ASSESMENT OF WATER QUALITY OF TUBE-WELLS AT EDOZHIGI FOR IRRIGATION.

BY

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2003/14894EA

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FEDRAL UNIVERSITY OF TECHNOLOGY,

MINNA, NIGER STATE.

NOVEMBER, 2008.

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BEING A FINAL YEAR PROJECT SUBMITTED IN PARTIAL

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MINNA, NIGER STATE.

NOVEMBER, 2008

DECLARATION

I hereby declare that this project is a record of a research work that was undertaken and written by me. It has not been presented before for any degree, diploma or certificate at any University or institution. Information derived from personal communication, published and unpublished works of others were duly referenced in the text.

26TH MARCH, 2009

TANKO IDRIS SULEIMAN DATE

2003/14894EA

CERTIFICATION

This project entitled "Assessment of Water Quality of Tube-Wells at Edozhigi for Irrigation" by Tanko Idris Suleiman meets the regulations governing the award of Bachelor of Engineering (B. ENG) of The Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

26-03-09

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Head of Department of Agricultural Engineering.

18/11

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External Examiner Date

DEDICATION

This project work is dedicated to Almighty God who in his infinite mercy makes it possible for me to successfully complete my degree program in The Federal University of Technology Minna. And to my Gentle father, who took the giant step supporting, encouraging and financing my educational career.

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Finally, my gentle Daddy, I can't pay you for your love also my mother thank you for coming in when all hope was lost. Time and space will not allow me to appreciate every one that contributed to my successful stay in Minna God Bless you all.

ABSTRACT

Irrigation is one of the oldest methods through which man produce crops for both consumption and commercial purpose. It is the application of artificial water to grow crops during periods of short rainfall and in dry seasons. One of the sources of irrigation water is ground water. This is the water below the earth surface in what is known as an aquifer. Tube wells which are the subject of this project work are shallow boreholes that penetrate water bearing stratum of the aquifer over the years. concern as been raised over the quality of irrigation water and its effect to plant growth and productivity. The quality and quantity analysis of this tube wells was carried out and they were both found to be satisfactory. Sodium absorption ratio was analyzed to be 1.523, 0.935, 0.989 respectively. This is within the specified range of 0-5 according to FAO standard. Also using a 5.5hp water pump, it was discovered that the tube wells can produce 2L/s to 5L/s of discharged rate. This is also sufficient to irrigate the given fadama land during period of peak demand.

TABLE OF CONTENTS

LIST OF TABLES

TABLE

ABBRIEVIATIONS, SYMBOLS AND NOTATIONS

ADP	Agricultural development programs
APHA	America Public Health Association
Ca^{2+}	Calcium ion
CWR	Crop Water Requirement
CO_3^{2+}	Carbonate ion
dS/m	decisiemen per litre
FAO	Food and Agricultural Organisation
FC	Field Capacity
Fe	Iron
Fe^{2+}	Iron (2) ion
Fe^{3+}	Iron (3) ion
EC	Electrical Conductivity
ESP	Exchangeable Sodium Percentage
Hg	Mercury
H_2O	Water molecule

HCO_3^-	Hydro carbonate ion
L/S	Land slope
Me/l	Milliequivalent per liter
m	Metre
Mg/l	Milligram per liter
mm	Millimetre
Mg^{2+}	Magnesium ion
Na^+	Sodium ion
NSWB	Niger State Water Board
OH^-	Hydroxyl ion
Ppm	parts per million
PWP	Permanent Wilting Point
SAR	Sodium Adsorption Ratio
S.S	Suspended Solids
T.D.S	Total Dissolved solids
°	Degree
"	Minute

µs/cm	Microsiemen per centimeter
°C	Degree Celsius
°F	Degree Fahrenheit
<	Less Than
>	Greater Than
=	Sign of Equality
≤	Less Than or Equal to
≥	Greater Than or Equal

CHAPTER ONE

1.0 INTRODUCTION

1.1 Water is a colorless odorless liquid when pure. Its main constituents are hydrogen and oxygen. It is also a universal solvent because it can dissolve almost everything with time. Because of its importance to life, it is practically impossible to live without it.

Water has a boiling point of 100°C (212°F) and a freezing point of 0°C (32°F) at standard atmospheric pressure (760mm Hg).

Water also exists in three states namely solid in ice form, liquid and gas in vapor state.

In both plants and animals, water is necessary for the metabolic breakdown of food substances.

In plants it is the main transport media through which the plants nutrients are transported to all parts of the plants (Microsoft Encarta 2007).

1.2 WATER QUALITY IN IRRIGATION

The quality of irrigation of water today is of paramount importance to any agricultural enterprise whether public or private. Impurities the irrigation leads to severe problems ranging from health hazard to low level of crop productivity and even interference with some chemical processes in agricultural industries.

The main concern of this project work is to determine the quality of irrigation water, as such the need to understand various types of contaminants in irrigation waters:

1.2.1 Physical contaminants are contaminants resulting from erosion and disposed waste.

1.2.2 Biological contaminants are contaminants from human, animal and industrial waste.

1.2.3 Chemical contaminants are as a result of industrial processes and agricultural use of fertilizers, pesticides, herbicides, and such.

Also in irrigation, it is necessary to determine the source of the contamination, hence, the types of sources

1.2.4 Point source are sources from animal feedlots, chemical dump sites, Storm drain and sewer outlets, mine outlets, and other identifiable points of origin.

1.2.5 Non-point source include run-off from forest and agricultural land, Hillside seepages, small subsurface drain outlets, and other diffuse sources. Non-point sources are often difficult to identify and corrected (Schwab et al, 1993). All the above listed contaminants and their sources consequently lead to irrigation water degradation.

1.3 GROUND WATER AND ITS SOURCES

Ground water is that located beneath the surface of the earth in soil pore spaces and in fractures of litho logic formations (Wikipedia, 2008).

Ground water is the water that occupies the voids within rocks and the soil. Subsurface material containing ground water may be divided into zones of saturation and aeration. Voids within the zone of saturation are completely filled water, while the voids within the zone of aeration are partially filled with water and partially with air (James, 1993).

1.3.1 GROUND WATER SOURCES

An aquifer is a geological structure that is capable of yielding substansible quantity of water to a well. An aquifer is also a geological unit (or layer) of permeable material (like sand, gravel, or fractured bedrock) that is capable of providing usable quantities of water (Wikipedia, 2008).

Aquifers are zones that yield significant quantities of water (James, 1993). Aquifers may be confined or unconfined. Confined aquifers have low permeability of confining layers (an aquitard or aquiclude). Such as clay above and below, which restricts the upward and downward movement of water from the aquifer?

An unconfined aquifer is that which has no material restricting it from yielding water and are in the form of artesian wells that flows freely without the need of a pump. (Wikipedia,2008).

The media through which water flows in aquifers are:

- Unconsolidated rocks e.g. sand and gravels
- Semi consolidated rocks
- Other geological structures. (James, 1993).

1.4 AGRICULTURAL DEVELOPMENT PROGRAMMES (PILOT PROGRAMMES IN FADAMA LANDS)

Fadama literally means a land where water is retain or found the year round in some substantial amount that warrants dry season farming. There are times when the water table falls below the root penetration zone; hence, open wells, tube walls, and bore holes are drill on the farm site to augment shortage.

Agricultural development projects are found in every state of the federation and these aimed at boosting the agricultural input of every state (ADP Office Bida, 2008).

1.5 "EDOZHIGI" WHY IT WAS SELECTED FOR AGRICULTURAL DEVELOPMENT PROGRAMME

Edozhigi is a land blessed by God with a vast expanse of fadama land where the locals grow rice, sugar cane and other crops, the year round. In order to assist in dry season farming when there is no sufficient water to support plant growth, Agricultural development projects came into play by building of canals to transport water from the near by river as well as sinking of tube wells in the fields to augment shortage of water from ground and to assist in dry season farming.

1.6 SCOPE OF THE PROJECT WORK

The scope of this project work is to determine the suitability of tube wells for irrigational purposes.

1.7 LIMITATIONS OF THESE PROJECT WORK

The limitations encountered in the course this research work was lack of cooperation from the local farmers to access the tube wells because of damage to crops and also fear that government was about seizing the farmlands.

1.8 OBJECTIVES OF THE PROJECT WORK

The objectives of this project are:

- To analyze the quality of waters from the tube wells.
- To determine quantity volume of the waters from the tube wells to know their sufficiency.

1.9 JUSTIFICATION

Irrigation, a process whereby artificial water is applied artificially to the crop to aid in its growth during periods of short supply is one of the oldest method by man has been using in cultivating crops daily consumption and also commercial purposes. But due to advancement in technology, irrigation has improved tremendously in terms of machinery, methods, and the quality of the waters use for irrigation. In terms of quality, it is a known fact that qualitative water is necessary for optimum plant yield and reduction in the cost of reclamation of agricultural lands affected by hazards such salts accumulation. However, due to non-literacy of rural farmers, cost of water quality analysis, and of Agricultural development agencies, most of the waters used for irrigation rarely assessed. Furthermore, assessment ensures proper productivity and reduces loss of capital input while increasing overall productivity. Hence, it is noteworthy that prevention is better cure.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 TUBE WELLS

A tube well is a long vertical pipe (or tube) which is bored (or drilled) into the ground. The diameter of the tube varies from 8-60cm and the depth varies from 50-150m. A tube well intercepts a number of water bearing strata (aquifers). The area of flow and velocity in a tube well are more than that of an open well. In a tube well, a strainer is usually provided which prevents the movement of particles into the wells. This consequently leads having a large velocity of flow (Modi, 2006).

2.1.1 TYPES OF TUBE WELLS

a. **STRAINER TUBE WELLS**: These are the most popular types of tube wells generally used for irrigation. In such a tube well, a strainer (or screen) is placed against the water bearing strata so that it permits the flow but prevents sand particles from entering into the tube well. It can be constructed up to a depth of 150m in alluvial formations. The flow nature in this well radial (Garg, 2005).

b. **CAVITY TUBE WELLS**: A cavity tube well does not make use of a strainer. Rather they draw their supply from its bottom through a cavity and not from it's sides. In practice, it is similar to an open well which is deep. The flow is spherical in nature (Modi, 2006)

c. **SLOTTED TUBE WELL**: A slotted tube well consists of wrought iron pipe which is slotted for a part of its length at the lower portion and the rest of the length is plain (i.e. blind pipes). The slotted portion is placed against water bearing strata. The length of the pipe is about 5m. The slots are rectangular in shape with $2.5cm \times 0.3cm$ dimension. The spacing of the slots is 1.0cm to 1.20cm. The slotted part of the pipe is shrouded to prevent sand particles from going into the well (Arora, 2007).

d. **ARTESIAN TUBE WELL**: An artesian tube well can be constructed only where artesian or confined aquifers exist having a high piezometric surface so that the flow occurs automatically. Such tube wells are called flowing tube wells (Modi, 2006).

e. **TUBE WELLS ON HARD ROCKS**: A tube well can be constructed in hard rock formation with fissures through which water can easily flow. The overburden in such a well may require casing to eliminate the risk of caving-in. drilling is carried-out deep and left so water can easily flow into crevices and fissures into the bore. Water can be pumped out after lowering a suitable pump, depending upon the discharge and static water level (Garg, 2005).

2.1.1 TUBE WELLS CONTRUCTION TECHNIQUE

In West Africa, five main techniques are employed in tube wells construction. And they can be grouped under two headings as shown below:

a. **Drilling Techniques:** this employs the aid of a drill bit to penetrate the soil profile. The sub headings under it are:

- Small rotary rig method: this is the most versatile method since it is restricted only by hard rock formations. These rigs are designed to penetrate a maximum depth of 60 meters (Kaduna State ADP office, 2008).

- Percussion bailer (cable-tool) method: this equipment is made-up of a heavy drill bit, a bailing bucket consisting of a tube wit, a check valve at the bottom and a bail attached for attaching a cable or rope to the top. The method consist of alternating raising and dropping the chisel-edged bit to break loose and pulverize material from the bottom of the hole (FAO,2008).
- Vibro-bailer technique: this is a combined hand augering and bailing method of drilling in sandy river beds. It is limited to shallow depths of up to 10meters and holes 75mm in diameter. It is not suitable where layers of sand and clay are embedded except with use of special augers. Three semi-skilled technicians can easily mobilized 4-tube wells per day at close locations depending on litho logy (FAO, 2008).

b. **Jetting Technique:** The jetting technique uses a velocity stream of water to bore the well. The stream is generated by either by a motor or by a hand powered pump. The excavating material is washed. The erosive action of water is however ineffective in cases of hard materials. Semi hard materials may be penetrated by a combination of hydraulic and percussion effects which are obtained by raising and dropping a chisel-edged jetting bit. Moving coarse materials such as gravel vertically out of the hole requires a greater velocity than finer materials. Water pressure of $3kg/cm^2$ for sand and $7\text{-}11kg/cm^2$ for clay or gravel has been recommended. Basically two techniques are used:

- Clear water wash bore method: this jetting technique uses a plastic casing to support the wall of the hole until the slotted PVC lining has been placed. The temporary casing is then removed. Technically, the method appears to be quite satisfactory, except (common with jetting all methods) when penetrating clays. One solution used is hand augering through the clay layer using small diameter percussion tool inside the drilling pipe (having disconnected the water supply) or inside the casing (necessitating temporary removal of drilling). In cases of jetting through fine sands, it is often worthwhile continuing to greater depth in the hope encountering coarse material. The static water level will still rest within suction depth of surface but the yield of the hole will be significantly greater than if drilling stops in the fine materials (Michael and Ojha, 2003).

- Mud wash bore method: the mud wash bore method should be considered where full penetration of the aquifer is not possible with the clear water wash bore method because of lost of circulation in coarse sands and gravels (FAO, 2008).

2.1.2 HISTORY OF TUBE WELLS IN NIGERIA

In Nigeria, from 1983-1990, more than 15,000 wash bores and drilled tube wells were constructed in the three states of Sokoto, Bauchi, and Kano to irrigate 16,200 hectares of fadama lands. However, considering the 11 northern states and the middle zone states, more than 18,000 hectares were being irrigated with wash bores and drilled tube wells. The tube wells and wash bores technology for small scale irrigation has proven to very successful in Nigeria. It is much cheaper than large scale irrigation. The individual farmer's ownership of wells and the pumpers provides considerable independence in selecting crops, cropping patterns, and times of planting. It also allows adjustment of irrigation schedules in accordance with observed crop needs rather than rotation of large scale irrigation schemes. The success recorded by the various Agricultural development projects in Nigeria led to the National Fadama Development project in 1992. The 4-year project aimed at constructing 50,000 shallow tube wells in Bauchi, Jigawa, Kano, Kebbi, Sokoto and other eligible states. The maximum irrigation potential would be 100,000 hectares. Actual realization was expected to be around 50,000 hectares. The project would simplify drilling technology, privatize drilling operations, conduct aquifer studies, upgrade irrigation technology and organize fadama farmers for irrigation management (FAO, 2008).

2.2 IRRIGATION

Irrigation is the application of artificial water to the soil usually for assisting in growing crops. In crop production, it is mainly in dry areas and in periods of short rainfall. Irrigation is has been one of the oldest methods applied in growing crops in many parts of the world especially Africa and Asia (Wikipedia, 2008).

2.2.1 IRRIGATION PRACTICES IN NIGERIA

In Nigeria, irrigation is carried-out in the north and middle belt zones of the country where there is longer dry seasons and periods of short rainfall. The major source of irrigation water in these regions are dams, dug-out wells and recently tube wells and bore holes. One of the oldest techniques is the use of sardoff to lift water from dug-out wells or ditches to the field. Nowadays, mechanical pumps operated by diesel or petrol engines have replace sardoff.

2.2.2 TYPES OF IRRIGATION SYSTEMS

Irrigation systems are arrangements that facilitates the use of artificial water to grow crops in the most effective and efficient manner. They are majorly categorized into two:

a. **Surface Irrigation:** In surface irrigation systems, water flow on land surface in order to wet it and infiltrate into the soil. It can be further sub-categorized into:

- Furrow Irrigation: In furrow irrigation system, small, evenly spaced, shallow channels are installed down or across the slope of the field to be irrigated. Water is applied at the high end until the desired application and lateral penetration is obtained. Furrow irrigation is primarily used with clean tilled crops planted in rows. Many different soils are satisfactorily irrigated with furrow slope for 3-6%. Furrow lengths of 100 to 200m range are common (Egharevba, 2002).
- Level Border Irrigation: A border makes use of parallel earth ridges called borders to guide a sheet of flowing water across a field. The area between two borders is the border strip. Level border (basin) theoretically has no transverse slope. If practicable, it is best to make the border slope from 0.2 to 0.4%. The size of stream turned into a single border varies from 15 to 300 L/S depending on the kind of soil, the border size, and the nature of soil. Impervious sub-soils overlain by compact loam permit long border strips, whereas open soils having highly permeable gravelly sub-soils necessitate short narrow strips. Border strips may vary from 3 to 30m in width and 100 to 800m in length. Level border are normally dike at the downstream to prevent run-off (Michael, 1999)
- Graded Border Irrigation: in graded border (sloping), transverse slope occur. The under border irrigation is divided unto graded strips by constructing parallel dikes or border ridges. The ends of the border are usually not closed. Water is turned in at the upper end and flow as a sheet down the strip (Egharevba 2002).

b. **Localize Irrigation:** localize irrigation is a system where water is distributed under low pressure through pipe network, in a pre-determine pattern, and applied as small discharge to each plant or adjacent to it. It is sub-categorized into:

- Drip Irrigation: Trickle irrigation is also another name applied to drip irrigation. It consists of an extensive network of pipes usually of small diameter that deliver filtered water directly to the soil near the plant. The water outlet device in the pipe is called an emitter, water spread laterally and vertically by soil capillary forces augmented in the vertical movement by gravity. The wetted area by an emitted depends upon the flow rate, soil type soil moisture, and the soil hydraulic properties.

  The system components include the main, sub-main, laterals, emitters, pump, fertilizer injector, pressure regulator (gauge), and vacuum breaker. The filter system must remove essentially all debris, send, and clay to reduce clogging of the emitters. Lateral lines are generally in flexible PVC or polyethylene pipe 12 to 32mm in diameter. Emitters are inserted into the lateral lines at a pre-determine spacing chosen to fit crops and soil conditions (Egharevba, 2002).

- Sprinkler Irrigation System: A sprinkler irrigation system uses pressure energy to form and distribute "rain like" droplet over the surface. Sprinkler irrigation system is made of the following components sprinkler, riser pipe, and the pumping plant. Sprinkler irrigation is adaptable to many crops, soil and topographic conditions. Sprinkler system are classified according to whether the sprinkler heads are operated individually (gun or boom sprinkler) or as a group along a lateral, and according to how they are moved (or cycled) to irrigate the entire field. Fix-head sprinklers include most of the spray-type/mini sprinklers currently available. (Wikipedia, 2002).

2.2.3 SOURCES OF IRRIGATION WATER

The source of irrigation waters includes the following:

- Ground water
- Rivers
- Lakes
- Reservoirs
- Treated waste water
- Desalinated drainage water.(Egharevba, 2002)

2.4 QUALITY OF IRRIGATION WATER

The salinization /sodification hazard possessed by irrigation water can be readily predicted on the basis of the amount and types of salts contained in the water. (Eghareuba2002)

Salinization is the accumulation of salts in the upper layers of the soil from some outside source (Hand book of Agricultural Engineering, Volume I).

Three different hazards are distinguished respectively:

a. **Salinity hazard.** This refers to the danger of the use of irrigation water which will lead to osmotic problem in the soil/plant; that is uptake of water from soil would be difficult. The hazard may be diagnosed on the basis of Electrical conductivity value (in mm has $cm^{-}1$) of irrigation water. (Egharevba, 2002).

b. **Sodicity hazard:** This is dispersion problems caused by relatively high percentage occupancy of soil exchange by Na^+ which result in poor soil structure due easy dispersion of the colloids in the soil. This hazard can be appraised on the basis of two main diagnostic parameters (Electrical conductivity and sodium absorption ratio values). In general problems are not experienced in soils with Electrical conductivity value of $< 15\%$ (Egharevba, 2002).

c. **Toxicity hazard:** Toxicity problems are caused by a high concentration in the soil solution of particular ion or by the unbalance between two or more ions, harming plant growth (Wikipedia, 2008).

TABLE 2 GUIDELINE FOR INTERPRETATION OF WATER QUALITY FOR IRRIGATION

Potential Irrigation Problem			Units	Degree of Restriction on Use		
				None	Slight to moderate	Severe
Salinity (affects crop water available)						
	ECw		dS/m	<0.7	0.7-3.0	>3.0
	(or)					
	TDS		mg/l	<450	450-2000	>2000
Infiltration (affects infiltration rate of water into the soil. Evaluation using ECw and SAR together)						
SAR	=0-3	**and ECw** =		>0.7	0.7-0.2	<0.2
	=3-6	=		>1.2	1.2-0.3	<0.3
	=6-12	=		>1.9	1.9-0.5	<0.5
	=12-20	=		>2.9	2.9-1.3	<1.3
	=20-40	=		>5.0	5.0-2.9	<2.9
Specific Ion Toxicity (affects sensitive crops)						
	Sodium (Na)					
	Surface irrigation		SAR	<3	3-9	>9
	Sprinkler irrigation		me/l	<3	>3	
	Chloride(Cl)					
	Surface irrigation		me/l	<4	4-10	>10
	Sprinkler irrigation		me/l	<3	>3	
	BORON (B)5					
	Trace elements (see table 3)					
Miscellaneous Effects (affects susceptible crops)						
	Nitrogen (NO_3-N)		me/l	<5	5-30	>30
	Bicarbonate (HCO_3) (overhead sprinkling only)		me/l	<1.5	1.5-8.5	>8.5
	pH			Normal Range 6.5-8.4		

SOURCE: FAO, 2008

TABLE 3 LABORATORY DETERMINATIONS NEEDED TO EVALUATE COMMON IRRIGATION WATER QUALITY PROBLEMS

water parameter	symbol	unit	Usual range in irrigation water	
SALINITY				
Salt Content				
Electrical Conductivity	ECw	dS/m	0-3	dS/m
(or)				
Total Dissolved Solids	TDS	mg/l	0-2000	mg/l
Cat ions and Anions				
Calcium	Ca++	me/l	0-20	me/l
Magnesium	Mg++	me/l	0-5	me/l
Sodium	Na+	me/l	0-40	me/l
Carbonate	CO3-	me/l	0-.1	me/l
Bicarbonate	HCO3-	me/l	0-10	me/l
Chloride	Cl-	me/l	0-30	me/l
Sulphate	SO_4 -	me/l	0-20	me/l
NUTRIENTS				
Nitrate-Nitrogen	NO3-N	mg/l	0-10	mg/l
Ammonium-Nitrogen	NH4-N	mg/l	0-5	mg/l
Phosphate-Phosphorus	PO4-P	mg/l	0-2	mg/l
Potassium	K+	mg/l	0-2	mg/l
MISCELLANEOUS				
Boron	B	mg/l	0-2	mg/l
Acid/Basicity	Ph	1-14	6.0-8.5	
Sodium Adsorption Ratio	SAR	(me/l)	0-15	

SOURCE: FAO, 2008

d. **Salinity hazard.** This refers to the danger of the use of irrigation water which will lead to osmotic problem in the soil/plant; that is uptake of water from soil would be difficult. The hazard may be diagnosed on the basis of Electrical conductivity value (in mm has $cm^{-}1$) of irrigation water. (Egharevba, 2002).

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f. **Toxicity hazard:** Toxicity problems are caused by a high concentration in the soil solution of particular ion or by the unbalance between two or more ions, harming plant growth (Wikipedia, 2008).

2.4.1 SODIUM ABSORPTION RATIO (SAR)

Sodium absorption ratio is the ratio for soil for extracts in irrigation water use in expressing the relative activity of sodium ions in exchange reactions with soils (Michael, 1999).

It is express as:

$$SAR = Na^{+}/\surd(Ca^{++} + Mg^{++})/2 \quad (1)$$

Where Na^+, Ca^{2+} and Mg^{2+} represents the concentration of this elements in the irrigation water (Meq $L^{-}2$) (Egharevba, 2002)

2.4.2 EXCHANGEABLE SODIUM PERCENTAGE COMUTATION(ESP)

This is the degree of saturation of the soil exchange complex with sodium and may be calculated by the formula:

ESP =100(0.015 SAR)/1+ 0.015SAR (Egharevba, 2002). (2)

2.4.3 . CLASSIFICATION OF SALTY SOILS

Using EC, ESP, SAR and soil Ph, salt affected soils are classified as:

2.4.3.1 Saline soil: The process that results in the accumulation of neutral soluble salts are referred to as salinization. The salts are mainly chlorides and sulphates of sodium, calcium, magnesium and potassium. Saline salts contain a concentration of these salts sufficient to interfere with growth many plants. The electrical conductivity EC of saturation Extract of the soil solution is more than 4ds/m[4]. Salts are commonly brought to the soil surface by evaporating waters, creating white crust, which accounts for the name "white alkali" that is sometimes used to designate these soils.

The exchange complex of saline soils is dominated by calcium and magnesium. As a result, the exchangeable sodium percentage (ESP) is less than about 15, and the pH usually is less than 8.5.

The Na^+ ion concentration in the soil solution of saline soil may be some what higher than that of Ca^{2+} and Mg^{2+} due to the presence of soluble salts that are commonly high in sodium. However, because of the greater affinity of the soil colloids for divalent cat ions, such as Ca^{2+} and Mg^{2+}, the sodium adsorption ratio (SAR) of saline soils is less than 13. Plant growth on saline soils is not generally constrained by poor soil physical conditions. The soluble salts help prevent dispersion of the soil colloids that otherwise would be encouraged by high sodium levels (Brady and Weil, 1999).

2.4.3.2 saline-Sodic Soils: these soils have characteristics intermediate between those of saline and sodic soils. Like saline soils, they contain appreciable level of neutral soluble salts, as shown by EC levels of more than 4ds/m. but they have higher ESP levels (greater than 15) and higher SAR values (at least 13). Crop growth can be adversely affected by both excess salts and excess sodium levels. The physical and chemical conditions of saline-sodic soils are similar to those of saline soils. This is due to the moderating effects of the neutral salts. These salts provide excess cat ions that move closely to the negatively charged colloidal particles, thereby reducing their tendency to repel each other, or to disperse. These salts help keep the colloidal particles associated with each other in aggregates. Unfortunately, this situation is subject to rather rapid change if the soluble salts are leached from the soil, especially if the leaching waters are high in Na^+ ions- that are if the SAR of the water is high. In such a case, the exchangeable sodium level will increase, as well as the pH (to above 8.5). Since Na^+ ions are not attracted very closely to the soil colloids, the effective electro negativity of the colloidal particles causes them to repel each other or to disperse, thereby breaking the soil aggregates. The dispersed colloids clog the soil pores as they move down the profile. Water infiltration thus is greatly reduced and the puddle condition, hence, the characteristics of sodic soils (Brady and Weil 1999).

2.4.3.3 Sodic Soils: the preceding brief description of how sodic soils form suggests that they are the most troublesome of the salt affected soils. While their levels of neutral soluble salts are low (EC less than 4ds/m), their ESP values are above 13, suggesting a comparatively high level of sodium on the exchange complex. The pH value of sodic soils exceeds 8.5, rising to 10 or higher in some soils. The high pH is largely due to the hydrolysis of sodium carbonate.

$$2Na^{+} + CO_3^{2+} \rightarrow 2Na^{-} + HCO_3^{-} + OH^{-} \quad (3)$$

The sodium on the exchange complex also undergoes hydrolysis.

$$Na^{+} + H_2O \rightarrow H^{+} + Na^{+} + OH^{-} \quad (4)$$

Few plants tolerate these conditions. Plant growth on these soils is restricted by toxicities of $Na^{+,}$ OH^{-} and HCO_3^{-} ions, as well as by their very poor soil physical conditions and slow permeability to water. Because of the extremely alkalinity resulting from high sodium content, the surface of sodic soils often is discolored by the dispersed humus that can be carried upward by the capillary water and deposited when it evaporates. Hence, the name "black alkali" has been used to describe these soils. Sometimes located in small areas called "Slick Spots". Sodic soils may be surrounded by soils that are relatively productive (Brady and Weil, 1999).

TABLE 3: UNITED STATES SALINITY LABORATORY CLASSIFICATION SYSTEM OF SALTY SOILS.

ESP ≤ 15%	EC ≤ 4mm hos cm^{-1}	EC > 4mm hos cm^{-1}
	Non-saline soils	Saline soils
	Non-sodic soils	
ESP > 15%	Sodic soils	Saline soils

2.4.3.4 pH VALUE OF SALTY SOILS

In general, the ph value of a soil or neutral water is a measure of its alkalinity or acidity. More accurately, the ph value is a measure of the hydrogen-ion concentration in water. Water molecules (H_2O) have a slight tendency to breakdown into positive and negative ions. The chemical formula of water can also be written as HOH. When a water molecule breaks down, it divides into H^+ and OH^-. In distilled water, the number of hydrogen ion formed is such that their concentration is expressed by a ph value of 7 (mathematically this is the log to base 10 of the hydrogen ion concentration of pure water). This ph of value 7 indicates neutrality. A ph value of 7.5 to 8.0 indicates the presence of carbonates of calcium and a ph of 8.5 or above usually indicates appreciable exchangeable sodium (Michael, 1999). Therefore, the ph value of salty soils often fits the following pattern:

- Saline soils ph < 8.5

- Saline sodic soils ph = 8.5 (determined at the saturation extract)
- Sodic soils ph = 8.5 to 10 (determined at the saturation extract) (Egharevba,2002)

2.5 GUIDELINES FOR IRRIGATION WATER QUALITY APPRAISAL

The dangers posed salty soils includes the following:

- Interference with plant growth
- Dispersion of soil particles
- Reduction in permeability
- Poorer tilts
- Makes soil sticky and plastic when wet
- Formation of clods and crust in dry soil
- Reduction in plant yield (Schwab et. al, 1993).

With adequate quality appraisal, the condition of soils can be well determine, which leads to overall increase in plant yield and reduction in the cost of capital input. Some of the methods of salty soil reclamation include:

- Replacement of excessive adsorbed sodium with either calcium or magnesium. This commonly achieved by the addition of gypsum.
- Acid-forming amendments such as sulfur or sulfuric acid may be used on calcareous soils
- Leaching with sufficient water provided there is adequate drainage.
- Deep ploughing and inversion of the top soil (Schwab et al, 1993).
-

2.6 CROP WATER REQUIREMENT (CWR).

The quality of irrigation water needed to irrigate a given land area depends on a number of factors, the most important are:

- Nature of the crop
- Crop growth circle
- Climatic conditions
- Type and condition of soil
- Land topography
- Field application efficiency
- Conveyance efficiency
- Water quality

The crop takes its water from moisture held in the soil. Useful water for the crop varies between two levels i.e. the permanent wilting point (PWP) and field capacity (FC) Egharevba, 2002)

2.7 PROBLEMS ASSOCIATED WITH IRRIGATION IN NIGERIA, AFRICA AND THE WORLD

The problems associated with irrigation in Nigeria, Africa and the world over are:

- Competition for surface water rights
- Depletion of underground aquifers
- Ground subsidence
- Build-up of toxic salts on soils surfaces in areas of high evaporation

- Over irrigation because of poor distribution uniformity or management of waste waters and chemicals which leads to water pollution (Wikipedia, 2008).

2.4 RELATED WORK/ LITERATURE IN NIGERIA

India has made impressive gains in the last 30 years, increasing its irrigated land by more

than 50 percent. Besides undertaking close to 700 large irrigation projects on its rivers,

India has tapped underground water, employing hundreds of thousands of motor-driven

tube wells (Encarta, 2006).

Nigeria's Fadama Project is centered on developing small scale irrigation by extracting shallow groundwater with low cost gasoline- driving pumps for tube wells. About 30,000 hectares were irrigated using the complete tube well-pump package and with 30,500 pumps distributed to farmers. The project had a positive impact on farmer's income significant poverty reduction, and estimated rate of economic return of 40%. Additional benefits involved the development of a simplified well drilling technology, training of farmers to help other farmers construct wells, infrastructure for transporting and storing products, establishment of a Fadama User Association, and development of an extensive monitoring and evaluation system. The improved well fare of Fadama farmers can be attributed to the project (World Bank, 2002).

In Nigeria, shallow aquifers aquifers have been extensively tapped for irrigation since 1980s. Groundwater is present at depth of less than 200m in most fadamas throughout the dry season. Most agricultural development projects have used small mechanized rigs (Small rotary, percussion bailer and vibro-bailer. Agricultural development projects in Sokoto, Niger, Adamawa, Taraba and Benue State introduced manual bailers for drilling shallow tube wells. Well jetting was introduced in Nigeria in 1980s. more than 15,000 wells were drilled with jetting (or wash boring) technology between 1983 and 1990 in Bauchi, Kano, and Sokoto states, providing water sources for small scale irrigation of more than 16,000 hectares. Well jetting has also been undertaken extensively in 11 northern and middle zone states. In 1999-2000, wellspring Africa trained drillers on hand percussion in Nigeria. The organization manufactured the equipment locally, and trained technicians to operate it (RWSN community site, 2008).

The World Bank began a project in Nigeria in 1983 that involve installation of 15,000 low cost shallow tube wells technology. Combined technology that soon acquired the name "Fadama Irrigation". Fadama is the Hausa name for irrigable land- are flood plains and low laying areas underlined by shallow aquifers, found along Nigeria river systems. In 1992 the bank prepared a new project which will construct about 50,000 shallow tube wells, conduct aquifer studies, up grade irrigation technology, and privatize drilling(World Bank, 2008)

CHAPTER THREE

3.1 LOCATION OF PROJECT AREA

Edozhigi fadama land which is the project site is located along Bida-Mokwa road, though it is under Bida local government of Niger State. On the equator it is located on latitude 5°7″ East and longitude 8°10″ North (Mustapha and John, 2008).

3.2 GEOLOGY OF PROJECT AREA

The study area is located on Bida sandstone unit. It consist flat of lying poorly exposed coarse to fine elastic and icon stones known from bore holes and mesa sections. Sediments found in this project area are multicoloured varying from brown and yellow to green and white. The most commonly underlines the planes in the Bida area and is generally exposed in the lower mesa's hopes (Adeleye and Dessau Vagre 1994)

3.2 HYDROLOGY OF STUDY AREA

River Kaduna is the main river that supplies water to the fadama land. It has two sub rivers which are Kupanko and Ejiko which are perennial streams. Mostly at the end of may and at the beginning of june the rivers show rising followed by a peak in September and subsequent decline thereafter (Mustapha and John, 2008).

3.3 VEGETATION OF PROJECT AREA

Bida is located on the sudan savanna of Northern Nigeria. This area is by shrubs and small woody trees.

3.4 MATERIALS OF SAMPLE COLLECTION

The samples were collected from three tube wells in the study area. From each tube well one litre of water was collected in clean plastic water bottles. The samples were taken to the laboratory for analysis that same day for analysis.

3.5 METHODS OF ANALYSIS

3.5.1 WATER ANALYSIS

American public health association (APHA) format was used in carrying out the laboratory water quality analysis at Niger State water board (NSWB) central water quality laboratory.

3.5.1.1 DETERMINATION OF ELECTRICAL CONDUCTIVITY

- The conductivity meter/ T.D.S were switched on by pressing the appropriate button.
- the probe was immersed in a beaker containing the deionized water to rinse the probe.
- The probe was immersed in the beaker containing the sample. The probe was moved up and down and taped on the beaker to free any bubbles from the electrode area. The probe was immersed beyond the vent holes.
- The reading was recorded in microsiemens/cm (us/cm) or millisiemens/cm (ms/cm)

3.5.1.2 DETERMINATION OF TEMPERATURE

- Temperature/Conductivity/T.D.S meter was switched on by pressing the appropriate button.
- The probe was immersed in the beaker containing the deionized water to rince.
- The probe was immersed in the meter containing the sample, and moved up and down and taped on the beaker to free any bubbles from the electrode area. The probe was immersed beyond the vent holes.
- The reading was recorded in degrees Celsius (°C).

3.5.1.3 DETERMINATION OF PH (POTENTIAL HYDROGEN)

The PH was determination using universal PH strips and lovibond colour comparator with phenol red as an indicator.

- 2 clean 10ml cuvettes were used.
- Distilled water was filled in one of the 10ml cuvette to the mark as blank.
- The samples were filled in one of the 10ml cuvette and 1 to 2 of phenol red added.
- The phenol red disc was placed in the lovibond comparator. It as then rotated for colour matching. The reading was then recorded.

3.5.1.4 DETERMINATION OF TOTAL HARDNESS

- 100ml of water sample was poured in a 100-ml graduated mixing cylinder
- 1.0ml of Calcium and Magnesium indicator solution using 1.0ml measuring dropper was added. It was inverted several times to mix.
- 25ml of solution was added into each of the samples cells.

- one drop of 1MEGTA solutions was added to one cell (the blank) . It was too swirled to mix.
- One drop of EGTA solution was added to another cell (the prepared sample) and swirled to mix.
- A stored program number for magnesium was entered. 225 READ/ENTER were pressed. For units of mg/l mg as $CaCO_3$. The display showed: DIAL nm TO 522.
- The wavelength dial was rotated until the small display shows:522 nm
- READ/ENTER was pressed

  The display showed:

  Mg/l $CaCO_3$ mg

- The blank was placed into the cell holder. The light shield was closed
- Zero was pressed

  The display showed:

  WAIT Then 0.00mg/l $CaCO_3$ mg

- The prepared sample was placed into the cell holder. The light shield
- was closed.
- READ/ENTER was pressed
- The display showed:
- WAIT
- Then the result in mg as $CaCO_3$ was recorded.
- CONFIG/METH was pressed two times
- A stored program number for calcium was entered.

READ/ENTER was pressed for units of mg/l Ca as $CaCO_3$ was pressed. The display showed: DIAL nm TO 522

- READ/ENTER was pressed
- The showed: mg/l $CaCO_3$ Ca
- READ/ENTER was pressed
- The display showed:
- WAIT
- Then 0.00mg/l $CaCO_3$ Ca
- Placed the third sample into the cell holder.
- READ/ENTER was pressed
- The display showed:

WAIT

Then the result in mg/l Ca $CaCO_3$ as $CaCO_3$ was displayed

NOTE mg/l hardness equals mg/l plus mg/l mg $CaCO_3$

The conversion factors for determination of total hardness shown in Table 3.1

TABLE 4: CONVERSION FACTORS FOR TOTAL HARDNESS DETERMINATION.

TO CONVERT FROM	TO	MULTIPLY BY
Mg/l Ca as $CaCO_3$	mg/l Ca	0.400
mg/l Mg as	mg/l $MgCO_3$	0.842
mg/l $MgCO_3$	mg/l Mg	0.29
mg/l Mg as $CaCO_3$	mg/l Mg	0.243

3.5.1.5 DETERMINATION OF IRON CONTENT

- The stored program number for iron (Fe), ferrous powder pillows was entered.
- The wavelength dial was rotated until the displayed showed 510 nm.
- READ/ENTER was pressed.

  The display showed:

  Mg/1 Fe Fv

- A cell with 25ml of sample was filled
- The contents of one ferrous Iron powder pillow was added to the sample cell (the prepared sample) and swirled to mix. An orange color indicates the presence of Iron.

- SHIFT TIMER was pressed
- A 3- minute's reaction period began
- When the timer beeps, the display showed:

  Mg/1 Fe Fv

  Another sample cell (the blank) was filled with 25ml of sample.

- The blank was placed into the cell holder. The light shield was closed
- Zero was pressed.

  The display showed: WAIT

  Then: 0.00 Mg/1 Iron was closed.

- Within thirty minutes after the timer beeped, the prepared sample was placed into the cell holder. The light shield was closed.
- READ/ENTER was pressed

  The display showed: WAIT

  Then the result in Mg/1 Iron was displayed.

  NOTE: Samples containing visible rust was allowed to react at least five minutes.

3.5.1.6 DETERMINATION OF CHLORIDE

- 100ml of the sample and Mercuric Nitrate (Hg $(NO_3)_2$) titration cartridge corresponding to the volume of sample were selected.
- A clean delivery tube was inserted into the titration cartridge.

- Digital titration with the cartridge tip pointed up. Delivery knob of was turned to eject air and a few drops of the titrate. The counter was reset to zero and the tip was tip was wiped.
- A clean graduated measuring cylinder was used to measure 100ml of the sample. The sample was transferred into 250ml of conical flask.
- One Diphenyl Carbazone powder pillow was added and swirled to mix.
- The delivery tube tip was placed into the solution and swirled while titrating with the Mecuric Nitrate from a pale yellow to light pink color. The number of digits was recorded.
- Calculation:
- Digits X Digit Multiplier = Mg/l Chloride.

3.5.1.7 DETERMINATION OF SODIUM AND POTASSIUM

1000ppm stock solution of sodium (Na) and potassium (K) were prepared as described in the corning 410 flame photometer instruction manual and various dilutions made for the preparation of the calibration curves.

To obtain maximum linearity, corning recommends that the highest standard concentration does exceed 30ppm for sodium (Na) and 10ppm for potassium (K). Both standard solutions for Na and K were aspirated starting with the highest concentration standard. The value of each standard was noted and the result was plotted on a graph against standard concentration on linear graph paper

The sample and blank were also aspirated using a flame photomter with the filters of sodium and potassium. The value of respective elements was evaluated by extrapolating from the standard graph .

3.5.1.8 DETERMINATION OF SUSPENDED SOLIDS

- The stored program number was entered for suspended solids.

  630 read/enter was pressed

  The display showed:

  Dial nm to 81

- The wavelength dial was rotated until the small display shows
- 810nm
- Read /enter was pressed
- The display shows:
- Mg/l suspended solids.
- The sample cell with 25ml of tap or deionizer water (the blank) was filled
- The blank was placed in the holder .the light was closed.
- Zero pressed

  The display shows:

  WAIT

  Then: 0.mg/l suspended solids.

- The prepared sample cell was swirled to remove any gas bubbles and uniformly suspend any residue.

- The prepared sample was placed into the cell holder. The light shield was closed.
- The display showed :

  WAIT

  Then result in mg/l suspended solids was displayed.

3.5.1.9 DETERMINATION OF PHOSPHATE

This is determined by measuring 10ml of water sample into a micro-kjadhl flask,1ml of conc. H_2SO_4 should be added followed by 5ml of conc. HNO_3. this solution should be digested on digestion rack until the volume is reduced to 1ml and the solution turned colourless. This should be allowed to cool and 20ml of distilled water and one drop of phenolphthalein indicator should be added to the solution. 1M of NaOH should be added in drops until a fainmt pink tinge is observed . This could be made back to 100mls with distilled water.

Standard phosphate solution should also be prepared by accurately weighing 0.2195g anhydrous potassium di-hydrogen phosphate, KH_2PO_4 and dissolved it in 1 litre distilled water. Various concentrations are then prepared from the standard after digestion.

Molybdate reagent (ii) (25g of $(NH_4)_6$ $Mo_7O_{24}.H_2O$) should be dissolved in 175ml distilled water. 280ml H_2SO_4 of conc. should be added to 400ml distilled water which is made up to 1 litre . the different concentrations are then run on a spectro-photometer at 690nm in order to measure the intensity of the blue colour developed and this should be used to prepare standard calibration curve for phosphate .

The samples should also be treated the same and determine phosphate phosphorus and extrapolated from the standard curve

Calculation could be done using equation:

$$PO_4\text{-}P\ (mg/l) = \frac{reading\ from\ curve \times 1000\ D}{ml\ of\ sample} \qquad (5)$$

Where D is dilution factor

3.5.1.10 DETERMINATION OF NITRATE

This is determined by preparing stock nitrate solution by nitrate hethe stock by dissolving 20ml of the stock solution to 1litre of distilled water. Various concentrations should then be prepared from standard solution in the range 2ml-10ml. 50ml of water samples should be evaporated to dryness and 2ml of conc. Ethanol should be added to the residue after cooling and mix quickly. 15ml distilled water should be into the sample residue. 15ml of NaOH should be added which makes the colour turn yellow which indicates the presence of nitrate. The absorbance is then read on a spectrophotometer at 420nm.

Various concentrations of standard should be treated the same way as samples. Blank reagent should be prepared with sodium salicylate addition which is treated the same way. The absorbance of standard solution and the blank should also be read on spectrophotometer and the calibration curve should be drawn and samples concentrations are extrapolated from the curve.

Calculation could be done using equation:

$$NO_3\text{-}N\ (mg/l) = \frac{reading\ from\ curve \times 1000\ D}{ml\ of\ sample} \quad (6)$$

Where D is dilution factor

3.6 REAGENTS AND MATERIALS

The reagents and materials for the laboratory analysis are:

- Three water samples
- Analar perchloric acid
- Hydrochloric acid
- Distilled water
- BDH concentrated nitric acid
- Platinum crucibles
- Bibby hotplates bicasa product
- Thermometer
- Corning flame photometer 410 bicasa product
- Lovibond colour Bicasa product
- Biby merit W4000 Distiller
- Hach conductivity/ TDS meter
- DR/2000 direct reading spectrophtomter

- Back-ups 600
- HACH digital Titrator
- 60ml oxygen bottles
- Masking tape
- Wall clock
- 25ml sample cells
- Volumetric flasks
- Pipettes
- Dissolved oxygen 1 reagent
- Dissolved oxygen 2 reagent
- Dissolved oxygen 3 reagent
- Universal pH strips
- Iron reagent powder pillow
- sulphover 4 reagent powder pillow
- Calcium and Magnesium indicator
- Alkali solution
- Ethylenediamine-Tetra-acetic acid (EDTA) solution
- Ethylebis(oxyethlenenitrilo)Tetra-aceticacid(EGTA) solution
- Chloride 2 indicator powder pillow
- Silver nitrate (AgNO3) titration cartridge
- Sulphuric acid titration cartridge
- Phenolphthalein indicator powder pillow
- Bromo cresol green-methyl red indicator powder pillow

- Flame photometer standard 1000ppm potassium
- Flame photometer standard 1000ppm sodium
- Corning Air compressor 850
- Phenol red indicator Delivery tubes
- Clean towel
- COD vial adapter
- Zincover 5 reagent powder pillow
- Cyclohexanone
- Razor blade
- Chromium 1 reagent powder pillow
- COD Reactor
- Delivery tubes.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

TABLE 5 RESULT OF LABORATORY ANALYSIS

S/N	PARAMETERS	TUBE WELL 1	TUBE WELL 2	TUBE WELL 3
1.	Electrical Conductivity (us/cm)	110	180	80
2.	Temperature °C	31.6	31.6	31.6
3.	PH	6.8	7.2	6.9
4.	Total Hardness (mg/l)	50.0	40.0	80.0
5.	Iron Content (mg/l)	3.30	3.30	1.34
6.	Phosphate (mg/l)	0.2	0.133	0.155
7.	Total Alkalinity (mg/l)	70	110	45
8.	Hydroxyl (mg/l)	0.0	0.0	0.0
9.	Bicarbonate (mgl)	70	110	45
10.	Sulfate (mg/l)	9.0	4.0	2.0
11.	Chloride	20.10	15.00	8.60
12.	Suspended solids	66	44	60

(mg/l)			
13. Nitrate (mg/l)	0.11	0.09	0.116
14. Ca (mg/l)	4.88	3.91	7.81
15. Mg (mg/l)	7.32	5.86	11.72
16 Sodium (m/l)	8.10	6.32	9.41
17 Potassium (m/l)	2.23	1.54	1.83

4.2 DISCUSSION

4.2.1 ELECTRICAL CONDUCTIVITY

Electrical conductivity is actually a measure of salinity. It is the ability of irrigation water to conduct electricity. This is as a result of total dissolved solids in the water (TDS). This dissolved solids are mostly are positively charged ions as well negatively charged ions in irrigation. Excessive salinity can affect plants in the following ways:

- specific toxicity of a particular ion(such as sodium).
- higher osmotic pressure around the plants roots prevents an efficient water absorption by the plant.

Some plants are susceptible to salinity effects than other. Electrical conductivity is temperature dependent that is more temperature more EC. Lower temperatures also imply lower ECs. The values obtain from the three tube wells are 110, 180 and

80µs/cm respectively. They fall between the maximum and minimum value hence they are good for irrigation. (John L.H et al 2006).

4.2.2 TEMPERATURE

Temperature of irrigation of water can have a significant effect on plant growth. When the temperature is lower or higher than that of the soil, it can lead to plant shock. It is therefore advisable to irrigate during period of less heat of the day. It is for crop irrigation as it is constant through the wells (Hand of agricultural Engineering vol. i).

4.2.3 pH

The pH is a variable that regulates all biological function. Sometimes it has an inhibitory effect on process rates. It is the degree of acidity or alkalinity to soil or irrigation water. Recommended value ranges from 6.5-8.5. the pH scale is from 0-14, seven is the neutral point while from seven to one shows increase in acidity, similarly, from seven to fourteen indicates increase in alkalinity. The obtain values from the three tube wells are 6.8, 7.2 and 6.9 respectively. These values are within the normal range hence the water is good for irrigation. (John L.H et al 2006).

4.2.4 SUSPENDED SOLID

The presence of solids in suspension usually made from clay or from other materials derived from drainage waters, generally does not cause significant damage to crops (although it may leave an anesthetic covering of covering sediment on plant leaves). Clay and silt deposits affects irrigation canals in every part of world. (Hand book of agric-engineering).

4.2.5 IRON

Iron is an essential micronutrient that aids in the formation chlorophyll. It activates a number of important respiratory enzymes in plants. It is absorb principally as Fe^{3+} ions and also as Fe^{2+} ions. Deficiency results in severe chlorosis of the leaves,especially the young leaves. The values from the three tube wells are 3.30, 3.30 and 1.34 respectively. They fall within the normal range. (olaitan and lombin 1989).

4.2.6 CALCIUM

Calcium is absorbed as Ca^{2+} ion. It is an important constituent of middle lamella of plants cell walls. Calcium is essential for the growth meristem, root hairs, and root tips. It affects the permeability of cell membranes and influences the transport of carbohydrates and proteins in the plants. Calcium deficiency in plants leads to stunted growth with particularly poor root development. The readings show that the level of calcium is normal between the ranges which are: 4.88, 3.91 and 7.81 respectively. (Olaitan and Lombin 1989).

4.2.7 MAGNESIUM

Magnesium is absorbed as the divalent cation Mg^{2+}. Its deficiency leads to chlorosis and whitening of vein tissue on plants. This effect is mostly observed on leafy crops and maize. The level of magnesium in the water is very high as compared to the standard range of 0-5 this values are: 7.32, 5.86 and 11.72. (John L.H et al 2006).

4.2.8 SULPHATE

Sulphate is absorb by the plant in the form SO_4^{2+}. It is a major constituent of cell sap and some plant oils such as ground nut. Deficiency of sulphate results in stunted growth and spindly, pale green leaves with light colour veins. Yellow or white steaks may also be seen parallel to the veins of the leaves. Its level is normal within the given standard of 0-20 and the readings are: 9.0, 4.0 and2.0 respectively for the three tube wells. (John L.H et al 2006).

4.2.9 NITRATE

Nitrate is an important nutrient in pnt growth and gives leaves a good green colour. It is an essential part proteins nd some of these perform regulating functions in the plants ıd influence the utilisation of many other nutrients. The values obtain arerithin tl nomal range of 0-10 which are: 0.11, 0.09 and 0.116 respectively for th three tuwells. (John L.H et al 2006).

4.2.10 PHOSPHATE

This helps in development of reproductive plants. Deficiency leads to slow plant growth, slander stalks, delayed m y yield. Maize deficiency may lead purple colouration of the leaves. Th in are within the normal range of 0-2 and they are: 0.2, 0.133 and l vely for the three tube wells. (John L.H et al 2006).

4.2.11 CHLORIDE

This helps in osmosis and cation neutralisation which are important to biochemical processes. The values obtain are within the normal range of 0-30 and they are 20.10, 15.00 and 8.60. (Olaitan and lombin 1989).

4.2.12 POTASSIUM

Apart from nitrogen potassium is the second larger nutrient absorbed by plants. It assists in plants early stages of growth.

Its quantity in the irrigation water collected from the three tube wells are 2.23, 1.54 and 1.83 respectively and they fall between the normal range of 0-2 with a slight increase of 0.23 from the firs tube well. (Olaitan and lombin, 1989).

4.2.13 SODIUM

Sodium is very essential for plant growth but if it exceeds the required standards it can cause severe problem to the crop as well as the soil itself. It is leading in causing soil sodicity and salinity hazards.

The values obtain so far are above the normal range of 0-5 and they are: 8.10, 6.32 and 9.41. (Olaitan and lombin,1989).

compared to the standard range of 0-5 this values are: 7.32, 5.86 and 11.72. (John L.H et al 2006).

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4.2.12 POTASSIUM

Apart from nitrogen potassium is the second larger nutrient absorbed by plants. It assists in plants early stages of growth.

Its quantity in the irrigation water collected from the three tube wells are 2.23, 1.54 and 1.83 respectively and they fall between the normal range of 0-2 with a slight increase of 0.23 from the firs tube well. (Olaitan and lombin, 1989).

4.2.13 SODIUM

Sodium is very essential for plant growth but if it exceeds the required standards it can cause severe problem to the crop as well as the soil itself. It is leading in causing soil sodicity and salinity hazards.

The values obtain so far are above the normal range of 0-5 and they are: 8.10, 6.32 and 9.41. (Olaitan and lombin,1989).

4.2.14 BICARBONATE/TOTAL ALKALINITY

The result shows the quantity of bicarbonates/total alkalinity is within the specified range of 5-30.

4.2.15 TOTAL HARDNESS

The first and second readings are within the specified range while the reading is off the range with about 0.33me/l.

4.2.16 SODIUM ADSORPTION RATIO (SAR) FOR TUBE WELL 1 It was calculated to be 1.523, 0.935, and0.989 respectively. This values are within the specified range of 0-5. Hence the irrigation water do not pose any danger to crops.

4.3 WATER QUANTITY

Using a 5.5hp water pump machine, the discharge from the wells showed that the wells can produce 2L/s to 5L/s of discharge rate. This is sufficient to irrigate the fadama land during period of peak demand.

CHAPTER FIVE

5.1 CONCLUSION

Conclusively, the water samples from the three tube-wells taken are good for irrigational purpose terms of quality and quantity. Although it was observed that some of the parameters are a bit higher than the given standard but the difference is not that much to cause severe damage to the crops.

5.2 RECOMMENDATION

It was observed that the galvanized pipes used for the tubing were attacked by corrosion; therefore it recommended that polymer pipes that can withstand the pumping pressure should be used.

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APPENDICE

Converting EC to T.D.S, $TDS = 0.67 \times EC\ \left(\frac{dS}{m}\right)$

1000μs/cm = 1 dS/m

dS/m = decisiemen/metre in S.I units (equivalent to 1 mmho/cm = 1 millimmho/centi-metre)

mg/l = milligram per litre ≈ parts per million

me/l = milliequivalent per litre (mg/l ÷ equivalent weight = me/l); in S.I units, 1 me/l = 1 millomol/litre adjusted for electron charge