ANALYSIS OF THE SALINITY EFFECTS OF SODIUM ON MAIZE CROP

(*Zeamays*)

(Case Study of Maizube Farm Minna, Niger state Nigeria)

BY

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MATRIC No. 2005/21640EA

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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

DECEMBER, 2010

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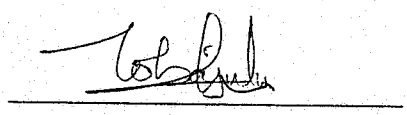
BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

DECEMBER, 2010

DECLARATION

I hereby declare that this project work 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 Information derived from personal communications, published and unpublished work were duly referenced in the text.



Obajulu Tinia

06-12-2010

Date

DEDICATION

I dedicate this work to my late sister Karosi Obajulu and my lovely parents Mr. & Mrs. S. Obajulu for their un-ending support. I also wish to remember my supervisor Mallam H. Adamu for his immense contribution throughout the period of research.

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I wish to thank GOD Almighty who gave me the strength and wisdom to write this project. My most special thanks go to my supervisor Mallam H. Adamu who was ever ready to provide the necessary guidance required at achieving my aim. I also use this medium to acknowledge the contributions of my head of Department Engr. Dr. A.A. Balami and my lecturers who encouraged me during the process of writing this project.

My thanks also go to my family members, my dad, Mr. S Obajulu, my mum Mrs. J.M. Obajulu as well as my lovely sisters. This acknowledgement will not be complete if I do not thank my friends Sayuti H. Ibrahim, Ibrahim Mohammed Baba, Yakubu Joel and most especially Bose Shaibu.

ABSTRACT

Analysis of the salinity effects of sodium on maize crop (*Zeamays*) was carried out for Maizube farms in Minna area of Niger state. The results from this analysis were compared with that of Pescod '93. For this study, irrigation water samples were taken from the farm at 3 different times between the months of June and August. The samples taken were then put up for laboratory analysis in order to determine the TDS, SAR and the bicarbonate concentration of the irrigation water. Statistical analysis was then carried out to determine the actual quality of the irrigation water in the farm. This would aid in determining the amount of salt entering the soil, its effect on the crop and the potential effects as time pass. The values obtained from the analysis were then compared with the standard of Pescod '93. In statistically analyzing the data, it was discovered that the EC_w was 0.117dS/m, SAR was 0.024 and the TDS was 78.39mg/L. Hence, when compared with the standard which recommended a range of <0.7dS/m for EC_w, SAR of 0-3 and a TDS of <450mg/L, it was discovered that the irrigation water of Maizube farms is of high quality and can be used for irrigating without carrying out other management practices. Therefore it is recommended that a continous analysis of the irrigation water should be made and periodic checks should be carried out on the farm in order to examine the state of salinity build up in the soil.

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Abbreviation or Symbols or Notations

TDS	Total dissolved solids
EC_w	Electrical conductivity of irrigation water
EC_e	Soil electrical conductivity
EC_{dw}	Salinity of drainage water
LR	Leaching requirement
LF	Leaching fraction
SAR	Sodium adsorption ratio
mg/L	milli-gram per litre
meq/L	milli-equivalent per litre
mM	milli-million
FAO	Food and
ROS	Reactive oxygen species
SOD	Superoxide dismutase
APX	Ascorbate peroxide
GR	Glutathione reductase
GPX	Guaiacol peroxide

NCRI	National cereal and research institute
NaCl	Sodium chloride
Na_2CO_3	Sodium carbonate
$CaCl_2$	Calcium chloride
H_2O_2	Hydrogen peroxide
$^1O_2$	Singlet oxygen
OH	Hydroxyl

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CERTIFICATION

This is to certify that the project entitled "Analysis of the salinity effects of sodium on maize crop (*zeamays*) (Case Study of Maizube farms Minna, Niger state Nigeria)" by Obajulu Tinia 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 Supervisor	16 – 12 – 10 Date
Engr. Dr. A. A. Balami Head of Department	16/12/10 Date
External Examiner	8/12/2010 Date

CHAPTER 1

1.0 INTRODUCTION

1.1 Background to the study

Soil degradation is a serious environmental problem in Nigeria. Deforestation, soil erosion, desertification, soil salinization, alkalinization and water logging form different but often inter-related aspects of soil degradation (Karshenas, 1994). In Nigeria, soil degradation affects about 50million people and leads to the greatest loss of GNP relative to other environmental problems.

Salinity is one of the serious environmental problems that causes osmotic stress and reduction in plant growth and crop productivity in irrigated areas of arid and semiarid regions which is mainly due to low precipitation and high transpiration causing disturbance in salt balance in the soil; this also renders ground water brackish and affects plant growth adversely. Hence, salinity can be defined as the accumulation of water soluble salts in the soil column or regolith to a level that has a drastic impact on agricultural production, environmental health and even the welfare of a country (Owaiye 1995).

The problem of soil salinity is of immense importance particularly for those countries that lies in arid to semi-arid zones. Generally, high evapo-transpiration due to high temperature in the semi-arid and arid zones is the basic cause for salt accumulation on the soil surface. The evaporation rate is generally high and exceeds that of precipitation. Thus, the insufficient rainfall together with high evaporative demand thereby increases the demand for irrigation.

Irrigation brings about the desired yield increase but many irrigation water supplies contain substantial amounts of salts. For example, a water source with an electrical conductivity of 1.0mmhos/cm, a quality suitable for irrigation for most crops contains nearly 1 ton of salt in

every acre-foot of water applied. Irrigation water can therefore contribute a substantial amount of salt to the soil which may either directly affect plant growth or add salt to the soil so that plant growth is eventually affected by the increasing level of soil salinity. Applying more irrigation water may raise the water table under the area. If the water table is saline and shallow enough to be in the root zone, plant growth could be affected.

1.2 Statement of the problem

A major problem of crop production in arid and semi arid region is salinity. Due to this problem, crops are often subjected to water stress, hyper osmotic and ionic stress, which results in the alteration of plant metabolism which includes reduced water potentials, ionic imbalances and specific ion toxicity. To address this problem, a good plan is required such that water, fertilizers being applied to the soil do not glide from being beneficial to being harmful to them.

1.3 Objectives of the study

The aims of this study are:

i. To analyze the irrigation water quality.

ii. To determine the effects of salinity on maize crop production.

1.4 Justification of the Study

Numerous researches have been conducted around the world on the various effects of salinity on crops. Although these studies have been able to provide very useful information, however, very limited field research and information are available in Nigeria. Because of these limited information, it is therefore necessary to conduct research into the various effects of

salinity on maize plant on the Nigerian soil. The data collected would serve as a supplement to the existing information on soil salinity problems in the country.

1.5 Scope of the Study

The problem of soil salinity is of immense importance particularly for those countries that lies in arid to semi-arid zones. Generally, high evapotranspiration due to high temperature in the semi-arid and arid zones is the basic cause for salt accumulation on the soil surface. The evaporation rate is generally high and exceeds that of precipitation. Thus, the insufficient rainfall together with high evaporative demand and shallow ground water in most locations enhances the movement of salts to the soil surface. Improper irrigation practices and lack of drainage have aggravated the problem leading to significant reductions in crop productivity.

Hence, this study is aimed at providing necessary information on how best to carry out various farm practices without causing damage to our crops and farm land in the long run.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Previous works

Earth is a predominantly salty planet, with most of its water containing about 3% NaCl. This concentration of salt has rendered the land very salty. It is projected that about 900 Mha of land is affected due to salt which considerably poses a serious threat to agricultural productivity (Flowers and Yeo, 1995; Munns, 2002) because most agricultural crops will not grow under conditions of high salt concentration. Hence, the existing salinity is a great challenge to food security. Accumulation of water-soluble salts, especially sodium-chloride (NaCl), sodium carbonate (Na_2CO_3) and partially calcium chloride ($CaCl_2$) results in salty soils. Wyn Jones (1981) was of the view that soil salinity develops due to high amount of chloride or sulfate salts of sodium.

Naturally occurring salinization is primarily caused by capillary water level elevation and subsequent evaporation of saline groundwater. However, man-made salinization is wide spread. Especially, irrigated land in arid regions is highly susceptible to salinization. Irrigation practices lead to ground water level elevation and a subsequent increased evaporation. This is particularly true in countries of arid and semiarid regions of the world (Owaiye 1995).

More than 800 million hectares of land throughout the world are salt-affected, either by salinity (397 million ha) or the associated condition of sodicity (434 million ha) (FAO, 2005). This is over 6% of the world's total land area. Most of this salinity, and all of the sodicity, is natural. However, a significant proportion of cultivated agricultural land has become saline

because of land clearing or irrigation. Of the 150 million ha of land farmed by dry land agriculture, 32 million (2%) are affected by secondary salinity to varying degrees. Of the current 230 million ha of irrigated land, 45 million ha are salt-affected (FAO, 2005). High amounts of salts in soils, taking into account both human made and naturally occurring salinisation, are responsible for yield reduction on one third of the global arable land.

High salt levels do not only lead to damaging effects on plants but also increase the pH level of the soil. Most plants do not grow well under high pH-levels. Salt stress also leads to deterioration of soil structure and hinders desirable air-water balance essential for biological processes occurring at plant roots. As a result of all the detrimental effects of salinisation, crop yields are decreasing, while arable land is being lost irreversibly (Egharevba 2009). Salt stress causes various effects on plant physiology such as increased respiration rate, ion toxicity, changes in plant growth, mineral distribution, and membrane instability resulting from calcium displacement by sodium (Marschner, 1986), membrane permeability (Gupta *et al.*, 2002), and decreased photosynthetic rate (Hasegawa *et al.*, 2000; Munns, 2002; Ashraf and Shahbaz, 2003;Kao *et al.*, 2003; Sayed, 2003).

Salt stress affects plant physiology at whole plant as well as cellular levels through osmotic and ionic stress (Hasegawa *et al.*, 2000; Muranaka *et al.*, 2002 a, b; Ranjbarfordoei *et al.*, 2002; Murphy and Durako, 2003). Despite causing osmotic and ionic stress, salinity causes ionic imbalances that may impair the selectivity of root membranes and induce potassium deficiency (Gadallah, 2000). The accumulation of high amounts of toxic salts in the leaf apoplasm leads to dehydration and tugor loss and eventually death of leaf cells and tissues (Marschner, 1995). As a result of these changes, the activities of various enzymes and plant metabolism are affected (Lacerda *et al.*, 2003). At high rates of transpiration, the xylem of all species contains much

lower chloride and sodium concentrations than those in the external saline medium. Salt stress enhances the accumulation of NaCl in chloroplasts of higher plants, affects growth rate, and is often associated with decrease in photosynthetic electron transport activities (Adelana 2006).

2.2. Causes of soil salinity

Salts are naturally present in all soils. However, additional salts can build up in the soil root zone by:

i. High concentration of salts in irrigation water

ii. Consistent application of fertilizer to the soil

iii. Poor soil structure that limits drainage or leaching

iv. Salinisation of the root zone by high water tables which may bring salt from other areas or from the soil below.

2.3. Effects of salt stress on plant growth

Salt stress causes reduction in plant growth because plant may suffer four types of stresses (Greenway and Munns, 1980) i.e.

i. Osmotically induced water stress

ii. Specific ion toxicity due to high concentration of sodium and chloride

iii. Nutrient ion imbalance, due to high level of Na^+ and Cl^- which reduce the uptake of K^+, NO^-, PO_4^{3-} etc.

iv. Increased production of reactive oxygen species which damage the macromolecules.

Salinity hazard ⟶ plants ⟶ saline soil condition

Sodium ⟶ soils ⟶ sodic soil condition

2.3.1 Osmotic stress

Salt stress reduces the plant's ability to take up water, and this leads to reduction in growth. This is the osmotic or water-deficit effect of salt stress. Both cellular and metabolic processes involved in osmotic stress due to salinity are common to drought. The rate at which new leaves are produced depends largely on the water potential of the soil solution, in the same way as for a drought-stressed plant. Salts themselves do not build up in the growing tissues at concentrations that inhibit growth, as the rapidly elongating cells can accommodate the salt that arrives in the xylem within their expanding vacuoles. So, the salt taken up by the plant does not directly inhibit the growth of new leaves (Munns, 2005).

Reductions in the rate of leaf and root growth are probably due to factors associated with water stress rather than a salt-specific effect (Munns, 2002). This is supported by the evidence that Na^+ and Cl^- are below toxic concentrations in the growing cells themselves. For example, in wheat growing in 120mM *NaCl*, Na^+ in the growing tissues of leaves was at most only 20 m*M*, and only 10 m*M* in the rapidly expanding zones, and Cl^- only about 50 m*M* (Hu *et al.*, 2005). Similarly, Neves-Piestun and Bernstein (2005) found that Na^+ and Cl^- were, only 40 m*M* in the most rapidly growing tissues, and that the degree of inhibition by salt stress of either the elongation rate or the total volume expansion rate did not correlate with the Na^+ or Cl^- in the tissues of maize growing in 80 m*M* NaCl. Fricke (2004) found only 38 and 49 m*M* Na^+ in mesophyll and epidermal cells, respectively, in the growing cells of barley after 24 h of exposure to 100 m*M NaCl*. That this Na^+ was not inhibitory to growth, but was probably beneficial as it might be taken up into the expanding vacuole for osmotic adjustment, was indicated by the fact

that the growth rate increased with time over 24 h (after a temporary decline when the salt was applied) while the cellular Na^+ increased.

The rapid expansion of the growing cells would help to keep the salt from building up to high concentrations. Results of experimental manipulation of shoot water relations suggest that hormonal signals, probably induced by the osmotic effect of the salt outside the roots, are controlling the rate of cell elongation growth (Munns *et al.*, 2000). Inhibition of plant growth due to salt stress largely depends on the severity of the stress. Mild osmotic stress leads rapidly to growth inhibition of leaves and stems, whereas roots may continue to grow and elongate (Hsiao and Xu, 2000). The degree of growth inhibition due to osmotic stress depends on the time scale of the response, the particular tissue and species in question, and whether the stress treatments are imposed abruptly or slowly (Ashraf, 1994; Munns *et al.*, 2000).

2.3.2 Specific ion toxicity

Toxicity occurs as a result of uptake and accumulation of certain toxic ions from the irrigation water, within a crop itself. It is different from salinity problem. It may occur even when the salinity is low. These toxic constituents include mainly sodium, chloride and sulphate. They can reduce crop productivity and eventually cause crop failures. Not all crops are equally affected but most crops and woody perennial plants are sensitive (Abrol *et al.*, 1988). The salt taken up by plant concentrates in the old leaves; continued transport of salt into transpiring leaves over a long period of time eventually results in very high Na^+ and Cl^- concentrations, and the leaves die. The cause of the injury is probably due to the salt load exceeding the ability of the cells to compartmentalize salts in the vacuole. Salts then would rapidly build up in the cytoplasm and inhibit enzyme activity. Alternatively, they might build up in the cell walls and dehydrate the

cell (Munns, 2005) but Mühling and Läuchli (2002) found no evidence for this in maize cultivars that differed in salt tolerance. Mechanisms for tolerance of the salt-specific effects of salinity are of two main types: those minimizing the entry of salt into the plant; and those minimizing the concentration of salt in the cytoplasm. Root cytosolic Na^+ concentrations are probably in the order of 10–30 m*M* (Tester and Davenport, 2003). Leaf Na^+ cytosolic concentrations are unknown, but are considered to be much less than 100 m*M* (Wyn Jones and Gorham, 2002). The concentration at which Cl^- becomes toxic is even less defined. Roots must exclude most of the Na^+ and Cl^- dissolved in the soil solution, or the salt in the shoot will gradually build up with time to toxic levels. Plants transpire about 50 times more water than they retain in their leaves (Munns, 2005).

Husain *et al.* (2003) used two durum wheat genotypes with contrasting rates of Na^+ transport to leaves to assess the effects of the Na^+ exclusion trait on preventing leaf injury and enhancing yield. They found that older leaves of the high-Na^+ lines lost chlorophyll more rapidly and died earlier than the low-Na^+ lines. The low-Na^+ trait improved yield by greater than 20% in saline soil at moderate salinity. However, yield was not improved at high salinity. This indicates that traits other than Na^+ exclusion are important at high salinity, where the osmotic effect of the NaCl outweighs its salt-specific effect on growth and yield. Na^+ increment inside plants had toxic effects on seed germination, mainly by affecting the plant water relations or through displacement of Ca^{2+} by Na^+ from critical cell wall binding sites, which could disrupt cell wall synthesis and hence inhibit plant growth (Xue *et al.*, 2004). According to Loreto and Bongi (1987) Cl^- concentration more than 80m*M* in total tissue water alters plant morphology, stomata become less responsive to environmental changes and leaf thickness is reduced. Chloride is not adsorbed by soils but moves readily with the soil water. It is taken up by roots and moves

upward to accumulate in the leaves. The toxic level of chloride causes leaf burn or drying of leaf tissues, which occurs first at extreme leaf then tips of older leaves and progresses back along the edges as severity increases. Marschner (1995) found that extreme leaf burn due to toxic level of chloride leading to early leaf drop, because of which finally the whole plant became defoliated.

2.3.3 Nutritional imbalance

Excessive amounts of soluble salts in the root environment cause osmotic stress, which may result in disturbance of the plant water relations, in the uptake and utilization of essential nutrients, and also in toxic ion accumulation. As a result of these changes, the activities of various enzymes and the plant metabolism are affected (Munns, 2002; Lacerda *et al.*, 2003). The interactions of salts with mineral nutrients may result in considerable nutrient imbalances and deficiencies (McCue and Hanson, 1990). Ionic imbalance occurs in the cells due to excessive accumulation of Na^+ and Cl^- and reduces uptake of other mineral nutrients, such as K^+, Ca^{2+}, and Mn^{2+} (Karimi *et al.*, 2005). High sodium to potassium ratio due to accumulation of high amounts of sodium ions inactivates enzymes and affects metabolic processes in plants (Booth and Beardall, 1991) Excess Na^+ and Cl^- inhibits the uptake of K^+ and leads to the appearance of symptoms like those in K^+ deficiency. The deficiency of K^+ initially leads to chlorosis and then necrosis (Gopal and Dube, 2003). The role of K+ is necessary for osmoregulation and protein synthesis, maintaining cell turgor and stimulating photosynthesis (Freitas *et al.*, 2001; Ashraf, 2004). Both K^+ and Ca^{2+} are required to maintain the integrity and functioning of cell membranes (Wenxue *et al.*, 2003). Maintenance of adequate K^+ in plant tissue under salt stress seems to be dependent upon selective K+ uptake and selective cellular K^+ and Na^+ compartmentation and distribution in the shoots (Munns *et al.*, 2000; Carden *et al.*, 2003). The

maintenance of calcium acquisition and transport under salt stress is an important determinant of salinity tolerance (Soussi *et al.*, 2001; Unno *et al.*, 2002). Salt stress decreases the Ca^{2+}/Na^{+} ratio in the root zone, which affects membrane properties, due to displacement of membrane-associated Ca^{2+} by Na^{+}, leading to dissolution of membrane integrity and selectivity (Kinraide, 1998). The increased levels of Na^{+} inside the cells change enzyme activity resulting in cell metabolic alteration; disturbance in K^{+} uptake and partitioning in the cells and throughout the plant that may even affect stomatal opening, thus diminishing the ability of the plant to grow. Externally supplied Ca^{2+} has been shown to ameliorate the adverse effects of salinity on plants, presumably by facilitating higher K^{+}/Na^{+} selectivity (Hasegawa *et al.*, 2000). Another key role attributed to supplemental Ca^{2+} addition is its help in osmotic adjustment and growth via the enhancement of compatible organic solutes accumulation (Girija *et al.*, 2002). Ca^{2+} has also been implicated in stress protection by stabilizing membranes and reducing the oxidative damage (Larkindale and Knight, 2002). High K^{+}/Na^{+} ratio was observed due to ABA treatment in to common bean plant that seems to limit sodium translocation to shoot (Khadri *et al.*, 2007).

2.3.4 Reactive oxygen species

Exposure of plants to salt stress can up-regulate the production of reactive oxygen species (ROS) such as H_2O_2 (hydrogen peroxide), O^{2-} (superoxide), $^1O_2$ (singlet oxygen) and .OH (hydroxyl radical). Excess of ROS causes phytotoxic reactions such as lipid peroxidation, protein degradation and DNA mutation (McCord, 2000, Wang *et al.*, 2003; Vinocur and Altman, 2005; Pitzschke and Hirt, 2006). In plant cells, ROS, mainly H2O2, superoxide anion (O2-), and hydroxyl radical (.OH) are generated in the cytosol, chloroplasts, mitochondria, and the

apoplastic space (Bowler and Fluhr, 2000; Mittler, 2002). While ROS have the potential to cause oxidative damage to cells during environmental stress. Recent studies have shown that ROS play a key role in plants as signal transduction molecules involved in mediating responses to pathogen infection, environmental stresses, programmed cell death and developmental stimuli (Mittler *et al.*, 2004; Torres and Dangl, 2005). Membrane injury induced by salt stress is related to an enhanced production of highly toxic ROS (Shalata *et al.*, 2001). A rise in reactive oxygen species (ROS) production may result from stomata closure, causing a decrease in CO2 concentration inside the chloroplasts. This in turn causes a decrease in $NADP^+$ concentration with the concomitant generation of ROS (Foyer and Noctor, 2003). The increased concentration of ROS damages the D1 protein of PS II leading to photo inhibition. Stress enhanced photorespiration and NADPH activity also contributes to increase in H_2O_2 accumulation, which may inactivate enzymes by oxidizing their thiol groups. This toxicity of H_2O_2 is not due to its reactivity alone, but requires the presence of a metal reductant to form the highly reactive hydroxyl radical (.OH), which has the ability to react with all biological molecules (Halliwell and Gutteridge, 1989). Salinity-associated reductions in elongation in the expansion zone of maize leaves are associated with reduced ROS levels and could be alleviated by the addition of ROS (Rodriguez *et al.*, 2004).

2.4. Plant Responses to salt stress

Soil salinity affects various physiological and biochemical processes which result in reduced biomass production. This adverse effect of salt stress appears on whole plant level at almost all growth stages including germination, seedling, vegetative and reproductive stages. However, tolerance to salt stress at different plant developmental stages varies from species to species. For

example, it has been observed that the degree of salt tolerance at different developmental growth stages varies in rice (Akbar and Yabuno, 1977), barley (Norlyn, 1980) and wheat (Ashraf and Khanum, 1997). In contrast, salt tolerance in some other crops *Medicago sativa, Trifolium alexandranium* and *T. pratense* examined at the seedling stage was also confirmed at the later growth stages (Ashraf *et al.*, 1986). Similarly, while working with safflower Ashraf and Fatima (1995) also found that salt tolerance does not vary at different plant growth stages in these plants. Different scientists have reported that variation in salt tolerance in a number of crop species depends on the extent of Na+ exclusion at root level or ability to compartmentalize salts in the vacuole (Munns, 2002; 2005; Ashraf, 2004). For example, Wyn Jones *et al.* (1984) found the higher salt tolerance of *Agropyron junceum* than that of *Agropyron intermedium* was related to its efficient exclusion of both Na^+ and Cl^-. In another study, Carden *et al.* (2003) found that the salt tolerant variety maintained a 10-fold lower cytosolic Na^+ in the root cortical cells than the more sensitive variety. It is well established that high accumulation of Na^+ in shoots inhibits enzyme activity, and other metabolic processes such as protein synthesis and photosynthesis (Ashraf, 2004; Munns, 2005) thereby reducing leaf growth or causing leaf death. Thus, in most plant species, particularly glycophytes, Na^+ exclusion from the shoot and retention in the root is a general trend and hence an important component of salt tolerance (Ashraf, 2004). However, Mansour *et al.* (2005) found that salt induced increase in Na+ accumulation compared with a decrease in K^+ and Ca^{2+} was higher in salt tolerant maize cultivar Giza 2 compared with that in salt sensitive Trihybrid 321. Furthermore, it was found that high accumulation of proline and glycinebetaine was associated with salt tolerance in maize. Although accumulation of toxic ions in the leaves can cause toxicity, variation in specific ion toxicity at inter-specific or intra-specific level could be due to some adaptations to tolerant high levels of toxic ions. A number of studies

have shown that photosynthetic capacity of different species is reduced due to salinity (Ashraf, 2004; Dubey, 2005). It is evident that higher photosynthetic capacity causes increased plant growth under normal or stress conditions as has earlier been observed in a number of plant spp, e.g., in cotton (Pettigrew and Meredith, 1994), *Zea mays* (Crosbie and Pearce, 1982), Brassica spp. (Nazir *et al.*, 2001) and wheat (Raza *et al.*, 2007). Furthermore, salt-induced reduction in photosynthesis could be due to stomatal and non stomatal limitations or combination of both. High accumulation of Na^+ and Cl^- in the leaves also reduces the photosynthetic capacity and Na^+ content in the leaves of rice (Yeo, 1998), and wheat (James *et al.*, 2002), while high Cl^- contents in the citrus (Walker *et al.*, 1981), and in the chloroplast of *Phaseolous vulgaris* (Seemann and Critchley, 1985) were found to be detrimental to photosynthesis. In view of all these reports, it can be concluded that growth inhibition may occur due to both osmotic and toxic effects. However, osmotically induced reduction in growth occurs at early growth stages under salt stress. Furthermore, photosynthesis is also one of the main contributing factors in salt-induced reduction in plant growth and yield. Tolerance of photosynthetic system to salinity depends on how effectively plant excludes or compartmentalizes the toxic ions. However, extent of the adverse effects of salt stress on photosynthesizing tissue or on growth varies with the type of species, level of stress and duration of stress.

2.5. Maize

Maize is the third most important cereal crop after wheat and rice and is grown all over the world both for human and animal consumption. The present world production rate of maize is about 594million tons from about 139 million hectare (FAO STAT, 2000). The crop is grown in climates ranging from temperate to tropic during the period when mean daily temperatures are

above 15°C and frost free. The plant does well on most soils but less on very heavy dense clay and very sandy soils. The soil should preferably be well aerated and well drained as the crop is susceptible to water logging.

Maize is moderately sensitive to salinity and is considered as salt sensitive cereal (Mass and Hoffman, 1977). Yield decrease under increasing soil salinity is:

i. 0% at EC_e of 1.7mmhos/cm
ii. 10% at EC_e of 2.5mmhos/cm
iii. 25% at EC_e of 3.8mmhos/cm
iv. 50% at EC_e 5.9mmhos/cm
v. 100% at EC_e 10mmhos/cm

2.6. Responses of maize to salt stress

Although, maize (*Zeamays)* is widely grown in many regions of the world where soil salinity is one of the major agricultural threats to its productivity. While comparing different crops for their response to salinity stress this crop has been categorized as moderately salt-sensitive (Maas and Hoffman, 1977), but there is evidence that considerable intra-specific genetic variation for salt tolerance exists in maize (Ashraf, 1989; Azevedo Neto *et al.*, 2004; Mansour *et al.*, 2005).

Although the degree of salt tolerance in maize cultivars observed at early growth stages was not confirmed at later growth stages, germination stage was found to be resistant to salt stress than the seedling stage. Similarly, Cicek and Cakirlar (2002) also observed that maize plants were more tolerant to salt stress at the germination stage compared with later growth stages.

Salt sensitivity of maize plants has been found to be due to high accumulation of Na^+ in the leaves (Munns, 1993; Fortmeier and Schubert, 1995). For example, Benes *et al.* (1996) found that salt tolerant maize cultivars restricted Na^+ and Cl^- in their roots with a subsequent transport of these ions to shoot. In contrast Mansour *et al.* (2005) found that salt sensitive maize cultivar Trihybrid 321 was lower in leaf K^+ and higher in leaf Na^+ than those of salt tolerant maize cv. Giza 2. Similarly, a decade ago, Cramer *et al.* (1996) found that high biomass producing hybrid Pioneer 3578 accumulated Na^+ two times higher than the low biomas producing Pioneer hybrid 3572 and concluded that the growth response of maize to salinity was primarily affected by osmotic factor. Salt-induced reduction in growth in most crop species is due to generation of reactive oxygen species (ROS) (Mittler, 2002). The reactive oxygen species such as superoxide (O^{2-}), hydrogen peroxide (H_2O_2), and hydroxyl radical (OH) and singlet oxygen ($^1O_2$) are produced during normal aerobic metabolism when electrons from the electron transport chains in mitochondria and chloroplasts are leaked and react with O_2 in the absence of other electron acceptors (Smirnoff, 1993; 1998; Noctor and Foyer, 1998; Mittler, 2002). To overcome saltmediated oxidative stress, plants up-regulate a battery of antioxidative mechanisms to detoxify and eliminate these reactive oxygen species. The antioxidant defense system includes antioxidant compounds (tocopherol and carotenoids) and enzymes like superoxide dismutase (SOD), catalase (CAT), peroxidase (POD) and others. Plants differ in their ability to scavenge ROS (Mittler, 2002). While dissecting the role of antioxidant enzymes in salt toleranee of maize, Azevedo Neto *et al.* (2006) found that salt stress enhanced ascorbate peroxidase (APX), guaiacol peroxidase (GPX) and glutathione reductase (GR) in this crop. However, this increase in enzyme activities was more pronounced in salt tolerant maize cultivars than in the salt sensitive ones. In contrast, salt stress did not affect CAT activity in salt tolerant line, but the activities of this

enzyme was reduced significantly in salt sensitive cultivars (Azevedo Neto *et al.*, 2006). The results from different studies with maize show that salt tolerance is often correlated with either ion exclusion or with more efficient oxidative system to protect photosynthesizing tissues.

2.7. Impacts of salinity

i. Decreases availability/productivity of agricultural land

ii. Increased food insecurity as naturally growing specie disappear

iii. Serious scarcity of safe drinking water

iv. Loss of bio-diversity e.g. decrease in tree specie

CHAPTER 3

3.0 MATERIAL AND METHOD

3.1 Climate of the study area

Minna is one of the towns in Niger state on longitude 6.4° and latitude 9.5°. The agro climatic and environmental characteristic of the town is shown in table 3.1. Generally, the climate of the area can be classified into three seasons:

a) Wet humid season of June to September. This season is characterized with rainfall, high relative humidity which ranges from 76.4% to 86.6% with peak value recorded in the month of august. The mean daily temperature during the season ranges from 26.8°C to 27.7°C with the highest value in June.

b) The dry, cold harmattan season of October to mid-February. This season is characterized with little or no-rainfall, low temperatures ranging from 16°C to 23°C, low relative humidity ranging from 26% to 43% and high wind speed. The season is cold due to poor incident radiation because of harmattan dust.

c) The dry-hot season of February ending in may. This season is characterized by no rainfall, low humidity and high mean temperatures ranging from 25°C to 29°C. Evaporation is usually very high and the weather generally harsh.

Table 3.1: Agro climatic and Environmental characteristics of Minna

Features	Characteristics
Agro climatic zone	Sub humid
Agro ecological zone	Southern guinea savanna
Length of growing period (days)	181 - 200
Annual rainfall (mm)	1200 – 1500
Altitude meter above sea level	450
Rainy season	June – October
Solar radiation ($MJ/m^2/day$)	15
Rainfall pattern	Bimodal
Mean annual temp	23.5
Vegetation	*Adropogen spp, Imperical cylindrical, Daniella spp, parkia biglobossa, Buterosperum spp, Ammarindus indica.*

Source: Umaru M.T (1999) personal communication NCRI Badeggi, Niger state, Nigeria

3.2 Data collection and computation

Samples used were collected from 3 different points between the months of June and August from the irrigation water of Maizube farms. After running a quality test on the irrigation water, it was easy to define

i. The total concentration of soluble salts

ii. The relative proportion of sodium to other cations

iii. The bicarbonate concentration as related to the concentration of calcium and magnesium

iv. The concentration of specific elements and compounds.

3.3 Analysis of irrigation water quality

Irrigation water quality is determined by the total amount of salts and the types of salts present in the water. Water may contain a variety of salts which includes sodium chloride (NaCl), sodium sulphate, gypsum(calcium sulphate $CaSO_4$), epsom salt(magnesium sulphate $MgSO_4$) etc.

To evaluate the salt hazards of irrigation water, the water sample should be analyzed for three major factors:

i. Total dissolved solid

ii. Sodium hazard

iii. Toxic ions

3.3.1 Total dissolved solids

This measures the salinity hazard by estimating the combined effects of all the different salts that may be in the water. It is measured as the electric conductivity of irrigation water (EC_w). Salty water carries an electrical current better than pure water and EC rises as the amount of salt increases.

3.3.2 Sodium hazard

This is based on the calculation of the sodium adsorption ratio (SAR). This measurement determines if sodium levels are high enough to damage the soil or if the concentration is great enough to reduce plant growth.

3.3.3 Toxic ions

These include elements like chloride, sulphate, sodium and boron. Sometimes, even though the salt is not excessive, one or more of these elements may become toxic to plant.

Table 3.2: General guideline for the interpretation of water quality for irrigation

Potential irrigation problem	Units	Degree of restriction on use		
		None	slight to moderate	severe
Salinity				
EC_w	dS/m	<0.7	0.7-3.0	.3.0
Total dissolved salt	mg/L	<450	450-2000	>2000
permeability				
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	<1.3
SAR = 20-40		≥5.0	5.0-2.9	<2.9
Specific ion toxicity				
Sodium N_a				
Surface irrigation	SAR	<3	3.9	>9

Sprinkler irrigation	mg/L	<70	<70	
Chloride(Cl)				
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
Miscellaneous effects				
Nitrogen	mg/L	<5	5-30	>3.0
Bicarbonate	mg/L	<90	90-500	>500

Source: Adapted from Pescod (1992)

3.4 Determination of electrical conductivity

Measuring the amount of total dissolved solids in irrigation water would be difficult hence; the electrical conductivity of the water (EC_w) is measured. Note that the electrical conductivity of the water is as a measure for the total dissolved solids. The EC_w can be measured using portable meter which is inserted to a certain level in the irrigation water.

The EC_w reflects the capacity of water to conduct electrical current and is directly related to the concentration of salts dissolved in water. This is because the salts dissolve into positively charged ions and as well as negatively charged ions that conduct electricity.

The EC_w is also temperature dependent i.e. the higher the temperature, the higher the conductivity. Electrical conductivity of water increases by 2-3% for an increase of 1°C of water temperature.

The commonly used units for measuring EC_w are:

¼ S/cm (microsiemens/cm) or

dS/m (decisiemens/m)

Where 1000 ¼ S/cm = 1 dS/m

Converting electrical conductivity (EC) to TDS can be done using

$$TDS\ (ppm) = 0.67 \times EC\ (¼\ S/cm) \quad 3.1$$

$$= 670 \times EC\ (dS/m) \quad 3.2$$

3.5 Determination of the sodium adsorption ratio (SAR)

Plants are detrimentally affected both physically and chemically by excess salts in some soils and by high levels of exchangeable sodium in others. Soils with an accumulation of exchangeable sodium are often characterized by poor tilth and low permeability making them unfavorable for plant growth.

The SAR is an indicator of the relative proportion of sodium ions in a water sample to those of calcium and magnesium. The SAR is used to predict the sodium hazard. It is accepted that the SAR and the electrical conductivity of irrigation water can be assessed for potential to cause dispersion in a soil. Sandy soils are not affected by the sodium due to its low clay content but the plants growing on them may be affected. The SAR is used to predict the potential for

sodium to accumulate in the soil, if sodic water was in constant use. A water sample with high SAR and low residual alkalinity usually has high sodium content due to the predominance of NaCl.

Table 3.3: General classification of water sodium hazard based on SAR values

SAR values	*Sodium hazard of water*	*Comments*
1-9	Low	Use on sodium sensitive crops must be cautioned
10-17	Medium	Amendments such as gypsum and leaching required
18-25	High	Generally unsuitable for continous use
≥26	Very high	Generally unsuitable for use

Mathematically, SAR can be represented as

$$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^{2+}] + [Mg^{2+}]}{2}}} \qquad 3.3$$

Where [ ] represents the concentration of cation

Na^+ is the sodium ion

Mg^{2+} is the magnesium ion

Ca^{2+} is the calcium ion

All in meq/L from the water analysis

In order to calculate the SAR from water analysis data, it is essential to convert the units from parts per million (ppm) or milligrams per litre (mg/L) to millie-equivalents per litre.

$$meq\ \ L = \frac{ppm(mg\ \ L)}{Equivalent\_weight} \qquad 3.4$$

Where the atomic weights are:

- Calcium = 20
- Sodium = 23
- Magnesium = 12.2

$$\text{Equivalent weight} = \frac{\text{atomic weight}}{\text{Valence ion}} \qquad 3.5$$

Where are: sodium = 1

Calcium = 2

Magnesium = 2

This parameter qualifies the ratio of sodium to calcium and magnesium in terms of the ability of the sodium to dominate the soil. The lower SAR the less likely the water is to cause structural degradation of susceptible soils.

3.6 Determination of the leaching fraction

There is a continual build up of salt with each irrigation. These salts would accumulate in the rooting depth until it gets it gets to damaging concentrations. A portion of added salt must be leached from the root zone before the concentration affects crop yield. Leaching is carried out 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.

Hence, the leaching fraction is the amount of extra irrigation water that must be applied above the amount required by crops in order to maintain acceptable root zone salinity depending on the salinity of the water it is being irrigated with.

To estimate the needed leaching fraction required, we apply

$$\text{Leaching fraction} = \frac{\text{Depth of water leached below the root zone}}{\text{Depth of water applied at the surface}} \qquad 3.6$$

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 are known, 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

$$LF = \frac{EC_w}{EC_{dw}} \qquad 3.7$$

Where LF is the leaching fraction

EC_w is the conductivity of irrigation water

EC_{dw} is the salinity of the drainage water

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Result of water analysis

Table 4.1 shows the result of the physio-chemical analysis of irrigation water carried out. The result reveals the amount of total dissolved solids, the sodium hazard, alkalinity and the specific ions of the irrigation water.

Table 4.1: Result of the physio-chemical ananlysis of irrigation

Parameter	Units	Measured value
Conductivity	µS/cm	133
pH		6.29
Turbidity	NTU	1.84
TDS	mg/L	89.11
Carbonate	mg/L	0.0
Nitrate-Nitrogen	mg/L	2.39
Calcium	mg/L	23.02
Magnesium	mg/L	67.06
Sulphate	mg/L	0.00
Phosphate	mg/L	0.02
Sodium	mg/L	3
Manganese	mg/L	0.00
Potassium	mg/L	5.36

Bicarbonate	mg/L	24
Chloride	mg/L	29.49

Parameter units		Measured Value 1	2
Conductivity	µS/cm	113	105
pH		6.31	6.18
Turbidity	NTU	11.44	10.58
TDS	mg/L	75.71	70.35
Carbonate	mg/L	0.0	0.0
Nitrate-nitrogen	mg/L	0.48	0.36
Calcium	mg/L	93.08	71.06
Magnesium	mg/L	9.01	16.01
Sulphate	mg/L	3	5
Phosphate	mg/L	1.5	2
Boron	mg/L	0.0054	0.005
Sodium	mg/L	1.0	1.5
Manganese	mg/L	0.7	0.9
Potassium	mg/L	3.35	3.35
Bicarbonate	mg/L	10	10
Chloride	mg/L	27.49	24.99
Iron	mg/L	0.43	0.33

Total hardness	mg/L	102.09	87.07

4.2 Statistical Analysis of the Result

4.2.1 Conductivity of the irrigation water

From the result of the water analysis, the measured values for the conductivity of the irrigation water were 133, 113 and 105μS/cm. To get the EC_w, the average of the values would be taken as

$$EC_w = \frac{133+113+105}{3}$$

$$= 117\mu S/cm$$

$$= 117 \times 10^{-6}\mu S/cm.$$

But we know that 1000 ¼ S/cm = 1dS/m

Hence, 117 μS/cm = 0.117dS/m

From the result obtained the total dissolved solids can be evaluated by

$$TDS = 670 \times EC$$

$$= 0.67 \times 0.117$$

$$= 78.39$$

4.2.2 The sodium adsorption ratio (SAR)

From the water analysis test result, the SAR can then be evaluated in order to determine to relative proportion of sodium to magnesium and calcium in the water sample.

In evaluation,

$$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^+] + [Mg^{2+}]}{2}}}$$

Where [ ] represents the concentration of cation

Na^+ is the sodium ion

Mg^{2+} is the magnesium ion

Ca^{2+} is the calcium ion

From the analysis result, the units were in mg/L which means it has to be converted to meq/L. In doing this, the formula below can be applied

$$meq\ \ L = \frac{ppm(mg\ \ L)}{Equivalent\_weight}$$

Where the atomic weights are:

- Calcium = 20
- Sodium = 23
- Magnesium = 12.2

Where the equivalent weight is $\frac{\text{atomic weight}}{\text{Valence electron}}$

From the result obtained,

Sodium = 3.0, 1.0, 1.5 mg/L

Calcium = 23.02, 93.08, 71.06mg/L

Magnesium = 67.06, 9.01, 16.01mg/L

They can therefore be converted to meq/L.

- For Sodium

  Taking the average of the samples = 1.83 mg/L

  Equivalent weight = 23/1 = 23

  meq/L= 1.83/23

  = 0.080meq/L

- For calcium

  Taking the average of the samples = 62.37mg/L

  Equivalent weight = 20/2 = 10

  meq/L = 62.37/10

  = 6.237meq/L

- For magnesium

  Taking the average of the samples = 30.70mg/L

  Equivalent weight = 12.2/2 = 6.1

  meq/L = 30.70/6.1

  = 5.033meq/L

The solved values can hence be substituted into equation 3.3.

Mathematically, SAR can be represented as

$$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^+] + [Mg^{2+}]}{2}}}$$

$$SAR = \frac{0.080}{\sqrt{6.237 + 5.033}}$$

$$SAR = 0.024$$

4.2.3 Leaching requirement

It is possible to ensure that salt levels in the soil do not exceed that of the irrigation water by leaching the salt beyond the root zone. Adequate drainage should ensure that this salt laden water does not cause further environmental damage.

The fraction of irrigation water that must pass through the root zone to control salts at an acceptable level is described as the leaching requirement or leaching fraction, derived from the following equation.

$$\mathbf{LR = EC_w \div (5EC_{ec} - EC_w)}$$

Where:

EC_w = irrigation water salinity (dS/m)

EC_{ec} = Threshold salinity (dS/m) a user specified value, based on knowledge of plant tolerances and soil types

$$LR = EC_w \div (5EC_e - EC_w)$$

But the EC_e of maize are:

$EC_e = 1.7$ for 100% yield potential

$EC_e = 2.5$ for 90% yield potential

At 100% yield potential

$$5EC_e = 5 \times 1.7 = 8.5$$

$$\text{Therefore } LR = 0.117/(8.5 - 0.117)$$

$$= 0.014$$

At 90% yield potential

$$5EC_e = 5 \times 2.5 = 12.5$$

$$LR = 0.117/ (12.5 - 0.117)$$

$$= 0.117/12.383$$

$$= 0.009$$

From the calculation, the leaching requirement data obtained helps to tell the amount of irrigation water which is required to leach the salt below the root level.

4.3 Discussion of Result

The primary objective of irrigation is to provide a crop with adequate and timely amounts of water, thus avoiding yield loss caused by extended periods of water stress during stages of crop growth that are sensitive to water shortages. However, during repeated irrigations, the salts in the irrigation water can accumulate in the soil, reducing water available to the crop and hastening the onset of a water shortage. Understanding how this occurs will help suggest ways to counter the effect and reduce the probability of a loss in yield.

The plant extracts water from the soil by exerting an absorptive force greater than that which holds the water to the soil. If the plant cannot make sufficient internal adjustment and exert enough force, it is not able to extract sufficient water and will suffer water stress. This happens when the soil becomes too dry. Salt in the soil-water increases the force the plant must exert to extract water and this additional force is referred to as the osmotic effect or osmotic potential. For example, if two otherwise identical soils are at the same water content but one is salt-free and the other is salty, the plant can extract and use more water from the salt-free soil than from the salty soil. The reasons are not easily explained. Salts have an affinity for water. If the water contains salt, more energy per unit of water must be expended by the plant to absorb relatively salt-free water from a relatively salty soil-water solution.

From the water analysis result obtained, the total dissolved solids in the irrigation water, sodium hazard and the toxic ions were determined. Their determination was a useful instrument in the evaluation of the quality of irrigation water being used.

With reference to Pescod 1993, a good quality irrigation water should have electrical conductivity of less than 0.7dS/m with a total dissolved solids of less than 450 and also a SAR value of between 0-3 for electrical conductivity of greater than or equal to 0.7dS/m.

From the result calculated, the conductivity of the irrigation water was evaluated to be 0.117dS/m which when compared to Pescod standard of '93 it fell within the set limit of <0.7dS/m. Also, the SAR value was calculated to be 0.024. In comparison with Pescod, the value fell within 0-3. Also, the TDS of the irrigation water was calculated to be 78.39 which was quite insignificant in comparison with the set limit of <450.

In conclusion, it can be stated that the irrigation water of Maizube farms is of good quality and thereby require little or no management strategies before they can be used.

4.4 Sodium effects

Excessive sodium in irrigation water 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.

Excessive sodium concentration can also be noted with symptoms such as leaf burn, scorch and dead tissue along the outside edges of leaves. An extended period of time (many days or weeks) is normally required before accumulation reaches toxic concentrations. Symptoms appear first on the older leaves, starting at the outer edges and, as the severity increases, move progressively inward between the veins toward the leaf centre. Sensitive crops include deciduous fruits, nuts, citrus, avocados and beans, but there are many others. For tree crops, sodium in the leaf tissue in excess of 0.25 to 0.50 percent (dry weight basis) is often associated with sodium toxicity. Sodium toxicity is often modified or reduced if sufficient calcium is available in the soil. Whether an indicated sodium toxicity is a simple one or is more complicated involving a possible calcium deficiency or other interaction is presently being researched. Preliminary results indicate that for at least a few annual crops, calcium deficiency rather than sodium toxicity may be occurring.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The conclusion deduced from this study include

i. The conductivity of the irrigation water which was calculated to be 0.117dS/m when compared with standards derived from pescod 1992 shows that the EC_w obtained was less than 0.7 hence there is no restriction to its usage.

ii. The sodium adsorption ratio (SAR) was calculated as 0.024. Going by Pescod 1992 it shows that with SAR with ranges between 0-3 and conductivity of less than or equal to 0.7 is good enough to be used for irrigation purposes. This also certifies that the irrigation water is suitable for use.

iii. The leaching requirement obtained was 0.014 and 0.009 at 100% and 90% yield potential using an EC_e of 1.7 and 2.5. This hence tells that little irrigation water is required for the leaching process as a result of the low salinity level of the soil.

iv. Hence, it can be concluded that the irrigation water is of very suitable quality for growing the maize plant.

5.2 Recommendation

The following recommendation were made with the experience gained from this work

i. That the evaluation of irrigation water quality should be carried out before being used for irrigation purposes to avoid the risk of building up salinity on the farm.

ii. Proper management practices must be carried out to avoid salinity build up as a result of the various farm operation like fertilizer application which also contribute to salinity build up.

iii. The result of this project should be verified and published so that farmers, research institutes and other organization can make use of it to reduce the problem of water salinity being faced.

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APPENDIX

➢ Test procedures for Irrigation Water Analysis

i. Total Dissolved solid

Total Dissolved Solids of all the samples are calculated from the value of electrical conductivity of each sample. Total dissolved solid is calculated from conductivity value as follows;

Calculated TDS = conductivity × (0.55 – 0.7). The adopted value by Regional Water Quality Laboratory Minna is 0.67. therefore;

TDS = conductivity × 0.67

ii. Conductivity

Measurements are made in the field using electrical conductivity meter made by WPA (CMD 8000). The meter is calibrated on per use basis.

iii. pH

Measurements are made in the field using pH meter made by Wagtech International (WG PH Scan 3). It uses 3 points calibration with a buffer solution of PH 4.01, 7.00 and 10.01.

iv. Turbidity

Measurements are made in the field using turbidity meter made by Wagtech International (WG –WT 3020). It is a multi-point automatic calibration (up to 4 points) equipment.

v. Sodium

1. Turn on the fuel at the source. Switch on the air compressor.
2. Depress the power switch to switch on the flame photometer. The power the

LED will be illuminated and an ignition cycle will commence.

3. If the flame on LED is not illuminated at the end of the ignition cycle, check the setting of the fuel control.

4. Set the filter selector to the required position.

5. Insert the nebulizer inlet tube in a beaker containing 100ml of diluents and allow 15minutes for the operating temperature to stabilize. This will ensure a stable burner temperature when solutions are aspirated, after the warm up period.

6. During the warm up period prepare a set of calibration solutions to cover the required measurement range. To obtain maximum linearity, Sherwood Scientific recommend that the highest standard concentration does not exceed 30 mg/L forSodium, 10mg/L for Potassium and 10mg/L for Lithium.

7. While aspirating diluents, adjust the blank control so that the display read 0.0

8. Aspirate the highest concentration standard.

9. Allow 20 seconds for a stable reading and then adjust coarse and fine controls for a convenient reading e.g. 20mg/L of Sodium can be set to read 20 on the display.

10. Remove the standard solution, wait 10 seconds, then aspirate a blank solution of diluents for 20 seconds . Adjust the blank control for a 0.0 reading. Remove the blank solution and wait 10 seconds.

11. Repeat paragraph 8,9,10 until the blank reading is 0.0 (within ± 0.2) and calibration reading is within ± 1%. If a chart recorder is being used set zero on the blank solution and set span while aspirating the calibration curve.

12. Aspirate each of the remaining calibration standards for 20 seconds (starting with the lowest concentration to avoid carry over) again allowing 10 seconds between measurements. Note the value of each standard and plot the results on a graph against standard concentration on linear graph paper.

13. Check calibration standards and blank readings.

14. Dilute the unknown solutions with diluents to give a concentration of the element under test within the range of the calibration standards. Several attempts might be necessary to determine the correct dilution ratio.

15. Aspirate each of the diluted unknowns for 20 seconds, then note the readings. The concentration of the element in the unknown sample can be calculated by reading the sample concentration from the calibration curve and multiplying it by the dilution factor.

vi. Calcium

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 ll and pink for murexide.

Calculation:

Calcium hardness as $CaCO_3$

mg $CaCO_3/L = (A-B) \times D \times 1000/Ml$ of sample

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

d. magnesium hardness (mg $CaCO_3/l$)= total hardness – calcium hardness

e. calculated magnesium as mg^{2+}

mg mg^{2+}/l = magnesium hardness as mg $CaCO_3$/l X 0.244

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Fax 066:224178
Our Ref:.....
Your Ref:.....

RESULT OF PHYSICO-CHEMICAL ANALYSIS

Date Sample Collected 22/06/2010
Date / Time Sample Delivered To the Laboratory: 22/06/2010 17/08/2010
Client: Student Project
Sample Analyzed by: Laboratory Analysts
I hereby certify that we have analyzed the above described sample in the condition submitted to us and stated hereunder our findings.

Parameter	Units	Measured Value
Conductivity	µS/cm	133
pH		6.29
Turbidity	NTU	1.84
TDS	mg/L	89.11
Carbonate	mgL	0.0
Nitrate-Nitrogen	mg/L	2.39
Calcium	mg/L	23.02
Magnesium	mg/L	67.06
Sulphate	mg/L	0.00
Phosphate	mg/L	0.02
Iron	~~mg/L~~	~~0.01~~
Sodium	mg/L	3
Manganese	mg/L	0.00
Potassium	mg/L	5.36
Bicarbonate	mg/L	24
Chloride	mg/L	29.49

Iron Total Hardness
Boron

Jamilu Habu
Laboratory Manager

REGIONAL WATER QUALITY
LAB MINNA.
LABORATORY MANAGER
SIGN
DATE 5/8/2010

FEDERAL MINISTRY OF WATER RESOURCES

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Your Ref:.....

RESULT OF PHYSICO-CHEMICAL ANALYSIS

Date Sample Collected 17/08/2010
Date / Time Sample Delivered To the Laboratory: 17/08/2010
Client: Student Project
Sample Analyzed by: Laboratory Analysts
I hereby certify that we have analyzed the above described sample in the condition submitted to us and stated hereunder our findings.

Parameter		Measured Value	
Units		1	2
Conductivity	µS/cm	113	105
pH	-	6.31	6.18
Turbidity	NTU	11.44	10.58
TDS	mg/L	75.71	70.35
Carbonate	mgL	0.0	0.0
Nitrate-Nitrogen	mg/L	0.48	0.36
Calcium	mg/L	93.08	71.06
Magnesium	mg/L	9.01	16.01
Sulphate	mg/L	3	5
Phosphate	mg/L	1.5	2
Boron	mg/L	0.0054	0.005
Sodium	mg/L	1.0	1.5
Manganese	mg/L	0.7	0.9
Potassium	mg/L	3.35	3.35
Bicarbonate	mg/L	10	10
Chloride	mg/L	27.49	24.99
Iron	mg/L	0.43	0.33
Total Hardness	mg/L	102.09	87.07

Jamilu Habu
Laboratory Manager

REGIONAL WATER QUALITY
LAB MINNA.
LABORATORY MANAGER
SIGN
DATE 30/9/2010