A COMPARATIVE ANALYSIS OF WATER QUALITY IN THE KANO RIVER AND THE NEW TAMBURAWA TREATMENT PLANT IN KANO, NIGERIA

BY

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DECLARATION

I, Ibrahim Mukhtar, hereby declare that this thesis is an original work written by me based on field investigations. It has not been presented else for a higher degree award and all sources of information quoted are specifically acknowledge by use of references.

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CERTIFICATION

This is to certify that the thesis "A comparative analysis of water quality in the Kano river and the new Tamburawa treatment plant in Kano, Nigeria" submitted by Ibrahim Mukhtar meets the requirements for the award of the master of science degree of the Ahmadu Bello University Zaria is an original work based on field investigations that has been read and approved by

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DEDICATION

This work is dedicated to my parents Alhaji Malamijo A. Ibrahim and Hajiya Hauwa.

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My special thanks goes to my supervisors, Prof E.O. Iguisi and Dr A.L. Bello, my Family, Friends, colleagues and well wishers. May Allah bless you all, thank you.

ABSTRACT

The analysis of water in the Kano river was carried out to determine the concentration of three selected metals; Cu, Fe and Mn before and after treatment from January 2009 to September 2009. Water quality monitoring in developing countries is inadequate, especially in rivers affected by urban effluents and runoff from agricultural lands. As a result of findings by previous studies within the up- stream area of the drainage basin, especially by Akan et al, (2007), it was revealed that metals investigated were above the WHO standards for drinking water. This study was situated in the down- stream area of the drainage basin, where the Challawa River merges with the Kano River, so as to capture effluents probably not captured by the previous studies and to investigate the efficiency of the treatment plant in removing metal pollutants.

The concentrations of the metals were determined using the spectrophotometer after digestion of both the raw and treated water samples using the Nitric acid digestion method. The result of the laboratory analysis revealed that the selected metals were present within the basin in varying concentrations across the seasons. Statistical analysis using the T-test revealed that there was significant difference in concentration of Cu between the treated and raw water during the dry season, but showed no significant difference during the rainy season. This implies better treatment in the dry season. Fe showed significant difference between raw and treated water in both seasons, this shows better efficiency in the treatment of the water for Fe. There was less reduction in the concentration of Mn across the seasons with no significant difference between raw and treated water. All observed concentrations for raw water were above the WHO standards, while the treated water concentration for Fe was above the international standard that of Mn and Cu were within WHO limits. Generally there was better reduction in concentrations of

the pollutants in the dry season than the rainy season. Human activities and changing land uses have brought about the increase in the concentration of the selected metals. Even though the treatment plant reduces the metal concentrations it is still below the WHO standard.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the study

The Greek philosopher Pindar described water as the “best of all things”. This view is not surprising since the need for water, throughout human history, has always been appreciated. Water is present everywhere without which life will simply cease to exist. It is constantly in motion, passing from one state to another and from one location to another. Irrespective of its movement as rivers or streams or stationary as it is in lakes, it invariably contains extraneous materials, due to natural causes and human activities (Biswas, 2008). Almost all of the planet’s water (97%) occurs as salt water in the oceans (Bouwer, 1978). Of the remaining 3%, two-thirds occur as snow and ice in polar and mountainous regions, and only about 1% of the global water as freshwater (Bouwer, 2000).

Global water problems are neither homogenous nor constant or consistent over time. There is a spatio-temporal variation within a particular country as well as from one region to another. Solutions to these problems depend not only on water availability, but also on many other factors such as competence and capacities of institutions that manage them, availability of funds, climatic, social and environmental conditions of the countries concerned. They also depend on the levels and availability of technology, modes of governance and quality of academic research (Biswas, 2008).

Today, the perception about water goes to the very height of the increasing worldwide concern about human health, the environment, and the path towards sustainable development. Of all the natural resources needed for economic development, water is one of the most essential, particularly in arid and semi-arid regions. At the dawn of the 21st century, human kind is faced with multiple challenges of rapid population growth which increases the demand for the quantity of water to satisfy people's needs both in agriculture and in expanding urban centers. Similarly, the failing water quality due to increasing pollution, groundwater depletion and attendant environmental impacts and health risks also pose other major challenges (Duda et al., 2000).

The impending water crises need both national and international attention. An estimated 1.4 billion people are presently living without access to safe drinking water, about 2.3 billion lack basic sanitation, 7 million die every year from water-borne diseases, and half of the world's rivers and lakes are seriously polluted (Serageldin, 1999). Recent assessment conducted for the UN (World Meteorological Organization, 1998) and for the World Commission on Water (Seckler et al., 1999; Water Supply and Sanitation Collaborative Council, 1999) added a sense of urgency to these figures. Currently, almost half a billion people face shortages of water in 29 countries. By 2050, almost two-thirds of the people on our planet are forecast to experience some types of water stress, and for over a billion of them, the shortage will be severe and socially disruptive (Duda et al., 2000).

Research on water quality and pollution is very paramount, particularly in the developing countries like Nigeria where water availability to serve both domestic and industrial demands continues to be a problem of great concern. Water quality control and watershed management would only be possible with adequate information on the water bodies within a given locality, region or a country.

Therefore, continuous assessment of the quality of water supplied to the public is very important and necessary, in order to meet the United Nations' campaign for providing good quality drinking water for all by the twenty first century (Knapp, 1989). The quality of water plays an important role because its mere availability does not qualify it for use, Biswas, (1998) reported that the qualities of water defines the extent of the uses it could be put. The better the quality of water the wider the range of uses it could be put. Thus, the need to properly assess the quality of water before and after treatment is of paramount importance. Different researches have been carried out by scholars (Iguisi *et al* 1999, Dim *et al*,2000, Butu 2002), on quality of groundwater, surface water, and pipe borne water, which some pollutants were found to be above the international permissible limit for water meant for domestic and agricultural uses.

1.2 Statement of the Research Problem

The Tamburawa water treatment plant recieves its water supply from the Kano River which has its source from the foot slopes of the Jos Plateau located south of Kano. The water treatment plant supplies about 150million litres of treated water per day to the Kano populace. The plant was established in 2006 to supplement the water supplied by the old Challawa and Tamburawa treatment plants as well as to ease the problems of water scarcity in the state. The water treatment plant is the conventional water treatment system which involves the conventional procedure for water purification . The effectiveness of this conventional purification method to eliminate metal pollutants in the raw water has never been studied. There is a strong possibility that the river water may contain significant amount of metal pollutants because the Kano river drains a substantial part of the industrial section of Kano metropolitan area. Furthermore much of the drainage basin is under intensive cultivation and as a result receives pollutants through the application of chemical fertilizers, pesticides and herbicides. In addition, Industrial and agricultural effluents known to contain metallic pollutants also drain into the river.

It was also observed during a reconnaissance visit to the plant that chemicals used to test for the presence of heavy metals were not always available in the plant's laboratory. Hence this research emphasized on the analysis for the presence of some selected heavy metals and their current levels in the river before and after treatment in comparison with World Health Organization (WHO) water standards.

A lot of researches have been conducted to investigate the quality of surface and groundwater for irrigation and domestic uses in the Kano region (Tanko, 2000). In the late 1970's investigation into the natural drainage system around Bompai industrial zone in Kano, indicate that waste water discharge was the major source of pollution of the river (UNDP, 1978). Bello (1985), and Tanko (1987), reported similar findings in the Sharada industrial estate.

Another study by Akan et al.,(2007) on the level of pollutants in the effluents discharged by the Mario-Jose tannery in Kano, revealed that there were high levels of chromium and iron, which were above FEPA permissible limits. Levels of manganese, copper, zinc, lead and cobalt were also found to be within the minimum permissible limits for effluents discharged into the river. It was also discovered that there was a decrease in concentration of heavy metals with distance from point source up to 400 meters (Akan *et al.* 2007). Furthermore, a similar study by Akan *et al.,* (2007) within the Kano river drainage basin found concentration of heavy metals to be significantly above USEPA and WHO permissible limits for drinking water. Levels of oxygen and phosphates were also observed to exceed FEPA tolerance limit for drinking water and water meant for domestic uses. All these studies by Akan and co-authors were carried out at the upper course of the Challawa River. To extend further on the scope of their works, this study analyzes water down stream where the Challawa and Kano rivers meet so as to capture the pollutants collected within both rivers and to asses the efficiency of the treatment plant in eliminating the three selected metals.

The selected elements are Copper, Manganese and Iron owing to their significance to human health at a certain quantity, as well as their potential hazards when present in high concentrations. The conventional treatment plants are usually successful in eliminating the organic pollutants through chlorination, but not the heavy metals because previous researches have revealed that such pollutants usually occur in concentrations above the World Health Organization (WHO) permissible limits especially in the up-stream area of the river.

1.2 Aim and Objectives

The aim of this study is to compare the quality of water in the Tamburawa area of Kano River before and after treatment during the dry and rainy seasons. This will be achieved through the following objectives;

(1) To determine the current levels of concentration of three selected pollutants in the river.

(2) To compare the quality of raw water in the river with the treated water.

(3)To assess the level of purity of the treated water by comparing it with the WHO standards

(4) To asses the variations in the seasonal concentrations of these selected metals present in the water samples.

1.3 Research Hypothesis

There is no significant difference in water quality between raw and treated water from the Kano River.

1.4 Scope of the study

The study focused on the Tamburawa area of the Kano river drainage basin and the new treatment plant. The sampling points were beside the water intake pipe within the Kano river for the raw water samples and a tap within the treatment plant for the treated water samples. Three metals were selected for the study (Cu, Mn and Fe) during a period of eight months across the rainy and dry seasons.

CHAPTER TWO

LITERATURE REVIEW

2.1 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 (Vutukuru, 2005; Dirilgen, 2001). 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 world wide serve as recipient of great quantities of waste discharged by agricultural, industrial and domestic activities Mimoza, (2007). Zhang et al (2007) also 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 (Hem, 1985; Feller, 2007; Hussain et al., 2008; Raymond et al., 2008), 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 et al., 2004; Alam et al., 2006; Zhang et al., 2007; Hussain et al., 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).

Anthropogenic activities like mining, disposal of treated and untreated waste effluents containing toxic metals as well as metal chelates (Amman et al., 2002) from different industries, e.g tannery, steel plants, battery industries, thermal power plants etc and also the indiscriminate use of heavy metals containing fertilizers and pesticides in agriculture resulted in deterioration of water quality (Ghosh and Vass, 1997; Das et al., 1997). Though some of these metals like Cu, Fe, Mn, N and Zn are essential as micro nutrients for life processes in plants and micro-organisms, while many other metals like Cd, Cr and Pb have no known physiological activity, but they are proved to be detrimental beyond certain limit (Marschner, 1995; Bruins et al., 2000).

Heavy metals are regarded as serious pollutants of aquatic ecosystems, because of their persistence (Armitage et al., 2007), toxicity, and ability to be incorporated into food chains (Forstner and Wittman, 1983)

Trace amounts of heavy metals are always present in freshwaters from the weathering of rocks and soils(Muwanga, 1997; Anderson, 2003; Babel and Opiso, 2007, Igwe et al., 2008, Al-juboury, 2009).

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; Campbell, 2001; Lwanga et al., 2003; Lomniczi et al., 2007)

Empirically, the anthropogenic activities that influence the river water quality in the drainage of Axios/Vardar River can be grouped into industry, agriculture, domestic waste water and uncontrolled landfills. Emissions of heavy metal pollution from industrial activities are the major source of water quality degradation in the basin especially in FYROM. The drainage basin also receives effluents from the use of fertilizers and pesticides mainly from the lowland of Axios/ Vardar bed and also from the protected delta area, contaminates surface and groundwater (Takova-Arsova,N., 1996) and (Lepitkova,S. and Boev, B., 2002). This can be attributed to the high population of people living around the basin, with the capital Skopje having about 600,000 inhabitants, this is followed by the second larges city of Greece, Thessaloniki, with the inhabitants of 120,000.The study evaluated water quality parameters such as BOD, nitrate, nitrite, ammonium, total phosphorus and heavy metals. It was discovered that there was a significant pollution from zinc and lead smelting industries which contribute Pb, Zn, Cd, and Cr as a result of disposal of solid waste in illegal landfills located near the river network.

Zhang et al., (2010) conducted a similar study on the impacts of human activities on surface water quality using Xiangjian River, China as a case study. The results indicated that the water problems in Xianjian Basin are primarily related to water pollution by nutrients, heavy metals pollution in the surface water as well as in sediments and soil in the watershed. The study confirms the findings of Chen et al., (2004), Tang et al., (2008) and Zhang et al., (2009). The study further observed that heavy metals pollution is considered to be point source which is primarily discharged from smelting and heavy industrial enterprises in addition to other non-point sources like domestic waste water and agricultural run off.

Okonkwo et al., (2004) 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. 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 can be 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 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 respectively. 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 et al., (2010) have recently investigated the heavy 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 at most of the sites and NEMA, (2006) maximum permissible limit of discharge of waste water into the environment (100um/L) .

Water resources management studies and water quality in particular has been one of the areas that draws attention. Iguisi et al, (1999) reported the presence of heavy metals in the Kubanni 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 Galma dam, Zaria, reported the presence of heavy metals in high concentration within the Galma dam.

Ahmed and Tanko, (1994) observed that concentration of calcium, magnesium, sodium, manganese, nitrate, chromium and lead vary spatially and seasonally within the Challawa drainage basin in Kano. Lead, chromium and manganese were observed to be in high concentration which could be a threat to the health of both animals and plants. The increase in chemical pollution of water in the basin was due to increasing use of chemicals in Agricultural activities and industrial discharge.

Akan et al,(2007) found high levels of heavy metals; copper, cobalt, zinc, iron, lead, manganese and chromium within the Challawa drainage basin. All observed concentration was above USEPA and WHO permissible limit for drinking water. Also observed is the level of phosphate exceeding the FEPA tolerance limit for drinking water and water meant for domestic uses.

The Kano River basin serves as the main source of water supply to metropolitan Kano. A study by Bichi and Anyata, (1999) within the basin reveals that the Salanta river receives the highest pollution from industrial discharge with COD of 8557.4mg/l, total solids of 16934.6mg/l, hardness of 1349.6mg/l $CaCO_3$, and ammonia- nitrogen of 5150.0mg/l. The Challawa river had COD of 598.7mg/l, total solids of 1609.9mg/l, hardness of 1332.0mg/l $CaCO_3$ and ammonia-nitrogen 400mg/l. Both rivers empty into the Kano River where the COD was 1166.9mg/l, total solids 1458.0mg/l, hardness 2506.8mg/l $CaCO_3$ and ammonia-nitrogen 530mg/l. Although these rivers are used extensively for water supply, irrigation and fishing, the quality of water was found to be unsuitable for these purposes. It is based on the foregoing that it's necessary to carry out a research that will assess the quality of some selected elements that were found to be in high concentrations by previous studies.

2.2 SEASONAL VARIATION OF HEAVY METALS CONCENTRATION IN RIVERS

Kar et al., (2007) has also observed a seasonal variation in the concentrations of Fe, Mn, Zn, Cu, Cd, Cr, Ni and Pb in the surface water of river Ganga in three different seasons. Similar trends of results were also observed by Haque, et al., (2005) in the surface water of the river Ganga at Sundarban estuary. The highest concentrations of Cu, Cd, Cr, Ni and Pb were observed in winter, while those of Mn and Zn were observed in monsoon which may be due to a sudden rainfall followed by high river discharge from upstream environment (Khan, et al., 1998). But the maximum for Fe was observed in summer. The study further observed that among the eight heavy metals, significant seasonal change was noted in the concentrations of Fe, Mn, CD and Cr, whereas in the case of Zn, Cu, Ni and Pb, the seasonal change was not significant.

In another hydrological study of some rivers in Greece, a seasonal pattern of pesticides concentration was also observed. The major inputs of the compounds into the rivers occurred in the summer period (May-August) after their application in agricultural fields, as a result of surface run-off and the lower flow rates of the rivers (Albanis and Hela, 1998). In some cases a lower peak is observed in late September-October due to rainfall events after the dry summer period (Albanis et al., 1998; Lambropoulou et al., 2002). An earlier study by Thurman et al.,(1991) observed low concentration during the winter months because of the dilution effects of high-rainfall events and the increased degradation of pesticides after their application. Capel et al.,(2001) highlighted some critical factors that result in the time lapse between the period of pesticide application in their occurrence in rivers include the characteristics of the catchment (size, climatological regime, type of soil or landscape) as well as the chemical and physical properties of the pesticides.

2.3 IMPACTS 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. To small extent they enter our bodies via food, drinking water and air. As trace elements some metals are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metals are dangerous because they tend to bio-accumulate. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and are stored faster than they are broken down (metabolized) or excreted. Heavy metals can enter a water supply by industrial and consumer wastes, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers and groundwater.

In Japan, in 1932, sewage containing mercury was released by chisso's chemical works into the Minamata Bay. The mercury accumulated in sea creatures, leading eventually to mercury poisoning of the population. By 1952 the first incidence of mercury poisoning appeared in the population of Minamata Bay in Japan, caused by consumption of fish polluted with mercury, bringing over 500 fatalities.

In 1998, toxic chemicals in water from a burst dam belonging to a mine contaminated the Coto de Donana nature reserve in southern Spain. Tonnes of mud containing sulphur, lead, copper, zinc and cadmium moved down the Rio Guadimar River. Experts estimate that Europe's largest bird sanctuary, as well as Spain’s agriculture and fisheries will suffer permanent damage from the pollution.

Among the inorganic contaminants of river water, heavy metals are getting importance for their non-biodegradable nature and often accumulate through tropic level causing a deleterious effect /biological effect (Jain, 1978). Subsequent studies by Lantzt and Mackenzie, (1979), and that of Ross (1994) have discovered that the indiscriminate use of heavy metal containing fertilizers and pesticides in agriculture resulted in deterioration of water quality rendering serious environmental problems and posing threats to humans. These effects are responsible for the prevalence of deadly diseases like edema of eyelids, tumor, congestion of nasal mucous membranes and pharynx, stiffness of the head and gastro-intestinal, muscular, reproductive, neurological and genetic malfunctions(Johnson, 1998; Abbasi et al., 1998; and Tsuji and Karagatzides, 2001).Similarly, the studies of Lee et al.,(2007), and Lohani et al., (2008) also revealed that since heavy metals are non-biodegradable, they can accumulate in the human body system, thereby causing damage to the nervous system and other internal organs.

The impacts 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).

It was widely reported that among the animal species, fishes are the inhabitants of aquatic environment that cannot escape from the detrimental effects of these pollutants(Olaifa et al., 2004; Clarkson, 1998; Dickman and Leung, 1998). Vinodhini et al., (2008) conducted an experiment of heavy metals presence in different fish organs like gills, liver, kidney and flesh of the control fish surviving in natural water system. It was discovered that the gill is an important site for the entry of heavy metals that provokes lesions and gill damage. This result was also observed in earlier studies of Bols et al., (2001); and Lock and Overbeeke, (1981), these findings support the argument that heavy metal concentration definitely affects the aquatic life of fresh water fish.

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 neurotoxic potential and can produce mental diseases such as Alzheimers and Manganism(Dieter et al., 2005). High levels of manganese in drinking water have also been shown to affect intellectual functions in 10-year-old children in Araihazar, Bangladesh (Wasseman et al., 2006). Other metals such as Zinc can also cause demyelinating diseases in humans (Zatta et al., 2003). 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 (Heininger, 2000; 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 et al., 1996). Acute gastrointestinal effects, which include nausea, vomiting and diarrhea, maybe observed in some individuals at Cu concentrations in drinking water above 3mg/l (WHO, 1993).

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 et al., 1999; Ritter et al., 2002).

2.4 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 physio- chemical 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 also. Shaw, (1993) classified the parameters into inorganic, organic, aesthetic and microbiological parameters.

CHAPTER THREE

THE STUDY AREA

3.1 LOCATION, POSITION AND SIZE

The state is well drained with rivers flowing through all corners. It also serves as a nerve center for industrial, agricultural and commercial activities. The Kano river drainage basin occupies the south and western part of Kano state. It ranges between $11^0$35'N and $12^0$10'N of latitude and $7^0$55'E and $11^0$35'E of longitude. The prominent rivers within the basin are the Kano and Challawa rivers which are used extensively for domestic, industrial and agricultural purpose.

3.2 CLIMATE

The climate of Kano is typical dry and wet type classified as (Aw) by Koppen. Rainfall is the most critical element (Olofin and Tanko, 2002). Four main wet months (June to September) dominate and receive over 90% of the rain. The temperature is averagely warm to hot throughout the year at about 27 ± 7^0C (Olofin and Tanko, 2002) with annual monthly range of 10 – 15^0C and higher daily ranges. Mean annual rainfall ranges from over 1000mm in the extreme south to about 800mm in the extreme north. The duration of the rain is between two to five months. The mean temperature ranges between 26^0c to 33^0c. The state is characterized by four seasons: a dry and cool season, *Kaka* (mid-November to February), marked by cool and dry weather plus occasional dusty haze; the dry and hot season, *Bazara* (March to mid-May) when temperatures climb up to 40^0c and which is a transition period between harmattan and wet season; the wet and warm season, *Damina* (mid-May to September), is the proper wet season when the lowest diurnal temperatures are recorded; and a dry warm season *Rani* (October to mid-November), marked by high humidity and high temperature.

3.3 GEOLOGY

The geology of Kano is made up of the basement complex rocks (Uso, 1970) and (Olofin, 1987) which are deeply weathered, resulting in lateritic pans. It is about 430 – 450m above see level (Olofin and Tanko, 2002). The geology implies predominant surface hydrology, hence the network of rivers and streams (Bichi, 2000), and notable ground storage are common all over, in form of wells and boreholes. Quarzite, undifferentiated meta-sediments and basement complex rocks of the pre-cambrian and upper Cambrian origin make up more than two-third (2/3) of the Kano geological setting. Deep clay-rich regolith produced by prolonged weathering activities which subject them to laterization. Lateritic outcrops of the upland areas serve as caps for the regolith hills, example *Gwauron Dutse* and *Dala hill*. Other rock types include the well jointed younger granites of Jurassic origin which are found in ring complexes in the extreme south. A narrow strip of Chad formation occurs to the east (Olofin, 1991). The general height of the relief ranges from 500m in the lower plains to highlands of more than 1000m above sea level. The major landforms include the plains with grouped hills and alluvial channel complexes.

3.4 SOILS

The soils are divided in to four main groups. Generally, the ferruginous tropical soils formed on crystalline acid rocks are found in the south, south west and south east of the state. The brown and reddish brown soils and latosols occur in the northern part, the north eastern corner is occupied by the brown, reddish, juvenile and hydro-morphic soils are found along the alluvial channels. The character, profile, texture, structure and chemical characteristics are altered by the extensive use of manure and chemical fertilizers.

3.5 DRAINAGE

Rivers Kano, Challawa, Watari, Jatau, Dudurun Gaya join the hadejia river, which empties into Lake Chad while Gari, Tomas, and jakara disappear in to the Chad formation further east. Man-made lakes such as Tiga on the Kano river, Challawa gorge, Gari, Watari, Guzu-guzu, Kafin chiri, Magaga, Bagauda, e.t.c. have been constructed to improve portable water supply to the towns and villages and to provide water for irrigation.

3.6 VEGETATION

The natural vegetation consists of the Sudan savannah in the northern half and Guinea savannah in the southern part of the state, but thse have been replaced by secondary vegetation. Most of the state is now composed of farmed parkland, dotted with patches of shrub savannah. The Falgore game reserve is typified of the savannah woodland within the southern part of Kano state.

3.7 POPULATION AND HUMAN ACTIVITIES

The Population of Kano in 2006 was over ten million with a remarkable concentration of rural population. The gross population density is 370 per sq km, ranging from as low as 120 in Tudun Wada/ Dogowa LGAs with extensive forest reserves to over 10,000 in the metropolis. Kano was once a renowned Ground nut producer with pyramids of harvested crops. Other crops such as millets Sorghum and Cowpea are grown on fields which have been intensively cultivated annually for over a centaury on lands maintained by labour intensive management involving integration of live stock and crops, a practice evolved indigenously by the farmers. Kano has a tradition of irrigated agriculture and is known as the leading hydro-agricultural state in Nigeria. The economic development in Kano is aimed at identifying and utilizing materials, which foster interaction between industrial, agricultural and commercial resource centers.

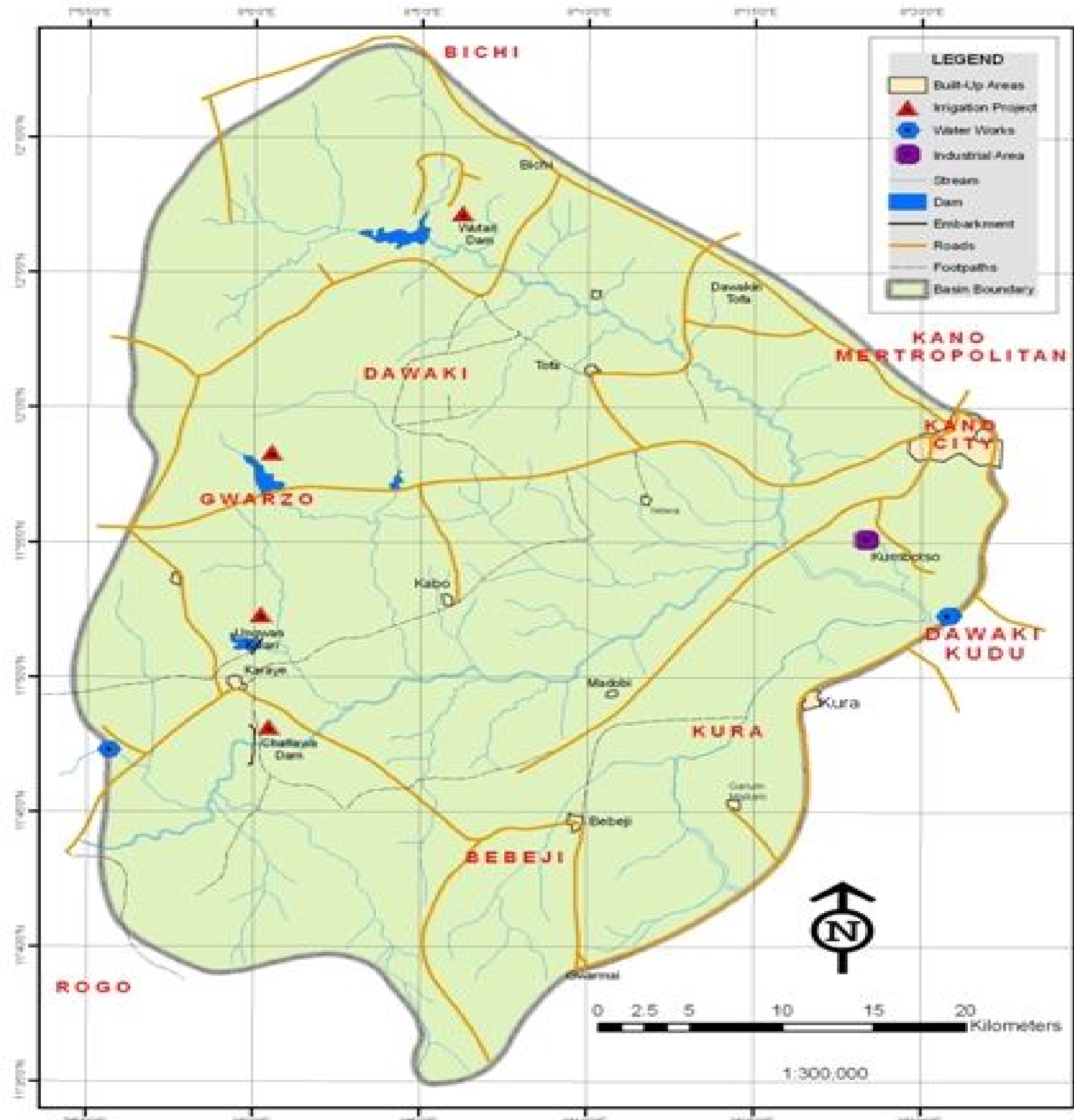

FIG. 3.1 MAP SHOWING THE DRAINAGE BASIN OF THE KANO RIVER

CHAPTER FOUR

METHODOLOGY

4.1 TYPES OF DATA COLLECTED

Raw water samples were collected directly from the river at a point very close to the intake pipe that connect the river with the treatment plant and treated water samples were collected immediately after treatment. The choice of these predetermined sampling points was to capture the various pollutants likely to be present in the water samples before and after treatment. Three elements which determine water quality parameters were purposefully selected for this study. These are Copper, Manganese and Iron owing to their significance to human health when present at certain permissible quantity, as well as their potential hazards at high concentrations. Also, previous studies carried out within the river basin have reported their presence in concentrations beyond the World Health Organization (WHO) permissible limits and it is known that heavy metals are not properly eliminated by conventional treatment plants. These samples were analyzed to identify and assess the concentrations of each parameter in the water samples based on the standard method for analyzing water, waste water, and sea water as recommended by the United States Environmental Agency (USEPA).

4.2 METHODS AND PROCEDURE OF DATA COLLECTION

Sixteen (48) water samples were collected for this research, 24 during the dry season (January – April, 2009) and 24 during the rainy season (June – September, 2009). Each of the selected parameters had eight water samples (4 raw and 4 treated) during the dry season and eight water samples (4 raw and 4 treated) during the rainy season. In the laboratory, the water samples were prepared for analysis using the spectrophotometer. The following are procedures used for the analysis of the parameters.

4.3 TECHNIQUES OF DATA ANALYSIS

4.3.1 LABORATORY ANALYSIS

To identify the presence of specific metallic element, the water samples collected were first filtered through a 0.45µm pore diameter membrane filter. The medium used in this study, however, was chosen to avoid contamination as a result of further weathering of solutes due to storage time and handling using decanting or oven drying method.

The assembled filtering unit was pre-conditioned by rinsing it with 50ml de-ionized water and then with 100ml of the sample and was discarded but the volume was recorded. This is to avoid contamination of the sample. The remaining sample was filtered and preserved with HNO_3 for further analysis (APHA, 1998).

About 50ml of the acidified sample was stirred and poured into a 100ml glass beaker using a pipette. 5ml of concentrated nitric acid, (HNO_3) was added and the solution digested on a hot plate to a volume of 20ml before salting out occurred. 5ml of HNO_3 was again added and covered with a watch glass then heated to obtain a gentler refluxing action. The solution was continuously heated and 2ml of concentrated nitric acid added as necessary until digestion was complete as shown by a clear coloured solution. At no point was the sample allowed to dry completely during digestion. Another 2ml of nitric acid was added and warmed slightly to dissolve the remaining residue. The digested sample was transferred into a 100ml volumetric flask with two 5ml portions of the filtered water after adding the rinsing from the walls of the beaker and watch glass to the volumetric flask. The solution was mixed, marked and allowed to cool.

Portions of the digested solutions of each water sample prepared as described above were taken for identification and their respective concentration levels measured on an Atomic Absorption spectrophotometer (DR/890). The concentration of each metal obtained was expressed in mg/l.

4.3.2 STATISTICAL ANALYSIS

The data obtained from laboratory analysis were used to statistically test the hypothesis stated in section 1.4, this is to

(i) compare the differences in quality between raw and treated water in the Kano River using the student's T-test

(ii) determine the temporal variability in the level of metals across the seasons, using the student's T-test

(iii) Compare with the W.H.O. standards

The student's T-test tested the degree of change that occurred in the water quality between the raw and treated water within the months and seasons. This was achieved by arranging the values of the parameters tested for in a table form. The values obtained from the laboratory analysis were computed as follows: (at 0.05% confidence level)

$$t = \frac{\bar{x}_1 - \bar{x}_2}{SEx_1 - x_2}$$

Where

$\bar{x}_1$ = mean of each pollutant in sample A

$\bar{x}_2$ = mean of each pollutant sample B

$SEx_1 - x_2$ = standard error of the mean of each pollutant of sample A and B (raw and treated water respectively)

t = comprehensive value between the raw and treated water samples.

Procedure

4. The sample from each pollutant was tabulated under category A and B which represent raw and treated water respectively.

5. The mean and the deviation from the mean (mean deviation) was calculated i.e.

$(\bar{x}_1, \bar{x}_2)$ and $[(x - \bar{x}_1), (x - \bar{x}_2)]$ respectively.

6. The mean deviation was squared and summed i.e.

$\Sigma(x_1 - \bar{x}_1)^2$ and $\Sigma(x_2 - \bar{x}_2)^2$

7. The variance and standard deviation was calculated

$V_1 = \Sigma \frac{(x_1 - \bar{x}_1)^2}{n_1 - 1}$ and $V_2 = \Sigma \frac{(x_2 - \bar{x}_2)^2}{n_2 - 1}$

$SD_1 = \sqrt{V_1}$ and $SD_2 = \sqrt{V_2}$

8. Standard error of the mean of each pollutant was obtained using

$SEx_1 = \sqrt{\frac{V_1}{n_1}}$ and $SEx_2 = \sqrt{\frac{V_2}{n_2}}$

9. The standard error of the difference between means of each pollutant 1 and 2

$(SE\bar{x}_1 - \bar{x}_2) = \sqrt{(SE\bar{x}_1)^2 + (SE\bar{x}_2)^2}$

10. The t-test was = t = $\frac{\bar{x}_1 - \bar{x}_2}{SE\bar{x}_1 - \bar{x}_2}$

11. Degrees of freedom for $t = (n_1 - 1) + (n_2 - 1)$ significance level = 0.05

Where:

$n_1 =$ number of samples for each pollutant in raw water

$n_2 =$ number of samples for each pollutant in treated water

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 RESULTS

Following the laboratory analysis of the water samples collected from the study area, the concentration levels of the selected metals were determined for both the raw and treated water at different seasons. Table 5.1 illustrates these variations at different seasons of the year.

5.1.1 LEVEL OF METAL POLLUTION OF RAW AND TREATED WATER

Table 5.1 Monthly metal concentrations for the treated and untreated samples for the selected metals.

Dry Season Cu (Mg/L)

Date	Raw	Treated
20/01/10	0.780	0.061
20/02/10	0.872	0.030
20/03/10	0.834	0.800
20/04/10	0.945	0.131

Rainy Season Cu (Mg/L)

Date	Raw	Treated
20/06/10	2.852	0.898
20/07/10	0.771	0.504
20/08/10	0.982	0.083
20/09/10	0.610	0.232

Dry Season Fe (Mg/L)

Date	Raw	Treated
20/01/10	2.610	0.961
20/02/10	2.640	0.561
20/03/10	2.340	0.090
20/04/10	2.450	0.923

Rainy Season Fe (Mg/L)

Date	Raw	Treated
20/06/10	3.015	0.048
20/07/10	2.370	0.056
20/08/10	2.340	1.870
20/09/10	3.300	1.042

Dry Season Mn (Mg/L)

Date	Raw	Treated
20/01/10	0.005	0.001
20/02/10	0.002	ND
20/03/10	0.298	0.024
20/04/10	0.143	0.011

Rainy Season Mn (Mg/L)

Date	Raw	Treated
20/06/10	0.372	0.014
20/07/10	1.182	0.170
20/08/10	1.298	0.524
20/09/10	0.520	0.275

(ND: not detected)

Concentration of Cu for the untreated water samples ranged from 0.780mg/l in January to a peak concentration of 2.852 mg/l in June. February, March and April had concentrations of 0.872 (mg/l), 0.834 (mg/l) and 0.945 (mg/l) respectively. This shows an increase in concentration from the months of January, July, August and September with concentrations of 0.271mg/l; 0.982 (mg/l) and 0.610 mg/l respectively. These months show a decrease from June, with September having the lowest concentration. The concentration of Cu for treated water samples showed almost the same trend with that of the untreated water samples, but with lower values of concentrations. The concentration ranged from 0.030 mg/l in February to 0.898 mg/l in June. The months of January, March, April, July, August and September had concentrations of 0.061 (mg/l), 0.80 0 (mg/l), 0.131(mg/l), 0.504 (mg/l), 0.083 (mg/l) and 0.232 (mg/l) respectively. The concentrations of treated water samples fluctuated with February having the lowest concentration of Cu.

The concentration of Fe for the untreated water samples showed a higher value compared to that of Cu which ranged from 2.340 (mg/l) in March and August to 3.30 (mg/l) in September. The months of January, February, June and July had values of 2.610 (mg/l), 2.640 (mg/l), 2.450

(mg/l) 3.015 (mg/l), 2.370 (mg/l) and 2.370 (mg/l) respectively. Two months(June and September) had a reasonably high concentration, but March and August had the lowest concentrations. The values for Fe showed almost the same trend as that of the untreated samples in terms of concentration, though with slight differences. August and September had highest concentrations, with the former having the highest value of 1.870 (mg/l) and latter 1.042 (mg/l). January and April had a value of 0.961 (mg/l) and 0.923 (mg/l) respectively. Lower values were recorded for the months of February and July with 0.561 (mg/l) and 0.056 (mg/l) respectively, while June had the lowest concentration of Fe with a value of 0.48 (mg/l).

Manganese (Mn) had the lowest concentration compared to the other selected metals. The untreated water samples had a concentration value ranging from 0.002 (mg/l) to 1.298 (mg/l) in February and August respectively. January values were quite low with a value of 0.005 (mg/l). The concentration of Mn for the months of March, April, June and September are 0.298 (mg/l), 0.143 (mg/l), 0.372 (mg/l) and 0.520 (mg/l). This shows a much higher value than that of January and February. The highest values of the study were recorded during the months of July and August with the latter having a higher value than the former with a value of 1.182 (mg/l). The treated water sample had lower concentration values than the untreated water samples. The concentration of Mn ranged from below detection point in February to a value of 0.524 (mg/l) in August. The concentration in January had a considerable low value of 0.001 (mg/l) and a little higher value of 0.024 (mg/l), 0.011 (mg/l) and 0.014 (mg/l) for March, April and June respectively. The much higher values were recorded during July and September with values of 0.170 (mg/l) and 0.275 (mg/l) respectively. The concentration of the metals exhibited almost the same pattern though with different characteristic as observed by Akan et al (2007).

5.1.2 SAFETY LEVEL OF TREATED WATER

Table 5.2 Percentages of reduction levels of the selected metals by the treatment plant.

Manganese (Mn)

S/N	Dry Season
1	$\frac{0.004}{0.005} x \frac{100}{1} = 8.800\%$
2	ND
3	$\frac{0.274}{0.298} x \frac{100}{1} = 91.946\%$
4	$\frac{0.132}{0.143} x \frac{100}{1} = 92.30769\%$

S/N	Rainy Season
1	$\frac{0.358}{0.372} x \frac{100}{1} = 96.23655\%$
2	$\frac{1.012}{1.182} x \frac{100}{1} = 85.61759\%$
3	$\frac{0.774}{1.298} x \frac{100}{1} = 59.6302\%$
4	$\frac{0.245}{0.520} x \frac{100}{1} = 47.11538\%$

Iron (Fe)

S/N	Dry Season
1	$\frac{1.649}{2.610} x \frac{100}{1} = 63.18007\%$
2	$\frac{2.079}{2.640} x \frac{100}{1} = 78.75\%$
3	$\frac{2.250}{2.340} x \frac{100}{1} = 96.1538\%$
4	$\frac{1.527}{2.450} x \frac{100}{1} = 62.3265\%$

S/N	Rainy Season
1	$\frac{2.967}{3.015} x \frac{100}{1} = 98.40796\%$
2	$\frac{2.314}{2.370} x \frac{100}{1} = 97.6371\%$
3	$\frac{0.470}{2.340} x \frac{100}{1} = 20.08547\%$
4	$\frac{2.258}{3.300} x \frac{100}{1} = 68.4242\%$

Copper (Cu)

S/N	Dry Season
1	$\frac{0.719}{0.780} x \frac{100}{1} = 92.17948\%$
2	$\frac{0.842}{0.872} x \frac{100}{1} = 84.2\%$
3	$\frac{0.034}{0.834} x \frac{100}{1} = 4.0767\%$
4	$\frac{0.814}{0.945} x \frac{100}{1} = 81.4\%$

S/N	Rainy Season
1	$\frac{1.954}{2.852} x \frac{100}{1} = 68.51332\%$
2	$\frac{0.267}{0.771} x \frac{100}{1} = 34.6303\%$
3	$\frac{0.899}{0.982} x \frac{100}{1} = 91.54786\%$
4	$\frac{0.378}{0.610} x \frac{100}{1} = 61.9672\%$

Table 5.2 presents the monthly reduction in the concentration of Cu by the treatment plant. During the study period, it ranged from 92% to 4% in January and March respectively. August, February and April had reduction values of 91%, 84% and 81% respectively. The remaining period of the study showed quite low values, with June having a value of 68%, September 61% and July having a lower value of 34%. Generally, dry season shows a better reduction in the concentration of Cu than the rainy season.

The treatment plant reduced the concentration of Fe in water supplied to the Kano city far more than that of Cu. The highest reduction was in the month of June with a value of 98% followed by July, March and February with values of 97%, 96% and 78% respectively. The other months showed considerably lower values of 68%, 63% and 62% for September, January and April respectively. August had the least value in respect to reduction of concentration of Fe by the treatment plant with a value of 20%.

The concentration of Fe was better reduced during the rainy season than in the dry season. March, April and June showed a steady rise in the reduction of concentration of Mn from 91% to 92% and then 96% respectively. There was a decline in the value from July with 85%, August with 59% and September 47%. The first two months of the dry season had values below detection. Generally the rainy season had a higher reduction in concentration values than the dry season of the study.

5.1.3 A COMPARISON BETWEEN RAW AND TREATED WATER.

The uses to which water can be put depend on its chemical quality. A comparison of concentrations of the metals between the treated and raw water samples and with the international standards for drinking water set by the world health organization (WHO), is presented on table 5.3 international standards for drinking water

Table 5.3 WHO International Standard for Drinking Water

Elements	Highest Desirable Level (Mg/L)	Maxim Permissible Level (Mg/L)
Fe	0.1	1.0
Cu	0.05	1.50
Mn	0.05	0.1

Source: WHO (1993)

Table 5.4 Comparison between Raw and Treated water samples (Dry Seasons)

SEASON	N	Mean	Std Deviation	Std Error Mean	t-value	DF	Significant	Remarks
UNTREATED Mn	4	0.11200	0.140364	0.070182	1.463	6	0.194	Not significant accept
TREATED	4	0.00900	0.011165	0.005583				
UNTREATED Cu	4	0.85775	0.69342	0.034671	3.316	6	0.018	Significant rejected
TREATED	4	0.25550	0.365450	0.182725				
UNTREATED Fe	4	2.51000	0.140712	0.070356	8.755	6	0.000	Significant rejected
TREATED	4	0.63375	0.404852	0.202426				

Table 5.5 Comparison between Raw and Treated water samples (Rainy Seasons)

Group Statistics[a]

SEASON	N	Mean	Std Deviation	Std Error Mean	t-value	DF	Significant	Remarks
UNTREATED Mn TREATED	4 4	0.84300 0.24575	0.464800 0.214262	0.232400 0.107131	2.334	6	0.058	Not significant accept
UNTREATED Cu TREATED	4 4	1.30375 0.32925	1.043346 0.384842	0.521673 0.192412	1.753	6	0.130	Not significant accept
UNTREATED Fe TREATED	4 4	2.78125 1.00400	0.452887 0.742078	0.226443 371039	4.089	6	0.006	Significant rejected

Table 5.6 Comparison between water sample and WHO Standards (Dry and Rainy Seasons)

	Test value = 0.05					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Mn	2.465	15	0.409593	0.252438	0.03418	0.47069

	Test value = 0.05					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Cu	3.722	15	0.002	0.636563	0.27203	1.00110

	Test value = 0.1					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fe	6.209	15	0.000	1.632250	1.07189	2.19261

Table 5.7 Comparison between water sample and WHO Standards (Dry Season)

	Test value = 0.1

	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Mn	0.277	7	0.790	0.10500	-0.07926	0.10026
Cu	3.550	7	0.009	0.506625	0.16917	0.84408

Table 5.8 Comparison between water sample and WHO Standards (Rainy Season)

	Test value = 0.1					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Mn	3.021	7	0.019	0.494375	0.10747	0.88128
Cu	2.422	7	0.046	0.766500	0.01812	1.51488

Table 5.9 Comparison between water samples and WHO Standards (Dry Season) (Fe)

	Test value = 0.05					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fe	3.998	7	0.005	1.471875	0.60123	2.34252

5.10 Comparison between water samples and WHO Standards (Rainy Season) (Fe)

	Test value = 0.05					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fe	4.579	7	0.003	1.792625	0.86680	2.71845

5.11 Comparison between Raw water samples with WHO standard

	Test value = 0.05					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Mn	2.401	7	0.047	0.427500	0.0640	0.84860
Cu	4.022	7	0.005	1.030750	0.42475	1.63675

	Test value = 0.1					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fe	21.013	7	0.000	2.545625	2.25916	2.83209

	Test value = 0.1					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fe	3.460	7	0.011	0.718875	0.22753	1.21022

From tables 5.3, 5.4, 5.5 and 5.6 the concentration levels of Cu from the rainy and dry seasons during the months of study had concentrations above the WHO highest desirable limits except for the month of February which had a concentration of 0.030 (mg/l), which is within the desired range. All concentrations observed during the study were below the WHO maximum permissible level. A comparison between the raw and treated water samples at 0.05% confidence levels gave a T- value of 3.216 during the dry season and a T- value of 1.753 during the rainy season. The difference in concentration during the dry season between the raw and treated water was significant while that of the rainy season was not. This shows efficiency in treatment during the dry season and not efficient in the rainy season. A comparison between concentrations of Cu with WHO standard for the raw water samples gave a T- value of 4.022 and 1.961 for the treated samples. The difference in concentration is significant for the raw samples but not significant for the treated samples. This implies that the raw water samples concentration is above the WHO standard while the treated water samples are within the limit. The concentration of Fe was below the highest desirable level in the months of March and June, 0.090 (mg/l) and 0.048 (mg/l) respectively. Most of the months of study showed a higher level of concentration that was above the WHO highest desirable level, except August and September with concentrations of 1.870 (mg/l) and 1.042 (mg/l) respectively. A comparison between raw and treated water during the dry season at 0.05% confidence levels gave a T- value of 8.755 and a T- value of 4.089 during the rainy season. This shows a significant difference in the concentration of Fe between raw and treated water across the seasons. This shows the treatment plant is efficient in reducing the concentration of Fe across the seasons. The raw water samples had a T- value of 21.013 while the treated samples had 3.460 when compared with the WHO standard. Even though reduced it is still below the WHO standard when compared.

The concentration of Mn during the study period was quite low when compared with that of Cu and Fe. During the dry season, comparison between raw and treated gave a T- value of 1.463 and 2.334 during the rainy season. This shows no significant difference in concentrations of Fe in both the dry and rainy seasons which implies less efficiency in treatment by the treatment plant in eliminating Fe. At 0.05% confidence level comparison with the WHO standard for Mn, gave a T- value of 2.465.This shows that there is significant difference between the concentration of Mn in the Kano River and the WHO standard. Raw water samples and treated water samples compared with the WHO standard gave a T- value of 2.401 and 1.158 respectively. This shows a significant difference in concentration of Mn between the WHO standard and the raw water, but the treated water had no significant difference. These shows the raw water samples are above the WHO standard, while the treated samples are within limits. Smith,(1972); Odun,(1977) reported that there should be a cause for concern where these metals exceed the WHO highest desirable level or maximum permissible level.

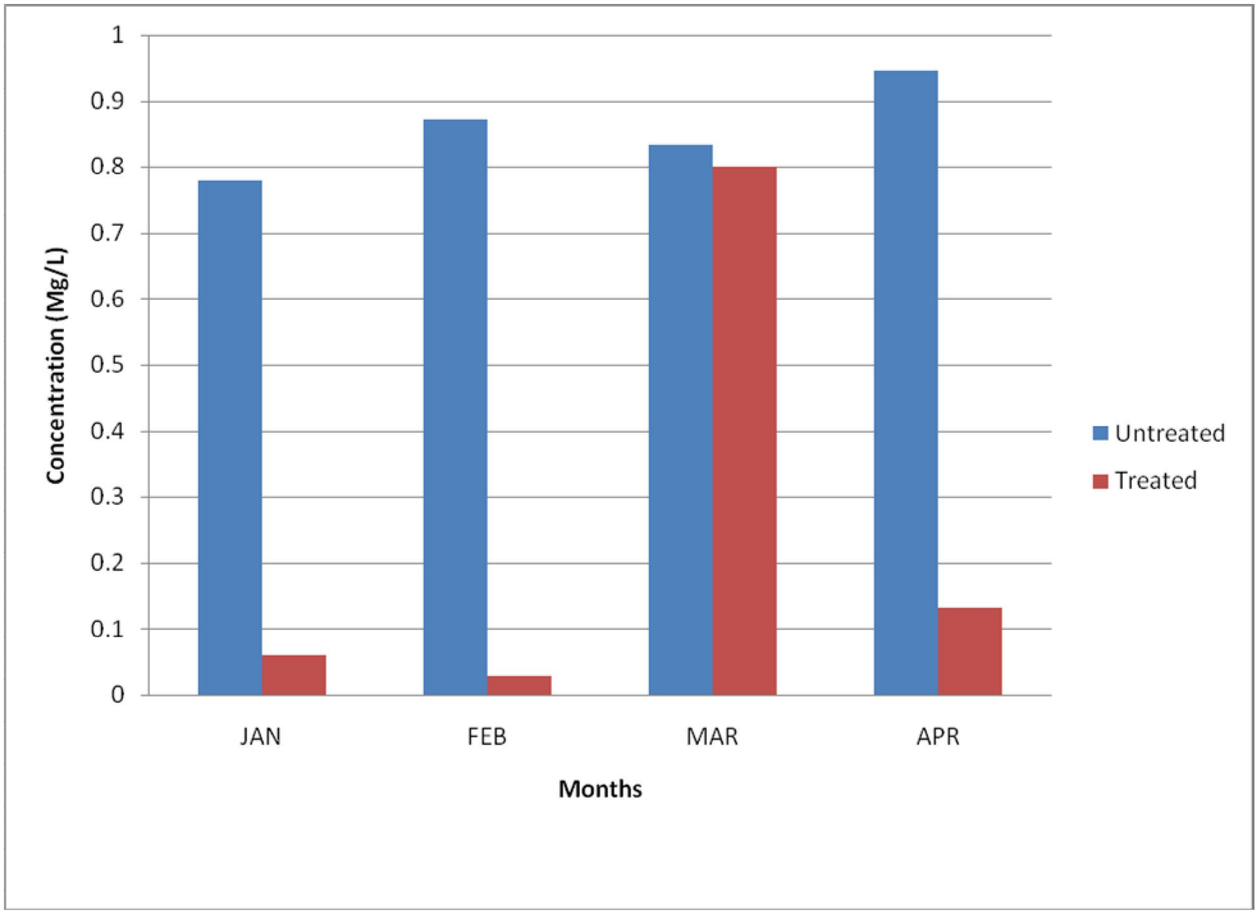

Fig. 5.1 Variation of Cu (Mg/L) concentration between treated and untreated water-Dry Season

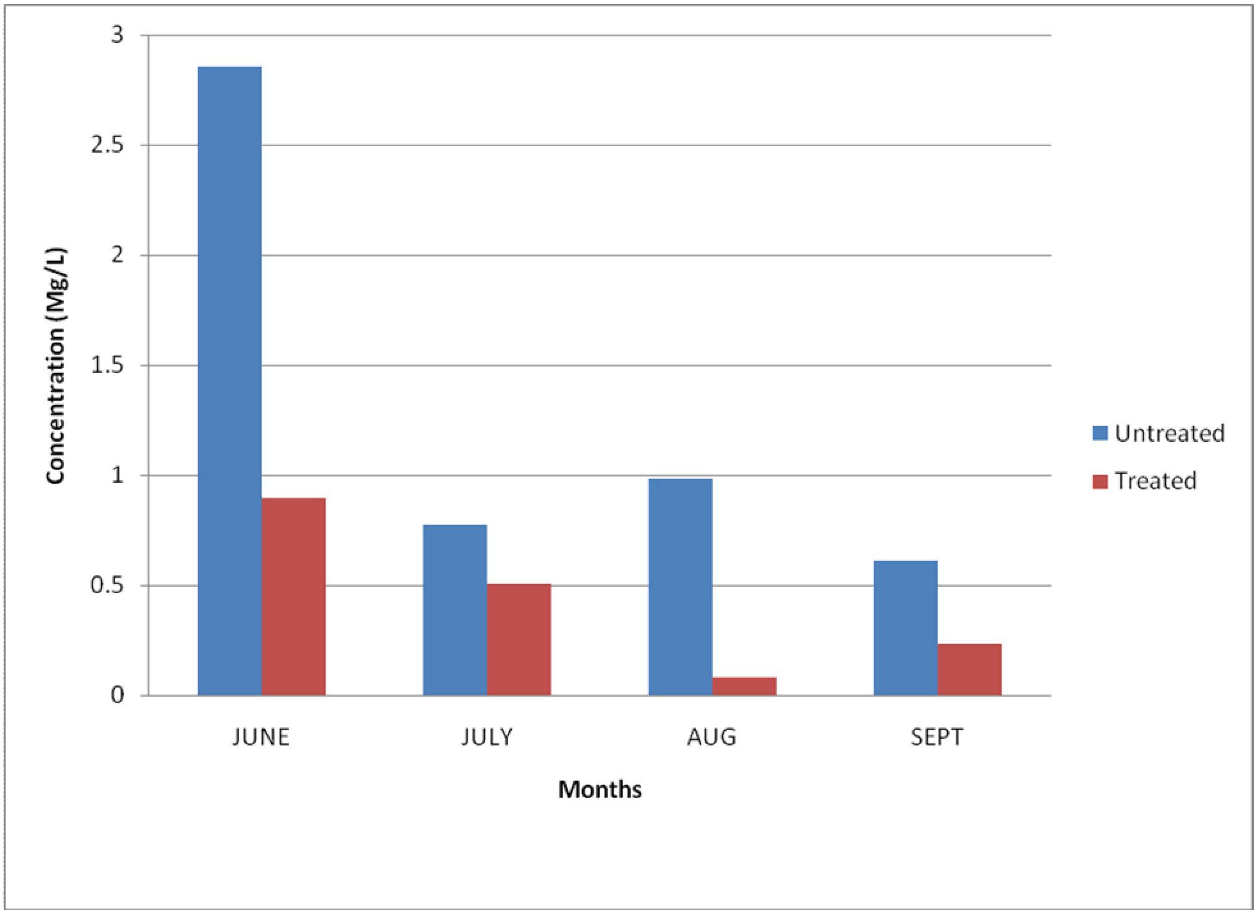

Fig. 5.2 Variation of Cu (Mg/L) concentration between treated and untreated water-Rainy Season

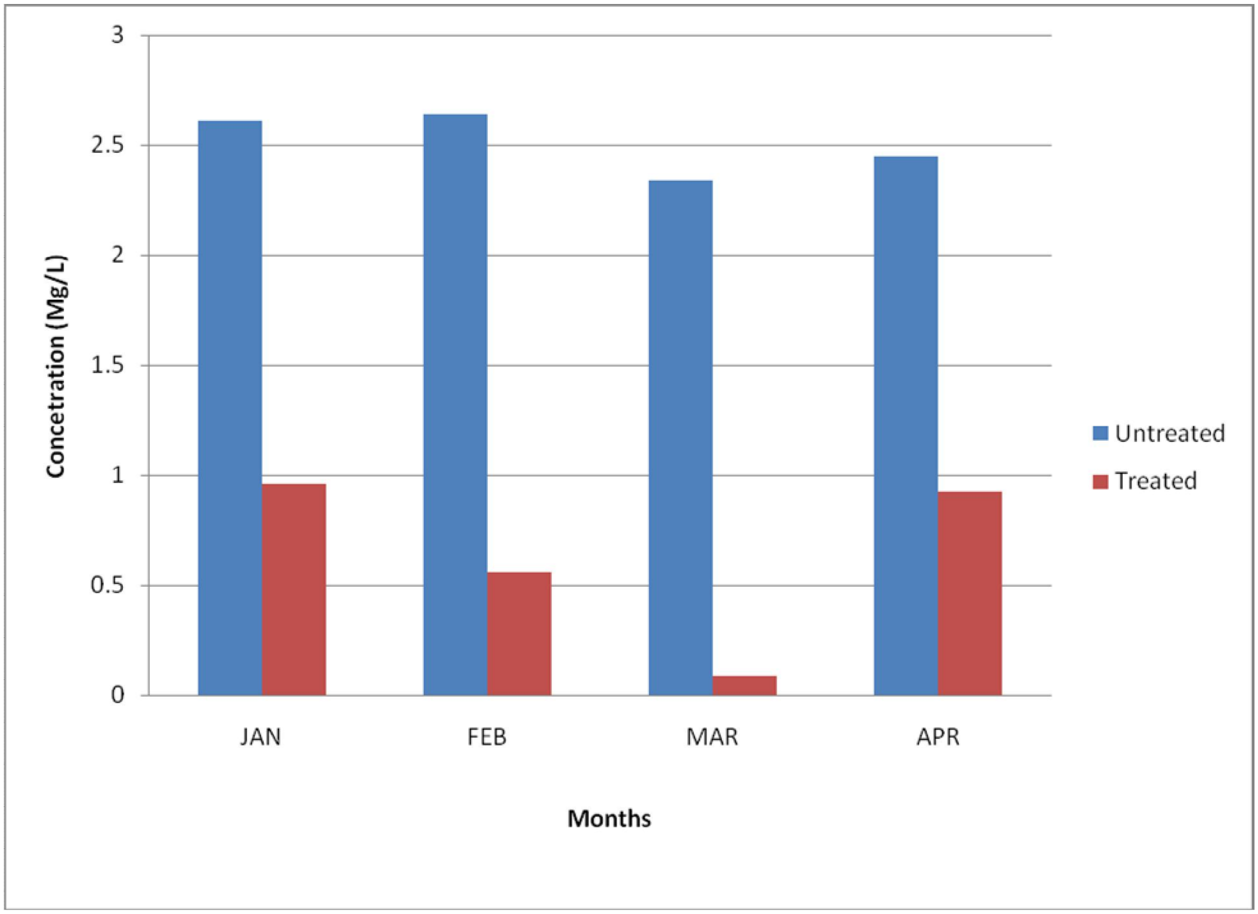

Fig. 5.3 Variation of Fe (Mg/L) concentration between treated and untreated water-Dry season

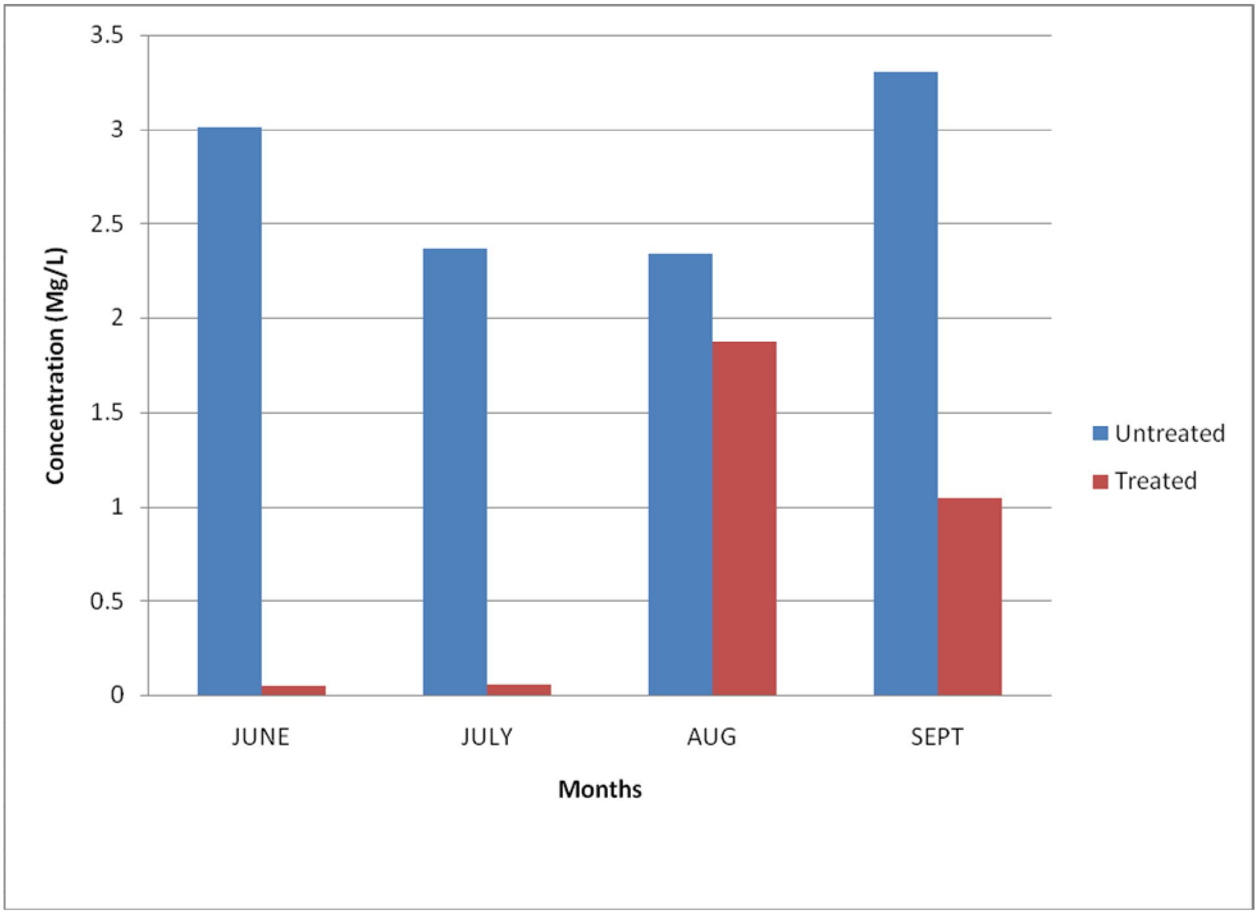

Fig. 5.4 Variation of Fe (Mg/L) concentration between treated and untreated water-Rainy season

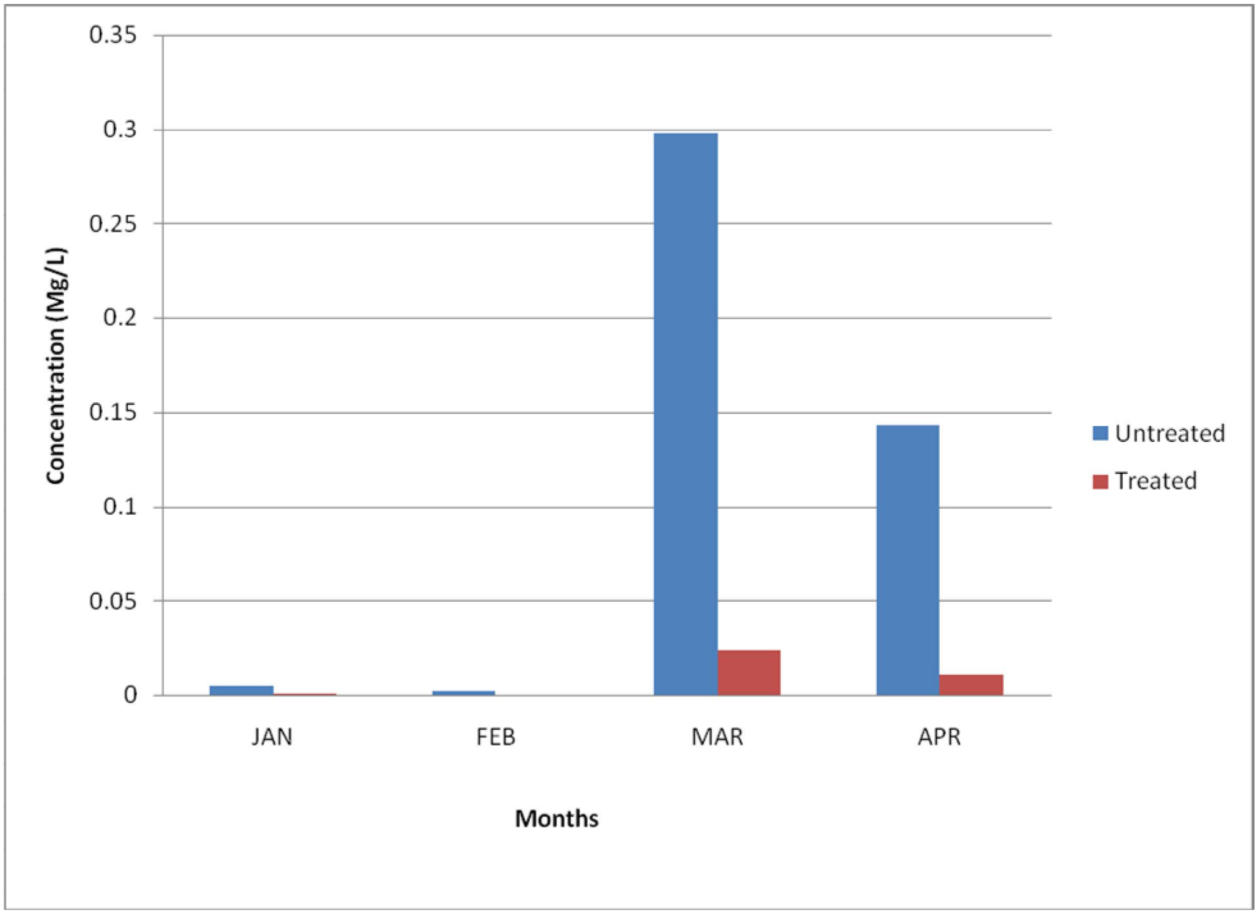

Fig. 5.5 Variation of Mn (Mg/L) concentration between treated and untreated water-Dry season

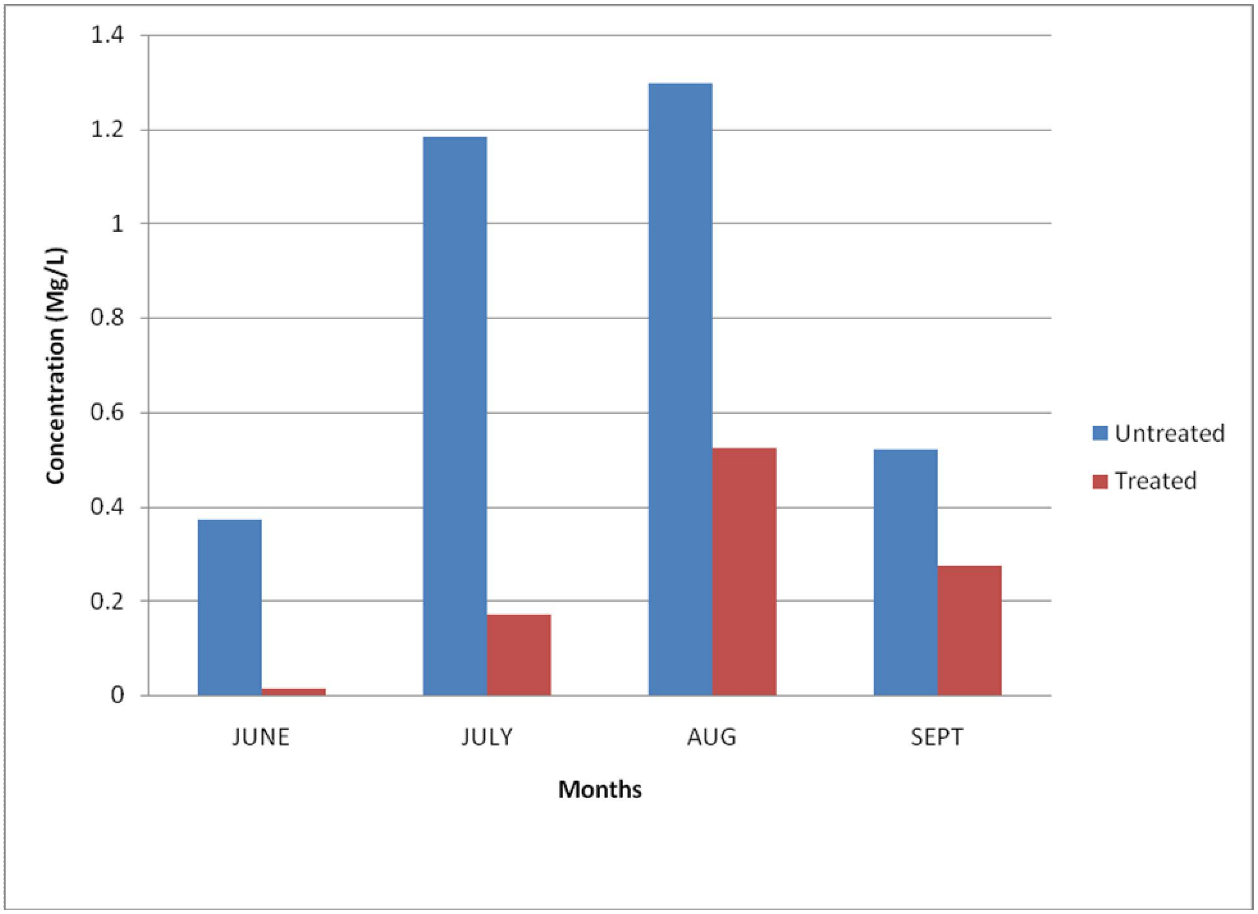

Fig. 5.6 Variation of Mn (Mg/L) concentration between treated and untreated water-Rainy season

5.2 DISCUSSION OF RESULTS

In this section the results described in section 5.1 are discussed. Explanations are given for the ranges of concentration of the three metals in the untreated and treated water samples. Variation in the metal concentrations between the seasons and possible sources of the metals in the study area are identified and explained with their likely health implication on people, animals and plants using both the untreated and treated water resources.

5.2.1 METAL CONCENTRATIONS OF Mn, Cu and Fe.

The Kano River drainage basin serves as a recipient of all sorts of effluents from agricultural, industrial and domestic sources (Bichi and Anyata, 1999). This is in accordance with the studies of Hem, (1985); Feller, (2007); Hussain et al.,(2008); Raymond et al.,(2008) which argued that the water quality of a river is influenced by many factors such as atmospheric chemistry, the underlying geology and anthropogenic activities. The concentrations of Cu, Fe and Mn within the Kano river drainage basin around the Tamburawa area were also influenced by the earlier stated factors. Throughout the study, Fe had the highest concentration in comparison with Cu and Mn. This is as a result of the underlying geology of the basin where Fe occurs as lateritic alluvial; this was also observed by Ahmed and Tanko, (1994) in a study within the basin. The concentration of Cu and Mn is compared with the findings from previous studies by Akan et al., (2007) up- stream of the Challawa River within the drainage basin. This study recorded higher concentration values than that of Akan et al., (2007), the sampling points for this study was located down- stream of the Challawa River, where it merges with the Kano River. It is believed that effluents and run-offs that were not part of the previous studies were captured by this study down- stream.

5.2.2 A COMPARISON BETWEEN RAW AND TREATED WATER

A comparison between the raw and treated water around the Tamburawa area of the Kano River drainage basin reveals that the raw water had higher concentration values than the treated water. The concentrations were further subjected to comparisons with the WHO water standards. The treatment plant effectively reduced the concentration of Cu during the dry season, because the calculated T- value was greater than the critical value. The rainy season concentration between the raw and treated water samples had no significant difference because the calculated T- value is less than the critical value. This shows that the efficiency in treatment during the rainy season is less effective than that of the dry season due to higher concentration of Cu during the rainy season as a result of run-offs and high river discharge of dissolved and particulate effluents in to the river channel as observed by Khan et al.,(1998) in a study on the Ganga river.

A comparison with the WHO standard for Cu with the raw water samples gave a significant difference in concentration, while the treated water had no significant difference as a result of reduction in concentration by the treatment plant, even though the concentrations for some months were fond to be above the WHO desirable limits. A comparison in the concentration of Fe between the raw and treated water samples revealed that during the dry and rainy seasons, there was significant difference in the concentration of Fe because the calculated T- value was greater than the critical value. This shows an efficient treatment by the plant across the seasons. When compared with the WHO standard for Fe, it gave a significant difference in concentration. This means the concentration of Fe is far above the required quantity in both the raw and treated water samples with the former having more concentration than the latter, although the treatment plant succeeded in reducing the concentration in the raw water, it is still above the WHO desirable limit.

The concentration of Mn was quite low when compared with Cu and Fe, but yet high in its own regard. Comparison between the raw and treated water gave no significant difference which indicates less effective treatment by the treatment plant. When compared with the WHO standard for Mn, there was significant difference between the concentration of Mn in the Kano River and the WHO desirable level. The treated water samples had no significant difference when compared to the WHO standard, this shows it is within the desired limit .

5.3 LIKELY SOURCES OF THE SELECTED METALS IN THE KANO RIVER AT THE TAMBURAWA AREA.

Apart from human activities within the drainage basin of the river which showed high concentrations of the selected metals, there are probably other factors responsible for the significant quantities observed in the study. Increasing exposure of the land surface as a result of widespread cultivation and overgrazing and indiscriminate removal of vegetation has consequently led to erosion and deposition of the metals. Materials containing iron fillings from metal workshops and construction sites especially from the upper catchment area of the river gets into the river through run-offs. These areas include Kura, Tiga, Tudun- Wada, Chiromawa, Kadawa and Garun Mallam towns and other surrounding smaller villages.

The Kano river drainage basin is a highly cultivated area which leads to the discharge of effluents containing pesticides, fungicides and animal wastes. Other sources that contribute the concentration of Cu in the river within the drainage basin are synthetic dyes and organic paints form the urbanized area of the drainage basin such as Panshekara and Sharada industrial estates as observed by Akan et al., (2007).

The concentration of Mn is attributed to industrial discharges from glass industries since it is used as a decolorizer and as a disinfectant, other sources could be from fertilizers and ceramics.

5.4 IMPLICATIONS OF RESULTS FOR HUMAN HEALTH

In humans it is well known that high concentration of heavy metals in food or drink can provoke serious health hazard for example, elevated copper and manganese levels in drinking water may have a neurotic potential and produce mental diseases such as Alzheimers and Manganism (Dieter et al, 2005). High levels of Mn in drinking water have also shown to affect intellectual's functions in 10 years old children in Araihzar and Bangladlesh (Wassemon et al., 2006). High levels of Cu in drinking water cause liver problems in infants (Fewtrell et al., 1996). Cu also causes astringent taste, discoloration of pipes, fittings and utensils. High levels can cause unpalatable tastes, and discoloration.

The Kano river, which is the main source of water to the new Tamburawa treatment plant which supplies about 150 million liters of water daily to the Kano populace does have the presence of and at high concentration levels of these heavy metals in the treated water supplied to the populace of Kano metropolis can have a serious health consequences on the consumers.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY

The study was carried out to identify the presence and concentration levels of some selected heavy metals. The study compared seasonal variation in metal concentrations, the concentrations between treated and raw waters and the concentrations of the metals with WHO international standards for drinking water.

Two sampling points were used as point sources for water samples collection. The first is within the river close to the water in-take pipe of the treatment plant for the raw water samples and the second is from a tap within the treatment plant for the treated water samples. The water samples were collected in clean plastic bottles (500ml) and were analyzed in the laboratory using the atomic absorption spectrophotometer to determine the concentration of the heavy metals. The results obtained from the laboratory analysis were used statistically to determine the variations in metal concentrations between the treated and untreated water, and seasons using T-test.

The results of the analysis revealed that the selected heavy metals Fe, Cu, Mn, from both the raw and treated water samples revealed significant variations throughout the duration of the study. The concentration of Cu varied significantly between the raw and treated water during the dry season, which indicates efficiency in treatment. But no significant difference was recorded in the rainy season, this show less efficiency in reducing the concentration of Cu by the treatment plant. A comparison of the results with the WHO standard showed significant difference for the raw water and no significant difference for the treated water. This indicates that concentrations for the raw water are above the WHO standard while the treated water is within limit. Significant difference was observed in the concentration of Fe between the treated and raw water samples during the dry and rainy seasons which also varied significantly with the WHO standard for both treated and raw water. The treatment plant succeeded in reducing the concentration of Fe in the water samples but was still found to be below international standards. In the case of Mn there was no difference between treated and raw water across the seasons, indicating less efficiency in treatment across the seasons. And when compared with the WHO standard, significant difference was observed in the raw water but not for the treated water, this show that the raw water samples are above the WHO standard, but the treated water samples are within the limits. Both Fe and Cu show no seasonal variations in concentration between dry and rainy seasons, but the concentration of Mn was significantly different across the seasons.

6.2 RECOMMENDATIONS

According to Kuhner et al; (1997) it is more economical to maintain the quality of water through source protection. In the Kano River drainage basin, the nature of pollutants generation and the attitude of residents within the drainage basin to sanitary, environmental ethics especially agricultural practices, are not very encouraging. In view of the importance of the drainage basin, it is required that specific recommendations are made to handle the problems.

1. Proper orientation should be given to rural farmers on the effect of chemical inputs on surface water and possible alternatives given.
2. The local authorities should provide waste management disposal systems that would take care of waste and refuse dumps within the basin.

3. Proper monitory of effluents discharge by industries and effluent receiving water by the concerned authorities.
4. There should be proper orientation and re-orientation of all communities within the basin on the impacts of indiscriminate waste discharge on water quality, health and environment.
5. The water treatment plants should be well equipped with state of the art facilities that will ensure proper removal of pollutants from the raw water especially the heavy metals so as to keep it within WHO safe drinking water standards.

The above recommendations are vital parts of policy formulation and enforcement and watershed management. If these are carried out the surface water quality in the kano river basin would have a more ensured quality.

6.5 CONCLUSION

The study has shown that Cu, Fe and Mn do have high concentrations in the raw water due to increasing human activities and contemporary uses within the basin. This study has also revealed that the raw water is better treated during the dry season than the rainy season. Even though the treatment plant reduces the concentration of these metals, they are still not always within the desirable limits of the WHO standards for drinking water. Therefore continuous accumulation over time by consumers could result in serious health complications.

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Appendix A: Student's T-Tables

Degrees of freedom	Rejection level of probabilities				
	P =0.1	P=0.05	P=0.02	P=0.01	P=0.001
1	6.31	12.71	31.82	63.66	636.62
2	2.92	4.30	6.97	9.93	31.60
3	2.35	3.18	4.54	5.84	12.94
4	2.13	2.78	3.75	4.60	8.61
5	2.02	2.57	3.37	4.03	6.86
6	1.94	2.45	3.14	3.71	5.96
7	1.90	2.37	3.00	3.50	5.41
8	1.86	2.31	2.90	3.36	5.04
9	1.83	2.26	2.82	3.25	4.78
10	1.81	2.23	2.76	3.17	4.59
11	1.80	2.20	2.72	3.11	4.44
12	1.78	2.18	2.68	3.06	4.32
13	1.77	2.16	2.65	3.01	4.22
14	1.76	2.15	2.62	2.98	4.14
15	1.75	2.13	2.60	2.95	4.07
16	1.75	2.12	2.58	2.92	4.02
17	1.74	2.11	2.57	2.90	3.97
18	1.73	2.10	2.55	2.88	3.92
19	1.73	2.09	2.54	2.86	3.88
20	1.73	2.09	2.53	2.85	3.85
21	1.72	2.08	2.52	2.83	3.82
22	1.72	2.07	2.51	2.82	3.79
23	1.71	2.07	2.50	2.81	3.77
24	1.71	2.06	2.49	2.80	3.75
25	1.71	2.06	2.49	2.79	3.73
26	1.71	2.06	2.48	2.78	3.71
27	1.70	2.05	2.47	2.77	3.69
28	1.70	2.05	2.47	2.76	3.67
29	1.70	2.05	2.46	2.76	3.66
30	1.70	2.04	2.46	2.75	3.65
40	1.68	2.02	2.42	2.70	3.55
60	1.67	2.00	2.39	2.66	3.46

APPENDIX B: T- test ANALYSIS

One-Sample Test

	N	Mean	Std Deviation	Std Error Mean
Mn	16	0.30244	0.409593	0.102398

One-Sample Test

	Test value = 0.05					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Mn	2.465	15	0.409593	0.252438	0.03418	0.47069

One-Sample Test

	N	Mean	Std Deviation	Std Error Mean
Cu	16	0.68656	0.684103	0.171026

One-Sample Test

	Test value = 0.05					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Cu	3.722	15	0.002	0.636563	0.27203	1.00110

One-Sample Test Statistics

	N	Mean	Std Deviation	Std Error Mean
Fe	16	1.73225	1.051597	0.262899

One-Sample Test

	Test value = 0.1					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fe	6.209	15	0.000	1.632250	1.07189	2.19261

One-Sample Test Statistics[a]

	N	Mean	Std Deviation	Std Error Mean
Mn	8	0.6050	0.107370	0.037961
Cu	8	0.55663	0.403643	0.142709

One-Sample Test[a]

	Test value = 0.1					
	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Mn	0.277	7	0.790	0.10500	-0.07926	0.10026
Cu	3.550	7	0.009	0.506625	0.16917	0.84408

One-Sample Test Statistics[a]

	N	Mean	Std Deviation	Std Error Mean
Mn	8	0.54438	0.462795	0.163623
Cu	8	0.81650	0.895171	0.316491

One-Sample Test[a]

	Test value = 0.1					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Mn	3.021	7	0.019	0.494375	0.10747	0.88128
Cu	2.422	7	0.046	0.766500	0.01812	1.51488

One-Sample Test

	N	Mean	Std Deviation	Std Error Mean
Fe	8	1.57188	1.041410	0.368194

One-Sample Test[a]

	Test value = 0.05					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fe	3.998	7	0.005	1.471875	0.60123	2.34252

One-Sample Test Statistics[a]

	N	Mean	Std Deviation	Std Error Mean
Fe	8	1.89263	1.107416	0.391531

One-Sample Test[a]

	Test value = 0.05					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fe	4.579	7	0.003	1.792625	0.86680	2.71845

One-Sample Test Statistics[a]

	N	Mean	Std Deviation	Std Error Mean
Mn	8	0.47750	0.503693	0.178082
Cu	8	1.08075	0.724862	0.256277

a. Treated = Raw

One-Sample Test[a]

	Test value = 0.05					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Mn	2.401	7	0.047	0.427500	0.0640	0.84860
Cu	4.022	7	0.005	1.030750	0.42475	1.63675

a. Treated = Raw

One-Sample Test Statistics[a]

	N	Mean	Std Deviation	Std Error Mean
Mn	8	0.12738	0.189058	0.66842
Cu	8	2.29238	0.349663	0.123625

a. Treated = Raw

One-Sample Test[a]

	Test value = 0.05					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Mn	1.158	7	0.285	0.077375	-0.8068	0.23543
Cu	1.961	7	0.091	0.242375	-0.4995	0.53470

a. Treated = Raw

One-Sample Test Statistics[a]

	N	Mean	Std Deviation	Std Error Mean
Fe	8	2.64563	0.342652	1.121146

a. Treated = Untreated

One-Sample Test[a]

	Test value = 0.1					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fe	21.013	7	0.000	2.545625	2.25916	2.83209

a. Treated = Raw

One-Sample Test Statistics[a]

	N	Mean	Std Deviation	Std Error Mean
Fe	8	0.8188	0.587723	0.207791

a. Treated = Raw

One-Sample Test[a]

	Test value = 0.1					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fe	3.460	7	0.011	0.718875	0.22753	1.21022

a. Treated = Raw