THE EFFECT OF IRRIGATION FARMING ON GROUNDWATER QUALITY: A CASE STUDY OF JIBIA IRRIGATION SITE, KATSINA STATE NIGERIA

BY

Abba Abdullahi ABUKUR
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DECLARATION

I declare that the work in this dissertation entitled **"The Effect of Irrigation Farmingon Groundwater Quality: A Case Study ofJibiaIrrigation Site, Kastina State Nigeria"**has been carried out by me in the Department of Geography and Environmental Management.The information derived from the literature has been duly acknowledged in the text and list of references provided. No part of this dissertation was previously presented for another degree or diploma at any other Institution.

Abba Abdullahi ABUKUR	_____	_____
Student	**Signature**	**Date**

CERTIFICATION

This dissertation entitled **"THE EFFECT OF IRRIGATION FARMING ON GROUNDWATER QUALITY: A CASE STUDY OF IN JIBIA IRRIGATION SITE"** by Abba Abdullahi ABUKURmeets the regulations governing the award of the degree of Masters in Geography of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Dr. Yusuf Y. Obadaki Chairman, Supervisory Committee	_____ (Signature)	_____ Date
Dr. B. Abdulkarim Member, Supervisory Committee	_____ (Signature)	_____ Date
Dr. A.K. Usman Head of Department, Geography and Environmental Management	_____ (Signature)	_____ Date
Prof. S.Z. Abubakar Dean, School of Postgraduate Studies	_____ (Signature)	_____ Date

DEDICATION

This dissertation is dedicated to Allah (S.W.T) for His mercy and support always. Alhamdulillah!

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ABSTRACT

Groundwater quality has become an important water resources issue due to rapid increase in population, rapid industrialization, unplanned urbanization and increasing use of fertilizers and pesticides in farming. This study examines the effect of irrigation farming on groundwater quality in Jibia Local Government Area, Katsina State. Fourresearch questions and objectives as well as two null hypotheses were formulated to guide the study. The objectives were todetermine the physico-chemical properties of groundwater in the study area, examine the effect of distance from irrigation site to groundwater quality in the area, find out the effect of seasons on the physico-chemical properties of the groundwater and compare the groundwaterquality in the area with WHO/NSDWQstandards .Borehole and well water samples were taken from a distance ranging from less than 10m to a distance of greater than 150m away from the irrigation site. Seven (7) deep and two (2) shallow wells identified within the 0 to less than 10m range while twenty-four (24)boreholes and four (4) shallow wells were from above the marked ranged of 10-150m of which 6 water samples (4 boreholes and 2 shallow wells) from less than 10m to a distance of greater than 10m each were collected for laboratory analysis.Water samples collected from the wells were subjected to laboratory test using standard procedures to determine the physico-chemical properties which were presented in tables showing their means and standard deviations. t-test was used to test for differences between groundwater quality of wells close to and far away from irrigation site as well as difference between compare the physico-chemical properties of groundwater in the study area with the WHO (2011)/NSDWQ (2007) standard for domestic water qualityat 0.05 alpha level of significance. Findings from the study amongst others revealed that distance does not have any significant effect on the concentrations of measured physico-chemical properties of water in the study area as

there was no significant difference between wells close to or far away from the irrigation site in all the physico-chemical properties of water in the study area except Chromium with a p-value of 0.00 less than the 0.05 level of significance.Also, there is no significant difference in almost all the physico-chemical properties of water from wells in the study area when compared to WHO (2011)/NSDWQ(2007) standards except for Calcium and Zinc which shows a significant value with p-values of 0.01 and 0.02 which are less than the 0.05 level of significance respectively.Although the result generally indicates that groundwater quality status is good for human consumption and may not pose health risk to the people,it was recommended amongst others that there is the need for continuous monitoring of groundwater to determine its quality status. This will serve as a guide to the public and water managers on action plans to be taken once the physico-chemical properties are found to exceed the permissible values given by the WHO and NSDWQ standards.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Water is the origin of life and safe drinking water is a basic human right essential to all (Versari, Parpinello and Galassi, 2002). Among the main sources of water available to the people in general is groundwater. The major source of groundwater is precipitation that infiltrates the ground and moves through the soil and pore spaces of rocks (Adetunde, Glover and Oguntola, 2011). According to Bhalerao and Tawde (2012), the flow of water underground and the pollutants that it may contain is very slow as compared with flow on land surface. As a result of this, it may take considerable time for the contaminants to move away from the source of pollution, and their occurrence in the groundwater may remain undetected for many years. Groundwater is an important water resource in both the urban and rural areas of Nigeria as it constitutes the major source of domestic water need in rural Nigeria.

Groundwater refers to all the water occupying the voids, pores and fissures within geological formations below the groundwater table. It orgininates from atmospheric precipitation either directly by rainfall infiltration or indirectly from rivers, lakes or canals (Ojo, Otieno and Ochieng, 2012). Groundwater is a valued fresh water resource and constitutes about two-third of the fresh water reserves of the world (Chilton, 1992). Buchanan (1983) also estimated that the groundwater reservoir of the world at about 5.0×10^{24} L, this volume is more than 2,000 times the volume of waters in all the world's rivers and more than 30 times the volume contained in all the world's fresh water lakes. Groundwater is abstracted through hand-dug wells, hand-pump operated shallow-wells and submersible pump operated deep well or boreholes (Ojo, 2012). Groundwater is often

high in mineral content such as magnesium and calcium salts, iron and manganese depending on the chemical composition of the stratum through which the rock flows (Todd, 1980).

Groundwater quality has become an important water resources issue due to rapid increase of population, rapid industrialization, unplanned urbanization and too much use of fertilizers and pesticides in agriculture (Joarder, Raihan, Alam and Hasanuzzaman, 2008). Similarly, Punmia and Jain (1998) posited that these resources are under threat from pollution either from human life style manifested by the low level of hygiene practiced in the developing nations. Groundwater pollution is one of the worrisome and widespread environmental problems in irrigated agricultural regions (Galloway, 2008). Inappropriate management of groundwater promotes the rapid deterioration of water quality, exposing human and animal communities to health and survival risks (Liu, Sun, Ji and Simunek, 2013). Due to the increase of anthropogenic nitrogen inputs at many watersheds (Vassiljev, Grimvall and Larsson, 2004), NO_3^- contamination constitutes an increasing problem in shallow groundwater systems underneath agricultural areas (Arumi, Oyarzun and Sandoval, 2005).

Agriculture is one of the major consumers of groundwater. Irrigation uses more than two-thirds of water of the available world's freshwater resources, producing 35% of the world's arable land. In all, agriculture uses 90% of all the freshwater (Shady, 1998). Irrigation farming depends on adequate water supplies of usable quality (Akinyemi and Souley, 2014). The assessment of groundwater quality status is important for socio-economic growth and development (Ishaku, 2011). Evaluation of water quality for human consumption, agricultural and industrial activities have not been given attention especially in developing countries like Nigeria. The chemical composition of water is an

important factor to be considered before it is used for domestic or irrigation purpose (Suresh, Naganna and Srinivas, 1991). Water may be rendered unfit for human consumption, and thus may lead to health problems. Olasumbo (2001) stated that farming has the largest water quality impact of any water use.

Nigeria is blessed with large quantity of groundwater resources. For instance, Olasumbo (2001) estimated the amount of groundwater resource in Nigeria to be 106×10^9 m^3 whichis distributed thus; southern zone (40%), central zone (43%) and the northern zone (17%). Irrigated farming development continues to increase in attempt to meet the nation's food growing demand which depends on groundwater resources. Groundwater beneath irrigated cropland is characterized by significantly higher concentration of hardness, alkalinity, calcium, magnesium, potassium, fluoride and nitrate then in water beneath undeveloped rangeland (Helgesen, Stullken and Rutledge, 1992). Similarly, Musa and Ahanonu (2013) posited that the application of various agrochemicals and fertilizers for improved and increased agricultural produce can release contaminants of various categories such as nitrate, bacteria, viruses, and hazardous household chemicals to the subsurface, posing potential threats to nearby wells and surface water. However, Jibia dam is usedfor domestic water supply to Jibia town and its neighbouring villages. Water is stored in the reservoir which has a capacity of 142 million cubic meters. A 105m intake tunnel passes through the body of the dam, and carries stored water from the reservoir to the irrigation and water supply plants and the river regulation outlet (Katsina, 2003). The irrigation activities of farmers pose a serious threat the water quality of the them because of the incessant use of fertilizer and pesticides for irrigation farming during the dry season.

1.2 STATEMENT OF THE RESEARCH PROBLEM

In the last few decades, there has been a tremendous increase in demand for fresh water due to rapid growth of population and the accelerated pace of industrialization (Tiwari and Nayak, 2002). Water in its natural state is free from pollution, but when man tampers with water bodies, it loses its natural conditions (Asadi, 2007) with groundwater inclusive. The importance of groundwater quality in human health has recently attracted a great deal of interest (Vasanthavisar, Srnivasamoorthy, Rajiv, Vijayaraghavan and Sarma, 2010). According to United Nations Educational, Scientific and Cultural Organization (UNESCO)(2006), 80% of all diseases in the developing world are directly related to poor drinking water.

Zhang, Tian, Zhang and Li(1996), reported that over half of 69 groundwater samples collected in north China exceed the NO_3^- standard for drinking water, and the highest NO_3^- concentration is 300mg/L in some intensive vegetable-producing areas, indicating a serious situation of NO_3^- pollution in groundwater. The N^- or NO_3^- aspects of groundwater contamination caused by agricultural activities in the North China Plain (NCP) has been reported by Chen, Tang, Sakura, Kondoh and Slen (2002), Tang, Chen and Shen (2003), and Ju, Kou, Zhang and Christie(2005). Even in the region where the groundwater table is deep, NO_3^- pollution of groundwater has been detected (Tang *et al*., 2003).

Shen, Lei, Yang and Kanae (2011) studied the effect of agricultural activities on nitrate contamination of groundwater in a Yellow River irrigated region. The vertical profiles of NO_3^- concentration of groundwater before and after irrigation was conducted which indicated how NO_3^- leaching associated with irrigation affects groundwater quality. The NO_3^- concentration changes significantly with agricultural activities between the two

growing seasons. Before irrigation, NO_3^- concentrations are less than 20mg/L, and irrigation accompanied with fertilizer application causes NO_3^- concentrations in the upper layers to reach 65mg/L. Fertilizer application caused a large increase in the NO_3^- loading to groundwater and the two peaks of nitrate NO_3^- in June and September reached the allowable limit for drinking water. This implies that much N^- fertilizer was not used by the crops and leached into the groundwater via infiltration/percolation causing long-term groundwater contamination. It further revealed that 4 of 27 water samples had NO_3^- concentrations that exceeded the allowable limits for drinking water, and the highest NO_3^- concentration was 100mg/L. Most samples were collected from domestic wells in vegetable producing areas, except for one sample collected from a sewage channel.

Amori, Oduntan, Okeyode and Ojo (2013), studied heavy metal concentration of groundwater in bore holes and hand dug wells. The study revealed that the values of zinc for the boreholes ranged from 0.50mg/L to 0.88mg/L while for hand dug wells ranged from 1.49mg/L to 1.97mg/L which was far above the desirable limit of 1.0mg/L but still within the maximum permissible limit of 3.0mg/L. The highest value recorded for zinc was attributed to the low depth of the wells, hence pollution due to persistent leaching along the top layers of the soil. The high occurrence of zinc in the sampled water implies that the water is not safe for human consumption particularly drinking and cooking. Nickel was particularly prevalent in water samples obtained from hand-dug wells as the values ranged between 0.17 and 0.99 while that of boreholes range from 0.17 to 0.86. The high occurrence of nickel in the water samples makes them unsuitable for drinking as most of values exceed the limit of 0.01 set by the WHO.

Arabi, Funtua, Alagbe, Zabosrki and Dewu (2010) investigated groundwater quality for domestic and irrigationpurposes around Gubrunde and environs. Fourteen groundwater

samples were collected and analyzed using Atomic Absorption Spectrometer (AAS), multi-analyte photometer and Flame photometer. The result revealed that Sodium Adsorption Ratio (SAR) values recorded ranges from 0.80-2.84, Exchangeable Sodium Ratio (ESR) 0.33-1.78, Magnesium hazard (MH) 5.19-47.9, Residual Sodium Carbonate (RSC) 0.00, Hardness 0.65-221.48 and Total Dissolved Solid (TDS) ranges from 130-407308mg/l. It also shows that 12 of the samples analyzed had medium Salinity Hazard (SH) and one each for high and low Salinity Hazard (SH), respectively. The authors further attributed the variation in chemical composition of groundwater in the study area to leaching of terrestrial salts, extensive use of chemical fertilizers and ion exchange between water and the host rock.

The review of existing literature shows that most studies conducted were limited to assessment of groundwater quality for irrigation purposes and not on the effect of irrigation farming on groundwater quality over time. The recent rapid growth of population in Jibia Local Government Area(LGA) as experienced in other towns in developing countries has created demand pressure on domestic water supply. The problem of domestic water supply is not restricted to quantity but to poor quality of water resources especially groundwater sources in the study area. Irrigation farming in Jibia has its benefits as well as its negative impacts on groundwater. As a result of irrigation farming, farmers make use of chemicals such as pesticides as well as fertilizers in order to grow their crops. The use of chemicals is not a challenge in itself, but the excessive use of these chemicals poses serious threats to human beings that make use of these chemicals for domestic functions as a result chemical elements found in excess could pose a serious health implication on the populace around the irrigation site. It is against this background that this study intends to fill the knowledge gap by examining the irrigation farming

practices and groundwaterquality in the study area. The study addressed the following question;

1. What are the physico-chemical properties of groundwater in Jibia irrigation site?
2. What is the effect of distance from irrigation site on groundwater quality?
3. What is the effect of seasonal variation on the physico-chemical properties of groundwater?
4. Are there significant differences between groundwater quality in the study area and WHO (2011) /NSDWQ (2007) standard?

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of this study is to examine the effect of irrigation farming on groundwater quality in Jibia LGA, Katsina State. The specific objectives are to:

i. determine the physico-chemical properties of groundwater in the study area;
ii. examine the effect of distance from irrigation site ongroundwaterquality in the area;
iii. examine the effect of seasonal variation on the physico-chemical properties of groundwater; and
iv. compare the groundwaterquality with WHO (2011) /NSDWQ (2007) standards.

1.4 RESEARCH HYPOTHESES

H_O1: There is no significant difference between groundwater quality of wells close to and far away from the irrigation site.

H_O2: There is no significant difference between the physico-chemical properties of groundwater in the study area and WHO/NSDWQ standard for domestic water quality.

1.5 SCOPE OF THE STUDY

The spatial scope of this study covered the some physico-chemical properties of groundwater (pH, Total Dissolved Solid (TDS), chromium, lead, calcium and zinc). The temporal scope was limited to the farming and off-farming season in year 2015 for the collection of water samples.

1.6 JUSTIFICATION FOR THE STUDY

According to World Health Organization [WHO](2003), the total domestic water demand by man is estimated as 250 litres per capita per day. The possibility of life existing in any particular place depends on the presence or accessibility to water. Hoevel (2008) stated that only 3% of the total amount of water on earth is fresh water used to sustain humans. However, the rapid growing world population is contributing to the deterioration of the available fresh water quality and is creating significant challenges for water managers, fishes and even the wildlife (Thomas, 2005).

Water as an important basic necessity of life with a multi-dimensional effect on quality of life, sanitation and hygiene and level of poverty in towns (Nnodu, 2008). In fact in September 2000, 189 United Nations member States adopted the Sustainable Development Goals (SDGs), as a measurement of people's quality of living. Although MDG 7 aims at reducing the proportion of people without access to safe drinking water and sanitation to half by 2015, for people in rural areas is far from reality. This is because their needs are not given priority in decisions on domestic water supply, provision, use, technology and management. Also, one cannot attest to the quality of water provided in some towns like Jibia because even at the national level, issues of water resources are not standardized or supervised by existing institutions (Federal and State). The above have

resulted to most of the residents being exposed to health hazards which are water related like typhoid fever, cholera and diarrhea.

Moreover, Olasumbo (2001) posited that the unsustainable use of groundwater reserves constitutes an important problem, mostly in drier areas of Nigeria where hardly any water is renewed and old or fossil groundwater often forms the only reliable water resource. Jibia LGA, the study area,faces the threat of groundwater depletion like the other north-eastern and north-western parts of the country. Other researchers have worked on other elements but this study was limited to six elements namely pH, Total Dissolved Solid (TDS), chromium, lead, calcium and zinc. The choice of these elements was prompted by the excessive application of fertilizers and pesticides during the dry season irrigation.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents general concepts relating to groundwater quality impacts with respect to irrigation farming. The conceptual issues highlighted the basic concept of groundwater, its physico-chemical quality and contamination as well as effect of contamination. Reviewed also were relevant literature concerning groundwater quality status in Nigeria and its physicochemical parameters.

2.2 CONCEPTUAL FRAMEWORK

2.2.1 Basic Concept of Groundwater

Groundwater is a form of water held under the ground in the saturated zone that fills all the pore space of soils and geologic formations. It is formed by rainwater or snowmelt water that seeps down through the soil and into the underlying rocks (Banks and Robins, 2002). It is the major resource of water supply for about half of the nations. It plays a key role in nature. It provides more than half of humanity's freshwater for everyday uses such as drinking, cooking, and hygiene, as well as thirty percent of irrigated farming and industrial development (Zuppi, 2007).

Kresic (2007) defined groundwater to be water found below the water table and usually fills all void spaces in the saturated zone of rocks. It is the most widely distributed resource of the Earth and forms an invisible component of the natural water resources. Groundwater occurrence within the Earth is influenced by the lithology of geological materials, structure of the regional geology, recharge sources availability and geomorphology of landforms (Hiscock, 2005). Groundwater plays a major role in the global system and water movement known as the hydrologic cycle.

Thomas (2003) enunciated groundwater as a component of the hydrologic cycle, which describes locations where water may occur and the processes by which it moves or is transformed to a different phase. In simple terms, water or one of its forms; water vapour and ice can be found at the earth's surface, in the atmosphere, or beneath the earth's surface. Thomas viewed hydrologic cycle is a continuum, with no beginning or end; however, it is often thought of as beginning in the oceans. Water evaporates from a surface water source such as an ocean, lake, or through transpiration from plants. The water vapor may move over the land and condense to form clouds, allowing the water to return to the earth's surface as precipitation (rain or snow). Some of the snow will end up in polar ice caps or in glaciers. Most of the rain and snowmelt will either become overland flow in channels or will infiltrate into the subsurface. Some of the infiltrated water will be transpired by plants and returned to the atmosphere, while some will cling to particles surrounding the pore spaces in the subsurface, remaining in the vadose (unsaturated) zone. The rest of the infiltrated water will move gradually under the influence of gravity into the saturated zone of the subsurface, becoming groundwater. From here, groundwater will flow toward points of discharge such as rivers, lakes, or the ocean to begin the cycle anew. This flow from recharge areas to discharge areas describes the groundwater portion of the hydrologic cycle (Thomas, 2003).

As deliberated by Stephen and Tushaar (2012), groundwater is water that fills pores and fractures in the ground. The top of groundwateris called the water table. Between the water table and the land surface is the unsaturated zone or vadose zone. In the unsaturated zone, moisture is moving down-ward to the water table to recharge the groundwater. The water table can be very close to the surface (within a few feet), or very deep (up to several hundred feet).

Thomas (2003) defined groundwater basin as an alluvial aquifer or a stacked series of alluvial aquifers with reasonably well-defined boundaries in a lateral direction and a definable bottom. Thomas (2003) perceived lateral boundaries as features that significantly impede groundwater flow such as rock or sediments with very low permeability or a geologic structure such as a fault. Bottom boundaries would include rock or sediments of very low permeability if no aquifers occur below those sediments within the basin. In some cases, the base of fresh water according to Thomas' perspective is considered the bottom of the groundwater basin, while a geologic formation from which significant amounts of groundwater can be pumped for domestic, municipal, or agricultural uses is known as an aquifer. In some cases, aquifers are vertically separated from each other by geologic formations that permit little or no water to flow in or out. A formation that acts as such a water barrier is called aquitard if it is much less permeable than a nearby aquifer but still permits flow (e.g., sandy clay). If the water barrier is almost impermeable (e.g., clay) and forms a formidable flow barrier between aquifers, it is known as an aquiclude (Thomas, 2003).

According to Vandas, Winterand Battaglin (2002), surface water and groundwater systems are connected in most landscapes. Streams interact with groundwater in three basic ways: streams gain water from outflow of groundwater through the streambed, streams lose water by inflow through the streambed, or they do both depending upon the stream order. It is the groundwater contribution that keeps streams flowing during the dry season. For a stream to gain water, the elevation of the water table in the vicinity of the stream must be higher than the streamwater surface. For a stream to lose water to groundwater, the water table must be below the elevation of the stream-water surface in the vicinity of the stream. If the water table has large variations during the year, a stream

segment could receive water from groundwater for a portion of the year and lose water to groundwater at other times. Surface-water bodies such as lakes and wetlands can receive groundwater inflow, recharge groundwater, or do both. The movement of water between groundwater and surface-water systems leads to the mixing of their water qualities. High quantities of nutrients or other dissolved chemicals in surface water can be transferred to the connected groundwater system.

2.2.2 Physico-chemical Quality of Groundwater

The chemical, physical and bacterial characteristics of groundwater determine its usefulness for various purposes. Chemical analysis of groundwater includes the determination of the concentrations of inorganic constituent. The analysis also includes measurement of pH and specific electrical conductance. Temperature, colour, turbidity, odour and taste are evaluated in a physical analysis. Bacteria analysis generally consists of tests to detect the presence of coli form organisms (Stephen and Tushaar, 2012). The term physicochemical quality is used in reference to the characteristics of water which may affect its acceptability due to aesthetic considerations such as colour and taste; produce toxicity reactions, unexpected physiological responses of laxative effect, and objectionable effect during normal use such as curdy precipitates (WHO, 1984).

2.2.2.1 Taste and Odour

Taste and odour depend on the stimulation of the human receptor cells, which are located in the taste-buds for taste and nasal cavity for odour (WHO, 1984). Taste and odour are complimentary, for example when tasting water; both the olfactory and gustatory nerves are active. In all taste it is actually flavour that is being measured flavour refers to the combination of taste, odour, temperature and feel. The close association between taste and odourmay be illustrated by the lack of flavour of many food substances, when the

sense of smell is lost during a head cold (Emslie-Smith, 1988 in Ojo, Otieno and Ochieng, 2012).

2.2.2.2 Temperature and pH

However, the growth rate of microorganisms, some of which produce bad tasting metabolites is positively associated with temperature. The odour of substance is also temperature influenced because of relationship between odour and vapour pressure, therefore odour measurement usually specifies temperature. On the other hand, pH influences the taste and odour of a substance significantly, especially when it controls the equilibrium concentration of the neutral and ionized forms of a substance in solution. The average threshold increases from 0.075 to 0.450 mg/l as the pH increases from 5.0 to9.0 (WHO, 1984).A balance is sought such that the level of residual chlorine is high enough for microbial safety without leaving an objectionable taste in drinking water(Thomas, 2005).

2.2.2.3 Total Dissolved Solids (TDS) and turbidity

Moreover, TDS comprise of organic matter and inorganic salts, which may originate from sources such as sewage, effluent discharge, and urban run-off or from natural bicarbonates, chlorides, sulphate, nitrate, sodium, potassium, calcium and magnesium. The major determinant of the TDS level in water is the geochemical characteristics of the ground it comes in contact with (Ishaku, Ahmed and Abubakar, 2011). TDS is related to other water quality parameters like hardness, which may occur if the high TDS content is due to the presence of carbonates. Similarly, turbidity is an expression of certain light scattering and light absorbing properties of the water caused by the presence of clay, silt, suspended matter, colloidal particles, plankton and other microorganisms (WHO, 1984). Turbidity can be measured byturbidity and nephelometry. Turbidity of water affects other water quality parameters such as colour, when it is imparted by colloidal particles. It also

promotes the microbial proliferation, thus affecting negatively the microbiological quality of water. It also affects the chemical quality of drinking water through the formation of complexes between the turbidity causing humic matter and heavy metals (WHO, 1984).

2.2.2.4 Colour and Dissolved Oxygen

Colour in groundwater is caused by the presences of coloured organic substances, usually humic, which originate from the decay of vegetation in surface water. Iron and manganese also give water a red and blue colour respectively by the action of bacteria, which oxidize them to their ferric and manganic oxides respectively. Colour is measured by visual comparison of the sample with platinum cobalt standards where one unit of colour is that produce by 1 mg/l platinum of chloraplatinate ion (WHO, 1984). Likewise, the level of dissolved oxygen in water is used as an indication of pollution and its portability. Thus forms a key test in water pollution control activities and waste treatment process control activities and waste treatment process control (Thomas, 2005).

2.2.2.5 Hardness

Hardness is simply the resistance of water informing lather with soap. Hard water thus requires a considerable amount of soap to produce lather. The principal ions causing hardness are calcium and magnesium. When the anion is carbonate, it is referred to as temporary hardness, since it can be removed by boiling, unlike when the anions are sulfates, chlorides and nitrates. According to Bhalerao and Tawde (2012), groundwater is often harder than surface water and may have levels up to several thousand mg/l because of it high solubilizing potentials, particularly for rocks containing gypsum, calcite and dolomite. Source of hardness include sewage and run-off from soils particularly limestone formations, building materials containing calcium oxide and textile and paper materials containing magnesium (Emslie-smith, 1988in Ojo, Otieno and Ochieng, 2012).

2.2.2.6 Alkalinity and Chloride

Alkalinity is an index of the buffering capacity of water produced anions of weak acids, like hydroxides, bicarbonates and carbonates. An increase in alkalinity causes a loss of colour, which is directly proportional to the alkalinity of the water sample and is usually close to its hardness value. Chloride in contrast, occurs in groundwater as a result of saline intrusion, brine in oil well operations, sewage discharge, irrigation water being drained, and contamination from refuse leachate (Thomas, 2005).

2.2.2.7 Other Toxic Chemicals

Nitrates and nitrites are considered together because conversion from one form to the other occurs in the environment and the health effect of nitrates are generally as a consequence of its ready conversion to nitrites in the body. Nitrite levels can be reduced doing water treatment by the oxidizing effect of chlorine. Moreover, Thomas (2005) sees lead as a natural constituent of the earth crust at an average concentration of about 16 mg/kg. Lead levels in drinking water are relatively low, because convectional water treatment procedures remove a significant amount of lead. Low pH and softness increases lead content of water by promotion corrosion.

Similarly, Iron is the most abundant element by weight in the crust, it occurs in water in its ferric and ferrous states, particularly in well-aerated conditions. Rock and mineral dissolution acid mine drainage, land fill leachates, sewage and iron related industries are causes of high iron levels in groundwater, lakes and reservoirs, particularly where reducing conditions are present (Okun,1983).Additional toxic chemicals include Ammonia in non-ionized form (NH_3) and ionized form (NH_4+); arsenic, asbestos, barium, boron, cadmium, chromium, copper and aluminum. Others include fluoride, mercury and organic contaminants (Thomas, 2005).

2.2.3 Groundwater Contamination

Stephen and Tushaar(2012) carried out a study on groundwater contamination in a Global Water Partnership (GWP) Perspectives vision. According to their submission, all water contains dissolved constituents. Even rainwater, often described as being naturally pure, contains measurable dissolved minerals and gases. As it moves through the hydrologic cycle, water dissolves and incorporates many constituents. The point at which a given constituent is considered a contaminant varies depending on the intended use of the groundwater and the toxicity level of the constituents.

Any place where surface water makes its way into groundwater, organic chemicals and pathogens potentially can enter (Winter, Harvey, Franke, and Alley, 1998). Inorganic chemicals that occur naturally in soils, sediments and rocks – for example, dissolved mineral matter can also degrade the quality of groundwater. Even though groundwater may be plentiful in a particular area, if the quality of the groundwater has been degraded by the entry of contaminants, the aquifer may not be usable as a water supply (Winter *et al*., 1998).

According to Harter (2003),human activities can alter the natural composition of groundwater through the disposal or dissemination of chemicals and microbial matter at the land surface and into the soil or through the injection of wastes directly into the groundwater. Groundwater contamination is nearly always the result of human activity. In areas where population density is high and human use of the land is intensive, groundwater is especially vulnerable. Virtually any activity whereby chemicals or wastes may be released to the environment, either intentionally or accidentally, has the potential to pollute groundwater. When it becomes contaminated, it is difficult and expensive to clean up. The deleterious effect include harm to human health, hindrance to aquatic

activities and the inability of the water to support farming, industrial and other related economic activities (Harter, 2003).

Groundwater contamination according to Stephen and Tushaar (2012) depends on its physical, chemical, and biological properties, a contaminant that has been released into the environment may move within an aquifer in the same manner that groundwater moves. It is possible to predict, to some degree, the transport within an aquifer of those substances that move along with groundwater flow. For example, both water and certain contaminants flow in the direction of the topography from recharge areas to discharge areas. Soils that are porous and permeable tend to transmit water and certain types of contaminants with relative ease to an aquifer below. Just as groundwater generally moves slowly, so do contaminants. Because of this slow movement, contaminants tend to remain concentrated in the form of a plume that flows along the same path as the groundwater. The size and speed of the plume depend on the amount and type of contaminant, its solubility and density, and the velocity of the surrounding groundwater (Stephen and Tushaar, 2012).

Groundwater and contaminants can move rapidly through fractures in rocks. Fractured rock presents a unique problem in locating and controlling contaminants because the fractures are generally randomly spaced and do not follow the contours of the land surface or the hydraulic gradient. Contaminants can also move into the groundwater system through macro-pores root systems, animal burrows, abandoned wells, and other systems of holes and cracks that supply pathways for contaminants (Velauthamurty, 2016).

Stephen and Tushaar(2012) concluded that, generally, the greater the distance between a source of contamination and a groundwater source, the more likely that natural processes

will reduce the impacts of contamination. Processes such as oxidation, biological degradation (which sometimes renders contaminants less toxic), and adsorption (binding of materials to soil particles) may take place in the soil layers of the unsaturated zone and reduce the concentration of a contaminant before it reaches groundwater. Even contaminants that reach groundwater directly, without passing through the unsaturated zone, can become less concentrated by dilution (mixing) with the groundwater. However, because groundwater usually moves slowly, contaminants generally undergo less dilution than when in surface water.

2.2.3.1 Effect of Groundwater Contamination

According to the United States Environmental Protection Agency [USEPA](2009) contamination of groundwatercan result in poor drinking water quality, loss of water supply, degraded surface water systems, high cleanup costs, and high costs for alternative water supplies, and/or potential health problems. The consequences of contaminated groundwateror degraded surface water are often serious. For example, estuaries that have been impacted by high nitrogen from groundwater sources have lost critical shellfish habitats. In terms of water supply, in some instances, groundwatercontamination is so severe that the water supply must be abandoned as a source of drinking water.

Stephen and Tushaar(2012) added that, a number of microorganisms and thousands of synthetic chemicals have the potential to contaminate groundwater. Drinking water containing bacteria and viruses can result in illnesses such ashepatitis, cholera, or giardiasis. Methemoglobinemiaor “blue baby syndrome,” an illness affecting infants, can be caused by drinking water that is high in nitrates. The serious health effect of lead are well known-learning disabilities in children; nerve, kidney, and liver problems; and pregnancy risks. Concentrations in drinking water of these and other substances are

regulated by federal and state laws. Hundreds of other chemicals, however, are not yet regulated, and many of their health effect are unknown or not well understood. Preventing contaminants from reaching the groundwateris the best way to reduce the health risks associated with poor drinking water quality.

USEPA (2009) discovered that, groundwater can be cleaned up and used again, if the contamination is not too severe and if the municipality is willing to spend a good deal of money. Follow-up water quality monitoring is often required for many years. Because groundwatergenerally moves slowly, contamination often remains undetected for long periods of time. This makes cleanup of a contaminated water supply difficult, if not impossible. If a cleanup is undertaken, it can cost thousands to millions of money.

Stephen and Tushaar(2012) resolved that, given the difficulty and high costs of cleaning up a contaminated aquifer, some communities choose to abandon existing wells and use other water sources, if available. Using alternative supplies is probably more expensive than obtaining drinking water from the original source. A temporary and expensive solution is to purchase bottled water, but it is not a realistic long-term solution for a community's drinking water supply problem. A community might decide to install new wells in a different area of the aquifer. In this case, appropriate siting and monitoring of the new wells are critical to ensure that contaminants do not move into the new water supplies.

2.3 LITERATURE REVIEW

2.3.1 Groundwater Quality Impacts of Irrigation Farming

From the preceding, it is clear that, groundwater is a 'very popular commodity' for farmers among others, since it is usually found close to the point-of-use, but could be polluted progressively when its quality is being degraded either naturally or as a result of

human activities (like farming). It has therefore become expedient to understand the basis behind irrigation farming and groundwater quality impacts. A review of the groundwater status would highlight the present picture which would aid subsequent analysis and conclusions in the case study.

Mutsvangwaand Doranalli (2006) defined irrigation as the ministering of land through the artificial application of water to ensure double cropping as well as steady supply of water in areas where rainfall is unreliable. Irrigation farming is another way of improving agricultural production both in subsistence and commercial farming. Irrigation is a very ancient agricultural practice which was extensively used by a number of early civilizations such as the ancient Egyptians (Grove, 1989). Punnet (1982) argued that irrigation has been carried out for centuries around the globe and it started with traditional methods like the Sakia and Shaduf.

Troehand Miller (1980) said that as early as 500BC the Egyptians cultivated land made fertile by the flood waters of the Nile River. By about 3000BC they had built Canal system that carried water from the Nile to their fields. This was after the realization that they had been recurrent droughts in Egypt and many dry parts could not reserve enough food for the whole year. Large irrigation systems also had been constructed by that time in parts of China, India and South-west Asia. According to Miller (1982), irrigation therefore facilitated the growing of crops in the flood plains of the Nile valley so that supplementary food could be accessed. An increase in crop production in almost every year as a result became the attracting feature for the country to increase irrigated lands.

Groundwater is well-suited to pressurized irrigation and high productivity precision farming and has ‘democratized’ irrigation by permitting irrigated farming outside canal command areas (Shah, Burke and Villholth, 2007). In developing and transforming

nations like Nigeria, the ‘groundwater-irrigation boom’ occurred at various economic levels, such as from subsistence farming to large-scale staple-crop production and commercial cash-crop cultivation (Garduno and Foster, 2010). It has brought major socioeconomic benefits to rural communities and in many countries has helped to alleviate agrarian poverty through increasing food security; by ensuring water availability at critical times for crop growth and mitigating devastating effect of drought on crop yields (Shah, 2009).

Foster and Rosenzweig(2005) parroted that, globally, irrigated farming is the largest abstractor and predominant consumer of groundwater resources, with important groundwater-dependent agro-economies having widely evolved. But in many arid and drought prone areas, unconstrained use is causing serious aquifer depletion and environmental degradation, and cropping practices also exert a major influence on groundwater recharge and quality.

Agricultural irrigation land-use practices exert a major influence on groundwater recharge quality through: leaching of soil nutrients where inorganic fertilizer applications have generally been much (Foster and Rosenzweig,2005).Another potentially serious problem but one more confined geographically to recharge areas of aquifers exhibiting high vulnerability to pollution from the land-surface, is where the more ’mobile’ pesticides (mainly certain herbicides and soil insecticides) have been regularly used at high application rates. Thus, Farmers are applied very large amount of animal wastes, manures and crop residues in addition to heavy application of inorganic fertilizers.

Ogedengbe (1980) lamented that, the possible effect on the groundwater include an increase in salinity, due to inadequate drainage and direct evapo-transpiration of irrigation return flow from soils whose salinity has been increased by salts from agrochemicals such

as fertilizer, pesticides and insecticides. Nitrate based fertilizers are also a significant contribution to groundwater pollution. This is because nitrogen in solution is neither fully utilized by plants nor absorbed by the soils. Stock piles of solid materials from construction sites, individual's plants residue are potential groundwater pollutants when precipitation falls on these piles, causing a leaching of heavy metals, salts and other organic and inorganic constituents

Physicochemical parameters as well as hydrochemistry were also studied by many researchers to assess the characteristics of groundwater (Sanchez, Pulido andCalaforra, 1999; Subbaet al.,2002; Bhardwaj and Singh, 2010). Major ionchemistry of the groundwater in the Ejina basin was studied by Jianhua, Xiaohu,Yonghong, Haiyang, and Zongqiang(2009). This study reported the dominance of gypsum halite dissolution and evaporation processes are predominantly controlling the groundwater quality. A series of factors, such as refreshing by recharge waters, concentration by evaporation, dissolution of evaporates, and mixing with older and more saline groundwater were identified as the sources of major chemical characteristics of the groundwater in arid regions of Namibia (Shanyengana,Seely, and Sanderson, 2004). Rim-Rukeh,Ikhifa and Okokoyo(2007) studied the physicochemical properties of both surface and groundwater in the Niger delta and reported severe health effect on human beings by the consumption of contaminated water.

2.3.2 Groundwater Quality Status in Nigeria

Fundamental to the study of groundwater in any place is the geology of the environment. Geology is the main controlling factor in groundwater hydrology. The nature and the properties of the rock, aquifer specific yield and retention, the chemistry of water are governed by the geology of the environment (Brassington, 1988; MacDonald et

al.,2005).According to Sajad, Rahimand Tahir(1998), the quality of groundwater is a function of natural processes as well as anthropogenic activities, and that the type, extent and duration of anthropogenic activities on groundwater quality are controlled by the geochemical and physical processes and the hydrological condition present (Matthess,1976). This anthropogenic concern has attracted overwhelming studies on the quality status of groundwater abstracted from shallow wells (hand dug wells) and deep wells (boreholes) for human consumption in urban areas of Nigeria.

In a baseline study on the inorganic and microbial contaminants of health importance in water from boreholes and open wells in Benin City, Erahet al.(2002) found that all of them were contaminated with abnormal levels of lead, chromium, zinc and faecal coliform. They concluded that consumption of water from these wells will have serious implications. In related studies, Alexander (2008); Efeet al.(2008), Al-Hassan and Ujo (2011) found groundwater to be slightly acidic, and calcium, magnesium, chloride and sodium concentrations were within WHO guide limit in Mubi town, Adamawa Stateand concluded that water was not safe for drinking.

In Gwagwalada area of Abuja Metropolitan City, Federal Capital Territory, Ishaya and Abaje (2009) found that groundwater from the boreholes analyzed has turbidity, total dissolved solids, magnesium, total hardness concentrations above the WHO prescribed limit for drinking water in some of the wells. Nitrate was however within WHO guide limit for drinking water. Studies carried out by Yerimaet al. (2008); Danmo, Debonah, Yusufu and Sangodoyin(2013) in Bama and Konduga towns in Bornu State in sudano-sahelian ecological zone, noted that nitrate, manganese, faecal coliform concentrations in both hand dug wells and boreholes were above the WHO permissible limit for drinking water. Idris-Nda, Isah, Waziri, andSadiq (2011) appraised the chemical quality of

groundwater quality of Minna metropolis Niger State and found heavy metals with high concentrations of magnesium, copper, arsenic and lead. Cations with highest concentration are manganese, sodium and dominant anions HCO_3,CO_2 and NO_3.The groundwater was generally found to be of good quality.

In Jimeta area of Yola town, Adamawa State, Ishaku and Ezeigbo (2010) analyzed the quality of groundwater and found concentrations of chloride, nitrate, total dissolved solids and coliform to far exceed the WHO allowable limit for drinking water and were higher in the wet season. This is traced to anthropogenic activities as household wastes, wastewater find their way into water sources. Relationship show positive correlation for chloride, total dissolved solids, nitrate, sulphate, nitrate and total dissolved solids and sulphate for dry season, while nitrate and sulphate, total dissolved solids and sulphate, chloride and sulphate and chloride and nitrate.

In Ibadan Metropolis of Oyo State, Ayantoboet al.(2012) assessed the quality of water from hand dug wells and noted nitrate, faecal coliform and total coliform at objectionable levels and are pronounced in wells located close to domestic wastes, abattoir, pit latrine and stagnant water and drainage. According to Omotoyinbo (2007) the pollution of groundwater by organic wastes in Ado-Ekiti of Ekiti State is attributed to location of wells in terms of distance to toilet and refuses dumps. Atarhe and Egbuna (2013) assessed the quality of water from hand dug well in Akure town, Ondo State and noted groundwater to be acidic, with electrical conductivity to exceed WHO prescribed limit for drinking water. Hydrochemical facies delineated are calcium-sodium and bicarbonate chloridesulphate water types. Geology of the area is concluded to influence the quality of groundwater of the area.

In a related study, Omono,Onwuka and Okogbue(2013) used principal component analysis(PCA) to identify factors controlling groundwater in Achara, Abakpa and Emene residential areas of Enugu town, Enugu State. PCA was able to extract 77.7%, 88.1% and 83.13% of the explained variables for the residential areas. PC 1 reflects weathering of the host rock minerals and constitutes the dominant controlling process of the areas. PC II and PC III of Achara and Abakpa is traced to both weathering/leaching of feldpatic minerals of host rocks giving rise to alkaline in groundwater and anthropogenic activities. Discriminant analysis of the groundwater quality of the area reveal total dissolved solids, sodium, manganese and chloride as dominant elements. Groundwater in the area is controlled both by geologic and anthropogenic activities.

Jegede and Alade (2010) in their assessment of water quality from hand dug wells in Ijebu-Ijesa of Ogun State. The parameters analyzed found lead, iron and cadmium levels to exceed WHO prescribed limit. Ocheri and Odoma (2013) in a baseline study analyzed the quality of water from boreholes in Lokoja town of Niger State and noted concentrations of total coliform and lead to be above the Nigerian drinking water standards. Correlation was noted between coliform and nitrate, total dissolved solids and calcium, calcium and lead and geology. Ocheri and Ode(2012) assessed the quality of water from hand dug well in Oju town, Benue State, found the concentrations of iron, nitrate, and coliform above the WHO prescribed limit for drinking water. They attributed this to the shallow depth of the wells, distance to latrine/soak away, improper well construction as well as land use.

Jatauet al. (2006) in a preliminary investigation of the quality of surface and groundwater in parts of Kaduna Metropolis, Kaduna State and noted groundwater to be slightly acidic, high iron , nitrate, faecal coliform concentrations. This is traced to leachates from wastes

and dumpsites. Earlier, Egbulum (2003) used faecal coliform and faecal streptococcus indicator to assess the microbial quality of groundwater from hand dug wells in Mando and Kawo area of Kaduna State, findings revealed that the wells were all contaminated, and that bacterial loadings increases from dry season to rainy season between 1998 and 2002.

While from the foregoing, it would be seen that several dimensions of the problem have been dealt with, a gap in knowledge has been observed by the failure in these studies to assess the effect of irrigation farming on groundwater quality over time. Other studies have worked on other elements but this study was limited to seven elements namely pH, Total Dissolved Solids, Salinity, Chromium, Lead, Calcium and Zinc which have not been carried out in the study area. This study therefore, tries to bridge that gap, with a view that such knowledge would assist policy makers to prioritize decisions on domestic water supply, provision, use, technology and management for people of Jibia LGA, Katsina State, Nigeria.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 THE STUDY AREA

3.1.1 Location and Size

Jibia is a town and a LGA headquarters in Katsina State. It is located in the northern part of Katsina State about 47km to the State capital. It lies within Latitudes 12º 45'N to 13º 15'N and Longitudes 07º 00'E to 07º 30'E. Jibia is bordered byKaitaLGAto the east, BatagarawaLGA to the south and ZurmiLGA to the west while to the north is Niger Republic (Katsina, 2003).It occupies a total land area of about 1,037km^2 (Iliya, 2014). See Figure 3.1.

3.1.2 Climate and Vegetation

Jibia LGA falls within climate that is largely controlled by the tropical maritime air mass and tropical continental air mass. The interaction between these air masses determines the intensity and duration of the wet and dry season. The wet season starts in May and ends in early October and dry seasons last longer from November to April with total rainfall vary from 600-700mm annually, mean annual temperature of about 25^{o}C. The area is characterized by high temperature of about 43^{o}C, constant low relative humidity 50% and shorter raining season (Olofin, 1993).

The study area is in Sudan savannah vegetation belt which stretches from Sokoto plains of Hausa land to the Chad basin. The actual vegetation is made up of short grasses whose average height is about 1.5-2m and some commonly growing trees species include *Azadirachtaindica* (neem tree) locally known as (Bedi or Dalbejia), *Acacia albida* (locally known as Gawo) and *Adansoniadigitata* (locally known as Kuka). In addition to these there is intensive tree crops cultivation in swampy areas (Katsina, 2003).

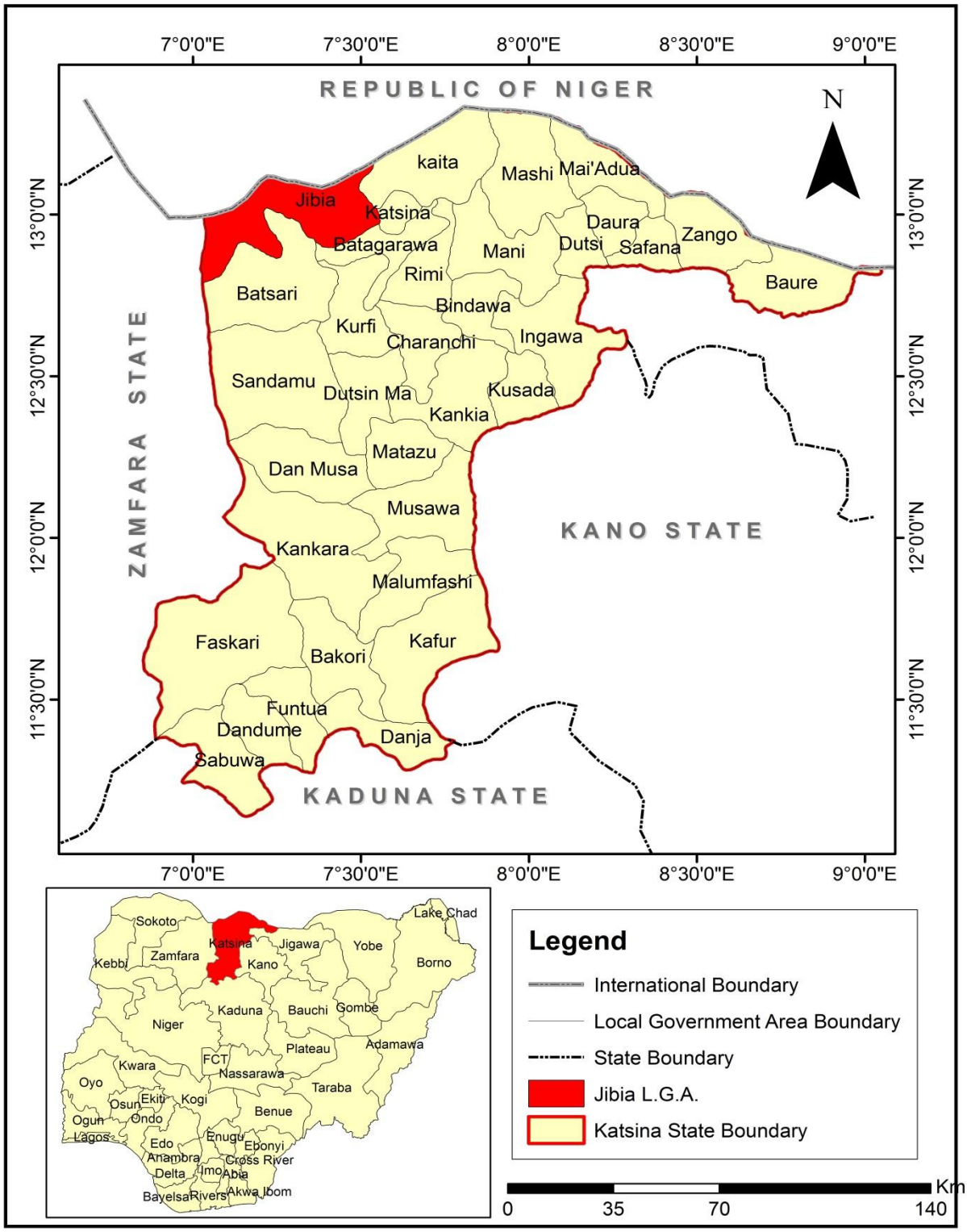


Figure 3.1: Map of Katsina State

Source: Modified fromadministrative Map of Katsina State

3.1.3 Geology and Soil

The study area falls within a mixed geology of both crystalline rocks and sedimentary rocks of Gundumiformation which is made up of sedimentary rocks of Cretaceous origin. The relief of the area is of the lower plains. The relative relief falls within the average of about 15 to 20 metres, the landform in the study area is sandy plains. However, it is not uncommon to find deposits of sand dunes of varying degrees especially when you move towards DaddaraKusa, Kaga villages in Jibia LGA. The dunes are formed from the deposition of eroded materials carried along by strong winds from across the Sahara desert, especially during the dry season (Shittu, 1999).

The soil consists of mostly unconsolidated sediments which are predominantly sandy, silt to sandy loam; it is brown or reddish brown in nature. This type of soil is formed from the deposition of eroded materials over sedimentary formation. They are less acidic and well drained, with fairly low clay content (Omale, 2012).

3.1.4 Population and Economic Activities

According to the 2006 population estimates, Jibia LGA has a population of 85,149 males and 82,286 females. Out of this, then Jibia town has an estimated population of 50000 people (National Population Commission, 2009). The area is dominated mainly by Hausa and Fulani ethnic group. The major occupation of the people in this area is farming which is of greater percentage and estimated to have taken about 85% of the total population. This 85% engage in various agricultural practices such as farming, livestock rearing and poultry, the remaining 15% of the people are engaged in other occupations such as trading, carpentry and blacksmithing. Much of the rural settlers (men) also carry out irrigation farming by the banks of the major rivers in the study area, to augment their income. Jibia irrigation site is advantageously located in a very good agricultural land

particularly for irrigation as this attracts more irrigation farmers to the area making it more populated than its environs. This is as a result of the fact that the land supports the cultivation of crops such as spinach, lettuce, tomatoes, maize and carrots. Other small-scale businesses also done in the study area include: furniture making, mechanic services and trading of all sorts.

3.2 METHODOLOGY

3.2.1 Reconnaissance Survey

As part of the study, a reconnaissance survey was undertaken to identify the areal coverage of the irrigation site and the boreholes. This further assisted the researcher to familiarize with the way the rural dwellers source their domestic water from the study area. Also during the survey the number of farmers registered with Jibia irrigation project was collected.

3.2.2 DataTypes Used

Data types used for this study include;

i. Locations of boreholes

ii. Distance of the boreholes to irrigation site

iii. Nature of the boreholes

iv. Physico-chemical properties of groundwater (pH, total dissolved solid, calcium, lead, zinc and chromium

v. WHO (2011) standards for groundwater quality

3.2.3 Sources of Data

The study required data from both primary and secondary sources.

3.2.3.1 Primary Source of Data

The study obtained primary data from the field observation and survey, coordinates of the deep and shallow wells with Global Positioning System (GPS), collection of water samples for laboratory analysis.

3.2.3.2 Secondary Source of Data

Secondary data was sourced from the WHO standard for groundwater quality.

3.2.4 Sample Size and Sampling Techniques

The borehole and well water samples were taken from a distance ranging from less than 10m to a distance of greater than 150m (Peter, Paul and Thomas, 1995) away from the irrigation site. There were 7 deep and 2 shallow wells respectively identified within the 0 to less than 10m range while 24 deep and 4 shallow wells were from above the marked ranged of 10-150m of which 6 water samples (4 deep and 2 shallow wells) from less than 10m to a distance of greater than 10m each were collected for laboratory analysis (Figure 3.2).

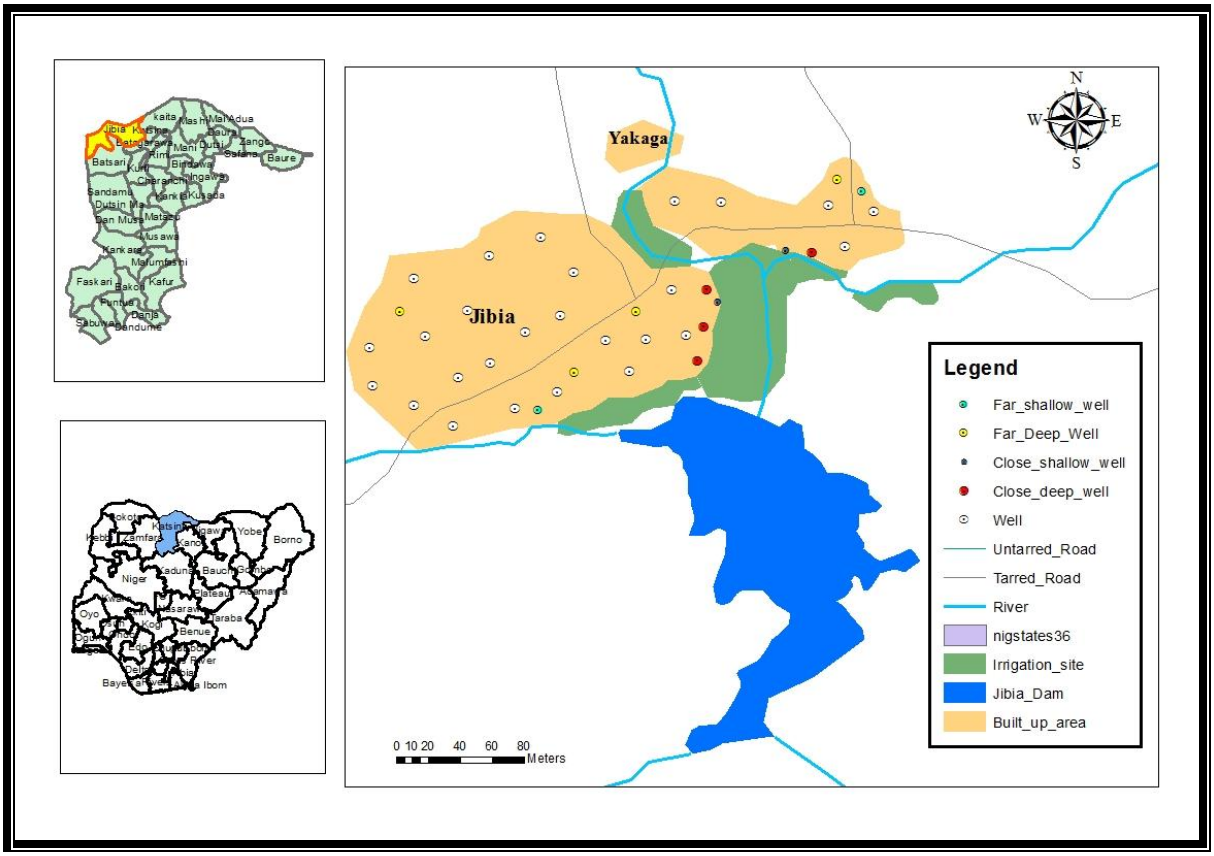


Figure 3.2: Location of Sampled Wells in the study area
Source:Modified from Jibia LGA

3.2.5 Data Analysis

Descriptive and inferential statistics were employed to analyze the data collected for this study using the Statistical Package for Social Sciences (SPSS) version 20. The analytical techniques used in achieving the objectives of the study were as follows:

Objective i: Determine the Physico-chemical Properties of Groundwater in the Study Area

Water samples collected from the deep and shallow wells were subjected to standard laboratory tests to determine the physico-chemical properties which were presented in tables showing the mean and standard deviation for the physical chemical properties of groundwater in the study area.

Objective ii: Examine the effect of distance from irrigation site to groundwater quality in the area

Water samples collected from wells that are close to and far away from the irrigation site were subjected to standard laboratory tests to determine the physico-chemical properties which were presented in tables showing the mean and standard deviation for the physical chemical properties of groundwater of the wells (close and far) in the study area.

Objective iii: Examine the Effect of Seasons on the Physico-chemical properties of Groundwater in the Area

Water samples collected from wells during the rainy and dry seasonswere subjected to standard laboratory test to determine the physico-chemical properties which were presented in tables showing the mean and standard deviation for the physical chemical properties of groundwater of the wells in the study area.

Objective iv: Compare the groundwater quality with WHO/NSDWQ Standards

The overall mean values for groundwater quality (that is, for both rainy and dry season) were compared with the WHO/NSDWQ Standards as the case may be and presented in tables

Testing of Hypotheses

The hypotheses were tested using t-test statistics to test for differences at 0.05 alpha level of significance.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This study was carried out to examine the effect of irrigation farming on groundwater quality in Jibia LGA, Katsina State. This chapter summarized and analyzed the physcio-chemical properties of the collected water samples as well as the questionnaire administered to farmers during the field survey. The results of the data analysedwere presented according to the objectives set for this study.

4.2 PHYSICO-CHEMICAL PROPERTIES OF GROUNDWATER

4.2.1 Physico-chemical Properties of Groundwater during the Rainy Season

The water samples from wells both close and far away from irrigation site during the rainy season were analysed for pH, Total Dissolve Solid (TDS), Chromium, Lead, Calcium and Zinc as salinity was not included because there are no standards for both the WHO (2011) and NSDWQ (2007). The physico-chemical properties of the groundwater during the rainy season are shown in Table 4.1.

Table 4.1: Physico-chemical Properties of Groundwater during the Rainy Season

Properties	Shallow Wells				Boreholes			
	Close		Far		Close		Far	
	$\bar{X}$	S.D	$\bar{X}$	S.D	$\bar{X}$	S.D	$\bar{X}$	S.D
pH	8.75	0.59	9.22	0.64	7.83	0.31	6.71	0.50
TDS	179	145.7	154	131.5	408.8	207.6	877.5	791.1
Chromium	0.44	0.04	0.21	0.20	0.65	0.06	0.02	0.03
Lead	0.24	0.03	0.26	0.03	0.24	0.03	0.24	0.03
Calcium	78.05	56.0	26.0	18.37	78.05	56.05	99.84	72.56
Zinc	0.00	0.00	0.00	0.00	0.08	0.14	0.25	0.20

Source: Author's Fieldwork, 2015

The pH values ranged from 6.71-9.22, which implies that the sampled water is basic (Table 4.1). Far shallow wells have the highest pH value of 9.22, while far deep wellshave the lowest recorded pH value of 6.71. This finding is in line with the findings of Al-Hassan and Ujo (2011) who found out that groundwater in Mubi town of Adamawa

state was slightly acidic. Total dissolved solid values range from 154.00-877.50 mg/l. The lowest value of 154.00 mg/l was at far shallow wells while far deep wells from the irrigation site recorded the highest value of 877.50 mg/l. Chromium values of sampled water were found to range from 0.02-0.65. The lowest value of 0.02 was recorded at far deep wells while the highest value of 0.65 was recorded at close deep wells.The values for Lead was consistent at 0.24 across the locations except at far shallow wells which has 0.26 and incidentally was the highest. The values for calcium were found to range between 26.0-99.84 with far shallow wells having 26.0 while far deep wells have the highest value of 99.84. The values of sampled water for Zinc from wells ranged between 0.00-0.25 with close and far shallow wells having values of 0.00 while close deep wells had a value of 0.8 as compared to far deep wells which has the highest value of 0.25.

This result revealedthat deep wells that are far away from the irrigation sites had lower values for pH and Chromium while values for TDS and Calcium were higher in far deep wells.This implies that the closer the wells to the irrigation site the higher the values of the pH and Chromium and vice versa. TDS, Chromium and Calcium for shallow wells close to irrigation site were higher as compared to the shallow wells that are far from the irrigation site.

4.2.2 Physico-chemical Properties of Groundwater during the Dry Season

Table 4.2 shows the result of the water samples analyzed for pH, TDS, Chromium, Lead, Calcium and Zinc during the dry season for the two locations.

The shallow wells dry up during the dry season completely as a result, water samples were only gotten from the deep wells.

Table 4.2: Physico-chemical Properties of Groundwater during the Dry Season

Properties	Boreholes			
	Close		Far	
	$\bar{X}$	S.D	$\bar{X}$	S.D
pH	8.19	0.21	8.76	0.15
TDS	435.25	169.6	499.75	191.69
Chromium	0.14	0.03	0.18	0.06
Lead	0.00	0.00	0.00	0.00
Calcium	60.55	19.40	80.44	29.13
Zinc	0.00	0.00	0.07	0.14

Source: Author's Fieldwork, 2015

Table 4.2 showed that the pH values range from 8.19-8.76, which implies that the sampled water was basic withboreholes far from the irrigation site having higher pH value of 8.76as against boreholes close to irrigation site with pH value of 8.19. The values for TDS ranges between435.25 and 499.75 mg/l withboreholes close to the irrigation sites having lower value of 435.25 mg/l as compared to the values recorded for boreholesfar from the irrigation site 499.75 mg/l.Chromium values of water sampled wells ranges between 0.14 and 0.18 with boreholes far away from the irrigation site having higher value of 0.18 and lower value of 0.14 for close boreholes. The values for Lead were consistent at 0.00 for both close and far boreholes indicating that distance has no effect on the Lead property of the water in the study area. Values for calcium ranged between 60.55 and 80.44 with far boreholes having the highest value. Zinc values ranged between 0.00 and 0.07 with close deep wells having the lowest value. This result indicates that the value/quantity of pH, TDS, chromium,calcium and zinc increased with distance away from the irrigation site. However, the Lead property of the water across the locations revealed no effect as a result of distance from the irrigation site.

4.3 EFFECT OF DISTANCE FROM IRRIGATION SITE ON GROUNDWATER QUALITY

4.3.1 Physico-chemical Properties of Groundwater and WHO (2011) / NSDWQ (2007) Standards

The physico-chemical properties of water from the various wells used for domestic purposes in the various agrarian communities were analyzed for wells that are close to and far away from the irrigation site and the average values were compared with the values of WHO (2011) and NSDWQ (2007) as presented in Table 4.3.

Table 4.3: Average Physico-chemical Parameters Determined for Wells Close to and Far away from Irrigation Site

Properties	Distance from Irrigation Site				Standards	
	Far wells		Close wells			
	$\bar{X}$	S.D	$\bar{X}$	S.D	WHO	NSDWQ
pH	8.03	1.21	8.16	0.46	N.S	7.5
TDS	581.70	552.55	373.39	192.3	500	500
Chromium	0.12	0.12	0.40	0.25	0.05	0.05
Lead	0.15	0.13	0.14	0.12	0.01	0.01
Calcium	77.31	53.8	61.27	39.45	250	N.S
Zinc	0.13	0.18	0.03	0.09	N.S	3

N.S – No Standard
Source: Field Survey, 2015

The acidity or basicity of domestic water is expressed as pH (< 7.0 acidic; > 7.0 basic). The normal pH range for domestic or drinking water is from 6.5 to 8.5 (7.5) according to NSDWQ (2007). The pH ranged between 8.03 and 8.16 which is well above the NSDWQ standard which indicates a high level of alkalinity minerals are present. High alkalinity does not pose a health risk, but can cause aesthetic problems, such as an alkali taste to the water that makes coffee taste bitter; scale build-up in plumbing; and lowered efficiency of electric water heaters (USEPA, 2007).

Total dissolved solids (TDS) for wells close to and far away from the irrigation site ranging between 373.39 and 581.7. Wells close to and far away from the irrigation

site are below and above the standard permissible TDS of 500 (WHO, 2011 and NSDWQ, 2007) respectively. This is an indication that water quality in wells close to irrigations sites are within the standards therefore making the water fit for drinking while drinking water from wells far away from irrigation site possess other indicators such as hardness, scale formation, bitter taste in drinking water caused by calcium carbonate ($CaCO_3$) and magnesium carbonate ($MGCO_3$), and salty or brackish taste resulting from sodium chloride (NaCl) and potassium chloride (KCl). The latter can increase the corrosive ability of water. High TDS levels are also responsible for leaving water spots on dishes and white mineral buildup on water faucets and swamp coolers. It can also affect the efficiency of hot water heaters (Arizona Owner's Help, 2009). The findings wells far away from irrigation site is in line with that of Ishaku and Ezeigbo (2010) who found concentrations of total dissolved solids and other elements to far exceed WHO allowable limit for drinking water.

The chromium values for wells close to and far away from irrigation site ranges between 0.12 and 0.40 mg/L. It was observed that the values obtained for both wells were higher than the recommended value of WHO (2011) and NSDWQ (2007). Chromium in excess is toxic thus leading to liver and kidney damage, internal hemorrhage, and respiratory disorders, as well as causing cancer in humans and animals through inhalation exposure, but it has not been shown to be carcinogenic through ingestion exposure (U.S. Environmental Protection Agency, 2009). The high value of chromium in the wells is an indication that the water is contaminated. This finding is in line with the findings of Erah*et al.* (2002) who found out that drinking water was contaminated with abnormal levels of chromium.

The values of Lead obtained for wells close to and far away from irrigation site ranged between 0.15 and 0.14. When the values obtained were compared with the WHO

(2011) standard and NSWDQ (2007), it was observed that the values obtained were higher than the recommended value which implies that the water is contaminated. Lead exposure across a broad range of blood Lead levels is associated with a continuum of pathophysiological effect, including interference with heme synthesis necessary for formation of red blood cells, anemia, kidney damage, impaired reproductive function, interference with vitamin D metabolism, impaired cognitive performance, delayed neurological and physical development, and elevations in blood pressure (U.S. Environmental Protection Agency, 2009).

The calcium value for wells close to and far away from irrigation site were found to range between 61.27 and 77.31 mg/l which are below the WHO (2011) standard for drinking water quality as no standard value was found for the NSDWQ (2007). From the observation, it could be deduced that based on the WHO standard, the water is fit for drinking because all the calcium values are within the WHO standard.

Zinc value for deep and shallow wells (close and far) were found to range between 0.03 to 0.13 which are below 3 which is the NSDWQ (2007). The values were not compared with the WHO standard for zinc because no health-based guideline value has been proposed for zinc in drinkingwater. Based on this, it can be concluded that water in the study area is fit for drinking.

4.3.2 Physico-chemical Properties of Water and Standards during Rainy and Dry Seasons Respectively

Table 4.4 shows the physico-chemical properties of water from the various wells during the rainyand dry seasons respectively and their average compared with the values of WHO (2011) and NSDWQ (2007).

Table 4.4: Average Physico-chemical parameters determined during the Rainy and Dry Seasons Respectively

Properties	Seasons					
	Rainy Season		Dry Season		Standards	
	$\bar{X}$	S.D	$\bar{X}$	S.D	WHO	NSDWQ
pH	7.84	1.06	8.47	0.35		7.5
TDS	484.24	530.12	467.5	171.08	500	500
Chromium	0.33	0.29	0.16	0.05	0.05	0.05
Lead	0.24	0.03	0.00	0.00	0.01	0.01
Calcium	68.48	58.08	70.49	25.26	250	
Zinc	0.11	0.17	0.03	0.10		3

Source: Field Survey, 2015

The values obtained for all the physico-chemical properties namely pH, TDS, chromium, calcium and zinc during both rainy and dry seasons all fall within the recommended range for WHO/NSDWQ implying that the water is fit for drinking except the values for lead during the rainy season 0.24ppm which is above the recommended standard of 0.01 for both WHO and NSDWQ. This implies that lead content is higher during the rainy season thereby making the water unfit for drinking due to its high presence in water. This finding for the rainy season is in line with the findings of Jegede and Alade (2010) who found lead levels exceeding the WHO prescribed limit for drinking water. This is an indication that irrigation farming does not affect the lead content of groundwater in the study area.

4.4 COMPARING GROUNDWATER QUALITY WITH WHO (2011) AND NSDWQ (2007) STANDARDS

The overall mean groundwater values for the physico-chemical properties (for both rainy and dry seasons respectively) were analyzed and compared with the WHO (2011) and NSDWQ (2007) standards to see if the groundwater water quality is fit for domestic consumption. This is presented in Table 4.5.

Table 4.5: Differences between Groundwater Quality in the Study Area and WHO/NSDWQ

Properties	Groundwater Quality			
	Overall		Standard	
	$\bar{X}$	S.D	WHO	NSDWQ
pH	8.155	0.705		7.5
TDS	242.35	265.156	500	500
Chromium	0.245	0.17	0.05	0.05
Lead	0.12	0.015	0.01	0.01
Calcium	69.485	41.67	250	
Zinc	0.07	0.135		3

Source: Field Survey, 2015

Table 4.5 showed the overall mean values of the physico-chemical properties of groundwater (both for the rainy and dry season) as compared to the WHO (2010) and NSDWQ (2007) standards for groundwaterquality. From the table, it was revealed that water pH, TDS, Calcium and Zinc were all found to be within the standards given by WHO and NSDWQ for drinking water quality implying that drinking water is fit for drinking. On the other hand, values for Chromium (0.245) and Lead (0.12) were found to be higher than the prescribed WHO and NSDWQ standards of 0.05 and 0.01 respectively implying that water from wells in the study area if taken could pose a serious health implication which is in line with the findings of Erah*et al* (2002) who found out that water is contaminated with abnormal levels of chromium and other elements. This may not be unconnected with the fact that farmers make excessive use of chemical fertilizers and pesticides during the dry season farming.

4.5 HYPOTHESES TESTING

4.5.1 Testing of Research Hypothesis One

Hypothesis One: There is no significant difference between groundwater quality of wells close to and far away from irrigation site.

Table 4.6 summarizes the result of t-test performed to check if distance of wells (close to or far away from) the irrigation site have any significant effect on physico-chemical properties of the groundwater in the study area.

Table 4.6: t-test on difference between groundwater Quality of Wells Close to and Far away from Irrigation Site

	Proximity	N	Mean	S.E	S.D	dF	t-cal	t-crit	p-value	Remark
pH	Wells Close	10	8.16	15	0.46	18	0.306	2.45	0.76	Not Sig.
	Wells Far	10	8.03	0.38	1.21					
TDS	Wells Close	10	199.46	73.41	232.16	18	.861	2.45	0.40	Not Sig
	Wells Far	10	382.0	198.97	629.20					
Chr	Wells Close	10	0.40	0.08	0.40	18	3.25	2.45	0.00	Sig.
	Wells Far	10	0.12	0.04	0.12					
Pb	Wells Close	10	0.14	0.04	0.13	18	0.06	2.45	0.95	Not Sig
	Wells Far	10	0.15	0.04	0.13					
Ca	Wells Close	10	61.27	12.6	39.85	18	0.76	2.57	0.46	Not Sig.
	Wells Far	10	77.31	17.0	53.77					
Zn	Wells Close	10	0.03	0.03	0.09	18	1.51	2.45	0.15	Not Sig.
	Wells Far	10	0.13	0.06	0.18					

Significant at $p \leq 0.05$

A careful analysis of Table 4.6 shows that there is no significant difference between wells close to or far away from the irrigation site in all the physico-chemical properties of water in the study area except chromium with a p-value of 0.00 less than the 0.05 level of significance. This is in line with the findings of the United States Geological Survey (USGS, 2006) who found out that there were no significant differences between the concentration of Total Dissolved Solids and other elements in Oklahoma. The implication of this is that distance does not have any significant effect on the concentrations of measured physico-chemical properties of water in the study area.

4.5.2 Testing of Research Hypothesis Two

Hypothesis Two: There is no significant difference between physico-chemical properties of groundwater in the study area and WHO/NDSWQ Standard for domestic water.

In order to test the null hypothesis one, a student t-test was carried out to compare each of the physico-chemical properties tested with either the WHO (2011) standard or the NSDWQ standards (2007) as appropriate as standards are not available for some of the physico-chemical properties in both WHO and NSDWQ.

Table 4.7: t-test on difference between the Physico-chemical properties of groundwater and the WHO/ NSDWQ Standards

Physicochemical Properties & Standards	N	Mean	SE	SD	dF	t-cal	t-crit	P-Value	Remark
pH	2	8.155	0.32	0.45	1	1.017	12.71	0.495	Not Sig
NSDWQpH	1	7.5							
TDS	2	475.87	8.37	11.84	2	2.88	4.303	0.102	Not Sig
WHO/NSDWQTDS	2	500.00	0.00	0.00					
Chromium	2	0.245	0.085	0.12	2	2.29	4.303	0.149	Not Sig.
WHO/NSDWQChromium	2	0.05	0.00	0.00					
Lead	2	0.12	0.12	0.17	2	0.917	4.303	0.456	Not Sig.
WHO/NSDWQLead	2	0.01	0.00	0.00					
Calcium	2	69.49	1.000	1.42	1	103.70	12.71	0.01	Sig
WHO Calcium	1	250							
Zinc	2	.070	0.04	0.06	1	42.29	12.71	0.02	Sig
WHO / NSDWQZinc	1	3.00							

Significant at $p \leq 0.05$

A careful analysis of Table 4.7 shows that there is no significant difference in almost all the physico-chemical properties of water from wells in the study area when compared with the WHO and NSDWQ except for calcium and zinc which shows a significant value with p-values of 0.01 and 0.02 which are less than the 0.05 level of significance respectively. This is in line with the findings of Al-Hassan and Ujo (2011) who found groundwater to be slightly acidic, and magnesium but chloride and sodium

concentrations were within WHO guide limit in Mubi town, Adamawa State. The implication of this is that the water in the study area is relatively safe for drinking.

Acute toxicity arises from the ingestion of excessive amounts of zinc, either accidentally ordeliberately as an emetic or dietary supplement and the major consequence of the chronic ingestion of zinc manifests in copper deficiency (WHO, 2011). Some effects of excess calcium are being reflectedon the reproductive system and its negative influence on fertilityas it demonstrates the oxidative stress induced infertility in men (Sengupta, Chaudhuri and Bhattacharya, 2013).

Irrigation farming has both positive and negative effects on the physico-chemical properties of groundwater in the area as not all the chemical elements tested were greater than the WHO/NSDWQ standards which makes the water unfit for drinking if the elements are singularly taken into consideration for the groundwater quality.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

INTRODUCTION

This chapter presents the summary of major findings of the study and the conclusions drawn from the findings. The chapter also presents recommendations made which were derived from the findings of the research.

5.1 SUMMARY OF THE FINDINGS

The study examines the effect of irrigation farming on groundwater quality in Jibia LGA, Katsina State. The study revealed that distance does not have any significant effect on the concentrations of measured physico-chemical properties of water in the study area as there was no significant difference between wells close to or far away from the irrigation site in all the physico-chemical properties of water in the study area except Chromium with a p-value of 0.00 less than the 0.05 level of significance.

The study revealed that there is no significant difference in almost all the physico-chemical properties of water from wells in the study area except for calcium and zinc which shows a significant value with p-values of 0.01 and 0.02 which are less than the 0.05 level of significance respectively.

5.2 CONCLUSION

This study investigated the physicochemical properties of the groundwater to understand the status of water quality in Jibia LGA. It was concluded that:

1. the closer the wells are to irrigation site the higher the values of the pH and chromium for deep far wells. TDS, chromium and calcium for shallow wells close

to irrigation site as compared to the shallow wells that are far from the irrigation site;

2. mean values for TDS, lead, calcium and zinc were higher for wells far from irrigation site;
3. mean values for chromium, lead and zinc were higher during the rainy season as compared to the dry season;
4. the overall mean values for TDS, calcium and zinc were less than the WHO/NSDWQ standards

The various tests and analysis shows that groundwater in the study area is fit for domestic use and may not pose health risks to the people even though some water quality indicators were found to be slightly above the set limits of WHOand NSDWQ standards.

5.3 RECOMMENDATIONS

Based on the findings above, the following recommendations are made:

i. Although the result generally indicates that groundwater quality status is good for human consumption and may not pose apparent health risk to the people,there is the need for continuous monitoring of groundwater to determine its quality status. This will serve as a guide to the public and to water managers on action plans to be taken once the physico-chemical properties are found to exceed the permissible values given by the WHO and NSDWQ standards.
ii. Wells close to or far away from irrigation sites should be tested seasonally as there is variation ininfiltration of physico-chemicals in groundwater during the rainy season which could in turn increase the physico-chemical properties present in wells close to irrigation sites

iii. Appropriate measures should be taken to treat the water where the physico-chemical properties are found to be well above the WHO and NSDWQ standards.

5.4 CONTRIBUTIONS TO KNOWLEDGE

The study established that:

i. there is no significant difference between wells close to or far away from the irrigation site in all the physico-chemical properties of water in the study area except chromium with a p-value of 0.00 <0.05 level of significance

ii. there is no significant difference in almost all the physico-chemical properties of water from wells in the study area and the WHO/NSDWQ standards except for calcium and zinc which shows a significant value with p-values of 0.01 and 0.02 <0.05 level of significance respectively

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Appendix I

Laboratory Result for some Tested Physico-Chemical Parameters during the Rainy and the Dry Season's Farming

MULTI-USER SCIENCE RESEACH LABORATORY

AHMADU BELLO UNIVERSITY

ZARIA

PROJECT ANALYSIS **16Th December, 2015**

RAINY SEASON						
Unit of Measurement	pH Neutral	TDS Mg/l	Cr ppm	Pb ppm	Ca ppm	Zn ppm
DWF	7.16	289	0	0.242	28.652	0.498
DWF	6.76	883	0	0.21	151.846	0.269
DWF	6.92	344	0	0.219	46.83	0
DWF	6	1994	0.064	0.286	172.033	0.222
SWF	8.76	247	0.067	0.233	38.958	0
SWF	9.67	61	0.344	0.278	12.978	0
SWC	9.17	75.9	0.415	0.214	12.7	0
SWC	8.33	282	0.47	0.258	45.558	0
DWC	8.22	295	0.596	0.206	48.235	0.024
DWC	7.65	689	0.603	0.259	148.874	0
DWC	7.92	216	0.716	0.226	20.95	0.285
DWC	7.53	435	0.698	0.269	94.15	0

DRY SEASON						
Unit of measurement	pH Neutral	TDS Mg/l	Cr ppm	Pb ppm	Ca ppm	Zn ppm
DWC	8.09	343	0.13	0	42.26	0
DWC	8.05	291	0.143	0	46.377	0
DWC	8.1	674	0.099	0	82.592	0
DWC	8.5	433	0.171	0	70.961	0
DWF	8.87	500	0.207	0	65.192	0
DWF	8.91	382	0.254	0	98.293	0
DWF	8.6	770	0.11	0	47.584	0.27
DWF	8.66	347	0.163	0	110.688	0

ANALYST Mohammed Muazu



Appendix II: Nature of Shallow Wells during the Rainy Season in the Study Area



Appendix III: Nature of Shallow Well during the Dry Season in the Study Area

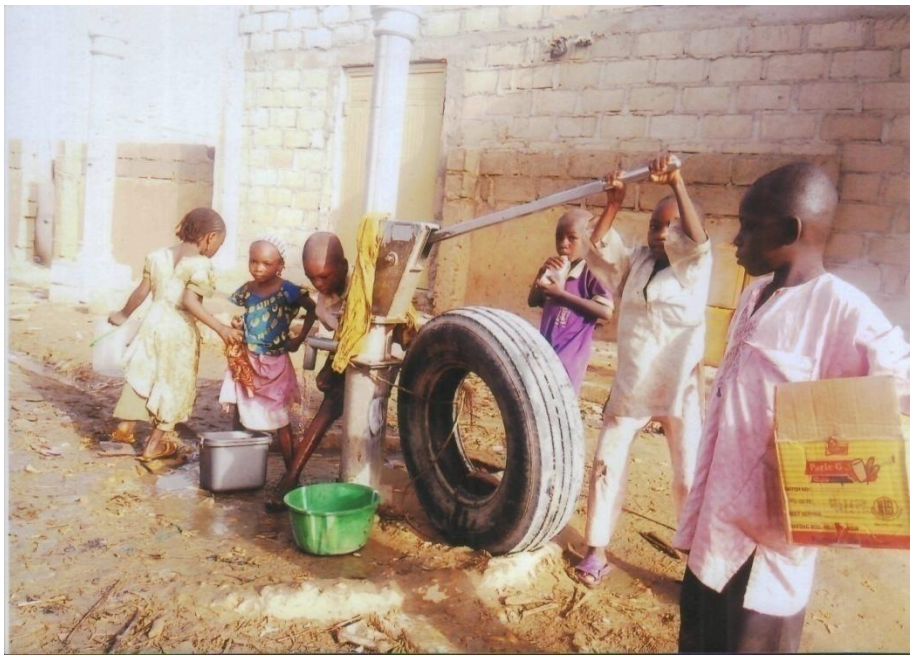


Appendix IV: Farmers Spraying Insecticides/ Pesticides in the Study Area





Appendix V: A Borehole in the Study Area





Appendix VI: Nature of Settlements Close to Irrigation Site in the Study Area



Appendix VII: Researcher Undertaking the Water Quality Test in the Multi-User Science Research Laboratory, Department of Chemistry, A.B.U, Zaria

