ASSESSMENT OF HEAVY METALS CONCENTRATION IN GURARA RESERVOIR, KACHIA LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA

BY

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Declaration

I declare that the work in this Dissertation titled "ASSESSMENT OF HEAVY METALS CONCENTRATION IN GURARA RESERVOIR, KACHIA LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA" has been carried out by me in the Department of Geography and Environmental Management, Ahmadu Bello University, Zaria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other Institution

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Student	**Signature**	**Date**

Certification

The dissertation titled‘‘ASSESMENT OF HEAVY METALS CONCENTRATION IN GURARA RESERVOIR, KACHIA LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA’’by Awa Umoru ALESA meets the regulations governing the award of the degree of Master of Science in Environmental Management of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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Dedication

This research work is dedicated to my late father,MallamUmoruA. Gadzama, who taught me never to give up in life, you are the best father one could ever have, continue to rest in peace.

Acknowledgement

To God be the Glory!Am most grateful to the Almighty for making me to see this time in my life, for indeed,everything that has a beginning must have an end.

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Abstract

The aim of this study was to assessthe level of concentration of heavy metals in Gurara Reservoir, Kachia local Government Area Kaduna State and the results compared with the World Health Organization (WHO) standard for quality drinking water. Three research hypotheses were formulated to guide the study. The study made use of six sample locations on the Gurara reservoir where water and sediment samples were collectedfor bothwet and dry season. Labelled as wet season water sample(WSWS),dry season water samples (DSWS),dry season sediment samples (DSSS) and wet season sediment sample(WSSS) respectively and taken to the laboratory of Defense Industrial Cooperation of Nigeria(DICON),Kaduna for analysis in order to assess the presence of heavy metals and their concentrations. Atomic Absorption Spectrometer (AAS) was used to identify heavy metals present in the water while the X-ray fluorescence was used for the sediment samples. The following heavy metals were present in the water namely; Cadmium (Cd), Nickel (Ni), Cobalt (Co), Iron (Fe),Copper(Cu), Chromium (Cr), Manganese (Mn), Lead (Pb),Aluminium (Al), while the heavy metals present in the sediments are; Titanium (Ti),Vanadium (V), Chromium (Cr),Manganese (Mn),Iron (Fe), Copper (Cu), Arsenic (As), Silver (Ag), Europium (Eu), Bismuth (Bi), Rhenium (Re), Aluminium (Al), Gold (Au), Nickel (Ni), Ytterbium (Yb), Lead (Pb), Platinium (Pt) and Mercury (Hg). It was observed that there were more presence and concentration of heavy metals in the sediments than in the water samples, this can be attributed to the fact that concentration tends to settle at the bottom. The concentration of heavy metals during dry season was higher than the concentration during wet season. The analysis of heavy metals concentration in the sediments and water samplesin sediment followed the order: Al, Fe, Bi, Pb, Ti, As, Hg, Ag, Pt, Au, Eu, Re, Cr, Mn, Ni, Yb, V, Cu and Al, Cd, Fe, Co, Cr, Mn, Cu, Pb, Nirespectively. Findings revealed that there

weresignificant difference betweensomeof the physiochemical properties of water during the dry and wet seasons as the p-values for some of the elements were above 0.05 level of significance. The mean concentration (mg/l) of heavy metals in water samples during dry and wet seasons were calculatedand t-test result indicated that there aresignificant variation ($p<0.05$)in five heavy metals (Cd, Co, Fe, Cu and Mn) in water during the wet season in the study area when compared with the WHO standard with p-values less than or equal to 0.05 while heavy metals (Cr, Ni, Pb and Al) did not showsignificant value with p-values of 0.14, 0.56, 0.37 and 0.37 which werehigher than the 0.05 level of significance respectively. This implied that there was a variation betweenthe heavy metals and the WHO standards in some of the identified heavy metals tested during wet season.A careful analysis of heavy metals in dry season shows that there is a significant difference in some of the heavy metals of water during the dry season in the study area when compared with the WHO standard forlead,aluminiumand andnickel which shows not significant value with p-values of 0.15, 0.11, and 0.89 which are greater than the 0.05 level of significance respectively. This is an indication in that the water in the study area was relatively safe for drinking.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Water is essential to life and its distribution and availability are closely associated withthedevelopment of human society. Apart from air, water is the most important resource to man. Man can survive longer without food than without water. Without sufficient supply of water, the human body dehydrates and death can occur within short period. Therefore,without it,life is impossible. Indeed, it is a foundation for human prosperity and adequate quality water supply provides basis for his development. It also support all forms of life and creates jobs and wealth, tourism recreation and fishing (Ward, 1975; Yusuf, 1992; Ntengwe, 2005;Young, 2006).

Water demand already exceeds supply in many parts of the world, andas world population continues to rise at an unprecedented rate, moreareas are expected to experience this imbalance in the near future. In most part of Africa, people have no access to potable water. The demand for freshwaterhas 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, 73% have no sanitation, and some of their waste eventually contaminate their drinking water supply leading to a high level of sickness (Vivan,Bashiru, and Adamu, 2012).

Globally, 768 million people lack access to an improved water source, and more than 80 % ofthese people live in rural areas World Health Organisation (WHO)2013 and United Nation Children'sEmergency Found (UNICEF)(2013).Reports by Food and

Agricultural Organization (FAO) revealed that in African countries, particularly Nigeria, water related diseases had been interfering with basic human development (FAO, 2007).

According to the World Commission on Water for the 21^{st} century, more than half of the world's major rivers are so depleted andpollutedthatthey endanger human health and poison surrounding ecosystems. Whenwastewater finds its way into any water body, itpollutes the water. Water pollution is primarily associated with domestic and industrial waste. Both types ofwastewater pose threats to water quality, which may be classified into health hazards and sanitation nuisances. Each day,about 25,000 people are said to die from daily use of waste water and millionsabout suffer from frequent and devastatingwater borne illness World Health Organisation (WHO, 2004). Worldwide demand for water is steadily increasing as industrialization, agricultural use, urbanization, and a rising standard of living for the globe is continuously growing population drive water consumption ever higher. Slightly more than one-half of available freshwater supplies are currently used for human purposes, and world water demand doubles every 20 years United State Agency for International Development (USAID, 2004).

Although heavy metals naturally occur at low concentrations with relatively short residence times in water, river catchments can become a source of concern if the level of heavy metals in them exceeds health guideline concentrations. The sources of heavy metal load include weathered soil or rocks, mining and metallurgical releases, and industrial emissions (Olatunji and Osibanjo, 2012)

In small quantity, heavy metals are nutritionally essential for animal and human health. They arereferred to as the traceelements. Examples include iron, copper, manganese, and zinc.These elements, or their compounds, are commonly found naturally in foodstuffs, in fruits and vegetables, and in commercially available multivitamin products.

Diagnostic medical applications include direct injection of gallium during radiological procedures, dosing with chromium in parenteral nutrition mixtures, and the use of lead as a radiation shield around x-ray equipment. Heavy metals are also widely used in industrial applications such as in the manufacture of herbicides, fungicides, pesticides, batteries, alloys, electroplated metal parts, textile dyes, and steel e.t.c. Many of these products are in our homes and actually add to our standard of living when properly utilized (Galadima and Garba, 2011).

Inevitably, modern man needs water for various purposes: agriculture, industry, domestic and municipal use and he depends largely on the rivers, lakes and aquifers to meet his needs. Its inadequacy in supply to household and its contaminations can cause offensive odour and thereby precipitate severe health problems like water related illnesssuch as typhoid fever, cholera, diarrhoea etc which are prevalent sometimes to an epidemic scale and food storage becomes critical(Anil-Kumar,2004;Ariyo and Jerome, 2004;Hinman, Blackburn and Curtis,2006;McCully, 2006)

Much human history is tied up in the struggle for and use of water. Not only does everyliving thing require water to maintain life, it is also essential in man’s efforts to increase his food, improve his industrial capacity and raiseshis living standard. These, therefore, justify the great need for the regular supply of water. Thus,Todaro (1982) states that there are certain basic needs which must be provided for the maintenance of life without which life would be impossible, to these life-sustaining needs water belongs. Water is freely available through rainfall, but man has until fairly recently taken this unique resource forgranted. Although, more than 70% of this earth’s surface is made up of water, still it has become a scarce commodity in many parts of the world today (Ayoade, 1985).

Water pollution is the most serious water related problem in many parts of the world today. Pollution generally affects the quality and quantity of available water for most purposes. Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, and aquifers). It occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove,harmful compounds.Water pollution occurs in different forms and is caused by various factors. The pollutant may for example be in liquid or solid form and thereby may affect the physical, chemical or biological characteristics of the water.In almost all cases, the effect is damaging not only to individual species and population, but also to the natural biological communities(United State Clean Water Act (CWA), 1987).

Sources of water pollutioncan be categorized as being a point source ornon-point sources. Point sourcewater pollutions refers to contaminants that enter a water body from a single identifiable source such as, a pipe or ditch. Examples include discharge from a sewage treatment plant, a factory or a city storm drain,as well as industrial storm water,such as construction sites. Non-Point Source(NPS) refers to diffuse contamination that does not originate from a single discrete source. It is often the cumulative effect of small amount of contaminants gathered from alargearea; a common example is the leaching out of nitrogen compound from fertilized agricultural land. Contaminated storm water washed off of parking loads, roads and highways calledurban runoffis sometimes included under the categories of nonpoint source pollution(United State Clean Water Act(CWA),1987).

Heavy metals become toxic when they are not metabolizedby the body and accumulate in the soft tissues. They may enter the human body through food, water, air, or absorption through the skin when they come in contact with humans in agriculture and in manufacturing, pharmaceutical, industrial, or residential settings (Lin, Wong, and Li, 2004; Galadima, Muhammed, and Garba, 2010).

Human beings are constantly in contact with heavy metals while carrying out their daily activities,due to the necessity of some of them in our daily life as kitchen utensils, packaging materials,fuel components(lead)and component of locomotives(Aluminum used in plane and boat construction due to its strength to weight ratio)as well as important parts of enzymes and circulatory pigments(iron,zinc,calcium and magnesium)(Nolan, 2003).Mercury and lead for example, are widely used in technology but are so toxic that minute quantity can destroy life.Pesticides are recognized worldwide as a veritable means of controlling pest, at the same time such chemicals are highly toxic to other species in the environment. The principal pathway that causes ecological impacts is that of water contaminated by pesticide run off. The two principal mechanisms are:(i) Bioaccumulation: This is the movement of chemicals from the surrounding medium into organisms. Some pesticides such as "Dichlorodiphenyltrichloroethane" (DDT) are "Lipophilic" – meaning that they are soluble in, and accumulated in, fatty tissue such as edible fish tissue and human fatty tissue. Otherpesticides such as glyphosate are metabolized and excreted. (ii) Biomagnification: This term describes the increasing concentration of chemical pesticides as food energy is transformed within the food chain. Some pesticides enter the bodies of tiny, bottom dwellingorganisms such as crustaceans. A hundred of these organisms are eaten by one small fish. One big fish eats a hundred of these small fish and consequently man consumes the big fish. Each organisms stores the pesticides in its tissues, so at each step along the food chain, the amount of the pesticides passed on to the next organism increase (Ubuch, 2016)

Galadima*et al*,(2010) stated that a good number of food items such as kolanuts, *eba, moi-moi* and *agidi* are wrapped in thick layers of leaves (which are good heavy metals sources), usually disposed off on the streets. In most cases the leaves on the streets find their way to gutters and when there is a heavy down pour, lakes, dams, streams and other water bodies used by local communities for drinking and other household activities. Toxicities ofheavy metals can range fromsevere illness to death of both plants and animals.

Heavy metals can generally be introduced into the environment and cconsequently living organism through air, water, food and soil (Ayodele and Abubakar, 2001; Ibeto and Okoye, 2010).However, the degree of concentration and reconcentration depends on the type of heavy metals and the activities taking place in a particular area.

Throughout the world, the provisions of water that meet human use standard are essential requirements. Unfortunately, the process of analyzing 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.In Nigeria today, several ways wereidentified through which specific heavy metal can be transmitted to living species. Continuous use of leaded gasoline contributed greatly to the number of cases ofchildhood lead poisoning. Leaded gasoline in Nigeria contains lead in the concentration range of 0.65 to 0.74g/l (Table 1.1)

The Clean Air Initiative proposed by Thomas and Kwong (2001) is to reduce the concentration of lead to 0.15 g/land finally to zero level of heavy metals.However, numerous studies revealed that, the initiative is just on paper due to government negligence (Orisakwe, 2009) and the consequences have been severe environmental problems. Upon the combustion of the leaded petrol in the engine, the organic lead is oxidized to lead oxide.The lead oxide formed reacts with the halogen carriers lead halides like lead chloride ($PbCl_2$), lead bromide ($PbBr_2$), lead chlorobromide PbClBr, which escape into the air through vehicles exhaust pipes.About 80% of lead in petrol escapes into the air.

Table 1.1: Concentration of Tetraethyl Lead in Gasoline in Various countrie

Country	Concentration (g/litre)
Nigeria	0.65-0.74
Algeria	0.60
South Africa	0.33
Libya	0.60
Morocco	0.30
Tunisia	0.50
Sudan	0.40
United Kingdom (UK)	0.00
United States of (USA)	0.00
Highest in the World	1.0

Source: Thomas and Kwong (2001)

Human beings, animals and soil are the ultimate recipientsof the lead particulate. It sometimes exists in soil as lead(II)sulphate ($PbSO_4$). Concentrations of about 100 to 1000 ppmhave been recorded depending on the nature of the activities,carried out in a particular area (Galadima *et al*, 2010; Garba,Hamza and Galadima, 2010).

High levels of pollutants in river water systems causes an increase in biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolve solids (TDS), total suspended solids (TSS), toxic metals such as cyanide (CN), cadmium (Cd),chromium (Cr), nitrate($N0_3$), lead(Pb) and faecal coliform hence make such water unsuitable for drinking, irrigation farming and aquatic life. Industrial wastewaters range from high (BOD), from biodegradable wastes such as those from human sewage, pulp and paper industries, slaughterhouses tanneries and chemical industry. Others include plating shops and textiles, which may be toxic and require on-site physicochemical pre-treatment before discharge into municipal sewage system. (Emongor, Nkegbe, Kealotsewe, Koorapetse, Sankwaseand Keikanetswe, 2005; Phiri, Mumba, Moyo, and Kadewa, 2005; Otokunefor and Obiukwu, 2005).

Environmental pollution is one of the most investigated problems at this present time, reason being that most industrial, municipal waste and chemical from farmland end up in our rivers and lakes. Inorganic substances like herbicides and pesticides from our farms have proven to be more persistent than organic matter in water pollution since they are not readily removed by in-situ oxidation. Thus, render the water unsuitable for aquatic organism, irrigation and domestic purposes, and therefore, it is important to know their level of concentration.

1.2 Statement of the Research Problem

Most cities have no central sewage system and therefore sewage is not only untreated, its disposal is grossly inadequate and inefficient. In many areas human waste are disposed offby means of septic tanks and pit toilet(i.e. *Salga*). In rural areas and in urban slums, these facilities do not exist and any available open spaces are used for defecation. Since there is no central sewage system and the sewage is not treated, it therefore easily contaminates or pollutes the underground and surface water. The common sources of water that are available to local communities in Nigeria are fast being severed by a number of anthropogenic factors, of which pollution remain the most dominant problem. Some of these pollutants are decomposed by the action of microorganisms through oxidation and other processes. The major problem is the re-concentrations of these harmful substances in natural food chain (Osuide, 1990). On the other hand, when this contaminated water is directly consumed without proper treatment (a common practice to local communities), spread of diseases such, as typhoid, dysentery, cholera, hepatitis and so forth will occur.

The National Environmental Standard and Regulatory EnforcementAgency (NESREA) established to check these environment abuses has had little or no 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 resources unwholesome and hazardous to man and other living resources. Water pollution is now a significant global problem (Ezeronye and Amogu, 1998).A number of contaminants are responsible for ground water contaminationincluding a wide variety of chemicals and pathogens. Most of these lead to reduction in normal oxygen content in water and hence make it unfit for consumption (Udaybir, Arvind and Jaswinder, 2014).

In Nigeria today, research indicates that, majority of the common Freshwater sources are polluted, resulting to serious outbreak of diseases,on the other hand, studies have also shown that industrial activities release heavy metals either as solid, gas and most especially liquids in the form of waste water or effluents if allowed draining into water ways orbodies (Bryee-Smith, 1971; Umeh, Amali, and Umeh, 2004; Jaji, Bamgbose, Odukoya and Arowolo, 2007; Olaoye and Onilude, 2009; Yusuf and Shuaibu, 2009; Garba*et al*, 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.

A study by Umeh *et al*(2004) showed that 48% of the people in Katsina-Ala Local Governmentarea of Benue State Nigeria are affected by urinaryschistosomiasis due to increase in water pollution index. Investigations indicate that 19% of the whole Nigerian population is affected, with some communities having up to 50% incidence. This has raised serious concerns to World Health Organisation, in an attempt to improve cultural and socio-economic standards of people in the tropical region (Okigbe, 1984; Umeh, 1989; Umeh*et al.,* 2004). Jaji *et al(*2007) examined the water quality of Ogun river in South – West Nigeria, which was studied by a field survey for a period of 1 year (covering dry season and rainy season). Water samples were collected from thirteen sites and analysed for physic- chemical and bacteriological parameters as well as heavy metals using standard methods. Generally, the values obtained for turbidity, phosphate, oil and grease, iron and faecal coliform from all the sites in both season were above the maximum acceptable limit set by the WHO for drinking water. Futhermore, Isreal, Bot, Umere, Mkpen and Ebony (2008) also observed the ineffectiveness ofwater purification system and remarked that wastewater may become seriously dangerous, leading to the accumulation of toxic products in the receiving water bodies with potentially serious consequences on the ecosystem. Olaoye and Onilude (2009) have 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 metals poisoning through drinking water have also been documented.

Garba*et al*,(2010) reported a mean arsenic concentration of 0.34 mg/l in drinking water from hand dug wells, boreholes and taps ofKaraye Local Government Area(LGA), Kano State. The arsenic levels are of serious concerns to regulatory agencies because they by far exceed the upper band (0.01 mg/l) recommended by WHO. The major issues of national and international interest are how these water pollution problems could be fully assessed and mitigated with proper knowledge and planning very essential.

Joint field studies were carried out by international organizations namely Medecins Sans Frontieres (MSF),Doctors without border, Blacksmith Institute (BI), World Health Organization (WHO)in collaboration with affected local governments, Zamfara State and the Federal authorities in Nigeria in 2010 on the blood-lead concentrations in 133 samples from young children in the villages of Yargalma and Dareta. The outcome revealed that 100% of the children had blood-lead levels exceeding 10ug/dL (theinternational standard for the maximum safe levels of leadin blood), 96% of the children exceeded 45 ug/dL.

Yusuf and Shuaibu (2012) also studied the effect of waste discharge on the quality of Samaru streams, in Zaria, Nigeria.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 of 15 as specified by the Nigerian Standard for Drinking Water (NIS). While the studies cited above have been conducted to analyse the different aspects of water quality, to the best of the researcher's knowledge, none of these studies have assessed the concentration of heavy metals in the Gurara Reservoir.

The Gurara Dam was completed in 2007 across the GuraraRiver with the aim of supplying the Federal Capital Territory with raw water into the Usuma dam. Since 2007, enormous amounts of sediments and pollutants have been eroded into the reservoir, including heavy metals.The Gurara River, which has its source from the Jos plateau, and flows through Kaduna State can be suspected to be polluted, particularly with heavy elements considering its extensive catchment area, with such a large catchment and flowing through such large urban settlements like Jos Plateau and Kaduna metropolis, it is highly probable that there is some level of concentration of heavy metals in the waters of the reservoir, which spans several urban and rural communities.

Basedon the foregoing the following research questions became apparent:

a. What are the heavy metals in the reservoir and its sediments during wet and dry season?

b. What is the level of concentration of heavy metals therein?

c. Is there any variation in thelevels of concentrations of the heavy elements in the reservoir and sediment?

d. Is the level of concentration acceptable by the WHO and natural water quality standard?

1.3 Aim and Objectives of the Study

The aim of the study is to assess the level of concentration of some heavy elements in the Gurarareservoir, Kachia LGA Kaduna State.This was achieved through the following specific objectives; which are:

i. identifythe heavy metals present in the water and sediment of the Gurara reservoir.

ii. determine the levels of concentration of the heavy metals in the water and sediments.

iii. examinethe variation in heavy metals concentration between surface water and sediments, during the wet and dry seasons.

iv. compare the levels of concentration with WHO natural water quality standard.

1.4 Hypotheses

Three hypotheses were formulated to guide this study, they are:

H_o1: There is no significant difference between heavy metals present in water during the wetand dry season.

H_o2: There is no significant difference between heavy metals present in sediments during the wetand dry season and the WHO standard.

H_o3: There is no significant difference between heavy metals present in water during dry and wet season and the WHO standard.

1.5 Scope of the Study

In terms of spatial extent, the studycovered the Gurara reservoir, which is located in Kachia LGA of Kaduna State. Water and sediment samples were collected and taken toDefenceIndustries Cooperation of Nigeria (DICON) laboratory Kaduna,todetermine the level of concentration of their heavy metals. The study wascarried out in the dry and wet season of2015.

1.6 Significance of the Study

Thisstudy helped to determine the concentration of some of the heavy metals because exposure to these heavy metals has resulted totoo many functional disturbances in humans.The major heavy metal cases in Nigeria were believed to be associated with lead poisoning. They are mostly severe in young children because their brains and central nervous systems are still being formed. Learning disability, stunted growth, poor brain sensation, behavioral problems, kidney damage andimpaired hearing are all associated with exposure to heavy metals like lead. This studyof heavy metals will mitigate most of this problem, and also avart future occurances.

High concentrations of lead in the body can result to mental retardation, coma and eventual death. Reported symptoms include constant headache, loss of appetite, vomiting, nausea, irritability and/or behavioral problem. Exposure to mercury by young children can have sense neurological consequences, preventing sheaths from forming properly. It damages the central nervous systems, endocrine system, kidneys and other organs. Exposure over long period results to death. The element and its compounds are toxic to fetuses and infants. Women who have been exposed tomercury during pregnancy have sometimes given birth to childrenwith serious birth defects (Galadima, Garba, Leke,Almustapha and Adam,2011). The determination of heavy metal concentration is important because all this functional disturbances will be taken care of and people will also be enlightened on best methods to avart future occurances.

Occupational exposure has resulted to many functionaldisturbances, including erethism, irritability, excitability,excessive shyness, and insomnia. With prolong exposure, a finetremor develops and may escalate to violent muscular spasms.Tremor initially involves the hands and later spreads to theeyelids, lips, and tongue. Severe exposure has been associatedwith more subtle symptoms of erethism, including fatigue,irritability, vivid dreams, depression and memory malfunction(Garba *et al*., 2010, Galadima*et al*., 2010; Galadima *et al*., 2011,Nubi and Oyediran, 2011).

Other heavymetals such as cadmium, chromium, nickel and zinc werereported to be associated with irritation of the eyes andrespiratory passages, damage to brain, liver, bones and kidney,bronchitis, dermatitis, emphysema, hypertension, rickets andasthma (Usman, 2000; Galadima*et al*., 2010). Others aremutagenic, carcinogenic and tetra genic. Even though certainlimit of iron is necessary for normal human health, higherconcentrations were found to be associated with stomach andintestinal corrosion, leading to bleeding and shock development.The level of concentration of the heavy metalsanalysed will be compared with the WHO recommended standard for drinking water and other water quality standards. This study will also show how safe the Gurara reservoir is for human consumptions and advice government on how best to treat and remove these heavy elements.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter tend to look at some previous study on heavy metals, and how best water quality can be monitored.

2.2 Water and Pollutants

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). 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.

Water supply and incidences of water pollution have been a major concern in all parts of the world. Okafor (1985) is of the view that the type of incidence of water-borne disease vary according to the socio-cultural characteristics and levels of economic development of a country. It is a common practice in Nigeria today to find hawkers and roadside sellers contributing tremendously to the deplorable stage of cleanliness in our environment, especially in cities Okafor (1985).

Tin cans used for packaging processed food, sweet wrappers, papers and polyethylene bags of the so-called "pure water" litter the streets. It is also common to find domestics and animal waste and dung in open spaces around our environment. Roadside mechanics also empty their oils and lubricants indiscriminately into open spaces and gutters. Most of these wastes often find their way into drainage gutters and eventually end up in rivers and dams. Ademoroti (1988) observed that the discharge of untreated or incompletely treated wastes containing algae, nutrients, and no biodegradable, organic, metals, and other toxicants will hasten deterioration of receiving water bodies such as rivers, lakes or dams. It is therefore very necessary to study the levels of concentration and the nature of chemical elements in our rivers that are used for domestic purposes.

Chemical elements are introduced into aquatic systems because of the weathering of soils and rocks, from volcanic eruptions, and from a variety of human activities involving the mining, processing, or use of metals and or substances that contain metal pollutants. The most common metal pollutants are arsenic, cadmium, chromium, copper, nickel, lead and mercury. There are different types of sources of pollutants; point source (localized pollution), where pollutants come from a single identifiable sources. The second type of pollutant sources are non-point sources (diffuse pollution), where pollutants come from dispersed sources, and often difficult to identify sources (Lentech, 2006*)*. The main threats to human wellbeing are associated with lead, arsenic, cadmium and mercury pollution (United Nations Environmental Protection (UNEP)/Earth watch 2006). Pollution of surface water by lead, cadmium and arsenic is very common in developing countries.

2.3 Water Demand and Human Population

Demand for water supply is increasing especially due to population explosion. According to the PopulationAction International, add another three billion people 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). Adewale (2002) observed that the current global inadequate water supply might become more precarious as three billion people are reported to be living in 48 water-stressed countries as against 58 billion who lived in 31 of such countries in the past.

Apart from the shortage in quantity, the available Freshwater 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(Soutari, 2003).

2.4 Freshwater Contamination and Quality Assessment

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 developmentover the last decades and 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). Farva and Milton (2009) commented that the advancements in present century technological development have not been met with desirable environmental consideration. Consequently the element of nature especially soil, water, air, plant and animals are being degraded at an alarming rate.

In rural and un-urbanized watersheds, the quality of surface water resources is high because of plenty oxygen available to help in natural or self-purification. Nowadays, however, most water resources contain several non - degradable materials such aschemical elements, organic biocides and other toxic materials, which are regarded as potential pollutants and are dangerous to plant and animal life(Butu, 2002).

Zhang, Shi, Huag and Yu (2007) argued that river systems carry a significant load of materials in dissolved and particulate phases from both natural and anthropogenic sources downstream.The water quality of a river is influenced by many factors including atmospheric chemistry, the underlying geology, climate changed 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; Hussain, Ahmed and Abulrrahaman, 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 accumulated though 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 (Forstner and Witman, 1983).

2.5 Water Quality Monitoring

Water quality monitoring has become a matter of concern in stream, and river systems affected by careless disposal of urban effluents. Run-offs, atmospheric deposition and domestic and industrial effluent discharges are the major sources of aquatic pollution (Linnik and Zubenko, 2000).

Dammo and Sangodoyin (2014) studied the effects of Socio-economic activities around Alau Dam on the quality of raw water supply to Maiduguri Treatment Plant, Nigeria. Data for study was generated through the administration of questionnaires interview and water quality analysis. The samples were subjected to physical, chemical and biological analysis to check the water suitability for drinking and agricultural use. The study reveals pollution of the water with high concentration of nitrate (260-230 mg-NO_3/l), phosphate (22-28mg/l) and Escherichia coli (13-24n/100mg). The study also revealed that these findings were because of improper sanitary management, inadequate public education on irrigation, indiscriminate waste disposal and some farming practices. The researchers lastly recommend regular monitoring of socio-economic activities around the dam, and doing away with unhealthy waste disposal practices to safeguard the raw water supply to the treatment plant.

2.6 Effect of Water Pollution on Human Health and AquaticOrganisms

The term heavy metalrefers to any metallic chemical element that has a relatively high density and is toxic at high concentration. Heavy metals are natural components of the earth's crust, which cannot be degraded or destroyed by nature. To some extend 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 consequence of marine pollution include creating a harsh environment, which adversely affects activities of marine micro flora as well a fish and other marine lives (Obire and Amusan, 2003).

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). Itai-Itai disease caused by cadmium poisoning originated in a prefecture factory in Japan. The disease damages the joints, softens the bones and causes the body to shrink and affected person dies painful death(Dieter, Bayer and Multhaup, 2005).

Zamfara lead poisoning is the worst and most recent heavy metals incidence in the Nigerian records that claimed the lives of over 500 children within seven months in 2010. Between January and July, illegal miners from seven villages of Bukkuyum and Gummi Local Governments in Zamfara State brought rocks containing gold ore into the villages from small-scale mining operations; however, the villagers did not know that the ore also contained extremely high levels of lead. The ore was crushed inside village compounds, spreading lead dust throughout the community (Blacksmith, 2010).

Aluminium in drinking water has been associated with the development of dementia-type syndrome and postulated as one of the etiological agents of Alzheimers disease (Kawahara, 2005). High levels of Copper in drinking water have also been associated with different pathologies in human. For example in London, there were several reports on specified liver complaints in infant patient who were found to live in areas served by public drinking water supplies that contained high Cu concentration (Fewtrell, Kay, Jones, Baker andMowat 1996). Acute gastrointestinal effects, which include nausea, vomiting and diarrhoea, may be observed in some individual at Cu concentration in drinking water above 3mg/l (WHO, 1993). Acute effects of lead are inattention, hallucination; delusion, poor memory, and irritability are symptoms of acute intoxication. Lead absorption in children may affect their development and also result 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-term intake of arsenic may give rise to skin lesion at concentration of 50mg/l. Arsenic was also reported to cause cancer of the skin, lungs, bladder, and other internal organs along with numerous non-cancer diseases (Tsai, Wang and Ko, 1999; Ritter *et al*., 2002).

2.7 Guidelines for Drinking Water Quality

The World Health Organisation (WHO) International Standards for drinking water have been among one of the most widely recognized and utilized WHO's. International water quality standard started in 1958 when WHO published its first International drinking water standard. In 1961, WHO aimed at providing upgraded standard to industrialized countries in Europe, beside the international standards. From there onward several other publications come from time to time, they include the revised edition of the WHO standard such as WHO (1993 and 2005) standard among others.

United Nation EducationalScientific and Cultural Organisation (UNESCO, 1978) classified the physical and chemical 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 significance 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 also.

2.8 Previous Studies on Heavy Metal Concentration

Dim, Ewa and Ikpokonte (2002) examined the Kubanni river sediments and reported the presence of uranium and thorium enrichment. They suggested that the probable contributory factors for the enrichment of these metals in the Kubanni river sediments are either phosphate fertilizers used on the neighbouring farms or aeolian deposition by the North Eastern trade (Harmattan) winds blowing from the Sahara desert across the Northern Nigerian Savannah region. The other major contributing factors are the annual weathering of the basement granites.

Butu and Bichi (2013) carried out a research on assessment of heavy elements in Galma dam, Zaria Nigeria.The result of the study showed that there is significant amountof Pb, Cr, Fe, Co, Zn andCu which occurred at different levels of concentration, and are distributed at both the upper and lower regions of Galmadam.A very low concentration of Cd also in the dam and the level of Ni at both region of the dam is below the detectable limit. Pb, Cr and Fe showed a slightly high enrichment levels above permissible standard and this may pose some health complication if the concentration increase above these levels in the long run.This is because heavy elements are known to be non biodegradable, they bioaccumulate progressivelyin aquatic organisms and human cells when expose to them over a long period. The presence of these heavy elements in the dam can be explained by pluvial processes, which washed synthetic debris that contained these metals into the dam during rainy season as well as release of some elements from geologic processes.

Ayenimo, Adeyinwo and Amoo (2004) in their research on heavy metal pollutions in Warri River,used Flame atomic absorption spectrophotometry method. They determined the total levels of Fe, Cu, Ba, Pb, Cd, Cr, Ni and Co in ppm specifically at upstream, effluent zone, and downstream of river in each industrial location. Fe, Cu and Pb were found to be the most abundant metals in the river. The metal distribution pattern of the river clearly indicates the source of pollution to be land-based and implicates the industries in the adjacent area as the most likely source. They also correlated elemental concentrations using correlation analysis which suggests that some of the metals were strongly associated, indicating a common source or chemical similarity for the coupled elements. The research further revealed variability in the concentrations of the metals obtained in different parts of the river which suggests that different industries contribute significantly to the heavy metal load of the river. The authors emphasized the value of constant monitoring of rivers and water bodies receiving effluents in order to forestall cumulative effects of metals in rivers, which may lead to sub-lethal consequences in the aquatic fauna and ensuring clinical poisoning to man.

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 concentration of Cd, Cu, Pb and Zn. The concentration value for the wet season is generally higher than that of the dry season. This they attributed to runoff from land into the river during the wet season. It was also observed that Pb concentration in water samples from all the rivers were significantly higher than the value for the other metals in both wet and dry season. This high level shown by Pb, they reported may be attributed to the deposition of Pb particulates on the roads next to the rivers especially during precipitations. The high concentration of Pb in Madanzhe and Mvudi Rivers may also have been influenced by the effluent from the nearby sewage treatment plant and a waste dumping site.Also the agricultural activities around the river may have contributed to the observed high level of Pb and Cd levels. Since these metals can occur in impurities in fertilizers and in metal – based pesticides and compound manure.

Nwaedoizie, Agbaji and Nwaedozie (2011) evaluated some trace metals concentration in bank sediments of river Kaduna. The evaluation of six toxic metals of lead, Manganese, Nickel, Zinc, Cadmium and Cobalt was done using Atomic Absorption spectrometer and it revealed that they were present in appreciable quantities as one move from less polluted area to area with high pollution index. The total metals determined in the soil samples ranged fromPb, 20.04 – 48.43; Mn, 7.47 – 57.09; Ni, 0.29.91; Zn, 18.43 – 58.53; Co, 0 – 29.98, mg/kg respectively, which indicates that most of the sites were polluted and required remediation so as to reduce the concentration of metals in the soil, which may find their way into the food chain and finally be consumed by man.

Umar and Ebong (2013) carried out a study on the determination of heavy metals in soil, water, sediment, fish and crayfish of JabiLake in the Federal Capital Territory, Abuja. In their study, water, sediment, soil, crayfish, and fish were analysed for copper (Cu), zinc (Zn), cadmium (Cd), nickel (Ni) and lead (Pb) using flame Atomic Absorption Spectrophotometry (AAS). The study showed that the pollution of sediment in the lake is related to the pollution in water because they follow the same pattern of decreasing concentrations of heavy metals: Zn >Cu>Cd >Ni >Pb.The pattern of decreasing concentrations from Fish and Crayfish were Cu > Zn > Cd > Ni > Pb. Average concentration of Zn in water (4.72 ± 0.630) and Cd (s0.28 ± 0.32) were found to be higher than international permitted range, while others (Cu, Ni and Pb) were within the range. Cu, which showed bioaccumulation in Fish and CrayFish samples to the magnitude 377.90 and 138.70 with concentration 107.37 ± 0.94 and 41.61 ± 1.38 respectively, was higher than international accepted range. Concentration of other metals (Zn, Ni, Cd and Pb) however fell within accepted range. Concentration values for soil (control) for all metals under study fell within accepted range, thus exonerating the surrounding soil of the Jabi Lake as being the possible source of heavy metals contamination in the lake. The study further showed that the most important source of heavy metals pollution in the lake was the sewage disposal point and erosional runoffs from the farm, which made the lake to be polluted with Zn and Cd, Crayfish and Fish with Cu.

The present study is different,as it intends to identify the heavy metals in Gurara reservoir, determine their level of concentrationsin water and sedimentsand compare their level of concentration with WHO and Nigerian water quality standard.

CHAPTER THREE

STUDYAREA AND METHODOLOGY

3.1 Introduction

This chapter presents how the work was carried out, and all the method used to achieve the aims and objectives.

3.1.1 Study Area

3.1.2 Location

The study area lies within the area designated as the middle belt of Nigeria (Atlast of Nigeria, 2002).The Gurara reservoirfalls within latitude 9°38'26.42''N - 9°45'21.81''N and longitude7°45'44.76''E - 7°47'36.16''E, covering approximately 100km^2. It covers parts of the Gurara Game Reserves with some scattered settlement such as Atara, Unguwar Kagarko, Unguwan and Kankara amongst others.The Reservoir is bounded by Chikum Local Government Area (LGA), Kajuru Local Government Area (LGA), Zangon Kataf and Kagarko (LGAs)in the west, north, east and south respectively as shown on Fig 3.1. The reservoir stores approximately eight hundred and eighty million cubicmetres(880,000,000cm^3)of water (Fadio, 2001).

3.1.3 Climate

The climate of Gurara is explained in terms of the seasonal lifting of two air masses (that is the Tropical Continental and Equatorial Maritime). The boundary between these two is known as the Inter Tropical Front (ITF). The Equatorial Maritime air mass is characterized by south -westerly winds, which originate at the Gulf of Guinea. These are the main rain bearing winds of the region, occurring April through October. The Tropical Continental air mass is the dry winds known as the Harmattan, which usually prevails during December through March.The latitudinal zone in which the study area lies is, well within the northern limit of movement of the Inter-Tropical Convergence Zone (ITCZ).

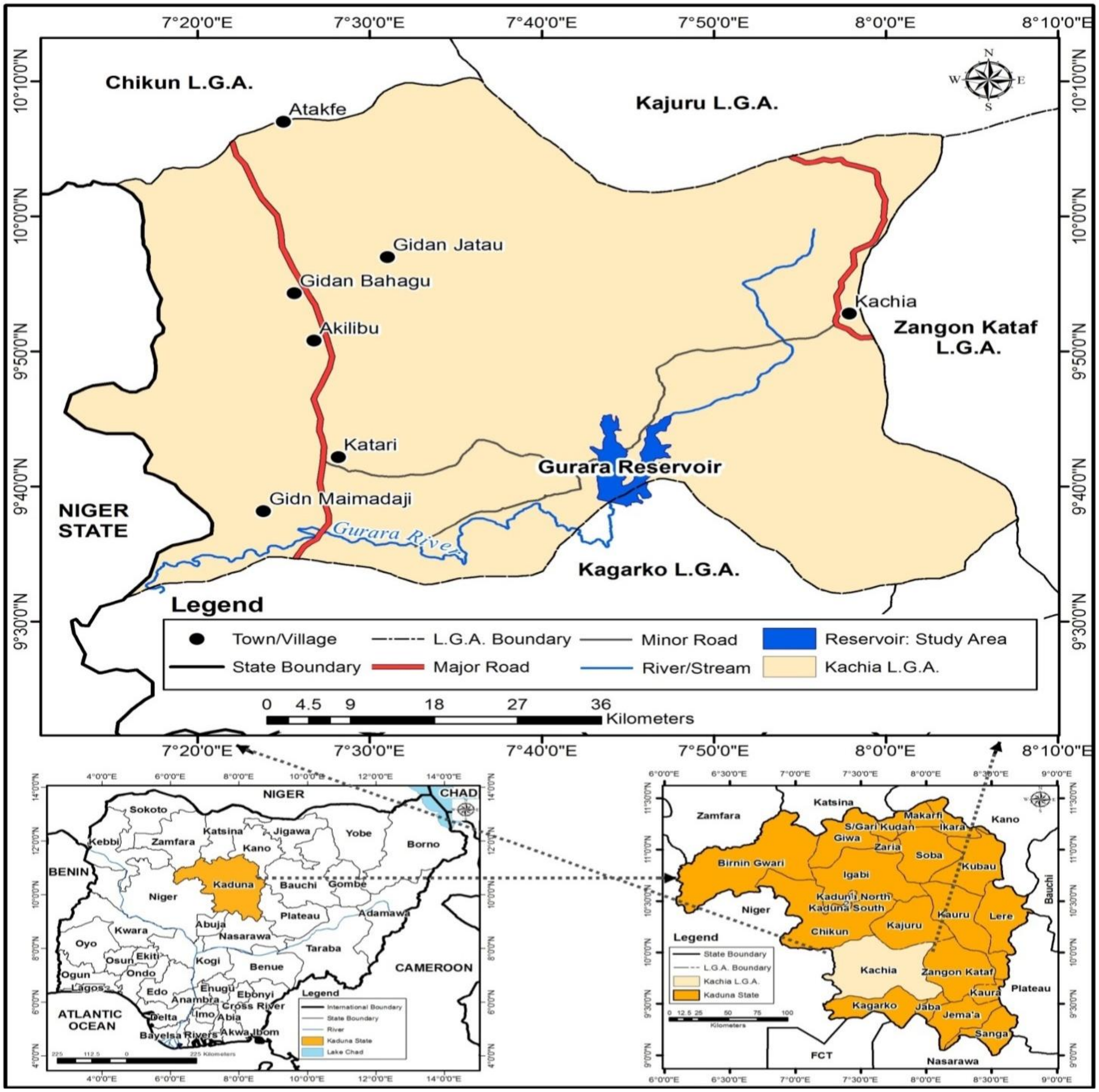

Figure 3.1: Kachia L.G.A. showing Gurara Reservoir, the Study Area(Source: Modified from the Administrative Map of Kaduna State, 2015)

This phenomenon of the global circulation of air masses is responsible for the general climatic characteristic of the area. However, any modification to the general pattern is attributable largely to variation in surface topography and the height of land relative to adjacent areas(Fadio, 2001).

Rainfall is the most important climatic variable and its seasonality, reliability and amount are of overriding importance in water availability and other environmental processes. Rainfall in the area show a trend of decreased amount from the south to the north, from FCT to Kachia and Kaduna. Mean annual rainfall ranges between 800mm to 1000mm and the duration of the rainy season is between five to seven months from April – October. Rainy season is defined as the number of days between the first and last rain day.

The mean annual temperature of the area is about 27^0C with values that very over the Yearsfrom a mean monthly minimum of 25^0C in July to a maximum 24.5^0C in March. Mean annual maximum temperature is 33^0C and the mean minimum is 22^0C. The highest Daily maximum temperature is 41.1^0C during March and the lowest is 13^0C in January. Seasonal and latitudinal variations affect the extreme and the dural and seasonal ranges (Fadio 2001).

The mean relative humidity (RH) fluctuateswith season reaching its peak in the wet season. The mean RH fluctuates from 50 to 60% and has far reaching impact on evaporation and evapo-transpiration from large water bodies and surrounding vegetation. The monthly RH value vary from 30% to 48% during the four months of December to March and from 80 to 88% during the five months of June to October around the Kaduna plain.The mean sunshine hours and radiation ranges between 150 to 180 Kg cal/cm^2/yr.

However, mean annual sunshine at Kaduna for a 9 – year period is about 2,770 hours making a daily average of 7.6 hours. The month with the longest sunshine is

December with 9.7 hours. August has the shortest period of sunshine with 4.9 hours daily. The distribution of the wind direction depends on the movement of the two air masses.The prevailingWinds are SW and are most frequently between May and August; NE wind which are mainly from December through February. With regards to wind speed observed at 9am, 3pm and 9pm, the fastest varies from 1.2 to 5m/s (values are found between January and March and vary from 7.2 to 9.5m/s (value from 4 to 5 of the Bean fort force). The data sets explained above are records from three meteorological stations, namely, Abuja, Minna and Kaduna (Fadio, 2001).

3.1.4 Relief andDrainage

Much of the study area (the Gurara Reservoir) is covered by undulating plains with sporadic rocky hills and dissected terrain. The general relief ranges from 20 – 30m. For example, the altitude ranges of the dissected zone towards the southern end of the area is730 – 58m. The Dinya plains range from 700 – 460m while the Idom plains range from 910 – 550 meters (Fadio, 2001).The Kaduna plain dissected zone is broadly characterized as dissected zone on Basement complex, the Dinya plains are plains on Complex; while the Idon plains are plains with hills on Basement complex (Fadio,2001).

3.1.5 Soil andVegetation

The study area covers the southern part of what is geographically described as the Gurara plain. The natural vegetation of the area surveyed reservoir is mixed with leguminous wooded savannah which consist of tall grasses with shattered trees, patches of forest are found on the upper and slopes of the plain. Secondary forest covers most of the tributaries. These types of vegetation are common in the Guinea savannah vegetation zone.

However, the classified vegetation zone of the study area into three groups namely; Derived Savannah, Southern Guinea Savannah, Northern Guinea Savannah. Broad change in the botanical composition of the vegetation occur gradually along a southto north gradient and is ascribed to climatic influences vegetation changes between one zone and another tend to be diffuse. Several tests boring have been done and one of there was being dug at the field survey and the geological column reconstructed from the cutting and cores in as given below (Fadio, 2001).

i.	Top soil (blackish brown)	0.08m
ii.	Completely weathered regolith (reddish brown sand clay)	0.8 – 5.0m
iii.	Completely weathered regolith (sandy clay to clayed sand)	5.0 – 8.0m
iv.	Incompletelyweathere regolith (sandy clay + clay sand + rock fragment)	
V	Freshbedrock (coarse grained gneiss)	

3.1.6 Geology of the Study Area

The geology of the area is entirely basement complex (all Precambrian to lower Paleozoic rock) according to McCurry (1976). The three main groups (number 1 – 3) of the Basement complex obtained around the study area include.

i. Basement complex (sensu stricto)

ii. Younger metasediments

iii. Older granite series

iv. Younger granite

v. Newer Basalt

The Basement complex (sensu stricto) which underlies the whole of Kaduna plains include all rocks than the younger metal sediments, the original rocks have been modified extremely by metamorphism and now mainly occur as migmatite and granite. The Younger Meta sediments mostly are comprised of schist, phyllite and bedded quartzite. The older granite series are mainly granite, and granodiorite but some elite and migmatite also occur in this series.

The basement rocks are extremely deformed and were affected by the Pan – African Orogeny. Three main fractures trends are observable from serial photograph.The north – south (N – S) the north-west (NW – SE) and theNorth East – South West (NE–SW) lineament. The most regional are pervasive appears to be N – S trend and this conform, to the trend of the foliations of the bedrock gneiss. The flow of the Gurara river is N – S and is controlled by this fracture. Downstream the Gurara River flow generally S70^{0}W and is controlled by the NE – SW and locally by NW – SE fractures. Smaller streams and head waters of the Gurara river appear to be somewhat controlled by both NW – SE and NE – SW fractures (Fadio, 2001).

The fracture intensity is variable within exposures of the gneiss at the dam construction site; the S70^{0}E fracture had intensity of 1 per 2 metres whereas N – S patterns were more intense with values of 1 per metre of 4 per metre.The area is part of the Precambrian basement complex of Nigeria which bears plants of thermo-tectonic events dating from Archaean to Early Paleozoic times. The rocks are essentially gneiss-schist suites cut by granitic intrusive. The granitic intrusive iron is Pan African in age (600ma) is well exposed as dome shaped hills and elongate where as the host Metasediments underline the Plains and subdued hills.

This good vegetation between topography and bed rock geology was very useful in delineating the postures of the intrusive from those of the host gneiss – schist suites which were often added by revolution and vegetation’s.The granitic gneiss is a biotite, muscovite, hornblende, quartz bearing Feld spathic gneiss of grano dioritic composition. The schists are typically enriched in mafic minerals and are relatively dark coloured. Minerals easily identified include biotite and hornblende. The banded gneiss in easily recognized as miginatites. It is distinguished from the rest by thealternating dark coloured felsic minerals. The granitic unit within mignatities very textually from aplitic to pegmatitics with lots of microchine porphy blast aligned subparallel to the foliation of the host rock (Atlast of Nigeria, 2002).

3.2 Research Methodology

3.2.1 Reconnaissance Survey

In preparation for this study, a reconnaissance survey was carried out in the study area. The aim was to obtain relevant information on the study area, seek for co-operation of relevant stakeholders and to obtain a general overview of the study area.

3.2.2 Types and Sources of Data

3.2.2.1*Primary data*

i. Data on the concentration of heavy metals analyzed from the raw water from the reservoir.

ii. Data on the concentration of heavy metals analyzed in the sediments from the reservoir.

3.2.2.2*Secondary data*

i. Data on water quality parameters from WHO and National Water Quality guidelines.

ii. Literature materials from books and journals were also consulted for literature review.

3.2.3 SamplingTechniques

Water and sedimentsfrom the reservoir were used as the main sources of data for this study. Grids were drawn across the vertical and horizontal sides of the reservoir. Based on the grids drawn, six sampling points were located over the reservoir, see Fig 3.2. Global Positioning System (GPS) was used to assist in locating samplingpoints. The water was collected using USDH- 48 sampler by dipping it into the reservoir. Samples were also taken for sediment at the reservoirbottom. A fisherman was used to assist in fetching the sediment from the bottom of the reservoir. By putting his hands inside a nylon bag, then swims down to the bottom to get the sediments samples.The samples were placed in clean plastic bottles and labelled. Both water and sediment samples were collected from the defined points during dry and wet seasons accordingly. Sample points 1, 2, 3, 4, 5, and 6 were identified by labelling them using acronyms (DSSS 1-6 and WSSS 1-6) for dry season sediment samples and wet season sediments samples respectively to differentiate the samples by seasons. Also acronyms DSWS and WSWS were usedfor wet season water samples dry season water samples respectively.The samples were treated immediately on site with nitric acid to preserve them before laboratory analysis.

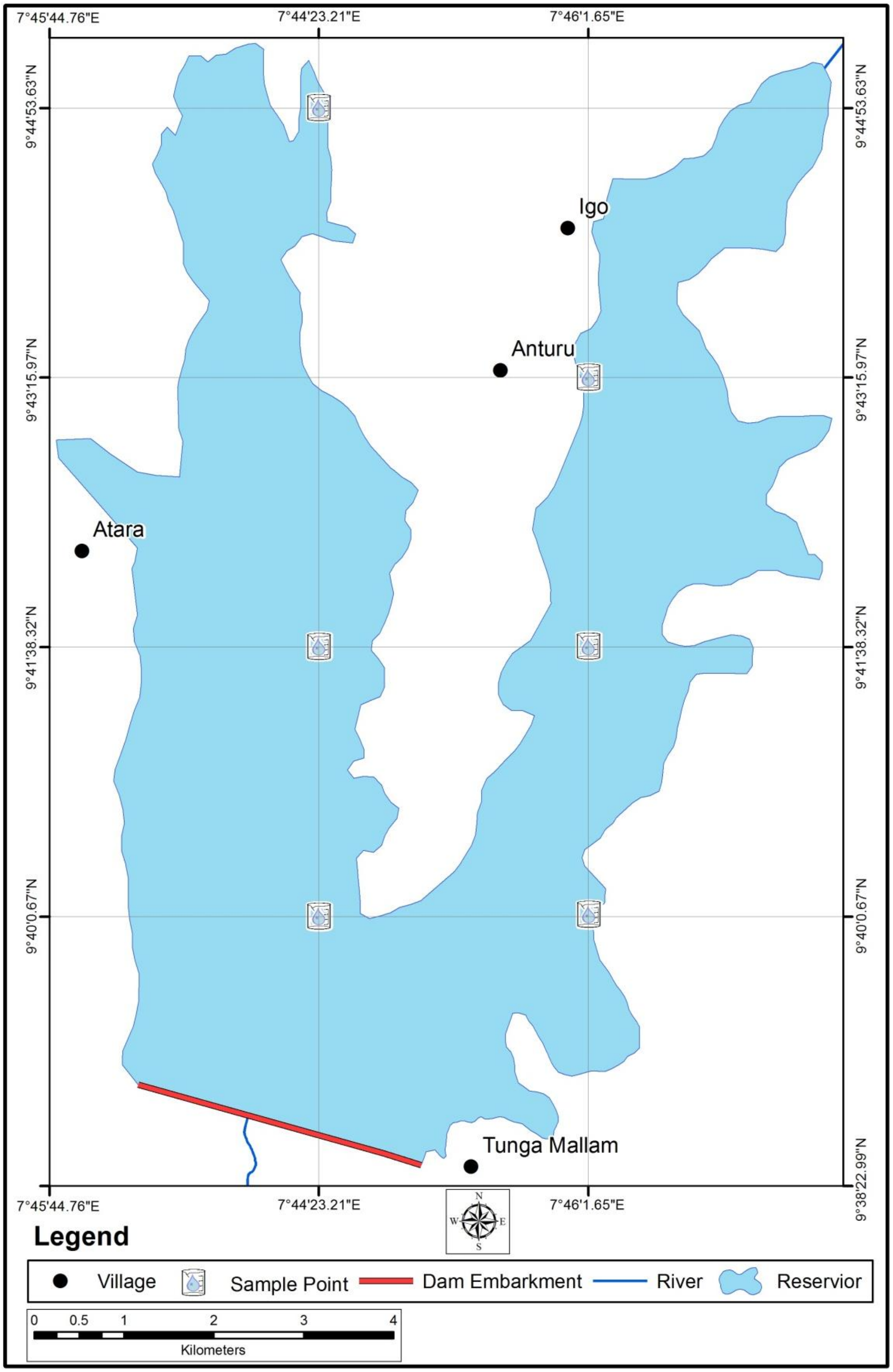

Figure 3.2: Gurara Reservoir showing Sampling Points
Source: Modified from the Administrative Map of Kachia L.G.A.

3.2.4 Laboratory analysis

The water samples were filtered in DICON laboratory Kaduna; the standard solution was run throughan Atomic Absorption spectrometer (AAS) for identification of heavy metals present and their concentration. X-ray fluorescence was used to analyse the sediment samples. The samples were dried in the laboratory at room temperarure, then grinded using a mortar and pestle. Each sample was then passed through the X-ray refractive flame. X-ray fluorescence was used because of its high precision and high sensitivity, high wavelength resolution to minimize overlapping effect, high signal to noise ratio for trace-element analysis, and long-term stability for reproducible result.

The X-ray fluorescence technique was used for elemental identification and concentration determination of materials by irradiating primary X-ray beam onto the materials to excite their constituent elements, and measuring the florescence characteristics X-ray intensities from the element. In X-ray florescence analysis, an X-ray system consists of an X-ray source, an analysing crystal and a detector. These three major components are important for the performance of a high sensitivity and high precision X-ray fluorescence analysis.

3.2.5 Data analysis

i. To identify the heavy metals present in water and sediment samples, the water sampleswerepassed through an Atomic Absorption Spectrometer(AAS) while the sediments were subjected to X-ray refractive flame.

ii. To determine the level of concentration of the identified heavy Metals in water and sediment, the samples were passed through the AAS and X-ray refractive frame respectively.

iii. To examine the variation of heavy metal concentrationin water during wet and dry season,t-testwas used.

iv. The comparison of levels of concentration ofheavy metals with WHO and natural waterquality standard, student t- test was conducted to see if there is any significant difference.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the analyzed data collected from both water and sediment samples obtained at the Gurara reservoir Kachia LGA Kaduna State. The data and discussion of findings are presented logically based on the objectives of the study.

4.2 Heavy Metals Present in Water

4.2.1 Heavy Metals Present in Water During Dry Season

Table 4.1 shows the heavy metals obtained from the dry season water samples.

Table 4.1: Heavy Metals in Water During Dry Season

Season	Heavy Metals	Total
DSWS	Cd, Ni, Co, Fe, Cu, Cr, Mn, Pb, Al	9

Source: Author's Analysis (2015).

Table 4.1 indicates that there are nine heavy metals present in the water during dry season, this include Cadmium (Cd), Nickel (Ni), Cobalt (Co), Iron (Fe), Copper (Cu), Manganense (Mn), Lead (Pb), Aluminium (Al). This result is in line with that of Ayenimo, Adeyinwo and Amoo (2004) in their research on heavy metal pollutions in Warri River. They determined the total levels of Fe, Cu, Ba, Pb, Cd, Cr, Ni and Co in ppm specifically at upstream, effluent zone, and downstream of river in each industrial location. Fe, Cu and Pb were found to be the most abundant metals in the river. The research further revealed variability in the concentrations of the metals obtained in different parts of the river which suggests that different industries contribute significantly to the heavy metal load of the river. The authors emphasize the value of constant monitoring of rivers and water bodies receiving effluents in order to forestall cumulative effects of metals in rivers which may lead to sub- lethal consequences in the aquatic fauna and ensuring clinical poisoning to man.

4.2.2 Heavy Metals in Water During Wet Season

Heavy metals identified from the analysed wet season water samples collected are presented in Table 4.2.

Table 4.2: Heavy Metals Present in Water During Wet Season.

Season	Heavy Metals	Total
WSWS	Cd, Ni, Co, Fe, Cu, Cr, Mn, Pb, Al	9

Source: Author's Analysis (2015)

Table 4.2shows that there are nine heavy metals present in the water samples collected during wet season namely;Cadmium (Cd), Nickel (Ni), Cobalt (Co), Iron (Fe), Copper (Cu), Chromium (Cr), Manganense (Mn), Lead (Pb), Aluminium (Al). This finding is in line with that of Butu (2002) who carried out a study on spatial variation in the level of concentration of metal contaminants in river Kubanni in Zaria Nigeria, it is observed that 29 metal pollutants exist in each of the four selected sampling points which represent different zones or section of the river. The study reveals that anthropoginic activities are the major contributing sources of metal pollutants in entire Kubanni water source.

4.2.3 Total Number of Heavy Metals in Water

Table 4.3 shows the total number of heavy metals in water for both dry and wet season.

Table 4.3 Total Number of Heavy Metals in Water

Season	Heavy Metals	Total
Wet and Dry Season	Cd, Ni, Co, Fe, Cu Cr, Mn, Pd, Al.	9

Source: Author's Analysis (2015)

It is clear fromTable 4.3 that there were nine heavy metals identified in the water samples, Cadmium (Cd), Nickel (Ni), Cobalt (Co), Iron (Fe), Copper (Cu), Chromium (Cr), Manganese (Mn), Lead (Pb), Aluminium (Al).

4.3 Heavy Metals in Sediment of Gurara Reservoir

4.3.1 Heavy Metals Present in Sediment Sample During Dry Season at Gurara Reservoir

From the laboratory analysis of the collected samples, the heavy metals present insediment of Gurara reservoirduring dry season are shown in Tables 4.4.

Table 4.4: Heavy Metals in Sediments During Dry Season

Sample	Heavy Metals	Total
DSSS	Ti, V, Cr, Mn, Fe, Cu, Ag, Eu, Bi, Re, Al, Ni, Yb, Pb, Pt, Au, Hg.	17

Source: Author's Analysis (2015)

Table 4.4 indicates that there are seventeen heavy metals present in sediment samples collected during dry season, this include; Titanium (Ti), Vanadium (V), Chromium (Cr), Manganese (Mn), Iron (Fe), Copper (Cu), Silver (Ag), Europium (Eu), Bismuth (Bi), Rhenium (Re),Aluminium (Al), Nickel(Ni),Ytterbium (Yb), Lead (Pb), Platinium (Pt), Gold (Au), Mercury (Hg).

4.3.2 Heavy Metals Present in Sediment During Wet Season

Table4.5 shows the heavy metals identified from the sediment samples collected during wet season, that were analysied in the laboratory.

Table 4.5: Heavy Metals in Sediment DuringWet Season

Season	Heavy metals	Total
WSSS	Ti, V, Cr, Mn, Fe, Cu, Ag, Eu, Bi, Re, As, Al, Au	13

Source: Author's Analysis (2015)

Table 4.5shows that there are thirteen heavy metals present in the sediment samples during wet season, they are ; Titanium (Ti), Vanadium (V), Chromium (Cr), Manganese (Mn), Iron (Fe), Copper (Cu), Silver (Ag), Europium(Eu), Bismuth (Bi), Rhenium (Re), Arsenic (As), Aluminium (Al), Gold (Au). This is due to the fact that some heavy metals were present in the dry season sediments samples but were absent in the wet season samples.This can be attributed to over flooding of the resrevoir,due to large water flowing from different rivers into the reservoir and some of the metals are over diluted in the water.

4.3.3 Total Number ofHeavy Metals in Sediment

Table 4.6 presents the total number of heavy metals present in sediments for both wet and dry season.

Table 4.6: Total Number of Heavy Metals in Sediments

Season	Heavy Metals	Total
Wet and Dry Season	Ti, V, Cr, Mn, Fe, Cu, Ag, Eu, Bi, Re, Al, Au, Ni, Yb, Pb, Pt, Hg, As.	18

Source: Author's Analysis (2015)

A total ofeighteen heavy metals were identified in the sediments samplesanalysed from the Gurara Reservior during the twoseasons.

4.4 Mean Concentrations of Heavy Metals for both Water and Sediments in Gurara Reservoir

Several heavy metals were identified in the water and sediments of the reservoir and their mean levels of concentration are presented in the Table 4.7. However the concentration of heavy metals in sediment and water for wet and dry season respectively can be seen in appendices II, III, IV and V.

The results of the analysis reveal that the mean level of concentration of heavy metals in sediments during dry season followed the decreasing order of: Al-59837, Fe-36592, Ag-12600, Ti-7581, Bi-3258, Pb-2568, Eu-757, Re-489, Mn-481, Au-363, V-259, Hg-250, Pt-206, Ni-147, Cu-98, Cr-79, Yb-31. While heavy metals in sediment during wet season follows a decreasing order of Al-47932, Fe-42856, Ag-16759,Ti-6929, Bi-12155, Eu-877, Re-163, Mn-434, Au-163, V-259, Cu-110, Cr-100. It was also observed that the concentrations of heavy metals in the water during dry season followed a decreasing order of Al-3.2645, Cd-2.7678, Co-0.8116, Fe-0.8047, Cr-0.4797, Mn-0.3416, Cu-0.2811, Pb-0.0446 and Ni-0.0276. Similarly,heavy metals present in water during wet season follow a decreasing order of Cd-2.7469, Al-2.6025, Fe-0.8122, Co-0.6676, Mn-0.3277, Cu-0.2829, Cr-0.2518, Pb-0.0533 and Ni-0.0258. It was observed that some heavy metals were present in the sediments during dry season but absent during wet season, this can be attributed to the increase in the volume of water during wet season. It was shown also that a lot ofheavy metals were present in the sediments but absent in the water.

Table 4.7: Mean Concentrations in mg/l of Heavy Metals in Water and Sediment during Wet and Dry Season of the Gurara Reservior

	Water		**Sediment**	
Heavy metals	Dry	Wet	Dry	Wet
Cd	2.7678	2.7469	NA	NA
Ni	0.0276	0.0258	147	NA
Co	0.8116	0.6676	NA	NA
Fe	0.8047	0.8122	36592	42856
Cu	0.2811	0.2829	98	110
Cr	0.4797	0.2518	79	100
Mn	0.3416	0.3277	481	434
Pb	0.0446	0.0533	2568	-
Al	3.2645	2.6025	59837	47932
Ti	-	-	7581	6929
V	-	-	259	259
As	-	-	-	119
Ag	-	-	12600	16759
Eu	-	-	757	877
Bi	-	-	3258	12155
Re	-	-	489	163
Au	-	-	363	163
Yb	-	-	31	-
Pt	-	-	206	-
Hg	-	-	250	-

Not Available(NA)
Source:Author's Analysis (2015)

This study agrees with that of Umar and Ebong (2013) who carried out a similar study on the determination of heavy metals in soil, water, sediment, fish and crayfish of Jabi Lake in the Federal Capital Territory, Abuja. In their study, water, sediment, soil, crayfish, and fish were analysed for copper (Cu), zinc (Zn), cadmium (Cd), nickel (Ni) and lead (Pb) using flame Atomic Absorption Spectrophotometry (AAS). The study showed that the pollution of sediment in the lake is related to the pollution in water because they follow the same pattern of decreasing concentrations of heavy metals: Zn >Cu >Cd >Ni >Pb.The pattern of decreasing concentrations from Fish and Crayfish were Cu > Zn > Cd > Ni > Pb. Average concentration of Zn in water (4.72 ± 0.630) and Cd (0.28 ± 0.32) were found to be higher than international permitted range, while others (Cu, Ni and Pb) were within the range. Cu, which showed bioaccumulation in Fish and CrayFish samples to the magnitude 377.90 and 138.70 with concentration 107.37 ± 0.94 and 41.61 ± 1.38 respectively, was higher than international accepted range. Concentration of other metals (Zn, Ni, Cd and Pb) however fell within accepted range.

4.5 Variation of Heavy Metals in Water Samples during the Dry and Wet Seasons

Studentt-test was conducted on the result on table 4.7 to see if there is a significant difference between the concentration of heavy metals in water during the wet season and dry season and the result is presented in Table 4.8.

From Table 4.8, it can be concluded that there is no significant difference between the concetrations of heavy metals in water during the dry and wet seasons. This is because the p-values of all the elements from Cadmium down to Aluminium are all greater than 0.05 level of significance.

Table 4.8: Difference Between Heavy Metals Concentrations of Water During the Dry and Wet seasons

Heavy Metals	Wet Season	Dry season	p-value	Remarks
Cadmium	2.767	2.769	0.356	N.S
Nickel	0.026	0.018	0.226	N.S
Cobalt	0.668	0.812	0.206	N.S
Iron	0.812	0.805	0.687	N.S
Copper	0.283	0.281	0.666	N.S
Chromium	0.314	0.386	0.229	N.S
Manganese	0.344	0.342	0.762	N.S
Lead	0.053	0.051	0.912	N.S
Aluminium	2.602	3.482	0.449	N.S

N.S: Not Statistically Significant
Source: Author's Analysis (2015)

4.6 Variation of Heavy Metals in Sediment Samples during the Dry and Wet Seasons

The Student'st-test was conducted on the to resultfrom table 4.7 to see if there is a significant difference between the concentration of heavy metals in water during the wet season and dry season.The result is presented in Table 4.9.

Table 4.9 shows that there is a significant difference in the chromium concentration in sediments during the dry and wet season with p-value of 0.05 while there was no significant difference in the concentration of Aluminium, Iron, Silver, Bismuth, Titanium, Europium, Manganese, Vanadium, Rhenium, Gold and Copper with p-values greater than 0.05 in sediments during the wet and dry season. This is because the p-values for these heavy metals are all greater than 0.05 level of significance.

Table 4.9: Difference Between Heavy Metal Concentrations of Sediments During the Wet and Dry Season

Heavy Metals	Wet Season	Dry season	p-value	Remarks
Aluminium	47932.33	59837.10	0.28	N.S
Iron	42856.52	36592.73	0.29	N.S
Silver	16760.65	12600.25	0.40	N.S
Bismuth	12155.39	3258.15	0.12	N.S
Titanium	6929.83	7581.45	0.12	N.S
Europium	877.19	756.89	0.37	N.S
Manganese	434.84	479.32	0.73	N.S
Vanadium	259.40	259.40	1.00	N.S
Rhenium	162.91	275.69	0.59	N.S
Gold	162.91	363.41	0.41	N.S
Copper	109.65	97.12	0.59	N.S
Chromium	99.00	63.28	0.05	Sig.

Sig = Statistically Significant; N.S = Not Statistically Significant
Source: Author's Analysis (2015)

Table 4.9 shows that there is a significant difference in the chromium concentration in sedimentsbetweendry and wet seasons with p-value of 0.05 while there was no significant difference in the concentration of Aluminium, Iron, Silver, Bismuth, Titanium, Europium, Manganese, Vanadium, Rhenium, Gold and Copper between the seasonswith p-values greater than 0.05 in sediments during the wet and dry season. This is because the p-values for these heavy metals are all greater than 0.05 level of significance.

4.7 Comparison of Heavy Metal Concentration with WHO Standards

The concentrations of the heavy metals in the water samples were compared with the WHO standard and result are presented in Table 4.10.

Table 4.10: Difference between Heavy Metal Concentrations of Water during Seasons and WHO (2011) Standards

Physicochemical Properties	Wet Season	WHO	p-value	Remarks	Dry Season	WHO	p-value	Remarks
Cadmium	2.77	0.003	0.00	Sig.	2.77	0.003	0.00	Sig.
Nickel	0.03	0.02	0.56	N.S	0.02	0.02	0.89	N.S
Cobalt	0.67	0.00	0.01	Sig	0.81	0.00	0.03	Sig
Iron	0.81	0.30	0.00	Sig.	0.80	0.30	0.00	Sig.
Copper	0.28	1.00	0.00	Sig.	0.28	1.00	0.00	Sig.
Chromium	0.31	0.05	0.14	N.S	0.39	0.05	0.00	Sig.
Manganese	0.34	0.20	0.00	Sig.	0.34	0.20	0.00	Sig.
Lead	0.05	0.01	0.37	N.S	0.05	0.01	0.15	N.S
Aluminium	2.60	0.20	0.37	N.S	3.48	0.20	0.11	N.S

N.S: Not Statistical Significant; Sig. = Statistically Significant
Source: Author's Analysis(2015)

Table 4.10 revealed that there is a significant difference in the concentrations of Cadmium, Cobalt, Iron, Copper, and Manganese and WHO (2011) standards in water during the wet season with p-values less than 0.05 while there was no significant difference in the concentrations of Nickel, Chromium, Lead and Aluminium and the WHO (2011) standards during the wet season with p-values of greater than 0.05.

Furthermore, the Table 4.10 revealed that there is a significant difference, between the heavy metals concentration of water during dry season and the WHO (2011) standards because they were lower than the WHO values for Cadmium, Cobalt, Iron, Copper, Chromium and Manganese with p-values all less than 0.05 level of significance but there is no significant difference between the heavy metal concentrations of water and the WHO (2011) standards for Nickel, Lead and Aluminium with p-values greater than 0.05 level of significance.

The findings from the study revealed that Cadmium, Nickel, Cobalt, Copper, Chromium, Manganese, Lead and Aluminium were found to be higher than WHO permitted range during the wet season with mean values of 2.77, 0.03, 0.67, 0.81, 0.28, 0.31, 0.34, 0.05, 2.60 while during the dry season, all elements were found to be higher than the WHO permitted range except for Nickel and Copper which were found to be within the permissible WHO range.

The findings of this study is in line with that of Nwaedozie, Agbaji and Nwaedozie (2011) in river Kaduna who found that Lead, Manganese, Nickel, and Cobalt are higher than the WHO standards during the rainy season which is an indication that the water in the study area is polluted. The presence of these heavy metals in water could provoke serious health hazards which can produce mental diseases such as Alzheimers and Manganism (Dieter, Bayer and Multhaup, 2005).

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of findings, conclusion and necessary recommendations.

5.2 Summary of Findings

This research assessed the concentration of heavy metals in Gurara reservoir, Kachia Local Government Area, Kaduna State. Sediment and Water samples from the reservoir were obtained from six points and Garmin 76S handheld GPS device was used to locate the sampling points. The water and sediment samples in Gurara reservoir were analysed using Atomic Absorption spectrometer (AAS) and the X-ray fluorescence respectively. The analysis revealed that nine (9) heavy metals were detected in the water samples namely; Cd, Ni, Co, Fe, Cu, Cr, Mn, Pb and Al, while there are eighteen (18) heavy metals found in sediment namely; Al, Ti, V, Cr, Mn, Fe, Cu, Ag, Eu, Bi, Re, Au, Ni, Yb, Pt, Pb, Hg and As.

The analysis of sediment and water samples revealed that there are more heavy metals in sediment samples than water samples. The analysis of levels of heavy metals concentration indicated that the mean concentration of heavy metals in sediment followed the decreasing order of: Al-59837, Fe-36592, Ag-12600, Ti-7581, Bi-3258, Pb-2568, Eu-757, Re-489, Mn-481, Au-363, V-259, Hg-250, Pt-206, Ni-147, Cu-98, Cr-79, Yb-31. While heavy metals in sediment during wet season follows a decreasing order of Al-47932, Fe-42856, Ag-16759,Ti-6929, Bi-12155, Eu-877, Re-163, Mn-434, Au-163, V-259, Cu-110, Cr-100. It was also observed that the concentrations of heavy metals in the water during dry season followed a decreasing order of: Al-3.2645, Cd-2.7678, Co-0.8116, Fe-0.8047, Cr-0.4797, Mn-0.3416, Cu-0.2811, Pb-0.0446, Ni-0.0276. Similarly,heavy metals present in water during wet season follow a decreasing order of: Cd-2.7469, Al-2.6025, Fe-0.8122, Co-0.6676, Mn-0.3277, Cu-0.2829, Cr-0.2518, Pb-0.0533, Ni-0.0258. The mean concentration (mg/l) of heavy metals in water samples during dry and wet seasons were calculated and t-test result indicated that there is significant variation ($p<0.05$)inheavy metals (Cd, Co, Fe, Cu and Mn) in water during the wet season in the study area when compared with the WHO standard with p-values less than or equal to 0.05, while heavy metals(Cr, Ni, Pb and Al) showed nosignificant value with p-values of 0.14, 0.56, 0.37 and 0.37 which are all greater than the 0.05 level of significance respectively. This implies that there is a variation between the heavy metals and the WHO standards in some of the identified heavy metals tested during wet season.A careful analysis of heavy metals in dry season shows that there is a significant difference in almost all the heavy metals of water during the dry season in the study area when compared with the WHO standard except for lead, Nickel and aluminium which shows not significant value with p-values of0.15, 0.89 and 0.11 which are greater than the 0.05 level of significance respectively.

5.3 Conclusion

This research assessed the concentration of heavy metals in Gurara reservoir, Kachia Local Government Area, Kaduna State. The analysis of sediment and water samples revealed that there are more heavy metals in sediment samples than water samples. The analysis of the levels of heavy metals concentration indicated that Aluminium has the highest mean concentration in sediment and water samples while Nickel has the lowest concentrations respectively. Variations were found between the heavy metals and the WHO standard in some of the identified heavy metals tested during wet season.This variation is however more pronounced during the wet season. However, from the general overview of the analysis, it can be concluded that the water in the study area is not safe for human consumption, especially during the dry season.

5.4 Recommendations

Water is a very important natural resource without which life on earth would be impossible, this therefore justifies the need for proper management and protection of available water sources from pollution by metal pollutants and pathogens. To protect the Gurara reservior and other water resources meant for human consumption from pollution by chemical contaminants, this study makes the following recommendations based on the finding of the research;

1. That a study of this nature be a continuous onein order to constantly asses the nature and level of concentration of the chemical pollutants in the reservoir and water bodies meant for humam consumption atregular interval.
2. The settlers within the Gurara Reservior should be properly enlightened and sensitized by government agencies responsible for environmental monitoring regularly on the dangers and health implications of dumping harmful wastes and consuming the water without being properly treated.
3. Sustainable means of locally treating the water should be provided by government in order to minimize the excessive concentration of the heavy metals.
4. The use of toxic chemicals for farming especially the use of pesticides and herbicides should be controlled. It is very possible to obtain optimum agricultural yield within the drainage basin without contaminating the river with chemical elements.

5. The problems associated with water pollutionhave the capabilities of affecting human and aquatic organisms to a great extent. Government alone cannot solve the entire problems related to water pollution. It is basically responsible for every member of the community when it comes to the problems facing the water we drink and use. People must become familiar with local water resources and learn about ways for disposing harmfulmaterials. The three (3) tiers of government in the country should ensure that, awareness, education, and effectiveagricultural waste disposal methods are promulgated through the use of attractive media.

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APPENDICES

APPENIX I: Author in Gurara Reservoir

Approaching water samples
Source: Author's field survey(2015)

Author in Gurara Reservoir moving towards sample points

Source: Author's field survey (2015)

Collecting water sample
Source: Author’s field survey(2015)

About entering Gurara river on boat for collections of samples.
Source: Author’s field survey(2015)

Author labelling collected samples

Source: Author’s field survey(2015)

Entering GuraraReservior for collection of sample

Source: Author’s field survey(2015)

APPENDIXII

Concentration of Heavy Metals in Sediment during Dry Season in mg/l

Metal	DSS1	DSS2	DSS3	DSS4	DSS5	DSS6	Mean
Al	62030.08	75939.85	52631.58	54135.34	58270.68	56015.04	59837.09
Fe	32225.56	46992.48	40827.07	28169.17	28221.8	43120.3	36592.73
Ag	12894.74	13646.62	13684.21	7781.955	14097.74	13496.24	12600.25
Ti	7969.925	8533.835	6766.917	7142.857	7067.669	8007.519	7581.454
Bi	NA	NA	19548.87	NA	NA	NA	3258.145
Pb	NA	7518.797	NA	NA	7894.737	NA	2568.922
Eu	676.6917	714.2857	977.4436	789.4737	330.8271	1052.632	756.8922
Mn	293.2331	289.4737	639.0977	451.1278	413.5338	789.4737	479.3233
Au	NA	NA	NA	714.2857	563.9098	902.2556	363.4085
Re	NA	563.9098	601.5038	NA	NA	488.7218	275.6892
V	259.3985	327.0677	251.8797	251.8797	176.6917	289.4737	259.3985
Hg	NA	NA	NA	NA	1503.759	NA	250.6266
Pt	NA	NA	NA	1240.602	NA	NA	206.7669
Ni	857.1429	22.55639	NA	NA	NA	NA	146.6165
Cu	165.4135	124.0602	90.22556	45.11278	75.18797	82.70677	97.11779
Cr	33.83459	93.98496	97.74436	75.18797	NA	78.94737	63.28321
Yb	150.3759	37.59398	NA	NA	NA	NA	31.32832

Source: Author’s Analysis (2015)
NA -Not Available

APPENDIX III

Concentration of Heavy Metals in Sediment during Wet Season in mg/l

Metal	WSS1	WSS2	WSS3	WSS4	WSS5	WSS6	Mean
Al	56390.98	NA	51127.82	66917.29	52631.58	60526.32	47932.33
Fe	34845.86	46503.76	29812.03	59511.28	36015.04	50451.13	42856.52
Ag	7067.67	39473.68	13984.96	13345.86	13233.08	13458.65	16760.65
Bi	18045.11	NA	20676.69	11278.20	22932.33	NA	12155.39
Ti	7744.36	7781.95	6390.98	6691.73	6578.95	6390.98	6929.82
Eu	864.66	1165.41	827.07	977.44	789.47	639.10	877.19
Mn	413.53	864.66	368.42	195.49	315.79	451.13	434.84
V	285.71	248.12	225.56	296.99	244.36	255.64	259.40
Re	NA	977.44	NA	NA	NA	NA	162.91
Au	NA	NA	977.44	NA	NA	NA	162.91
As	300.75	413.53	NA	NA	NA	NA	119.05
Cu	90.23	165.41	67.67	105.26	90.23	139.10	109.65
Cr	90.23	116.54	93.98	112.78	101.50	78.95	99.00

Source: Author's Analysis (2015)
NA=Not Available

APPENDIX IV

Heavy Metals Present in Water Samples During Dry Season

Heavy metals	**DSWS (mg/l)**	**DSWS 2 (mg/l)**	**DSWS 3 (mg/l)**	**DSWS 4 (mg/l)**	**DSWS 5 (mg/l)**	**DSWS 6 (mg/l)**	**Total (mg/l)**	**Ave.mg/l**
Cd	2.7700	2.7671	2.7654	2.7683	2.7700	2.7712	16.612	2.7687
Ni	0.0322	0.0077	0.0184	0.0077	0.0092	0.0327	0.1658	0.01763
Co	0.6065	0.5501	1.2553	0.7193	0.7898	0.9488	4.8698	0.812
Fe	0.8263	0.7831	0.8142	0.8315	0.7554	0.8176	4.8281	0.8047
Cu	0.2840	0.2878	0.2686	0.2801	0.2897	0.2763	1.6865	0.2811
Cr	0.3676	0.3956	0.3956	0.3863	0.3816	0.3910	2.8781	0.4797
Mn	0.3627	0.3456	0.3507	0.3336	0.3353	0.3217	2.0496	0.3416
Pb	0.0326	0.0130	0.0522	0.0783	0.0196	0.0718	0.2675	0.0446
Al	4.4011	3.2633	4.5714	2.0710	4.2852	0.9947	19.5867	3.2645

Source: Author’s analysis(2015)

APPENDIXV

Heavy Metals Present in Water Samples During Wet Season

Heavy metals	WSWS 1 (mg/l)	WSWS 2 (mg/l)	WSWS 3 (mg/l)	WSWS 4 (mg/l)	WSWS 5 (mg/l)	WSWS 6 (mg/l)	Total (mg/l)	Ave. (mg/l)
Cd	2.7712	2.7683	2.7648	2.7665	2.7642	2.7689	16.4817	2.7469
Ni	0.0383	0.0337	0.0215	0.0153	0.0245	0.0215	0.1548	0.0258
Co	0.5783	0.4937	0.8181	0.5078	0.7334	0.8745	4.0058	0.6676
Fe	0.7865	0.7831	0.8418	0.8245	0.7813	0.8557	4.8729	0.8122
Cu	0.2724	0.2897	0.2836	0.2724	0.2936	0.2878	1.6977	0.2829
Cr	0.0405	0.3162	0.3863	0.4143	0.3723	0.3536	1.5109	0.2518
Mn	0.3473	0.3473	0.3404	0.3422	0.3507	0.3387	1.9666	0.3277
Pb	0.0652	0.0391	0.0326	0.0326	0.0196	0.1305	0.3196	0.0533
Al	2.4117	5.4230	0.3134	0.1975	2.1869	5.0823	15.6148	2.6025

Source: Author’s analysis(2015)