007 and WHO 2006 standard of 250mg/l. however the concentration of TDS as compared to previous study by Lekwot et 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 upstream is 12NTU, 16NTU downstream, and 18NTU 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 observed that the colour of the water sampled at river Romi is light brown in appearance. This indicates the floating of waste oil from the refinery and dissolved dust particles from farmlands around the river Romi. It was also observed that the water in River Romi has a sharp choking smell especially downstream. At effluent discharge point, the water appearance is shining brownish colour, it is not available for WHO/NESREA standard. This indicates the presence of floating waste oil and oil chemicals.

The result for the biological oxygen demand (BOD) upstream is 3.45mg/l, downstream 4.37mg/l and 8.5mg/l at effluent discharge point. This is in conformity with the permissible standard of 10mg/l 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. Lekwot et al (2012) measured 2500-3000mg/l in Romi River which is ten times the strength of domestic water.

The chemical oxygen demand (COD) measured upstream is 45mg/l, downstream 66mg/l and 128mg/l at the effluent discharge point. The COD values as measured at these points are all higher than the permissible standard of 40mg/l of the NESREA 2007 and WHO 2006. Especially at the effluent discharge point, the COD value is three times the permissible standard. This indicates a high presence of organic pollutant and is higher than what is obtained by Lekwot et al (2012) COD do not conform to the permissible limits for inland waters but less than what is obtained in this study.

The results obtained in the sample for oil and grease at both upstream and downstream are 2.7mg/l and 4.7mg/l respectively. These values are within the admissible standard of 10mg/l of the NESREA 2007 and WHO 2006. The value measured at the effluent discharge point is 17.2mg/l this value is higher than the admissible standard. Similar result was observed by Lekwot et al (2012) with oil and grease upstream 3.5mg/l, downstream 4.0mg/l and higher at discharge point 20.1mg/l.

In terms of dissolved oxygen (DO), upstream is 6.7mg/l, 6.4mg/l downstream and 4.6mg/l at effluent discharge point. It was observed that the values for DO appear to be lower than stipulated 10mg/l of NESREA 2007 and WHO 2006 permissible standard while according to Lekwot et al (2012) DO content of water samples indicates that it is almost normal upstream 9.8mg/l at discharge point it decreases drastically to 2.0mg/l and increases as it moves downstream with 9.0mg/l. The reason for this low values could be as a result of activation, since the water at the effluent discharge point is being pumped with high pressure supplied by an air compressor.

Metals such as nitrate (NO₃) copper (Cu) zinc (Zn) iron (Fe) lead (Pb) cadmium (Cd) arsenic (As) and chromium (Cr) 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 river Romi 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 and 0.9mg/l which is lower than WHO 2006/NESREA 2007 permissible limits.

Iron (Fe) concentration upstream 0.93mg/l, 0.27mg/l downstream and at discharge point is 1.2mg/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 high with 0.9mg/l and 0.40mg/l upstream, 0.92mg/l for both seasons at discharge point, 2.66mg/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.

Copper (Cu) concentration measure upstream was 0.25mg/l, downstream 0.36mg/l and at effluent discharge point 0.96mg/l the values are lower than permissible limit of 1.0mg/l and 2.0mg/l stipulated by NESREA 2007 and WHO 2006 respectively. This result shows a gradual decrease downstream from discharge point and gradual increase from the upstream to downstream. Previous study conducted by Butu (2002) at Galma Dam observed a similar phenomenon where copper concentration increases from upper region to lower region of

the Galma Dam. However, this result does not conform with the study of Abui (2012) who reported that copper concentration decreases from upstream to downstream of river Romi.

Zinc (Zn) concentration of the water samples upstream is 0.27 mg/l, downstream 0.36 mg/l, upstream and at discharge point 0.42 mg/l which is lower than 1.0 mg/l NESREA 2007 and WHO 2006 permissible limit. The result of the study shows that zinc is far below permissible limit also when compared to the previous study by Abui (2012), both studies show similarities in Zn concentration which increases upstream to downstream of the river Romi.

The lead content of the effluents discharge point is 0.38 mg/l and 0.22 mg/l for both upstream and downstream. These values are above the permissible limit of 0.001 stipulated by NESREA 2007 and WHO 2006. Previous study done at river Romi by Lekwot et al (2012) observed that an average mean count on water samples of lead is 0.11 mg/l while Butu (2002) also observed high concentration of lead in Galma dam. The reason could be due to some chemicals which contain lead such as petroleum products that have been discharged into the river.

Cadmium (Cd) concentration upstream was found to be 0.022 mg/l, downstream 0.074 mg/l and at discharge point 0.078 mg/l, the values decrease downstream of the sampling points which is higher than WHO 2006/NESREA 2007 standard. The value is higher than previous study by Lekwot et al (2012) where it was found that cadmium was very low with upstream value 0.002 mg/l, downstream 0.0004 mg/l and at discharge point 0.024 mg/l, this difference may be as a result of sampling period and lubricating oil discharged around the rivers may have

contributed to the observed high Cadmium levels, since these metals can occur as impurities in fertilizers and in metal-based pesticides and compost manure.

Chromium (Cr) value upstream was 0.2mg/l, downstream 0.21mg/l and at discharge point 0.38mg/l, the values are low and decrease both at upstream and downstream from the effluent discharge point. This is below the permissible standard of NESREA 2007 and WHO 2006. The result is slightly different compared to Abui (2012) in which chromium was not detectable at upstream and downstream but small quantity was noticed at discharge point. The reason could be that little quantity is released into the water and also this difference may be as a result of sampling period.

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.

4.4 EFFECTS OF POLLUTION OF ROMI RIVER ON SOME SELECTED HUMAN ACTIVITIES

4.4.1 Age Distribution of Respondents

The age distribution of respondents is presented in table 4.4

Table 4.4: 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%

Source: Author's Analysis (2014)

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 4.5 Level 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%

Source: Author’s Analysis (2014)

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.

4.4.2 Location of Farmlands of Respondents

The location of farmlands of respondents is presented in table 4.6

Table 4.6: Location of Farmland of the Respondents

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

Source: Author's Analysis (2014)

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 4.7: 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%

Source: Author's Analysis (2014)

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 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.

4.4.4 Effects of the Effluent on Farming, Fishing, Swimming, Cooking and Drinking

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

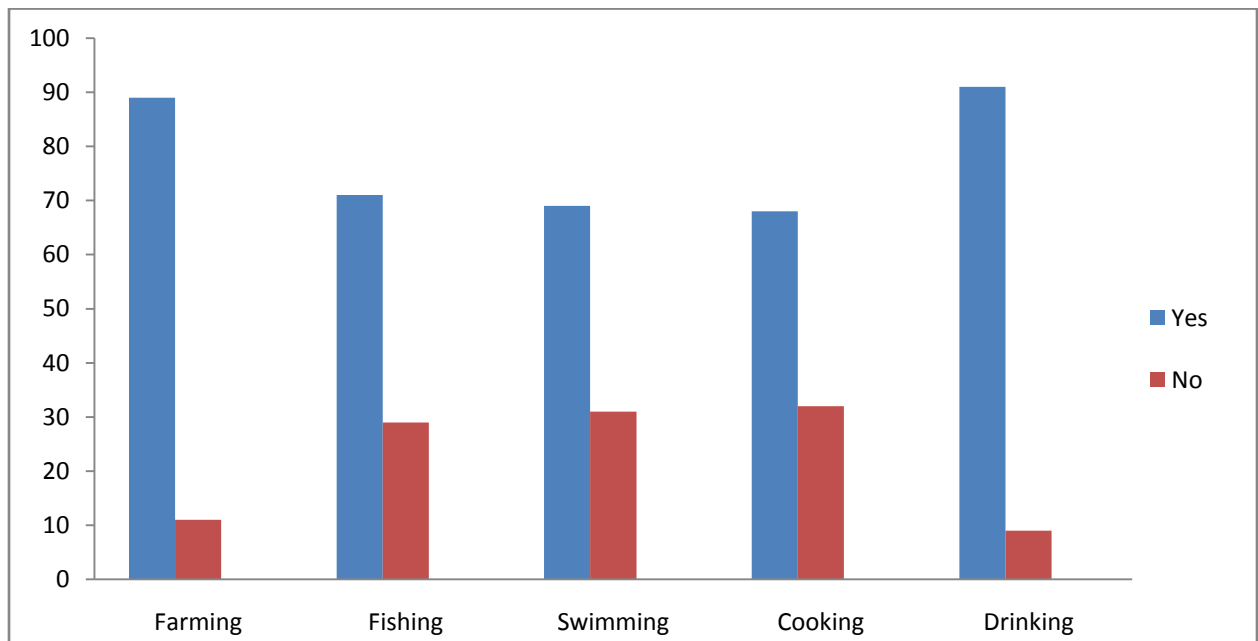


Figure 4.1: Effect of the Effluent on Farming, Fishing, Swimming, Cooking and Drinking

Source: Author's analysis 2014

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.

4.4.5 The Effect of Effluent on the Respondents Farmlands

During the interview with the host communities questions were raised by the researcher on the effect of effluent discharged on River Romi particularly whether it affects their farmlands and crop yield or not. The farmers revealed that they have been experiencing decline in crop yield over the years, and that the deteriorating crop output according to them was due to the pollution of the water from River Romi that usually over flood the farm during rainy season. According to the farmers, during the flood, deposit of oil, grease and other related organic chemicals causes immediate destruction of crops on the field. The farmers explained further that during these years, little or no harvest is made. The farmers also use the river for irrigation. See plate below



Plate 4.1: Pumping of Effluents Water from Effluent Channel to Irrigate Farm

4.4.6 The Effect of Effluent on the Fishes in River Romi

During the interview with fishermen, the fishermen were of the opinion that the effluent discharged into River Romi by the refinery was responsible for declining and loss of the fish population. The fishermen strongly complained that fishes have died and some have migrated; those that remained in the river were very tiny and are not palatable.

4.4.7 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.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter, summary, conclusion and recommendations are presented with an optimum view that if the recommendations are considered and implemented the effects of effluent discharged in River Romi can be managed in a sustainable way and the industries will therefore enhance economic development without destroying ecosystems and the environment at large.

5.2 SUMMARY OF THE MAJOR FINDINGS

The study was carried out to assess the effect of Kaduna Refinery effluent on the water quality of Romi River, the study considered the physico-chemical properties of water upstream, downstream and at discharge point of effluents. Heavy metals are compared with NESREA and WHO standard. It also analysed 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 248 μ m/cmupstream, 290 μ m/cm at discharge point and 263 μ m/cm downstream, also Total Dissolve Solid with values 300mg/l upstream, 495mg/l at discharge point and 324mg/l downstream, furthermore Chemical Oxygen Demand with values 45mg/l upstream, 128mg/l at discharge

point and 66mg/l downstream while Lead with values 0.221mg/l upstream, 0.388mg/l at discharge point and 0.228mg/l downstream, and Chromium 0.22mg/l, 0.38mg/l and 0.21mg/l etc. 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 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 proves that most of the farmers in the study area have been farming for a very long time.

5.3 CONCLUSION

The study analyzed water samples from River Romi, It was observed that River Romi has been contaminated by the effluents discharged from the refinery. The 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 34°C for upstream and downstream and 37°C at discharge point instead of 30°C by both NESREA and WHO, also turbidity with value 12NTU upstream, 18NTU at discharge point and 16NTU downstream instead of 5NTU by both NESREA and WHO while chromium with value 0.22mg/l upstream, 0.38mg/l at discharge point, 0.21mg/l downstream instead of 0.01 and 0.05 by NESREA and WHO. The result indicated that all samples collected at the collection points 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, TSS, TDS, Turbidity, Oil/grease, BOD, COD, DO, Nitrate, Iron, Copper, Zinc, Lead, Cadmium and Chromium.

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 Lekwot et al (2012) in River Romi.

5.4 RECOMMENDATIONS

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

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.

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.

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. See Plate 3.

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.

REFERENCES

- Abui, Y.M. (2012). *Environmental effect of Kaduna Refinery and Petrochemical Company effluents discharge in the Romi area of Kaduna State*. Unpublished PhD Dissertation submitted to the department of Geography and Planning, University of Jos, Nigeria.
- Adamu, U.F. (2003). *Water Quality Evaluation of Rigasa (downstream)*. Unpublished project, National Institute of Water resources, Kaduna.
- Ademorati, C.M.A. (1979). *Studies on Physicochemical Methods of Wastewater Treatment* Ph.D Dissertation. University of London pp394.
- Ademorati, C.M.A. (1983). *The Effect of Pollution on an Impounded Lake in Ibadan*. *AMAN*, (3)1:47-66.
- Adetola, K. (1990). *Notes and Model Answers on Geography for Secondary School Certificate and G.C.E Revised and Enlarged Edition*.
- Africa Report Prepared for Poster Presentation at the Open Meeting of The Global Environmental Change Research Community, Montreal, Canada.
- Ajayi, S.O. and Osibanji, O. (1981). *Pollution Studies on Nigeria Rivers I; Water Quality of some Nigerian Rivers*. *Environmental Pollution Series* 2, 87-95.
- Alam M.N, Elahi and Alkam, D.U. (2006). *Risk and water quality assessment over view of River Sitalikhya in Bangladesh*. *Arad*. Open internet Journal. [Http://www.acadjournal.com/2006vi9/part2/pa](http://www.acadjournal.com/2006vi9/part2/pa), Macmillan Publishers LTD, London, Pp. 275.
- Andrew, E.A. (2004). *Water Quality Assessment of River Rigasa (Mando bridge to panteka)*, Unpublished project, National Institute of water resources, Kaduna.
- Armitage, P.D. Bomes, M.J. and Vincent H.M. (2007). *Long-term Changes in Macro-invertebrate Communities of a Heavy Metal Polluted Stream: the river Nentcumbria, UK after 28 years research and applications*, 23, 997-1015.
- Asomugha, R.Q.E. Orisakwo O.J. Afone E. Obi J.C. Nduka C.E. and Dioka (2005). *Impact of Effluents from Cable Manufacturing Plant on Food, Water and Soil Quality in Nnewi, Nigeria* *Pakjournal of biological science*, 8(5), 744-747.
- Asthana, D.K. and Asthana, W. (2001). *Environmental Problems and Solutions*, second revised edition. New Delhi: Chand and Company Limited.
- Austin, B. (2010). *Kaduna Petrochemical Company Annual Environmental Audit report by Midlands Consultancy Services Kaduna*.

- Ayoade, J.O. (1988). *Tropical Hydrology and Water Resources*. London: Macmillan publisher's ltd, pp 275.
- Barnes, K.H. Meyer, J.L. and Freeman, B.J. (1998). Sedimentation and Georgia's Fishes: An analysis of existing information and future research: Georgia Water Resources Conference, University of Georgia and Athens Georgia.
- Bhagirath, B. and Reddy, V R. (2002). "Environment and Accountability: Impact of Industrial Pollution on Rural Communities", *Economic and Political*, Weekly, January 19.
- Buck, O, Niyogi, D.K. and Tournsend, C.R. (2004). Scale-Dependence of Land use Effects on Water Quality of Streams in Agricultural Catchments. *Environmental Pollution*. 130, 287-279.
- Bunker, S. (2005). *Extractive Economies, the Undevelopment of the Amazon*. Urbana, IL: University of Illinois Press.
- Butu, A.W. (2002). *Variations in the concentration of selected heavy elements in the lower and upper regions of Galma Dam, Zaria*. Unpublished M.Sc. Thesis geography department, Ahmadu Bello University, Zaria.
- Chhonkar, P.K. Datta, S.P. Joshi, H.C. and Pathak, H. (2000). Impact of Industrial Effluents on Soil Health and Agriculture. The Indian Experiences: Distillery and Paper Mill Effluents. *Journal of Scientific and Industrial Research*, 59(1), 350-361.
- Chino, M (1981). In: Kitagishi, K. & Yamane, I. (Ed): *Heavy metal pollution in soils of Japan*. *Japan Sci. Coc. Proc.*
- Ci Jun. (1969). Minamata disease and water pollution on industrial wastes. Review International Ocean Organisations. Med. pp 13-14.
- C.S.E. (1983). State of Indian Environment. A citizen report, Centre for Science and Environment (C.S.E). Delhi pp 23-25.
- Dieter, H.H. Bayer, T.A. and Multhaup, G. (2005). Environmental copper and manganese in the pathol physiology of neurologic diseases (Alzheimer's disease and manganism) *actahydrochimicaetHydrobiologica*, 33, 72-78.
- Dirilgen, W. (2001). Accumulation of heavy metals, in freshwater organizations. Assessment of toxic interactions. *Turkish Journal chemistry*, 25(3), 173-179.
- Dix, H.M (2001). *Environmental pollution*. London: J Willey and Sons Limited pp 60-82.
- ELE International limited (1991). *Environmental Instrumentation to Monitor the Environment*, England: Pp. 1-19.

- Emongor, V., Nkegbe, E., Kealotswe, B., Koorapetse, I., Sankwase, S. and Keikanetswe, (2005). Pollution indicators in Gaborone industrial effluent. *Journal of Applied Science* (5), 147-150.
- Ezeronye, O.U. and Amogu, N. (1998). Microbiological Studies of Effluents from the Nigerian Fertilizer and Paper Mill Plants. *International Journal of Environmental Studies*, 54, 213-221.
- Farva, M.T. and Milton, J.P. (2009). *The Careless-Technology. Ecology and International Development*. New York: The Natural History Press, Pp1030.
- Federal Environmental Protection Agency (FEPA) (2002), 2(10), 4-5.
- Feller, M.C. (2007). Forest Harvesting and Streamwater in Organic Chemistry in Western North America: a review *J. AM. Water Resource Association* 41, 785-811.
- Fewtrell, L., Kay, D., Jones, F., Baker, A. and Mowat, A. (1996). Copper in Drinking Water- An Investigation into Possible Health Effects. *Public Health*, 110, 175-177.
- Forster, U. Wittman, G.W., (1983). *Metal Pollution in the Aquatic Environment*. Springer-Verlag, Berlin.
- Garba, Z.N. Hamza, S.A. and Galadima, A. (2010). Arsenic Level Speciation in Fresh Water from Karaye Local Government Area, Kano State, Nigeria. *International Journal of Chemistry, India*. 20(2): 113-117.
- Glyn, H.J. and Gary, W.H. (1996). *Environmental Sciences and Engineering*, Prentice Hall International Inc. Pp. 778.
- Gupta, M.V. (2006). Challenges in Sustaining and Increasing Fish Production to Combat Hunger and Poverty in Asia. *NAGA* 29(1), 4-10.
- Hem, J.D. (1995). Study and Interpretations of the Water Chemical Characteristics of Natural Water. Science for a changing world. <http://puts.usgs.gov/wasp/wsp2254/pdf/intro.pdf>
- Hussain, M. Ahmed S.M. Abdurrahman, W. (2008). Choter Analysis and Quality Assessment of Logges Water at an Irrigation Project, Eastern Saudi Arabia. *Journal of Environmental Management*, 86, 297-307.
- Iguisi, E.O. (1996). Variations of Soil Loss in Two Sub- Basins Near Zaria, Nigeria. Unpublished Ph.D Dissertation, Department of Geography, Ahmadu Bello University, Zaria, Nigera.
- Igusi, E.O. (1999). The Nature and Magnitude of Toxic Chemical Element in ABU Dam. Paper presented at the 42nd Annual Conference of NGA held at Ogun State University, Ago-Iwoye, Ogun State, Nigeria. Pp. 16-21. May 1999.
- Ileoje, M. P. (1985). *A New Geography of Nigeria*. Longman, Nigeria. Pp. 21-56.

- Isreal, A.U., Bot, I.B., Umore, S.A., Mkpem, U and Ebong, G.A. (2008). Effluent and Solid Waste Analysis in a Petrochemical Company—A Case Study of Eleme Petrochemical Company Ltd, Port Harcourt, Nigeria. *E-Journal of Chemistry*, 5(1): 74-80.
- Jain, V.K. (1978). Studies on Effect of Cadmium on the Growth Pattern of Phaseolus auris varieties, *Absi, I. Bot. Conference. JIBS.*, 57-84.
- Jaji, M.O. Bamgbose, O. Odukoya, O.O. and Arowolo, T.A. (2007). Water Quality Assessment of Ogun River, South West Nigeria. Department of environmental management and toxicology, University of Agriculture, Abeokuta, Ogun State, Nigeria. *Environmental Monitoring and Assessment*. 133(1-3), 473-482.
- Kawahara, M. (2005). Effects of Aluminium on the nervous system and its possible link with neurodegenerative disease. *Journal of Alzheimer's disease*, 8(2), 171-182.
- Koppen, W. (1928). *Klimakarte de Erde*. Justus Perthes, Gotha: In Iguisi, E. O., (1996). Variations of Soil Loss in Two Sub-Basins near Zaria, Nigeria. Unpublished PhD Dissertation, Department of Geography, Ahmadu Bello University, Zaria, Nigeria.
- Lawal, F.A and Singh, K. (1981). Analytical study of waste water effluents of some Tanneries of Kano and Sokoto States for possible environmental pollution bulletin chemical society of Nigeria, 6.
- Lekwot, V. E, Adamu, I. C and Chikogu (2012). Public health effect of effluents discharge of Kaduna refinery into river Romi Kaduna. *Greener journal of Medical Sciences* 2(3), 61-69.
- Linnik, P.M., Zubenko, I.B. (2000). Role of bottom sediments in the secondary pollution of aquatic environments by heavy metal compounds lakes and reservoirs. *Resource Management* 5(1), 11-21.
- Lomnizzi, I. Boemo, A. Musso, H. (2007). Location and characterization of pollution sites by principal component analysis of trace contaminants in a slightly polluted seasonal river: A case study of the Arenales River (Salta, Argentina). *Water SA*, 33 (4), 47a-485.
- LVEMP (2002). Water Quality Management and Sustainability: The Experience of Lake Victoria Environmental Management Project.
- Lwanga, M.S., Kansime, F., Denny, P. and Scullion, J. (2003). Heavy metals in lake George, Uganda with relation to metal concentrations in tissues of common fish species. *Hydrobiology*, 499 (1-3), 83-93.
- Mahdieh, E. and Amirhossein, M. (2009). Water quality assessment of Bertam River and its tributaries in Cameron Highlands, Malaysia: World Applied Sciences Journal. Troth, Perak, Malaysia. Chino M, 1981: In: Kitagishi, K. & Yamane, I. Eds: Heavy metal pollution in soils of Japan, Japan Sci. Soc. Proc.

- Mathuthu, A.S, Mwanga, Kand Simoro, A. (1997).Impact Assessment of Industrial and Sewage Effluents in Water Quality status of three vulnerable fresh water lakes of suburban Chennai,India.
- Mdamo, A. (2001).Accumulation of Nutrients and Heavy Metals in plants at Kagondo natural Wetland (Draft Paper).
- Moran, S. R, Clayton, L, Leb Hooke R, Fenton M. M and Andriashek, L. D. (1980).Glacier-bed landforms of the Prairie Region of North America.*Journal of Glaciology* 25, 457-476.
- Mosley,L.Sarabject, S. and Aaibersberg, B. (2004).WaterQuality Monitoring(1st edition)43p30cm,ISSN:1605-4377:SOPAC.The University of the South Pacific, Suva-fuji Island.
- Mimosa, M. (2007). Water Quality Assessment and Determination of Pollution Sources along the Axios/Vardar River, South Easter Europe, *Desalination*,213, 159-173.
- NEMA (2006). National Environmental Management Authority, *State of Environmental Report for Uganda*.
- Nsiah-Gyabaah, K. (2003). Urbanization, Environmental Degradation and Food Security inNigeria National Petroleum Corporation (NNPC) (2002).The Petroleum Industry and the Nigeria Environment.Seminar NNPC, Warri 9-12 November.
- Ntengwe,F.W.(2005).Designing a Domestic Water Supply System.The Engineer's Perspective and Considerations as a Challenge to Consumers.*PhysicsChem.Earth* 30(11-16), 850-858.
- Okwonkwo,J.C,Obiakor,M.O, Ezeonyejiaku,C.D and Ezenwelu, C.D. (2013). Physicochemical and Heavy Metal Distribution in Fresh Water Column: Season-Location Interaction Effects and Public Health Risk.*Journal of Life Science Biomedicine*,3(4): 308-317.
- Obire, O. and Amusan, F.O. (2003).The Environmental impact of oil field formation water on a fishmetar stream in Nigerian.*Journal of Applied Science Environmentalmanagement*,7, 61-66.
- Okonkwo,J.O and Mothiba, M(2005).Physicochemical characteristic and pollution of heavy metals in rivers in Thohoyandou, South Africa.*Journal of hydrology*,308, 122-127.
- Olaoye,O.A. and Onulide,A.A. (2009).Assessment of Microbial Quality of Sachet-Packaged Drinking Water in Western Nigeria and its Public Health Significance.*Public Health*, 123: 729-734.
- Oluyori, A.O. (1999).*The levels of Concentration of Heavy Metal in the Galma Dam* UnpublishedB.Sc. Dissertation Geography Department Ahmadu Bello University, Zaria

- Onyilo, D.O. (1999). *A chemical Analysis of Some Heavy Metals in the Galma Dam*
Unpublished B.Sc. Dissertation Ahmadu Bello University, Zaria.
- Osibanjo, O. Daso, A.P and Gbadebo, A M. (2011). The Impact of Industries on Surface Water Quality of River Ona and River Alaro in Oluyole Industrial Estate, Ibadan, Nigeria., *African Journal of Biotechnology* 10(4), 696-702.
- Otokunefor, T.V. and Obiukwu, C. (2005). Impact of Refinery Effluent on the Physicochemical Properties of a Water Body in the Niger Delta. *Applied Ecology Environmental Resources*, 3, 61-72.
- Perry, R.H. Green, D.W. and Maloney, J.O. (2007). *Perry's chemical engineers' handbook*. — 7th ed. McGraw-Hill: New York.
- Peters, N.E., Meybeck, M. (2000). Water Quality Degradation Effects on Freshwater Availability Impacts of Human Activities, *IWRA Water International*, 25 (2), 185-193.
- Perak, M. and Chino, M. (1981). In: Kitagishi, K. & Yamane, I. Eds: *Heavy metal pollution in soils of Japan*, Japan Sci. Coc. Proc.
- Phiri, O. Mumba, P. Moyo, B.H.Z. and Kadewa, W. (2005). Assessment of the Impact of Industrial Effluents on Water Quality of Receiving Rivers in Urban Areas of Malawi *International Journal of Environmental Science Technology*, 2, 237-244.
- Porter, E. (1973). *Pollution in Four Industrialized Estuaries*. HMSO London.
- Raymond, P.A., Oh, N.H., Turner, R.E and Broussard, W. (2008). Anthropogenic Enhanced Fluxes of Water and Carbon from the Mississippi River, *Nature* 451, 449-452.
- Reza, R. Jain, M.K. and Singh, G. (2009). Impact of Mining Activities on Surface Water Quality in Angul-Talcher region of Orissa, India. *Mining Engineer's Journal*, 10(11), 22-28.
- Ritter, L., Solomon, K., Sibley, P., Hall, K, Keen, P., Mattu, G and Linton, B. (2002). sources, pathways, and relative risks of contaminants in surface water and groundwater: a perspective prepared for the walker ton inquiry. *Journal of Toxicol Environmental Health part A*, 65, 1-142.
- Royal Commission Reports (1974). Effect of Industrial Effluents in Urban Areas. Europe. No 23, 1529.
- Saad, M.A.H. El-Rayis, O. and Ahdy, H. (1984). Status of Nutrients in Lake Mariut, a Delta Lake in lake in Egypt Suffering from Intensive Pollution. *Mar. Pollution Bulletin*. 15(1), 408-411.
- Sani, M.K. (2004). Policies and Law on wastes management and environmental impact. 1 pp 2.

- Sekabira, K., Oryemoriga, H., Basamba, T.A., Mutumba G and Kakudidi, E. (2010). Assessment of Heavy Metal Pollution in the Urban Stream Sediments and its Tributaries *International Journal of Environmental Science Technology*, 7(3), 435-446.
- Soutari, A. (2003). Why the World Must Learn the Value of Water. The Punch Newspaper Monday June 2 pp 34.
- Tsai, S.M., Wang, T.Nand Ko, YC. (1999). Mortality for Certain Diseases in Areas with High Levels of Arsenic in Drinking Water, *Arch. Environmental Health* 54, 186-193.
- Umeh, J.C., Amali, O. and Umeh, E.U (2004). The Socio-Economic Effects of Tropical Diseases in Nigeria. *Economics and Human Biology*, 245-263.
- UNESCO and WHO (1978). Water Quality Survey. A Guide for the Collection and Interpretation of Water Quality Data. IHD-WHO Working Group. Pp. 32 – 785.
- United States Environmental Protection Agency (USEPA) (2004). Laws and Regulation, Clean Water Act, Nov 27 2002. Pp1.
- Vi, J. and Gustar, R. (1974). The singularities in Japanese pollution and hazardous heavy metals. IRCWD News, No 6 WHO International Conference Centre for Waste Disposal.
- Vivan, E.L., Bashiru, D. and Adamu, C.I. (2012). An Appraisal of Water Supply and Sanitation Situation in Some Selected Areas of Kaduna Metropolis. Published in GURARA Journal of Vocational Technology, School of Agricultural Technology Nuhu Bamalli Polytechnic, Zaria.
- Vivan, E.L., Blammah V.N and Ezemokwe, I.L (2012). Socio-economic impact of the Kaduna Refinery and Petrochemical Company (KRPC) on the Rido Area of Kaduna Metropolis. *Journal of environmental management and safety*, 3(5), 124-139.
- Vutukuru, S.S. (2005). Acute Effects of Hexavalent Chromium on Survival, Oxygen Consumption Hematological Parameter and Some Biochemical Profiles of the Indian Major Carp, Labeo Rhita. *International Journal Environmental Resource Public Health*, 2(3), 456-462.
- Walakira, P. (2011). Impact of Industrial Effluents on Water Quality of Receiving Streams in Nakawa-Ntinda, Uganda. Msc Dissertation, Department Of Science Environmental and Natural Resource, Makerere University Uganda.
- Wasserman, G., Liu, X., Parvez, F., Ahsan, H. L and Heavy, D. (2006). Water Manganese and Children's Intellectual Functions in Araihasar, Bangladesh. *Environmental Health Perspectives*, 114, 124 -129.
- Wasswa, S. (1997). Determination of levels of pollution within sediments in water channels from industries in selected parts of Lake Vizura. *Msc Thesis, Makerere University, Uganda*.

- WHO(1968).Water Pollution Control in Developing Countries.Technical Report Series No.404.
- WHO (1976).*International Standard for Drinking Water* 3rd Edition Geneva, Retrieved from www.rivernetwork.org Retrieved 2nd November, 2012.
- WHO (1993). Report on the Quality of drinking water. *WHO Geneva*.
- WHO (2001).Environmental Health Criteria 224: Arsenic and Arsenic Compounds, 2ndEd.*World Health Organization, Geneva*.
- WHO(2004).Surveillance of Drinking-water Quality. Retrieved on 15thOctober 2012, from www.who.int/watersanitation/health/publications/facts2004/en/index.html Assessed on 15th October, 2012.
- WHO (2006).Guidelines for Drinking Water Quality.First Addendum to the Third Edition Volume 1.Recommendations. Pp. 491-493.
- WHO (2008).Guidelines for Drinking Water Quality, 3rd Edition Incorporation the First and Second Agenda Vol. 1 Recommendations, *World Health Organizations Geneva*.
- Wikipedia (2008). Water Resources. Retrieved April 12, 2008 from http://en.wikipedia.org/wiki/water_Resources.
- World Bank(1998). Pollution Study on Clean up River Kaduna. Part C Report.KEPA/ABUCONS.
- Wotton,RJ. (1992).*Fish Ecology*.Glasgow:Blackie and Sons Ltd.
- Yabagi, I. J. (1989).Nature and Sources of Urban Sediments and their Relationship to Water Quality.Unpublished HND Dissertation, National Water Resources Institute Kaduna.
- Yamane, Y. (1967).*An Introductory Statistical Analysis*. McMillan Press.
- Yusuf, Y.O. and Shuaibu, M.I. (2009).The Effect of Waste Discharge on the Quality of Samaru Stream, Zaria. A Paper Presented at the Conference of the Waste Management Society of Nigeria Held at AguiyiIronsi HallMaitama Abuja.
- Zatta, P. Zucchini, R. VanRansbarg S. and Taylor A (2003).The Role of Metal in Neurodegenerative Processes.Aluminium,Manganese and Zinc. *Brain Research Bulletin* 62 pp15-28.
- Zhang. Q. L., Shi, X. Z., Huag, B. and Yu, D.S. (2007).Surface Water Quality of Factoring, Based and Vegetable Based Peri-Urban Areas in the Yangtze River Delta Region, *China. Atena*,69(1), 57-64.

APPENDIX I

AHMADU BELLO UNIVERSITY ZARIA,
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, Nigeria

Please fill in or tick where appropriate.

1. Name of community or village.....
2. Age
3. Sex: Male [] Female []
4. Educational status: (a) primary school (b) secondary school (c) ND/NCE (d) HND/B SC
(e) PGD/MSC. (f) No formal education
5. 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) If 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 []

14. What do you recommend as the best way to tackle the pollution problems.....

APPENDIX II

RESEARCH QUESTIONS FOR STRUCTURED INTERVIEWED WITH FARMERS AND HOST COMMUNITIES (ROMI/RIDO)

SECTION A: The Effect of Effluent on the Respondent Farmlands

1. Are you a subsistence or commercial farmer
2. Do you use river Romi for irrigation or rainy season farming
3. What are the types of crops grown on your farmland?
4. Has there been incidence(s) of oil (effluent) discharge by the Kaduna Refinery into the Romi River Yes or No
5. Does the water always have odour Yes or No
6. What is the colour of the water Colourless Coloured
7. How would you assess your crop output?

SECTION B: The Effect of Effluent on the Fishes in river Romi

8. Do you use river Romi for fishing Yes No
9. (a) Do you notice any absence or decline in species Yes No
(b) If 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) Climate change (d) others
10. Have these changes affected your yield (a) Yes (b) No

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

11. Do you use Romi river for bathing/swimming cooking drinking animal watering

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 []
14. In which season of the year is the pollution most or least noticed (a) Dry season []
(b) Rainy season []