

**DETERMINATION OF IRRIGATION WATER QUALITY FOR THE GROWTH OF**

**TOMATO(*Lycopersicon esculentum*)**

**(Case study of Maizube Farm, Niger state, Nigeria)**

**BY**

**MOGEKWU, IFEANYI NDUBUEZE**

**MATRIC No. 2005/21630EA**

**DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING**

**FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA**

**DECEMBER, 2010.**

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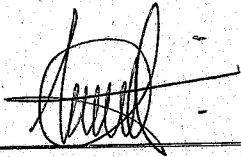
**MATRIC No. 2005/21630EA**

**BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL  
FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF  
ENGINEERING (B. ENG) DEGREE IN AGRICULTURE & BIORESOURCES  
ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER  
STATE.**

**DECEMBER, 2010**

## 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 or diploma or certificate at any university or institution. Information derived from personal communication, published and unpublished work were duly referenced in the text.



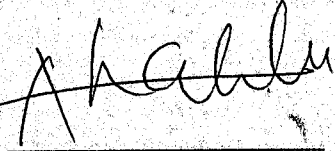
Mogekwu, Ifeanyi Ndubueze

12-12-2010

Date

## CERTIFICATION

This is to certify that the project entitled " Determination of Irrigation Water Quality For the Growth of Tomato ( Lycopersicon esculentum) Mogekwu, Ifeanyi Ndubueze meets the regulations governing the award of the degree 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.

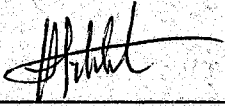


Mallam. H. Adamu

Project supervisor

16-12-10

Date



Engr. Dr. A.A Balami

Head of Department

16-12-10

Date



External Examiner

8/12/2010

Date

## DEDICATION

This project work is dedicated to the great God of the universe and to my beloved parents.

## ACKNOWLEDGEMENTS

I sincerely thank the Trinitarian God for his infinite mercy, blessings, guidance and sustenance over my life. My special appreciation goes to my supervisor, Mallam Adamu for his advice, corrections and guidance throughout my research work. May God bless you. Much thanks goes to the entire staff of Agricultural and Bioresources engineering department of the Federal University of Technology Minna, who in one way or the other have contributed to my success.

My thanks also goes to my caring and loving father, Mr Gabriel Moge kwu and also to my ever motivating mother, Mrs Josephine Moge kwu and my amazing sisters; Sandra, Pamela, Isioma, and Ifeoma, your unrelenting support and fervent prayers towards my academic advancement were and are invaluable contributions to my success. To my friends; so numerous to mention. You all were ever faithful and encouraging. Finally, to all members of the Anglican Students' Fellowship for your love and moral contributions and prayers.

## ABSTRACT

The main aim of this work is to analyse the irrigation water of Maizube's farm Minna, Niger state and determine the effect of poor irrigation water quality to the growth of tomato. The total amount of dissolved salts in the water and the amount of sodium (Na) in the water compared to calcium (Ca) plus magnesium (Mg) determine the suitability of water for irrigation use. Irrigation water quality can best be determined by chemical laboratory analysis. The irrigation water quality which has a Sodium Adsorption Ratio (SAR) of 0.1 me/l poses no immediate danger to tomato which has a soil salinity tolerance of 2.5. The criteria for irrigation water quality such as the leaching requirement, the sodium adsorption ratio, all fell within the standard. Irrigation water with such a quality is suitable for use on tomatoes, but extensive use of this quality of irrigation water on clay soils where little or no leaching occurs may eventually cause saline or sodic soil problem.

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## ABBREVIATIONS

SAR: Sodium Adsorption Ratio

RSC: Residual Sodium Carbonate

LF: Leaching Factor

LR: Leaching Requirement

EC<sub>dw</sub>: Salinity of drainage water percolating below the root zone

EC<sub>sw</sub>: Salinity of soil- water

EC<sub>w</sub>: Salinity of Applied Irrigation Water.

Na: Sodium

Ca: Calcium

Mg: Magnesium

## CHAPTER ONE

### 1.0 INTRODUCTION

#### 1.1 Background of Study

It is well documented that the amount and quality of irrigation water available in many of the arid and semi-arid regions of the world are the main limiting factors to the extension of agriculture (Mofeke, 2006). Saline-sodic irrigation water, coupled with the low annual rain fall and high evaporation and transpiration in the arid and semi-arid regions, have resulted in the accumulation of soluble salt in the soil solution which can alter the structure and consequently affect the soil hydraulic conductivity (Mofeke, 2006).

Conceptually, water quality refers to the characteristics of a water supply that will influence its irrigated agriculture is dependent on an adequate water supply of usable quality. Water quality concerns have often been neglected because good quality water supplies have been plentiful and readily available. This situation is now changing in many areas. Intensive use of nearly all good quality supplies means that new irrigation projects and old projects seeking new or supplemental supplies must rely on lower quality and less desirable sources. To avoid problems when using these poor quality water supplies, there must be sound planning to ensure that the quality of water available is put to the best suitable use, i.e. how well the quality meets the needs of the user (Babalola 1999).

Quality is defined by certain physical, chemical and biological characteristics. Even a personal preference such as taste is a simple evaluation of acceptability. For example, if two drinking waters of equally good quality are available, people may express a preference for one supply rather than the other; the better tasting water becomes the preferred supply. In irrigation water

evaluation, emphasis is placed on the chemical and physical characteristics of the water and only rarely are any other factors considered important (FAO 1993).

Specific uses have different quality needs and one water supply is considered more acceptable (of better quality) if it produces better results or causes fewer problems than an alternative water supply. For example, good quality river water which can be used successfully for irrigation may, because of its sediment load, be unacceptable for municipal use without treatment to remove the sediment. Similarly, snowmelt water of excellent quality for municipal use may be too corrosive for industrial use without treatment to reduce its corrosion potential (FAO 1993).

The ideal situation is to have several supplies from which to make a selection, but normally only one supply is available. In this case, the quality of the available supply must be evaluated to see how it fits the intended use. Most of the experience in using water of different qualities has been gained from observations and detailed study of problems that develop following use. The cause and effect relationship between a water constituent and the observed problem then results in an evaluation of quality of degree of acceptability. With sufficient reported experiences and measured responses, certain constituents emerge as indicators of quality-related problems. These characteristics are then organized into guidelines related to suitability for use. Each new set of guidelines builds upon the previous set to improve the predictive capability. Numerous such guidelines have become available covering many types of use (FAO 1993).

The build-up of salts in irrigated regions is of particular concern since 14% of cultivated lands that is irrigated supplies approximately half of the world's food (Akorado, 2000). This has prompted this research on the effect irrigation water quality has on plants, specifically tomato.



Tomato is a major vegetable crop that has achieved tremendous popularity over the last century. It is grown in practically every country in the world, in outdoor fields, greenhouses and net houses (Bolarinwa, 2004). Since salinity can alter the soil, making it less desirable for growing tomatoes which is used in many food products including; tomato sauce (ketchup), pasta, pizza etc. According to a steel packaging Tomato (*Lycopersicon esculentum*) is a major food plant and it is moderately sensitive to salinity (Bolarinwa, 2004). Extensive research is necessary to develop growing conditions in lands affected with poor irrigation water quality to produce good vegetative growth. The effect of irrigation water quality on plants has been studied in different tomato cultivars (Akoroda,2000)

## **1.2 Statement of the Problem**

The suitability of water for irrigation is determined not only by the total amount of salt present but also by the kind of salt. Various soil and cropping problems develop as the total salt content increases, and special management practices may be required to maintain acceptable tomato yields. As a result, there is no set limit on water quality; rather, its suitability for use is determined by the conditions of use which affect the accumulation of the water constituents and which may restrict crop yield. The soil problems most commonly encountered and used as a basis to evaluate water quality are those related to salinity, water infiltration rate, toxicity and a group of other miscellaneous problems

## **1.3 Objectives of the Study**

The objectives of this project are:

- i. To analyze the irrigation water in the area of study,
- ii. To determine the effect of water quality on the growth of tomatoes,
- iii. To determine methods of improving irrigation water quality available to crops.

#### **1.4 Justification of the Study**

Tomato is a widely distributed annual vegetable crop adapted to a large variety of climates. However, in spite of its broad adaptation, production is concentrated to a few warm and rather dry areas. In these areas with an optimal climate for tomato, Irrigation water quality is a serious constraint for maintaining high productivity. For this reason, the study on the irrigation water quality for the growth tomato cannot be over-emphasized.

#### **1.5 Scope of the Work**

The scope of the work is centred to analyzing the irrigation water quality for the growth of tomatoes using Maizube farm Minna, Niger state as a case study.

#### **1.6 Description of the study site**

The study site of this project is Maizube farm. Maizube farm is an integrated private farm located at km 26 Minna-Bida Road, Minna, Niger State, North-Central Nigeria. Maizube farm is on latitude  $09^{\circ} 25'95N$  longitude  $06^{\circ} 22'60E$ . The farm has been in existence for over 20 years. The farm consists of four major sections which are the dairy, orchard, green house and field crop farm. The annual rainfall varies from 1,100mm to 1,600mm. The maximum temperature is recorded between the months of March and June while the minimum rainfall is between the months of December and January. Also the rainy season lasts for about 150days. The source of the irrigation water is a flood dam located in the farm. The water from the dam is pumped to a storage reservoir.

## CHAPTER 2

### 2.0 LITERATURE REVIEW

#### 2.1 Historical Background

As an important occupation in Nigeria, agriculture provides employment for about 60 percent of the population (Onayemi, 1991). However, there is a wide gap between food production and the need of the whole population. There are evidences of malnutrition and under nutrition as most Nigerians are underfed in terms of protein and energy. Agricultural practice is still largely at the subsistence level, hampered by small farm holdings which have been found to be less than 0.5 ha (Fagoyinbo, 1992). Low productivity and high population growth necessitate investment into well-planned irrigation schemes. Obviously, irrigation schemes possess several advantage over non-irrigated schemes. Irrigation improves crop yield and quality while allowing for optimal utilization of water resources by application of water at the root-zone of the crop. Better dietary value of food eaten by the poor, higher standard of living and availability of varieties of food are some of the advantages of irrigation (Agunwamba, 1999).

Irrigated agriculture is dependent on an adequate water supply of usable quality. Water quality concerns have often been neglected because good quality water supplies have been plentiful and readily available. This situation is now changing in many areas. Intensive use of nearly all good quality supplies means that new irrigation projects and old projects seeking new or supplemental supplies must rely on lower quality and less desirable sources. To avoid problems when using these poor quality water supplies, there must be sound planning to ensure that the quality of water available is put to the best use (Ogunkunle, 1999).

Conceptually, water quality refers to the characteristics of a water supply that will influence its suitability for a specific use, i.e. how well the quality meets the needs of the user. Quality is defined by certain physical, chemical and biological characteristics. Even a personal preference such as taste is a simple evaluation of acceptability. For example, if two drinking waters of equally good quality are available, people may express a preference for one supply rather than the other; the better tasting water becomes the preferred supply. In irrigation water evaluation, emphasis is placed on the chemical and physical characteristics of the water and only rarely is any other factor considered important (FAO, 1993).

Specific uses have different quality needs and one water supply is considered more acceptable (of better quality) if it produces better results or causes fewer problems than an alternative water supply. For example, good quality river water which can be used successfully for irrigation may, because of its sediment load, be unacceptable for municipal use without treatment to remove the sediment. Similarly, snowmelt water of excellent quality for municipal use may be too corrosive for industrial use without treatment to reduce its corrosion potential (FAO, 1993).

The ideal situation is to have several supplies from which to make a selection, but normally only one supply is available. In this case, the quality of the available supply must be evaluated to see how it fits the intended use. Most of the experience in using water of different qualities has been gained from observations and detailed study of problems that develop following use. The cause and effect relationship between a water constituent and the observed problem then results in an evaluation of quality of degree of acceptability. With sufficient reported experiences and measured responses, certain constituents emerge as indicators of quality-related problems. These characteristics are then organized into guidelines related to suitability for use. Each new set of

guidelines builds upon the previous set to improve the predictive capability. Numerous such guidelines have become available covering many types of use (FAO, 1993).

There have been a number of different water quality guidelines related to irrigated agriculture. Each has been useful but none has been entirely satisfactory because of the wide variability in field conditions. Water used for irrigation can vary greatly in quality depending upon type and quantity of dissolved salts. Salts are present in irrigation water in relatively small but significant amounts. They originate from dissolution or weathering of the rocks and soil, including dissolution of lime, gypsum and other slowly dissolved soil minerals. These salts are carried with the water to wherever it is used. In the case of irrigation, the salts are applied with the water and remain behind in the soil as water evaporates or is used by the crop (FAO, 1993).

The suitability of water for irrigation is determined not only by the total amount of salt present but also by the kind of salt. Various soil and cropping problems develop as the total salt content increases, and special management practices may be required to maintain acceptable crop yields. Water quality or suitability for use is judged on the potential severity of problems that can be expected to develop during long-term use. The problems that result vary both in kind and degree, and are modified by soil, climate and crop, as well as by the skill and knowledge of the water user. As a result, there is no set limit on water quality; rather, its suitability for use is determined by the conditions of use which affect the accumulation of the water constituents and which may restrict crop yield. The soil problems most commonly encountered and used as a basis to evaluate water quality are those related to salinity, water infiltration rate, toxicity and a group of other miscellaneous problems (Ogunkunle 1993).

## 2.2 Water Quality-Related Problem In Irrigated Agriculture

### 2.2.1 Salinity

Soil salinity is a worldwide problem hampering the productivity of several agricultural crops.(Ogunkunle, 1999).The build up of salts in irrigated regions are of particular concern since 14% of cultivated land that is irrigated supplies approximately half of the world's food(Akoroda, 2000).Salinity exacts many economic and environmental costs. These include a reduction in agricultural productivity, a decline in the quality of water supplies for drinking, irrigation and industrial use, damage to urban infrastructure and the loss of biodiversity in both terrestrial and aquatic ecosystems many land degradation processes, including wind and water erosion, salinity is a natural process. However land use practices, such as clearing and irrigation, have significantly increased the extent of the problem (Idachaba 1992).

Salinity refers to the presence of soluble salts in the soil and water, including surface water and groundwater. The salt can be in many forms including sodium chloride, calcium, magnesium, carbonate, bicarbonate and sulphate. Some soils and landscapes are saline in their natural state, for example inland salt lakes and soils formed from saline parent materials. This is called natural or primary salinity. Secondary salinity is due to human activities such as land clearing and over-irrigation. These activities result in groundwater rising to the surface, dissolving the salts and then depositing them in the soil (Ogunkunle, 1999).

Groundwater is a layer of soil that is saturated with water that has slowly trickled down through the soil until it cannot go any further because it is stopped by a layer of impermeable soil or rock (bedrock).Salt can be found in many old, highly weathered landscapes and originates from:

Weathering of rock minerals,

Deposition of oceanic salt onto the landscape by wind or rain,

Soils formed from marine sediments left behind by retreating seas, (Adekunle, 2007).

In undisturbed landscapes, most of the salt is slowly leached into the subsoil, beyond the reach of plant roots. There are two main forms of salinity: dry land salinity and irrigation salinity (Adekunle 2007).

### **2.2.2 Dry land Salinity**

Salinity problems in the soil and surface water bodies occur when more water enters the groundwater system (through a process called recharge) than is discharged from the system. This imbalance causes the water table to rise. As it rises, the groundwater dissolves the soluble salts stored in the subsoil and brings salty water into the reach of plant roots. Evaporation and plant uptake of the water concentrates the salt in the topsoil - where it stays (Ogunkunle, 1999).

The main cause of rising groundwater is the clearing of deep-rooted, perennial native vegetation and its replacement with shallow-rooted, annual crop and pasture species. These introduced species use less water than the native vegetation, resulting in increased groundwater recharge and water table rise (Mustapha, 2008).

Land clearing is the past and present cause of dry land salinity. It takes approximately 30 years from the time of clearing for dry land salinity problems to appear, although in some areas they may appear sooner. The most obvious effect of salinity is the decline in agricultural productivity that is associated with saline soils. High concentrations of salt in the soil are toxic to plants, restrict plant uptake of water and prevent plants from taking up essential nutrients such as calcium (Idachaba, 1992).

Aside from declining agricultural productivity, salinity causes many other problems including:

Salinisation of groundwater aquifers and dams that supply water for human consumption, agricultural or industrial use,

Damage to infrastructure on farms and in regional towns including roads, buildings, fences, railways, water pipes, water supply systems, houses, gas pipes, and gas supply systems,

Loss of biodiversity as a result of degradation of remnant bush land, riparian vegetation, and wetlands,

Other land degradation problems such as wind and water erosion, (Agunwamba, 1999).

In addition to these economic and environmental costs, salinity also exacts a social cost. This cost includes the emotional and health-related costs of the family farm going bankrupt and the impact of facing the possibility the farm may not be passed onto the next generation (Agunwamba, 1999).

### **2.2.3 Management of Dryland Salinity**

Dry land salinity is essentially a water balance problem, since it is the movement of water that controls salt transport. Excess recharge into groundwater stores causes water tables to rise, carrying dissolved salts to the surface. Salinity management, therefore, focuses on reducing groundwater recharge (Mustapha, 2008).

The salinity problem is very difficult to solve because:

The issues are complex,

Management strategies that are effective in one area may not be applicable in another area,



The cost of salinity control is high,

Management strategies put into place today may take many years to have any effect, (Mustapha, 2008).

There are several approaches to salinity control, including protection of remnant vegetation, agronomic measures and engineering solutions. The consensus seems to be that a combination of management practices is the most realistic approach to salinity management. (Mustapha, 2008)

Protection of remnant vegetation,

Protecting remnant vegetation can help control recharge and has the added benefit of helping to maintain the biodiversity and heritage values of the landscape,

Agronomic measures,

Agronomic approaches to dry land salinity management include:

Improving the way traditional crops and pastures are farmed by using strategies such as opportunity or response cropping where planting is timed to favourable climatic or soil conditions,

Introducing perennial crops and pastures, including some deep-rooted species, into farm rotations, which reduce deep drainage as they use water all year round and to a greater depth in the soil,

Planting trees to intercept rainfall and to use fresh, shallow groundwater, (Mustapha, 2008).

The main problem with agronomic approaches is the introduction of new crop, pasture and tree species into existing farming systems, as this means that new equipment may be needed and new

skills developed by the farmers. Additionally, there is uncertainty about the market prospects for new crops and a lack of commercially viable species suitable for low rainfall area (Akoroda, 2000).

Another management option is salt land farming, which involves planting salt-affected land with salt-tolerant grasses or shrubs. Planting discharge areas with salt-tolerant vegetation is an important strategy for decreasing the spread of salinity, reducing the visual impact of saline land, decreasing erosion and obtaining some productivity from salt-tolerant grasses and shrubs. Salt land farming is an important strategy for managing existing saline land; however its contribution to controlling groundwater recharge is minimal. (Mustapha, 2008)

Engineering options;

Low flat country is particularly prone to salinity and a combination of paths, channels and contour banks may be used to manage salinity.

Other engineering options include:

Drainage of surface water to alleviate flooding and water logging,

Drainage of saline groundwater to lower water tables and alleviate water logging,

Pumping of fresh groundwater to lower water tables and prevent the development of dry land salinity problems, (Idachaba, 1992).

Drainage can be advantageous as it effectively removes water from areas where it is problematic and, providing the water is potable (fresh), can supplement farm water supplies. However, engineering works can be expensive to install, operate and maintain, and there is the problem of

where to dispose the saline water without causing environmental problems downstream (Idachaba, 1992).

#### **2.2.4 Irrigation Salinity**

Irrigation salinity is the accumulation of salts in the topsoil under irrigation. It is caused by over-irrigation of agricultural land, inefficient water use, poor drainage and the irrigation of unsuitable and 'leaky' soils. All of the above increase groundwater recharge and result in water table rise, bringing salts to the soil surface. The problem is exacerbated by the use of low quality (i.e. salty) irrigation water. Even mildly saline water can cause salinity problems because evaporation and plant uptake remove the water, leaving the salt to accumulate in the soil (FAO, 1993).

#### **2.2.5 Problems Associated With Irrigation Salinity**

Irrigation salinity results in similar problems to dry land salinity including:

Decreasing agricultural productivity,

Damage to farm and urban infrastructure, including irrigation equipment,

Declining groundwater and surface water quality, (FAO, 1993).

#### **2.2.6 Management of Irrigation Salinity**

Like dry land salinity, irrigation salinity is a water balance problem and is managed by reducing groundwater recharge by;

Avoiding over-irrigation by using irrigation techniques such as drip irrigation, monitoring soil moisture to determine when the soil needs irrigating and matching water applications to plant water requirements,

Using deep-rooted crops and pastures to minimize deep drainage,

Grow salt-tolerant species on salt-affected land,

Engineering solutions such as subsurface drainage to intercept deep drainage, surface drainage to collect surface runoff or groundwater pumping (FAO, 1993).

A coordinated approach is generally required with a mixture of engineering and other solutions and over a large area. Salinity stress results in a clear stunting of tomato growth, which results in a considerable decrease in fresh and dry weights of leaves, stems and roots. Increasing salinity is also accompanied by significant reductions in shoot weight, plant height and root length (Babalola, 1999 and Agunwamba, 1993). Exposure of plants to salt stress usually begins in the roots. This leads to changes in growth, morphology and physiology of the root that will in turn change water and ion uptake and the production of signals that sends information to shoot. The whole plant is then affected when roots are growing in a salty medium. Tomato cultivars varied significantly in their response to different salinity levels. Increasing NaCl concentrations in nutrient solution adversely affect tomato shoots and roots, plant height,  $K^+$  concentration, and  $K^+/Na^+$  ratio. In the Mediterranean and arid climates, nearly 200 000 ha are under off season protected cultivation. Under protected agriculture, the risk of soil salinization is relatively high as salt can accumulate at a higher rate and in a shorter period, than under outdoor conditions (Owusu, 2009).

Therefore, it appears useful to understand, first the reaction of tomatoes to salinity and then to analyze its consequences for the yield and water use efficiency of the crop. This study is part of a long-term experiment on the use of saline water, started in 1989 at the Mediterranean Agronomic Institute at Bari, southern Italy. Previous papers (Munns et al., 2000) described the experimental

procedure and the effect of soil salinity on water stress, growth and yield of various crops (broad beans, wheat, potatoes, maize, sunflower and sugar beets).

The behaviour of the tomato plant under saline conditions appears to be similar to that under drought conditions. Ashraf (1994) reported a lack of response of leaf growth to water stress, whereas yield and fruit size decreased. Gadallah (2004) did not observe a remarkable difference in vegetative growth, but in reduced yield and a decrease of the fruit weight in case of deficit irrigation. The tomato plant apparently favours under conditions of water stress, owing either to salinity or to moisture deficit, the growth of foliage at the expense of fruit formation, which is the cause of the low yield and water use efficiency. This may be improved by balancing growth of foliage and fruit formation, e.g. blocking the growth of foliage by suppressing the terminal shoot.

### **2.3 Water Infiltration Rate**

An infiltration problem related to water quality occurs when the normal infiltration rate for the applied water or rainfall is appreciably reduced and water remains on the soil surface too long or infiltrates too slowly to supply the crop with sufficient water to maintain acceptable yields. Although the infiltration rate of water into soil varies widely and can be greatly influenced by the quality of the irrigation water, soil factors such as structure, degree of compaction, organic matter content and chemical make-up can also greatly influence the intake rate. (Agunwamba, 1999).

The two most common water quality factors which influence the normal infiltration rate are the salinity of the water (total quantity of salts in the water) and its sodium content relative to the calcium and magnesium content. A high salinity water will increase infiltration. A low salinity

water or a water with a high sodium to calcium ratio will decrease infiltration. Both factors may operate at the same time. Secondary problems may also develop if irrigations must be prolonged for an extended period of time to achieve adequate infiltration. These include crusting of seedbeds, excessive weeds, nutritional disorders and drowning of the crop, rotting of seeds and poor crop stands in low-lying wet spots. One serious side effect of an infiltration problem is the potential to develop disease and vector (mosquito) problems. An infiltration problem related to water quality in most cases occurs in the surface few centimeters of soil and is linked to the structural stability of this surface soil and its low calcium content relative to that of sodium. When a soil is irrigated with a high sodium water, a high sodium surface soil develops which weakens soil structure. The surface soil aggregates then disperse to much smaller particles which clog soil pores. The problem may also be caused by an extremely low calcium content of the surface soil. In some cases, water low in salt can cause a similar problem but this is related to the corrosive nature of the low salt water and not to the sodium content of the water or soil. In the case of the low salt water, the water dissolves and leaches most of the soluble minerals, including calcium, from the surface soil (FAO 1993).

## 2.4 Toxicity

Toxicity problems occur if certain constituents (ions) in the soil or water are taken up by the plant and accumulate to concentrations high enough to cause crop damage or reduced yields. The degree of damage depends on the uptake and the crop sensitivity. The permanent, perennial-type crops (tree crops) are the more sensitive. Damage often occurs at relatively low ion concentrations for sensitive crops. It is usually first evidenced by marginal leaf burn and interveinal chlorosis. If the accumulation is great enough, reduced yields result. The more

tolerant annual crops are not sensitive at low concentrations but almost all crops will be damaged or killed if concentrations are sufficiently high. The ions of primary concern are chloride, sodium and boron. Although toxicity problems may occur even when these ions are in low concentrations, toxicity often accompanies and complicates a salinity or water infiltration problem. Damage results when the potentially toxic ions are absorbed in significant amounts with the water taken up by the roots. The absorbed ions are transported to the leaves where they accumulate during transpiration. The ions accumulate to the greatest extent in the areas where the water loss is greatest, usually the leaf tips and leaf edges. Accumulation to toxic concentrations takes time and visual damage is often slow to be noticed. The degree of damage depends upon the duration of exposure, concentration by the toxic ion, crop sensitivity, and the volume of water transpired by the crop. In a hot climate or hot part of the year, accumulation is more rapid than if the same crop were grown in a cooler climate or cooler season when it might show little or no damage (Babalola, 1999).

Toxicity can also occur from direct absorption of the toxic ions through leaves wet by overhead sprinklers. Sodium and chloride are the primary ions absorbed through leaves, and toxicity to one or both can be a problem with certain sensitive crops such as citrus. As concentrations increase in the applied water, damage develops more rapidly and becomes progressively more severe (Babalola 1999).

## **2.5 Miscellaneous Problems**

Several other problems related to irrigation water quality occur with sufficient frequency for them to be specifically noted. These include high nitrogen concentrations in the water which supplies nitrogen to the crop and may cause excessive vegetative growth, lodging, and delayed

crop maturity; unsightly deposits on fruit or leaves due to overhead sprinkler irrigation with high bicarbonate water, water containing gypsum, or water high in iron; and various abnormalities often associated with an unusual pH of the water. A special problem faced by some farmers practicing irrigation is deterioration of equipment due to water-induced corrosion or encrustation (Mofeke,2006).

This problem is most serious for wells and pumps, but in some areas, a poor quality water may also damage irrigation equipment and canals. In areas where there is a potential risk from diseases such as malaria, schistosomiasis and lymphatic filariasis, disease vector problems must be considered along with other water quality-related problems. Vector problems (mosquitoes) often originate as a secondary trouble related to a low water infiltration rate, to the use of wastewater for irrigation, or to poor drainage. Suspended organic as well as inorganic sediments cause problems in irrigation systems through clogging of gates, sprinkler heads and drippers. They can cause damage to pumps if screens are not used to exclude them. More commonly, sediments tend to fill canals and ditches and cause costly dredging and maintenance problems. Sediment also tends to reduce further the water infiltration rate of an already slowly permeable soil (Mofeke, 2006).

## **2.6 Classification of Water Quality**

The most damaging effects of poor-quality irrigation water are excessive accumulation of soluble salts and/or sodium in soil. Highly soluble salts in the soil make soil moisture more difficult for plants to extract, and crops become water stressed even when the soil is moist. When excessive sodium accumulates in the soil, it causes clay and humus particles to float into and plug up large soil pores. This plugging action reduces water movement into and through the soil, thus crop



roots do not get enough water even though water may be standing on the soil surface (Gordon, 2003).

## 2.7 Interpretation of Water Classes

Oklahoma irrigation waters are grouped into six classes on the basis of soluble salt content and sodium percentage.

Interpretation of these classes in relation to their use follows:

Class 1. Excellent. The total soluble salt content and sodium percentage of this water are low enough that no problems should result from its use.

Class 2. Good. This water is suitable for use on most crops under most conditions. Extensive use of Class 2 water on clay soils where little or no leaching occurs may eventually cause a saline or sodic soil problem. Normal rainfall will usually dilute the soluble salts and eliminate the risk of salt accumulation. If the water's sodium percentage is high (above 30 percent), gypsum can be used periodically to remedy the problem.

Class 3. Fair. This water can be used successfully for most crops if care is taken to prevent accumulation of soluble salts including sodium, in the soil. Good soil management and irrigation practices must be followed. Class 3 water can be used with little danger on permeable, well-drained soils. The water table should be at least 10 feet below the surface to allow accumulated salts to be leached below the root zone by excessive irrigation when rainfall is limited.

Class 4. Poor. Use of this water is restricted to well drained permeable soils for production of salt tolerant crops. Irrigation practices must receive careful attention to avoid salt accumulation. Excess water must be applied when rainfall is not adequate to cause periodic salt leaching.

Good soil management practices must be used to maintain good physical condition of the soil.

Soil fertility levels must be maintained at adequate levels. Use of this water on medium

textured soils may cause soil salinity problems if good practices are not followed. This water is not recommended for use on fine textured soils.

Class 5. Very Poor. Use of this water is restricted to irrigation of sandy, well-drained soils in areas of the state which receive at least 30 inches of rainfall. This water should not be used without advice from a trained in irrigation water use.

Class 6. Unsuitable. Water of this quality is not recommended for crop irrigation.(Gordon, 2003).

The four problem categories previously discussed - salinity, infiltration, toxicity and miscellaneous -were used for evaluation. Water quality problems, however, are often complex and a combination of problems may affect crop production more severely than a single problem in isolation. The more complex the problem, the more difficult it is to formulate an economical management programme for solution (FAO 1993)

If problems do occur in combination, they are more easily understood and solved if each factor is considered individually. Therefore, the guidelines and discussion which follow treat each problem and its solution separately, so that a number of factors are evaluated for each of the problem areas, such as:

the type and concentration of salts causing the problem;

the soil-water-plant interactions that may cause the loss in crop yield;

the expected severity of the problem following long-term use of the water;

the management options that are available to prevent, correct, or delay the onset of the problem (FAO 1993).

## 2.8 Conditional Use of Low Quality Water

Water of undesirable quality may be used successfully when the undesirable aspects of the water are off-set by certain desirable aspects of the water or positive conditions of its use. These aspects include the following:

Gypsum content of the water /or soil,

Soil characteristics,

Effective rainfall,

Water table level,

Type of crop,

Gypsum additions,

Gypsum,

When water contains high concentrations of calcium and sulfate, some of these two chemicals will combine in the soil and form gypsum. Therefore, the harmful soluble salts left in the soil will be reduced somewhat, and there will be less risk in using this water. Water which is high in gypsum can be used on clay textured soils. Irrigation water which has a high sodium hazard (high SAR or RSC) may be used if the soil contains gypsum or if gypsum can be added to the soil. The amounts of gypsum required will depend on the excess sodium or residual carbonate in the water and how much water is applied (Gordon, 2003).

The amount of gypsum needed to off-set residual sodium carbonate in an acre-foot of water can be calculated using the formula:

$$\text{Ibs gypsum per acre} = 232 \text{ Ibs} \times \text{RSC}$$

The value of RSC, given in epm, is reported on the irrigation water analysis report. For example, if 24 inches (2 acre-feet) of water is applied during the growing season and the water has a RSC level of 2 epm, the gypsum required per acre-foot of water would be:

$232 \text{ lbs} \times 2 = 464 \text{ lbs gypsum per acre.}$

For the 2 acre-feet of water applied, twice as much would be needed.  $464 \text{ lbs gypsum per acre-foot} \times 2 \text{ acre-feet} = 928 \text{ lbs gypsum per acre (Gordon, 2003).}$

The gypsum could be added every four years at the rate of two ton per acre.

Many soils and waters in western Oklahoma contain native gypsum. Water which is of low quality because it contains excess residual sodium carbonate or excess sodium may be used on these soils with less risk. Water high in total salts, however, has more risk and should not be used on these soils (Gordon, 2003).

#### Soil Characteristics.

Sandy textured soils are less likely to accumulate salts or sodium and generally more water can be applied to them than fine textured soils. Because of this, there is less hazard in irrigation coarse textured soils with low quality water. Also, salts and sodium can be leached much easier from coarse textured soils if that becomes necessary (Gordon 2003).

#### Water Table.

It is extremely important that the water table be at least 10 feet below the surface when low quality water is used. This allows water movement below the root zone if leaching becomes necessary and it eliminates movement of salts from the water table to the soil surface (Gordon,2003).

### Effective Rainfall.

The risks of using low quality water are lessened as effective rainfall increases. Rain dilutes the salt and sodium in the soil. Therefore, areas which normally receive more than 30 inches of rain have less risk in using low quality water than areas receiving less rain (Gordon, 2003).

### Type of Crop.

Crops vary in their tolerance to salts; low quality water may be used on tolerant crops after they are established. Using low quality water during germination and seedling development should be avoided, however, since most plants are very sensitive to salts at this stage of growth (Gordon, 2003).

## CHAPTER 3

### 3.0 MATERIALS AND METHOD

#### 3.1 Materials

The following materials were used to carry out the analysis of irrigation water quality collected from Maizube's farm located at km 26 Minna-Bida road, Minna, Niger State.

##### 3.1.1 Equipment used

Table 1: The List of Equipment

S/N	Equipment
1	white porcelain dish, 200ml
2	burette, 25ml
3	graduated cylinder, 100ml
4	stirring rods
5	pH meter
6	volumetric flask, 50ml
7	colorimeter
8	spectrophotometer
9	filter photometer
10	measuring spoon
11	electric timer
12	magnetic stirrer
13	acid -washed glass ware

### 3.2 Sample Preparation

The irrigation water sample was collected from maizube's farm minna, in three sample bottles labeled A, B, and C respectively. The sample bottles were thoroughly cleaned and samples taken on different days to avoid exponential errors of the result of the physico-chemical analysis. The first sample was collected in the month of July and while the other two samples were collected in the month of September.

### 3.3 Physico - Chemical Analysis of Irrigation Water

Three general method of quantitative determination were used in the water analysis- gravimetric, volumetric, colorimetric. The gravimetric method consists of separating single substances from the water sample by chemical and mechanical means, weighing each substance separately and calculating the proportion of each with respect to the total sample. This method was used to determine the amount of undissolved solid in the sample it was also used for determining the total amount of dissolve solid.

The volumetric analysis was performed by adding to measured portion of the water sample the exact volumes of standard-strength of chemical solution required to bring about a specific chemical change, the procedure is called titration. The amount of each mineral constituent being analysis in the water sample was estimated directly from the volume of each standard chemical solution required

The colorimetric analysis were those whose result where base on comparism of colour produce in the water sample with those of prepare standard. The photometric water analyses is the precise photoelectric colour measuring instrument it comprises of a constant voltage

transformer, a prefocused bulb a holder for precise, optically polish glass cells and a sensitive and reproducible photocell. In line with the light beam is rotatable disc containing accurately designed filters. This filters server to accentuate the instrument ability to measure accurately the minute colour differences. In addition to major and minor element the water analyzer was also for determining the pH, turbidity and oxygen demand index of the water sample.

The analysis included total salt concentration or electrical conductivities cationic anionic composition, viz., calcium, magnesium, sodium, potassium, chloride, sulphate, bicarbonate, nitrate and boron.

### **3.4 Determination of Leaching Factor**

Salts are added to the soil with each irrigation. These salts will reduce crop yield if they accumulate in the rooting depth to damaging concentrations. The crop removes much of the applied water from the soil to meet its evapotranspiration demand (ET) but leaves most of the salt behind to concentrate in the shrinking volume of soil-water. At each irrigation, more salt is added with the applied water. A portion of the added salt must be leached from the root zone before the concentration affects crop yield. Leaching is done by applying sufficient water so that a portion percolates through and below the entire root zone carrying with it a portion of the accumulated salts. The fraction of applied water that passes through the entire rooting depth and percolates below is called the leaching fraction (LF).

After much successive irrigation, the salt accumulation in the soil will approach some equilibrium concentration based on the salinity of the applied water and the leaching



fraction. A high leaching fraction ( $LF = 0.5$ ) results in less salt accumulation than a lower leaching fraction ( $LF = 0.1$ ). If the water salinity ( $EC_w$ ) and the leaching fraction ( $LF$ ) are known or can be estimated, both the salinity of the drainage water that percolates below the rooting depth and the average root zone salinity can be estimated. The salinity of the drainage water can be estimated from the equation:

$$\text{leaching fraction (LF)} = \frac{\text{depth of water leached below the zone}}{\text{depth of water applied at the surface}} \quad (3.1)$$

$$EC_{dw} = \frac{EC_w}{LF} \quad (3.2)$$

where:

- $EC_{dw}$  = salinity of the drainage water percolating below the root zone (equal to salinity of soil-water,  $EC_{sw}$ )
- $EC_w$  = salinity of the applied irrigation water
- $LF$  = leaching fraction

[Adapted from mass (1984)]

### 3.5 Determination of Leaching Requirement

When the build-up of soluble salts in the soil becomes or is expected to become excessive, the salts can be leached by applying more water than that needed by the crop during the growing season. This extra water moves at least a portion of the salts below the root zone by deep percolation (leaching). Leaching is the key factor in controlling soluble salts brought in by the irrigation water. Over time, salt removal by leaching must equal or exceed the salt

additions from the applied water or salts will build up and eventually reach damaging concentrations.

To estimate the leaching requirement, both the irrigation water salinity ( $EC_w$ ) and the crop tolerance to soil salinity ( $EC_e$ ) must be known. The water salinity can be obtained from laboratory analysis while the  $EC_e$  should be estimated from appropriate crop tolerance data given in the tables in Section 2.4.3 of this paper. These tables give an acceptable  $EC_e$  value for each crop appropriate to the tolerable degree of yield loss (usually 10 percent or less).

The necessary leaching requirement (LR) can be estimated from Figure 7 for general crop rotations. For more exact estimates for a particular crop, the leaching requirement equation (9) (Rhoades 1974; and Rhoades and Merrill 1976) should be used:

$$LR = \frac{EC_w}{5(EC_e) - EC_w} \quad (3.3)$$

Where;

LR = minimum leaching requirement.

$EC_w$  = average soil salinity tolerated by the crop as measured on a soil saturation extract.

[Adapted from mass (1984)]

### 3.6 Determination of Sodium Adsorption Ratio

Excessive sodium in irrigation water also promotes soil dispersion and structural breakdown but only if sodium exceeds calcium by more than a ratio of about 3:1. Such a relatively high

sodium content ( $>3:1$ ) often results in a severe water infiltration problem due to soil dispersion and plugging and sealing of the surface pores, in much the same way as does the very low salinity water. This is due to lack of sufficient calcium to counter the dispersing effects of the sodium. Excessive sodium may also make it extremely difficult to supply enough water to meet the crop water demand. Other related problems such as soil crusting, poor seedling emergence, lack of aeration, plant and root diseases weed and mosquito control problems caused by the low rate of infiltration may further complicate crop management.

In the past, several procedures have been used to predict a potential infiltration problem. The Residual Sodium Carbonate (RSC) method (Eaton 1950; Richards 1954) was widely used at one time. The most commonly used recent method to evaluate the infiltration problem potential has been and probably still is the Sodium Adsorption Ratio (SAR) (Richards 1954).

In recent reports and journal articles, SAR is more and more frequently being reported as RNA and not SAR. The terms are synonymous. The SAR procedure encompasses the infiltration problems due to an excess of sodium in relation to calcium and magnesium. It does not take into account changes in calcium in the soil water that take place because of changes in solubility of calcium resulting from precipitation or dissolution during or following irrigation. Sodium, an important part of salinity, remains soluble and in equilibrium with exchangeable soil sodium at all times. Whether concentrated from withdrawal of water by the crop between long irrigation intervals, diluted with applied water, or leached away in drainage, outside influences have little effect on sodium solubility

or precipitation. Calcium, however, does not remain completely soluble or in constant supply but is constantly changing until an equilibrium is established. Calcium changes occur due to dissolution of soil minerals into the soil-water thus raising its calcium content, or to precipitation from soil-water, usually as calcium carbonate, thus reducing the calcium. Dissolution is encouraged by dilution and by carbon dioxide dissolved in the soil-water; precipitation may take place because of the presence of sufficient calcium along with enough carbonate, bicarbonate or sulphates to exceed the solubility of calcium carbonate (limestone) or calcium sulphate (gypsum). Soon after irrigation, dissolution or precipitation may occur, changing the supply of calcium and establishing an equilibrium at a new calcium concentration, different to that in the applied water. The SAR equation, since it does not account for these changes, is therefore somewhat in error. However, the SAR equation and procedure is still considered an acceptable evaluation procedure for most of the irrigation water encountered in irrigated agriculture.

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}} \quad (3.4)$$

where: Na = sodium in me/l  
 Ca = calcium in me/l  
 Mg = magnesium in me/l

[ Adapted from Rhoades and Merrill (1976)]

### 3.7 Calculation of Concentration of Deep Percolation.

$$EC_{sw} = EC_{dw} = \frac{EC_w}{LF} \quad (3.5)$$

Where;

$EC_{sw}$  = The concentration soil-water percolating below the root zone,

$EC_{dw}$  = Concentration of drainage water,

$EC_w$  = Electrical conductivity of irrigation water,

LF = Leaching fraction.

[ Adapted from Rhoades and Merrill (1976)]

## CHAPTER FOUR

### 4.0 RESULT AND DISCUSSION OF RESULTS

#### 4.1 Result

The results from the physico – chemical analysis of the irrigation water are given below.

#### 4.2 Result of Each Mineral Constituent Analyzed.

Table 4.1: Result of Physico-Chemical Analysis of Irrigation Water

Parameter	Measured Values			
	Units	1	2	3
Conductivity	$\mu\text{S/cm}$	113.00	105.00	133.00
pH	-	6.31	6.18	6.29
Turbidity	NTU	11.44	10.58	1.84
TDS	mg/l	75.71	70.35	89.11
Carbonate	mg/l	0.00	0.00	0.00
Nitrate-Nitrogen	mg/l	0.48	0.36	2.39
Calcium	mg/l	93.08	71.06	23.02
Magnesium	mg/l	9.01	16.01	67.06
Sulphate	mg/l	3.00	5.00	0.00
Phosphate	mg/l	1.50	2.00	0.02
Boron	mg/l	0.005	0.005	0.005
Sodium	mg/l	1.00	1.50	3.00
Manganese	mg/l	0.70	0.90	0.00
Potassium	mg/l	3.35	3.35	5.36
Bicarbonate	mg/l	10.00	10.00	24.00
Chloride	mg/l	27.49	24.99	29.49
Iron	mg/l	0.43	0.33	0.38
Total Hardness	mg/l	102.09	87.07	94.58

Table 4.2: Irrigation Water Quality Guide

Potential Irrigation Problem	Units	Degree of Restriction on Use		
		None	Slight to Moderate	Severe
<b>Salinity</b>				
EC <sub>w</sub>	ds/m	< 0.7	0.7-3.0	> 3.0
TDS	mg/L(10 <sup>-3</sup> kg/m <sup>3</sup> )	< 450	450-2000	> 2000
<b>Permeability EC<sup>b</sup> w</b>				
SAR= 0-3		≥ 0.7	0.7-0.2	< 0.27
SAR= 3-6		≥ 1.2	1.2-0.3	< 0.3
SAR= 6-12		≥ 1.9	1.9-0.5	< 0.5
SAR= 12-20		≥ 2.9	2.9-1.3	< 1.5
SAR= 20-40		≥ 5.0	5.0-2.9	< 2.9
<b>Specific ion toxicity<sup>c</sup></b>				
<b>Sodium (Na)</b>				
Surface Irrigation	SAR	< 3	3.9	> 9
Sprinkler Irrigation	mg/L	< 70	< 70	
<b>Chloride (Cl)</b>				
Surface Irrigation	mg/L	< 140	140-350	> 350
Sprinkler Irrigation	mg/L	< 100	> 100	
Boron (B)	mg/L	< 0.7	0.7-3.0	> 3.0
<b>Trace Elements</b> see: Pescod (1992)				
<b>Miscellaneous Effects<sup>d</sup></b>				
Nitrogen (total N)	mg/L	< 5	5-30	> 3.0
Bicarbonate (HCO <sub>3</sub> )	mg/L	< 90	90-500	> 500
PH	unit less		6.5-8.4 <sup>e</sup>	
Residual Cl (overhead)		< 1.0	1.0-5.0	> 5.0

Source: Adapted from Pescod (1992)

### 4.3 Result of the Sodium Adsorption Ratio;

From result of physico – chemical analysis;

Na = 3.0 mg/l, 1.0 mg/l, and 1.5mg/l (for the three samples, respectively )

Therefore;

$$Na = \frac{3 + 1.0 + 1.5}{3} = 1.83mg/l$$

Ca = 23.02mg/l, 93.08mg/l and 71.06mg/l (for the three samples, respectively )

Therefore;

$$Ca = \frac{23.03 + 93.08 + 71.06}{3} = 62.39 \text{ mg/l}$$

Mg = 67.06mg/l, 9.01mg/l, and 16.01mg/l (for three samples, respectively)

Therefore;

$$Mg = \frac{67.06 + 9.01 + 16.01}{3} = 30.69 \text{ mg/l}$$

Note;

Me/l = mg/l ÷ equivalent weight

$$\text{Equivalent weight} = \frac{\text{atomic weight (grams)}}{\text{valence}}$$

$$\text{Equivalent weight of Na} = \frac{22.9898}{1} = 22.99$$

$$\text{Equivalent weight of Ca} = \frac{40.08}{2} = 20.04$$

$$\text{Equivalent weight of Mg} = \frac{24.312}{2} = 12.16$$



Hence;

Sodium

$$\text{Na} = \frac{1.83}{22.99} = 0.08 \text{me/l}$$

Calcium

$$\text{Ca} = \frac{62.39}{20.04} = 3.11 \text{me/l}$$

Magnesium

$$\text{Mg} = \frac{30.69}{12.16} = 2.52 \text{me/l}$$

Substitution values into equation (i)

$$\text{SAR} = \frac{0.08}{\sqrt{\frac{3.11 + 2.52}{2}}} = 0.05 \approx 0.1$$

#### 4.4 Result of Leaching Requirement

The tolerance data given by mass, indicates that a full yield [potential should be obtained for nearly all crops when using a water which has a salinity less than 0.7 ds/m

Hence;

$$\text{LR} = \frac{0.117}{5(2.5) - 0.117} = 0.0094 \approx 0.01 \text{ (for a 100 percentage yield potential)}$$

$$\text{LR} = \frac{0.117}{5(3.5) - 0.117} = 0.0067 \approx 0.01 \text{ (for a 90 percentage yield potential)}$$

#### 4.5 Result of Leaching Fraction

Note: from the result of the physico-chemical analysis, the salinity of the applied water ( $EC_w$ ) is 0.117ds/m.

As a general rule thumb, at a 15-20% leaching fraction, salinity of the applied water ( $EC_w$ ) can be used to predict or estimate soil-water salinity ( $EC_{sw}$ ) or soil salinity ( $EC_e$ ).

Using the following equations;

$$EC_{sw} = 3 EC_w$$

$$EC_e = 1.5 EC_w$$

$$EC_{sw} = 2 EC_e \quad (\text{mass 1984})$$

Since;

$$EC_{dw} = 3EC_w \text{ (using general rule thumb)}$$

$$EC_{dw} = 3 \times 0.117 = 0.351$$

From equation 2;

$$EC_{dw} = \frac{EC_w}{LF}$$

Making LF subject of the formula

$$LF = \frac{EC_w}{EC_{dw}} = \frac{0.117}{0.351} = 0.3$$

#### 4.6 Result of Deep Percolation

Since;

$EC_w = 0.117$  ds/m (result of physio – chemical analysis of irrigation water)

$LF = 0.3$  [substituting the value of 'EC<sub>w</sub>' and 'LF' in equation (1)]

$$EC_{dw} = \frac{0.117}{0.3} = 0.39 \text{ ds/m}$$

#### 4.7 Discussion of results

From the result of 4.3, that is, the Sodium Adsorption Ratio (SAR) calculated in milliequivalent per litre (me/l), the result is 0.1me/l. When compared with the SAR and EC<sub>w</sub> values adopted from Rhoades 1997, and Oster and Schroer 1979, which are 0-3, and >1.9 for SAR and EC<sub>w</sub> respectively, the result of the Sodium Adsorption Ratio of the irrigation water falls between the range; that is 0-3 and the EC<sub>w</sub> of tomato is greater than 1.9 as given by the guideline adopted. This suggests full production capability of tomatoes without the use of special practices, since the guideline adopted indicates no restriction on use. Although the continuous use of this irrigation water would over-time lead to salt build-up, which would hamper the growth of tomato.

Considering the result in 4.4 which is the result of the leaching requirement, the salinity of the irrigation water would determine the leaching requirement. In the result of the leaching requirement, the salinity of the applied irrigation water is 0.117 ds/m. Bernstein and Francois 1973a classified low-salinity water and saline water as 0.6 ds/m and 3.8 ds/m respectively. When compared with the EC<sub>w</sub> value from the physico-chemical

analysis, it was discovered to be a low-salinity water, which would require a low leaching requirement, which based on this research is 0.01.

The leaching fraction (LF) calculated for in fig 4.5 is 0.30, which means that 30 percent of the applied irrigation water entering the surface percolates below the root zone of the tomatoes and 70 percent replaces water used by the tomato to meet its crop-water use (ET) demand and water lost by surface evaporation.

Hence, also note worthy is the concentration of the soil-water below the root zone in fig 4.6 which is equivalent to the concentration of the drainage water ( $EC_{dw}$ ) accumulating below the root zone. From the result given in fig 4.6, the salinity of the soil-water that is percolating from the bottom of the root zone ( $EC_{dw}$ ) is approximately 0.39 ds/m. This reveals that with leaching fraction of 0.3, the soil-water salinity is more concentrated than the applied irrigation water.

## CHAPTER FIVE

### 5.0 CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusion

The following conclusions were drawn from the results of this study;

1. The suitability of water for irrigation is determined not only by the total amount of salt present but also by the kind of salt.
2. Various soil and cropping problems develop as the total salt content increases, and special management practices may be required to maintain acceptable tomato yields.
3. There is no set limit on water quality; rather, its suitability for use is determined by the conditions of use which affect the accumulation of the water constituents and which may restrict tomato yield.
4. The soil problems most commonly encountered and used as a basis to evaluate water quality are those related to salinity.
5. Water quality or suitability for use is judged on the potential severity of problems that can be expected to develop during long-term use.

## 5.2 Recommendation

As a result of the research carried out on the irrigation water quality for the growth of tomatoes, using Maizube farm as a case study, the following recommendations are suggested;

1. More researches should be carried out on the irrigation water quality guideline specifically in view of Nigeria's climatic conditions, nature of soil and salt tolerance characteristics of tomato, as this is a major hindrance to irrigation water quality management directly or remotely.
2. In addition to proper crop selection, appraisal of irrigation water quality of Maizube farm would offer proficient information able to indicate how to improve tomato yield through the improvement and management of irrigation its water quality.

## REFERENCES

- Adekunle, I.M. Adetunji, M.T. Gbadebo, A.M. Banjoko, O.B (2007). Assessment of Groundwater Quality in a Typical Rural Settlement in Southwest Nigeria. *International Journal of Environmental Research and Public Health*. 4 (4): 307-318
- Agunwamba, J.C. (1993). Poverty, sustainable development and Environmental Technology. *Proceedings*, pp. 90-108.
- Agunwamba, J.C. (1999). Rethinking Efficiency, Effectiveness, Equity and Sustainability of Irrigation Development.
- Akorado, M.O. Agronomy in Nigeria,(2000).
- Ashraf, M. (1994). Breeding for salinity tolerance in plants. *Crit. Rev. Plant Sci.*, 13: 17-42.
- Ayers R.S. and Westcot D.W. (1976). *Water Quality for Agriculture*. FAO Irrigation and Drainage Paper 29, FAO, Rome. 97p.
- Babalola, O.( 1999). *Perspective on Land Use and Soil Management for Sustainable Agricultural Development*.
- Bernstein L. and Francois L.E.( 1973)b. Leaching Requirement Studies: Sensitivity of Alfalfa to Salinity of Irrigation and Drainage Waters. *Soil Sci. Soc. Amer. Proc.* 37:931-943.
- Branson R.L, Gustafson C.D., March A.W., Davis S. and Strohman R.A. (1974) *Monitoring Soil Salinity and Leaf Nutrient Levels in a Young Avacado Orchard Under Drip Irrigation*. *Proc. Second Internat. Drip Congress, San Diego, California*. P. 364-369.
- Fagoyinbo, J.H. (1993). Irrigation as an areal-neutral improvement to agricultural production: *Proceedings*, pp. 43-63.
- FAO (1993). *FESLM; An international frame work for evaluating sustainable land NSE National*

Conf. On Engineering and Technology in the eradication of poverty in Nigeria

Management and conservation service. FAO, Rome. 68 p.

Gadallah, M. A. A. (1999). Effect of proline and glycinebetaine on *Vicia faba* responses to salt stress. *Biol. Plant.*, 42: 249-257.

Gordon, J. and Hailin, Z. (2003). Classification of irrigation water quality.

Idachaba, F.C. (1992). Land use planning soil management for sustainable agriculture paper  
Presented at the 20<sup>th</sup> annual conference of the soil science society of Nigeria, University of  
Ilorin.

Mass, E.V. (1984). Salt tolerance of plants. In: *The Hand book of Plant Science in Agriculture*.  
B.R. Christie (ed). CRC Press, Boca Raton, Florida.

Mofeke, A.L.E, Ahmed, A, Mudiare, O.J.(2006). *An International Journal of Agricultural  
Sciences*, 3(4): 241-339.

Munns, R., R. A. Hare, R. A. James and G. J. Rebetzke. (2000). Genetic variation for salt  
tolerance of durum wheat. *Aust. J. Agric. Res.*, 51: 69-74.

Mustapha, M.K. Assesment of the water quality of Oyun Reservoir, Offa, Nigeria, Using (2008).  
Selected Physico-Chemical Parameters. *Turkish Journal of Fisheries and Aquatic Sciences*.  
8: 309-319

Ogunkunle, A.O. (1993). Soil in Land Sustainability Evaluation; An example with oil palm in  
Nigeria, soil use and management.

Ogunkunle, A.O; Omoti, U and Isenmila, A.E, (1999). Characteristics and Agricultural Potential  
Of some Niger Delta Soils in Nigeria.

Oster J.D. and Schroer F.W. (1979). Infiltration as influenced by irrigation water quality. *Soil*



Sci. Soc. Amer.J. 43:444-447.

Owusu-Sekyere, J.D. and M. Dadzie (2009). Effect of Deficit Irrigation on Growth and Development of Tomato Plant (*Lycopersicon esculentum* Mill). Journal of the Ghana Science Association. Vol. 11, No.2. pp 1-8

Rhoades J.D. (1977). Potential for using saline agricultural drainage waters for irrigation. Proc. Water Management for Irrigation and Drainage. ASCE, Reno, Nevada. 20-22 July 1977..

Rhodes, J. D. and J. Loveday.( 1990). Salinity in irrigated agriculture. -In: Steward, B.A., and Nielsen, D.R. (ed.): Irrig. Agri. Crops. pp: 1089-1142.

Richards L.A. (1954). Diagnosis and improvement of saline and alkali soils. USDA Agricultural Handbook No. 60, US Department of Agriculture, Washington DC. 160 p.

## APPENDIX

The following are some elements analysed for in the physico-chemical analysis of the Irrigation water.

### ➤ Chloride (Argentometric Method)

#### • Principle

Chloride is determined in a neutral or slightly alkaline solution by titration with standard silver nitrate, using potassium chromate as indicator. Silver chloride is quantitatively precipitated before red silver chromate is formed.

#### Interferences

Bromide, iodide and cyanide are measured as equivalents of chloride. Thiosulphate, sulphite and sulphide interfere and the end-point may be difficult to detect in highly coloured or very turbid samples.

#### • Apparatus

Porcelain dish, 200-ml capacity.

Graduated cylinder, 100 ml.

Stirring rods.

Burette, 25 or 50 ml. pH meter.

#### • Reagents:

Potassium chromate indicator solution: dissolve 50g  $K_2CrO_4$  in a little distilled water. Add  $AgNO_3$  solution until a definite red precipitate is formed. Let to stand for 12hours, filter, and dilute to 1L with distilled water.

Standard silver nitrate titrant, 0.0141M (0.0141N): dissolve 2.395g AgNO<sub>3</sub> in distilled water and dilute to 1000ml. Store in a brown bottle.

- Procedure:

Use a 100ml sample or a suitable portion diluted to 100ml. If the sample is highly coloured, add 3ml Al(OH)<sub>3</sub> suspension, mix, let settle and filter. If thiosulphate, sulphide or sulphite is present, add 1ml H<sub>2</sub>O<sub>2</sub> and stir for 1 min. Check the pH; it must be between 5.0 and 9.5 in this procedure. If the pH of the sample is below 5.0, add a small amount of calcium carbonate and stir. If the pH is above 9.5, add 0.1 mol /L nitric acid drop by drop to bring the pH to about 8. Stir, and add a small amount of calcium carbonate.

Add 1.0ml K<sub>2</sub>CrO<sub>4</sub> indicator solution. Titrate with standard AgNO<sub>3</sub> titrant to a pinkish yellow end point. Be consistent in end point recognition.

- Calculation:

$$\text{mg Cl-/L} = A \times N \times 35,450/\text{Ml sample (100)}$$

Where A = ml titration for sample

N = normality of AgNO<sub>3</sub>

NaCl

$$\text{mg NaCl/L} = (\text{mg Cl-/L}) \times 1.65$$

Nitrate as Nitrogen (NO<sub>3</sub><sup>-</sup>N) (Cadmium Reduction Method)

- Principle: NO<sub>3</sub>

N is reduced almost quantitatively to nitrite (NO<sub>2</sub><sup>-</sup>) in the presence of cadmium (Cd). This method uses commercially available Cd granules treated with copper sulphate (CuSO<sub>4</sub>) and packed in a glass column. The NO<sub>2</sub><sup>-</sup> produced is thus determined by diazotizing with sulphanilamide and coupling with N - (1 -naphthyl) - ethylenediamine dihydrochloride to form a

highly coloured azo dye that is measured calorimetrically. A correction may be made for any  $\text{NO}_2^-$  present in the sample by analyzing without the reduction step. The applicable range of this method is 0.01 to 1.0 mg  $\text{NO}_3^-$  N/L. The method is recommended especially for  $\text{NO}_3^-$  levels below 0.1mg N/L where other methods lack adequate sensitivity.

- Interferences:

suspended matter in the column will restrict sample flow. For turbid samples, screen or filter the sample. Concentration of iron, copper, or other metals above several milligrams per litre lower reduction efficiency. Add EDTA to eliminate this interference. Oil and grease will coat the Cd surface. Remove by preextraction with an organic solvent. Residual chlorine can interfere by oxidizing the Cd column, reducing its efficiency. Check samples for residual chlorine. Remove residual chlorine by adding sodium thiosulphate ( $\text{Na}_2\text{S}_2\text{O}_3$ ) solution. Sample colour that absorbs at about 540nm interferes.

- Apparatus

Reduction column: purchase or construct the column.

Colorimetric equipment: one of this is required

Spectrophotometer – for use at 543nm, providing a light path of 1cm or longer

Filter photometer – with light path of 1cm or longer and equipped with a filter having maximum transmittance near 540nm.

- Reagent

Nitrate free water: use redistilled or distilled, deionised water of highest purity to prepare all solutions and dilutions. Copper-Cadmium granules: wash 25g new or used 20-100 mesh Cd granules with 6N HCl and rinse with water. Swirl Cd with 100ml 2%  $\text{CuSO}_4$  solution for 5mins

or until blue colour partially fades. Decant and repeat with fresh  $\text{CuSO}_4$  until a brown colloidal precipitate begins to develop. Gently flush with water to remove all precipitated Cu.

Colour reagent: to 20ml of distilled water add 105ml conc. HCl, 5.0g sulphanilamide and 0.5g N - (1 - naphthyl) - ethylenediamine dihydrochloride.

Stir until dissolved. Add 136g of sodium acetate ( $\text{CH}_3\text{COONa} \cdot 3\text{H}_2\text{O}$ ) and again stir until dissolved. Dilute to 500ml with distilled water. This solution is stable for several weeks if stored in the dark.

Ammonium chloride - EDTA solution: dissolve 13g  $\text{NH}_4\text{Cl}$  and 1.7g disodium ethylenediamine tetra-acetic acid (EDTA) in 900ml distilled water. Adjust to pH 8.5 with conc.  $\text{NH}_4\text{OH}$  and dilute to 1L.

Dilute ammonium chloride - EDTA solution: dilute 300ml  $\text{NH}_4\text{Cl}$  - EDTA solution to 500ml with distilled water.

Hydrochloric acid, HCl, 6N Copper sulphate solution, 2%: dissolve 20g  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  in 500ml water and dilute to 1L.

Stock nitrate solution: dry potassium nitrate ( $\text{KNO}_3$ ) in an oven at  $105^\circ\text{C}$  for 24hrs. Dissolve 0.7218g in water and dilute to 1000ml; 1.00ml = 100mg  $\text{NO}_3 - \text{N}$ . Preserve with 2ml  $\text{CHCl}_3/\text{L}$ . This is stable for at least 6 months.

Intermediate nitrate solution: dilute 100ml stock nitrate solution to 1000ml with water; 1.00ml = 10.0mg  $\text{NO}_3 - \text{N}$ . Preserve with 2ml  $\text{CHCl}_3/\text{L}$ . This solution is stable for 6 months.

- Procedure:

Preparation of reduction column: insert a glass wool plug into bottom of reduction column and fill with water. Add sufficient Cu-Cd granules to produce a column 18.5cm long. Maintain water level above Cu-Cd granules to prevent entrapment of air. Wash column with 2ml dilute  $\text{NH}_4\text{Cl}$  -

EDTA solution. Activate column by passing through it, at 7 to 10ml/min, at least 100ml of a solution composed of 25%

1.0mg NO<sub>3</sub>-N/L standard and 75% NH<sub>4</sub>Cl – EDTA solution.

pH adjustment: adjust pH to between 7 and 9, as necessary, using a pH meter and dilute HCl or NaOH. This insures a pH of 8.5 after adding NH<sub>4</sub>Cl – EDTA solution. reduction: to 25ml sample or a portion diluted to 25.0ml, add 75ml NH<sub>4</sub>Cl – EDTA solution and mix. Pour mixed sample into column and collect at a rate of 7 to 10ml/Min. Discard first 25ml. Collect the rest in original sample flask. Colour development and measurement: as soon as possible, and not more than 15mins after reduction, add 2.0ml colour reagent to 50ml sample and mix. Between 10min and 2hrs afterwards, measure absorbance at 543nm against a distilled water reagent blank. Note: if NO<sub>3</sub> —N concentration exceeds the standard curve range (about 1mg N/L), use remainder of reduced sample to make an appropriate dilution and analyze again.

Standards: using the intermediate NO<sub>3</sub> —N solution, prepare standards in the range 0.05 to 1.0mg NO<sub>3</sub>-N/L by diluting the following volumes to 100ml in volumetric flasks: 0.5, 1.0, 2.0, 5.0 and 10.0ml. carry out reduction of standards exactly as described for samples. Obtain a standard curve by plotting absorbance of standards against NO<sub>3</sub> —N concentration. Compute sample concentrations directly from standard curve.

➤ Hardness (EDTA Complexometric Method)

• Principle

1. Ethylenediaminetetraacetic acid and its sodium salts(EDTA) form a chelated soluble complex when added to a solution of certain metal cations. The method depends on the ability of the EDTA and its sodium salt to form stable unionized complexes with calcium and magnesium ions. A buffer solution is added to the sample to adjust the PH to 10.1, followed by an indicator

(Eriochrome Black T) forming a pink complex. Upon titration, the EDTA removes the calcium and magnesium from the complex dye and changed the solution to its original blue colour as an end point.

- Interference:

some metals ions interfere by causing fading or indistinct end points or by stoichiometric consumption of EDTA. Reduce this interference by adding certain inhibitors before titration.

- Apparatus

Porcelain dishes, 100-ml capacity.

Burette, 25 or 50 ml.

Reagents:

Buffer solution: dissolve 1.179g EDTA disodium salt and 0.780g  $MgSO_4 \cdot 7H_2O$  in 50ml distilled water. Add this solution to 16.9g  $NH_4Cl$  and 143ml conc.  $NH_4OH$  with mixing and dilute to 250ml with distilled water. Store in tightly stoppered plastic or resistant glass container.

Eriochrome Black T indicator: mix together 0.5g dye and 4.5g hydroxylamine hydrochloride.

Dissolve this mixture in 100ml of 95% ethyl or isopropyl alcohol. Standard EDTA Titrant, 0.01M- dissolve exactly 3.723g EDTA disodium salt ( $Na_2H_2CrOD_8N \cdot 2H_2O$ ) in distilled water and dilute to 1L. Store in a polyethylene or Pyrex bottle.

- Procedure:

Measure 50ml sample into a 125 Erlenmeyer flask. Add 2ml buffer (sufficient to give a pH of 10.0-10.1). Add 1-2 drops of indicator and titrate slowly stirring continuously until the reddish tinge disappears from the solution. 1ml 0.01M EDTA should be equivalent to mg  $CaCO_3$ .

- Calculation:

Total hardness as  $CaCO_3$

$$\text{Mg CaCO}_3/\text{L} = (\text{A}-\text{B}) \times \text{D} \times 1000$$

ml of sample

where : A = ml of Titrant used for the sample

B = ml of Titrant used for the blank (use distilled water as blank and treat like the sample. Repeat all the procedure for it. Usually the ml of the Titrant used for the blank is always between 0 to 0.2ml.)

D = mg CaCO<sub>3</sub> equivalent to 100ml EDTA used.

= molarity of EDTA x molar mass of CaCO<sub>3</sub>.

### ➤ Calcium Hardness.

#### • Reagents:

Hydroxide solution 1N – dissolve 56.1g of KOH or 40g of NaOH in distilled water and dilute to 1L.

Calver II Calcium indicator – this is manufactured by the Hach company.

Murexide indicator (ammonium purpurate) – changes from pink to purple. Prepare by dissolving 150mg dye in 100g absolute ethylene glycol. Water solution of the dye are not stable for longer than 1 day. A ground mixture of dye powder and sodium chloride (NaCl provides a stable form of the indicator. Prepare by mixing 200mg murexide with 100g solid NaCl and grinding the mixture to 40 to 50 mesh.

#### • Procedure:

Measure a 50ml sample into a 125ml Erlenmeyer flask.

Add 2 ml of the 1N hydroxide solution (to Produce a pH of 12-13 in the 50 ml sample). Add 0.1 to 0.2g of calver II calcium indicator or murexide indicator

Titrate slowly with EDTA disodium salt solution (0.01m) until the colour changes



to blue for calver II and pink for murexide.

- Calculation:

Calcium hardness as  $\text{CaCO}_3$

$\text{mg CaCO}_3/\text{L} = (\text{A}-\text{B}) \times \text{D} \times 1000/\text{ml of sample}$

Calcium ion as  $\text{mg Ca}^{2+}/\text{L} = (\text{A}-\text{B}) \times \text{D} \times 400.8/\text{ml sample (100)}$

d. magnesium hardness ( $\text{mg CaCO}_3/\text{l}$ ) = total hardness – calcium hardness

e. calculated magnesium as  $\text{mg}^{2+}$

$\text{mg}^{2+} = \text{magnesium hardness as mg CaCO}_3/\text{l} \times 0.244$

➤ Manganese ( Persulphate Method)

- Principle:

Persulphate oxidation of soluble manganous compounds to form permanganate is carried out in the presence of silver nitrate. The resulting colour is stable for at least 24 hours if excess persulphate is present and organic matter is absent.

- Interference:

As much as 0.1g chloride ( $\text{Cl}^-$ ) in a 50-mL sample can be prevented from interfering by adding 1g mercuric sulphate ( $\text{HgSO}_4$ ) to form slightly dissociated complexes. Bromide and iodide still will interfere and only trace amounts may be present.

- Apparatus:

Colorimetric Equipment for use at 525nm, providing a light path of 1 cm or longer. Nessler tubes, matched, 100-mL, tall form

- Reagents

Special reagent: dissolve 75g  $\text{HgSO}_4$  in 400ml conc.  $\text{HNO}_3$  and 200ml distilled water. Add 200ml 85% phosphoric acid ( $\text{H}_3\text{PO}_4$ ) and 35mg silver nitrate ( $\text{AgNO}_3$ ). Dilute the cooled solution to 1L.

Ammonium per sulphate,  $(\text{NH}_4)_2\text{S}_2\text{O}_8$ , solid. Standard manganese solution – prepare a 0.1N potassium permanganate ( $\text{KMnO}_4$ ) solution by dissolving 3.2g  $\text{KMnO}_4$  in distilled water and making up to 1L. Age for several weeks in sunlight or heat for several hours near the boiling point, then filter through a fine filtered – glass filter crucible and standardize against sodium oxalate as follows: weigh several 100 to 200mg samples of  $\text{Na}_2\text{C}_2\text{O}_4$  to 0.1mg and transfer to 400ml beakers. To each beaker, add 100ml distilled water and stir to dissolve. Add 10ml 1+1  $\text{H}_2\text{SO}_4$  and heat rapidly to 90 to 95 °C. Titrate rapidly with the  $\text{KMnO}_4$  solution to be standardized, while stirring to a slight pink end point colour that persists for at least 1 min. Do not let temperature fall below 85 °C. If necessary, warm beaker contents during titration; 100mg  $\text{Na}_2\text{C}_2\text{O}_4$  will consume about 15ml permanganate solution. Run a blank on distilled water and  $\text{H}_2\text{SO}_4$ .

Normality of  $\text{KMnO}_4 = \frac{\text{g Na}_2\text{C}_2\text{O}_4}{(\text{A}-\text{B})} \times 0.06701$

Where A is ml Titrant for sample and B is ml Titrant for blank.

Average results for several titrations. Calculate volume of this solution necessary to prepare 1L of solution so that 1ml = 50µgMn as follows:  $\text{ml KMnO}_4 = \frac{4.55}{\text{normality KMnO}_4}$

To this volume, add 2 to 3ml conc.  $\text{H}_2\text{SO}_4$  and  $\text{NaHSO}_3$  solution dropwise, with stirring until the permanganate colour disappears. Boil to remove excess  $\text{SO}_2$ , cool, and dilute to 1000ml with distilled water. Dilute this solution further to measure small amounts of manganese. Hydrogen peroxide,  $\text{H}_2\text{O}_2$ , 30%, Nitric acid,  $\text{HNO}_3$ , conc.,  $\text{H}_2\text{SO}_4$ , conc. Sodium nitrite solution –

dissolve 5g  $\text{NaNO}_2$  in 95ml DDW. Sodium oxalate,  $\text{Na}_2\text{C}_2\text{O}_4$ , primary standard. Sodium bisulphide – dissolve 10g  $\text{NaHSO}_3$  in 100ml distilled water.

- Procedure:

To a suitable sample portion, add 5ml special reagent and 1 drop  $\text{H}_2\text{O}_2$ . Concentrate to 90ml by boiling or dilute to 90ml. Add 1g  $(\text{NH}_4)_2\text{S}_2\text{O}_8$ , bring to a boil and boil for 1min. Do not heat on a water bath. Remove from the heat source, let stand for 1min. Then cool under the tap. (Boiling too long result in decomposition of excess per sulphate and subsequent loss of permanganate colour; cooling too slowly has the same effect). Dilute to 100ml with distilled water free from reducing substances and mix. Prepare standards containing 1,500 $\mu\text{g}$  Mn by treating various amounts of standard Mn solution in the same way.

- Photometric measurement:

use a series of standard from 0 to 1,500 $\mu\text{g}$  Mn/100ml final volume. Make photometric measurements against a distilled water blank. Prepare a calibration curve of manganese concentration vs. absorbance from the standards and determine Mn in the samples from the curve. Wavelength is 525nm.

- Calculation:

When all of the original sample is taken for analysis,  $\text{Mg Mn/L} = \text{Mg Mn (in 100ml final volume)}/\text{ml sample}$  For light path of 1cm, take manganese ( $\mu\text{g}$ ) range of 100-1500 $\mu\text{g}$  to prepare standard.