I MPACT ASSESSEMENT OF SALTS IN THE FADAMA LAND OF EDOZHIGI, BIDA LOCAL GOVERNMENT AREA OF NIGER STATE

BY

SIYAKA ABDULRAHMAN

MATRIC NO. 2003/14892EA

DEPARTMENT OF AGRICULTURAL AND BIORESOUCES ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

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BEING A FINAL YEAR PROJECT SUBMITED IN PARTIAL FULFILMENT OF THE REQUIREMENTS BACHELOR OF ENGINEERING (B.ENG.) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING

FEDERAL UNIVERSITY OF TECTNOLOGY, MINNA.

NOVEMBER, 2008

DECLARATION

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 Information derived from personal communications, published and unpublished works of others were duly referenced in the text.

....

SIYAKA ABDULRAHMAN DATE

CERTIFICATION

This is to certify that this project "Impact assessement of salts in the fadama land of Edozhigi, Bida Local Government Area of niger state was carried out by Siyaka Abdulrahman under the supervision of Mrs H.I. Mustapha submitted to the agricultultural engineering department, Federal university of technology,Minna in partial fulfillment of the requirement of the award Bachelor of Engineering (B. eng) in Agricultural Engineering.

.... 02.02.09

Mrs H.I. Mustapha. Date

Project supervisor

....

Engr. Dr. (Mrs.) Osunde. Date

.... 19/11/08

External examiner Date

DEDICATION

This research work is dedicated to my late brothers Abdulmumuni and Abdulrasheed. May the Almighty Allah forgive you your sins and grant your souls an abode of paradise (Amin).

ACKNOWLEDGEMENT

My profound gratitude goes to Almighty Allah, who is the giver all true knowledge and master of all creatures. He alone is worthy of worship.

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ABSTRACT

Impact assessment of salts in the Fadama land of Edozhigi Bida Local Government Area of Niger state, jwas carried out in this project. Four samples of soil was collected from the project site at a depth of 10cm interval to a total depth of 40cm which determine root depth of a plant. The sample was sent to the laboratory for analysis and the result obtained show that soil sample A has an ESP of 0.876 and an EC of 45.1 while that of B has an ESP of – 1 101 and an EC of 42.3. Soil sample C has an ESP o f – 0.804 and an EC of 32.6 and soil sample D has an ESP of - 1.128 and an EC of 30.1

From the result , it shows that the soil has a low level of salinity and is safe for crop production as compared to the guidelines of table 2.1

ABBREVIATIONS AND NOTATIONS

ECe = Electrical conductivity

SAR = Sodium adsorption ratio

ESP = Exchangeable Sodium Percentage

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Chapter one

1.0 INTRODUCTION

1.1 Historical background

The fadama concept is an old age tradition in Hausa land. The hausa name for irrigable land, meaning dry season farming on fadama. The fadama land are flood plains and low lying area underlined by shallow acquifers and found along Nigeria's river system (Umar,1991).

Soil is defined as the topmost part of the earth's crust. (Sheinberg,and Latey, 1993). Soil consists of mineral and organic matter, as well as living organisms, soil comprising the pedosphere, is positioned at the interface of the lithosphere with the biosphere, atmosphere and hydrosphere. Soil formation, or pedegenosis, is the combined effect of physical, chemical, biological and anthropogenic processes on the geological parent resulting in the formation of soil horizons. (Sheinberg,and Laty, 1993).

Salt refers to a chemical compound formed by replacing the hydrogen ions in an acid with metallic or ammonium ions. A salt is the compound formed when all or part of the ionizable hydrogen of an acid is replaced by metallic or ammonium ions (Ababio, 2000).

Accumulation of excess salts in the rootzone resulting in a partial or complete loss of soil productivity is a World wide phenomenon. The problems of soil salinity are most widespread in the arid and semi- semi arid regions but salt affected soils also occur extensively in sub-humid and humic climates, particularly in the coastal regions where the ingress of sea water through estuaries and rivers and through ground water causes large – scale salt deposit.(Hansen et al, 1993).

Soil salinity is also a serious problem in areas where ground water of high salt content is used for irrigation. The most serious problems are being faced in the arid and semi – arid regions of the World and it is these very regions that irrigations is essential to increase agricultural production to satisfy food requirement (Ayers, and Westcot, 1996).

However, salinity problem are most extensive in the irrigated arid and semi – arid areas. In every river basin, prior to the introduction of irrigation, there exists a water balance between the rainfalls on the one hand and stream flow, ground water level and evaporation and evapotranspiration on the other. This balance is disturbed when large additional quantities of water are artificially spread on land for agriculture. An important new contribution to ground water is introduced in the form of seepage from irrigation channels, from irrigation water added over and above the quantities actually utilized for meeting the evapotranspirational needs of crops, and obstructions in the natural drainage brought about by new developments in the area (Gardner and Fireman, 1996).

Studies have shown that once the water table is within 1.o to 2.0m of the soil surface, salts get accumulated in the rootzone of the plant and therefore salinization problems is more severe when the salinity of ground water is high as is usually the case in arid regions(Hoffman, 2005).

Moreover, nearly 50 percent of the irrigated land in the arid and semi – arid regions have some degree of soil salinization problems (Rhoades, 1995).

To crown it all, the most challenging problems facing irrigation agricultures is salinity problems. Adequate measure is needed to counter the problems of salt – build up in agricultural land. This makes the assessment of the salt-build in agricultural land becomes Important.

1.2 Statement of the problems

Irrigation is a means of increasing agricultural productivity. One of its contending problem is soil salinity in the irrigated land which is harmful to crops. The available land resources is limited due to salinity problems. This makes the assessment of salts build – up in the soil a good research.

1.3 Objectives

The aim of this Research is;

(i) To determine the salt content in the soil.

(ii) To asses the impact of salts build – up in the soil with particular reference to it's effect on plant's growth.

1.4 Research Questions

(i) What are the effects of saline soils.

(ii) What are the origin and causes of salt build – up in soils

(iii) What are the effects of high water table - depth in the soils.

(iv) What is the effect of salt concentration in the rootzone on plants.

1.5 Justification

The aim of undertaking this project is to find a remedy to the problems of soil salinization which affects agricultural production. Adequate knowledge of salts build – up in the soil helps in the selection of crops to be grown in the salt affected soils.

However, there is a need to conserve soil resources to meet the global food requirement .

1.6 Scope of the study

The study is limited to salt concentrations in the Fadama land of Edozhigi, Bida Local Government Area of Niger state.

CHAPTER TWO

2.0 REVIEW OF RELATED LITERATURE

Salt affected soils are found on more than half of the Earth's arable lands. They dominate most arid and semi – arid region of the World. Extensive areas are used for range lands or dry land farming, but a significant portion is used for irrigated agriculture. Irrigation water from either reservoir or impoundments or ground water pumping systems can transform these dry areas into some of the world's most productive farmlands. In the united states,15% of cropland that is irrigated produces 40% of the total crop value (Carter, D. L 1999.)

Miton Whitney, 1998 reported that most arid and semi arid areas are mostly alkaline because water from rain or snow is insufficient to leach the base – forming cation (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, e.t.c) that are slowly released as the rocks and minerals weather. As a result, the percentage base saturation is high and PH values are typically 7.0 or above. In some areas the leaching is insufficient to remove even soluble salts such as $NaCl$, $CaCl_2$, $MgCl_2$ and KCl, leading to saline, as well as alkaline conditions.().

World wide, about one third of the irrigated lands have salts problems ()

Irrigation water transports salts from upstream watershed areas to the cultivated fields. If the irrigation systems do not provide good internal drainage, salts, particularly those conterminating sodium, can accumulate to levels that can engender chemical and physical problems that can render a soil ...ually useless as a habitat for plants (Richards, L.A. 1990.

While Royo, and Aragues, 1993 both reported that Alkaline and saline soils have also played a unique role in the World history, as the rise and fall of several ancient civilizations were tied to their irrigation and subsequent mismanagement.

2.1 Origin of salts in soil

Salt affected soils are caused by excess accumulation of salts, typically most pronounced at the top soil surface. Salts can be transported to the surface by capillary transport from a salt laden water table and then accumulate due to evaporation; they can also be concentrated in soils due to human activity. As soil salinity increases, salt effects can result in degradation of soils and vegetation.(Miller, and Donahue, 1995).

Salt is a natural element of soils and water. The ions responsible for salinization are: Na^+, K+, Ca^{2+} and Mg^{2+} As the Na^+(sodium) predominates, soils can become sodic. Sodic soils can present particular challenges because they tend to have very poor structure which limits or prevents water infiltration and drainage. As soil minerals whether and release salts, these salts are flushed or leached out of the soil by drainage water in areas with sufficient precipitation. In addition to mineral weathering, salts are also deposited via dust and precipitation. In dry regions salts may accumulate, leading to naturally saline soils. This is the case in large parts of Australia. Human practices can increase the salinity of soils by the addition of salts in irrigation water. Proper irrigation management can prevent salt accumulation by providing adequate drainage water to leach added salts from the soil. Disrupting drainage pattern that provide leaching can also result in salt accumulations. An example of this occurred in Egypt in 1970 when the Aswan High Dam was built. The change in the level of ground water before the construction had enabled soil erosion, which led to high concentration of salt in the water table. After the construction, the continuous high level of the water table led to the salinization of the arable land. (Mamedov, et al., 2000).

2.1.1 Effects of salinity on plant Growth

Salinity is the development of non saline soil into a saline soil. Salinity becomes a problem when enough salts accumulate in the rootzone to negatively affect plant growth. Excess salts in the rootzone hinder plant roots from withdrawing water from surrounding soil. This lowers the amount of water available to the plant, regardless of the amount actually in the rootzone. Excess salinity in soil water can decrease plants available and cause plant stress (Hamson and Grattan, 1999).

Soil water salinity is dependent on soil type, climate, water use and irrigation routines. This is because immediately after the soil is irrigated, plant available water is at its lowest. However, as plants use soil water, the remaining water is held tighter to the soil and becomes progressively more difficult for plants to obtain. As the water is taken up b by plants through transpiration or lost to the atmosphere by evaporation, soil water salinity increases because salts become more concentrated in the remaining soil water. Thus, evapotranspirational(ET) between irrigation periods can further increase salinity (Henderson, 2001).

2.2 Effects of Sodium and Sodicity on soil physical property.

The primary physical processes associated with high sodium concentration are soil dispersion and clay platelets and aggregate swelling. The forces that bind clay particle together are disrupted when too many large sodium ions come between them. When this separation occurs, the clay particles expand, causing swelling and soil dispersion.

Soil dispersion causes clay particles to plug soil pores, resulting in reduced soil permeability. When soil is repeatedly wetted and dried and clay dispersion occurs, it then reforms and solidifies into almost cement – like structure. The three main problems caused by sodium – induced dispersion are reduced infiltration, reduced hydraulic conductivity, and surface crusting.

Salts that contribute to salinity, such as Calcium and magnesium, do not have this effect because they are smaller and tend to cluster closer to particles(fig 2.0).Increased amounts of calcium an d magnesium will generally keep soil flocculated because they compete for the same spaces as sodium to bind to clay particles. Increased amounts of calcium and magnesium can reduce the amounts of sodium – induced dispersion (Hanson et al, 1999).

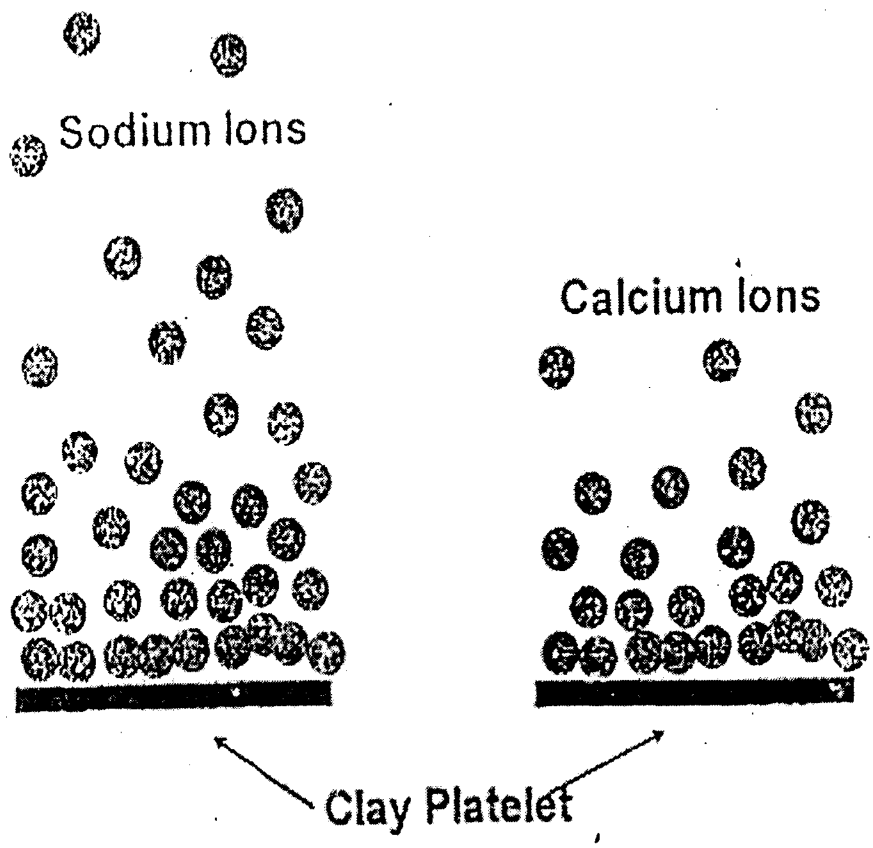

Figure 1. Behavior of sodium and calcium attached to clay particles. *(After et al 1999)*

2.2.1 Surface crusting

Surface crusting is a characteristic of sodium affected soils. The primary causes of sodium crusting are: physical dispersion caused by impact of raindrops or irrigation water and chemical dispersion, which depends on the rates of salinity and sodicity of the applied water.

Surface crusting due to rainfall is greatly enhanced by sodium induced clay dispersion. When clay particles dispersed within soil water, they plug macropores in surface soil by two means. First, they block avenues for water and roots to move through the soil. Second, they form cement like surface layer when the soil dries. The hardened upper layer or surface crust, restricts water infiltration and plant emergence (Agassi, et al., 1991).

2.2.2 Relationship between salinity and sodicity and soil physical properties.

The relationship between soil salinity and its flocculating effects and sodicity and its dispersive effects influence whether or not soil will stay aggregated or become dispersed under various salinity and sodicity combination. As irrigation water with low salinity is applied to the soil by irrigation or rainfall, this water flow s into the spaces between clay particles (microspores). If salinity of the applied water is low relative to soil salinity, swelling and dispersion of clay particles results. In contrast, irrigation water with higher salinity than the soil tends to cause particles to stay together, maintaining soil structure (Gortzen, 1994).

More than fifty years of research have been conducted to determine the relationship between salinity and sodicity of irrigation water and its effect on soil physical properties (Frenkel, and Rhoades, 2001). This relationship is now understood well enough to make accurate prediction of how specific soils will behave when irrigated water containing different levels of salts and sodium. The main concerns related to the relationship between salinity and sodicity of irrigation water the effects on soil infiltration rates and hydraulic conductivities (Frenkel, and Rhoades, 2001)

2.2.3 The swelling factor

The ratio of swelling to sodicity determines the effects of salts and sodium on soils. Salinity promotes soil flocculation and sodicity promotes soil dispersion. The combination of salinity and sodicity of soils is measured by the swelling factor, which is the amount a soil is likely to swell with different combinations of salinity and sodicity. Essentially, the swelling factor predicts whether sodium – induced dispersion or salinity induced flocculation will more greatly affect soil physical properties. Scientist have been able to get a good idea of the swelling factor by using figure 2.1. It is possible to draw a line from the sodium content (adjusted ESP) in the left column to the appropriate salt in the right column. The line intersects the middle columns, the swelling factor, indicating how much the soil will swell. For instance, drawing a line between adjusted Esp. = 2 and an EC = 40Meq/l(red line) yields a swelling factor of 0.0041 indicates that dispersion is likely.

In short, figure 2.1 help shows how dispersive effects of soil with high ESP can be lessened with the flocculating effects of irrigation water with high EC (Neal, 2003)

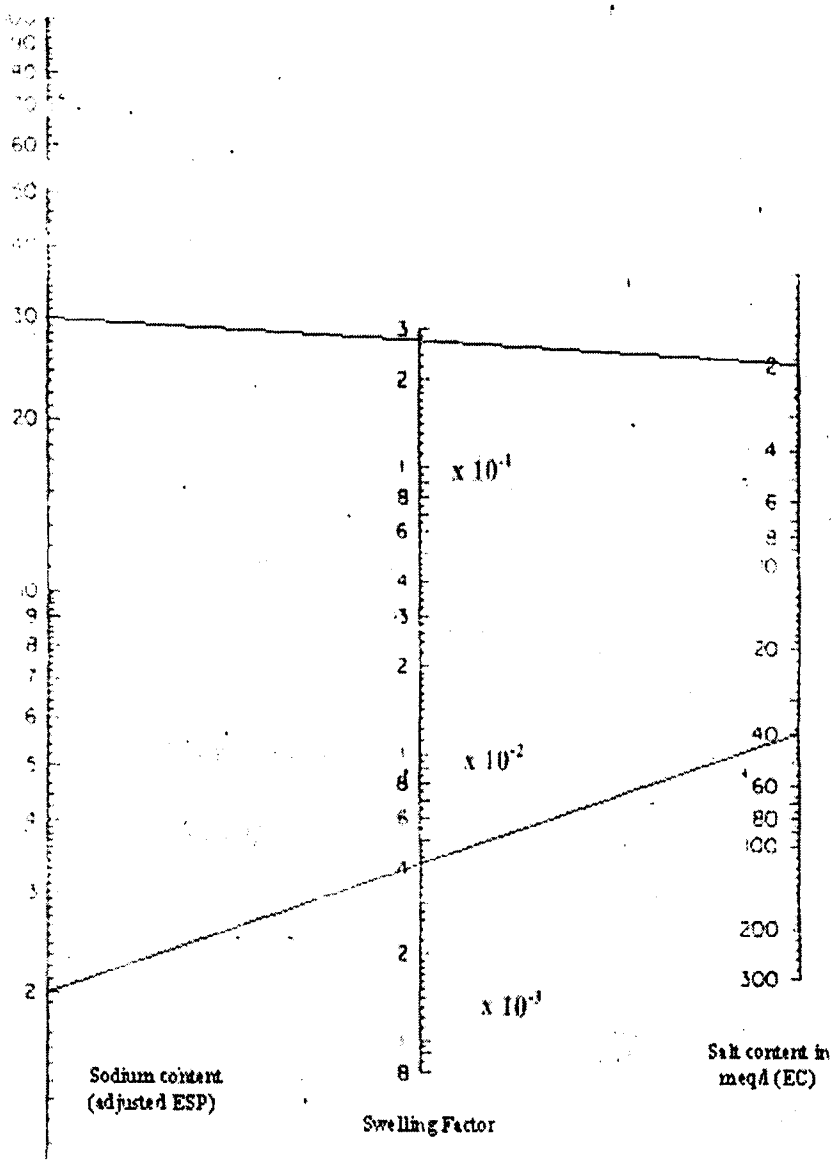

Figure 2.1

Swelling factor as a function of sodium content (adjusted ESP) of soil and salt concentration of soil water (*After McNeal, 1998*).

2.2.3.1 Infiltration Rates

Oster, and Schroer,2001 -also reported another approach to judging the effects of salinity (EC) and Sodicity (SAR) on soil physical properties is to asses potential impacts of various irrigation water qualities on infiltration rates. Figure 2.3 demonstrates the relationships between salinity and sodicity and infiltration rates. Severe salt problems are likely if the irrigation has low salinity and high sodicity. At SAR= 15, a severe reduction in infiltration will occur at an EC = 1. An EC of 2.5 or less results in a slight to moderate reduction infiltration. With an EC greater than 2.5, there will likely not be a reduction in infiltration rates. Table 1 numerically defines the relationship between EC, SAR, and infiltration rates. Factors such as climate, Soil type, crop and plant species and sodicity and soil physical properties. Intense rainfall can flush salts beneath the rootzone, but often can significantly reduce amounts of sodium of sodium bound to the soil. Therefore, rainfall can reduce salts and increase the likelihood that sodium – induced dispersion will occur (Oster, and Schroer, 2001).

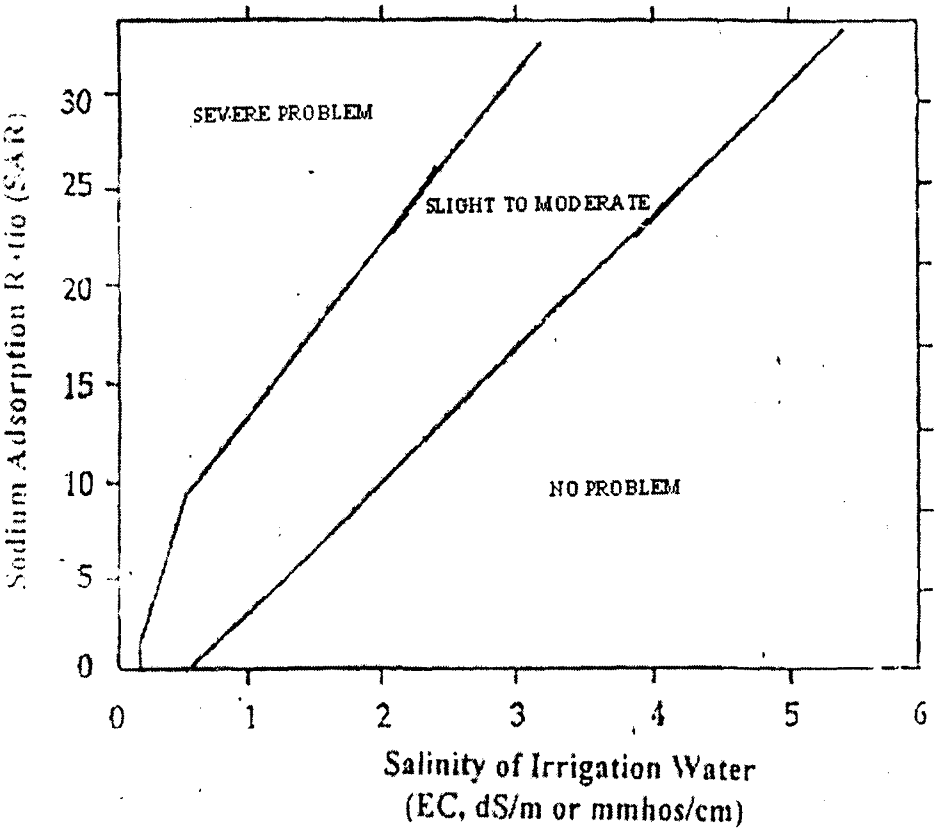

Figure 2.2. Potential for reduction in infiltration rates resulting from various combinations of EC and SAR of applied water (*After Hanson et al., 1999*).

Table 2.1 Guidelines for saline-sodic water quality suitable for irrigation, presented in terms of reduced infiltration (*After Ayers and Tanji, 1991*).

	EC ds/m	*EC ds/m*	*EC ds/m*
SAR	*No problem*	*Slight to moderate*	*Severe problem*
0 – 3	> 0.9	0.9 – 0.2	< 0.2
3 – 6	> 1.3	1.3 – 0.25	< 0.25
6 – 12	> 2.0	2.0 – 0.35	<0.35
12 – 20	> 3.1	3.1 _ 0.9	< 0.9
20+	> 5.6	5.6 – 1.8	< 1.8

2.2.3.2 The role of soil texture in irrigation agriculture.

Soil texture plays an important role in all irrigated agriculture, and the role of soil texture with respect to effects of salinity and sodicity is no exception. Soil texture is helps determine how much water the soil will be able to pass through the soil, how water the soil can store, and the ability of sodium to bind the soil. As they are composed of small particles, clay soils can hold more water and are slower to drain than coarse textured soils.

Smaller particles of clay pack closely together, block the spaces between particles and prevent water from passing through. Sand particles are larger and therefore, have larger pore spaces for water to pass through and will naturally be able to flush more water through the rootzone than clay soils. The end result is that sandy soil can withstand higher salinity irrigation water because more dissolved salts will be removed from the rootzone by leaching. (Frenkel, et. Al 1996).

2.2.4 Causes of Salt Accumulation

Saline or alkali soils are seldom formed insitu by residual weathering of rocks. On the other hand, hydrological conditions contribute substantially to the development of soil salinity and alkalinity. The hydrological processes release the salt constituents from the primary and secondary minerals to the surrounding waters. In arid regions, due to high evaporative conditions, salt concentration is gradually increased in the water sources.

In humid regions, salts thus released are transported to lower layers and ultimately by steams to the ocean. Moreover, the salts deposited by irrigation, are leached down to lower layers of the soil by rainfall. On the contrary, in arid regions the release salts may not be transported far away because of insufficient rainfall and whatever leaching of salts may occur, it would mostly be local. However, high evaporating conditions of the arid regions tend to decrease further the limited available ground water (Argawal, and Gupta, 2001).

2.1.4.1 Effects of salinity on plant Growth

Salinity is the development of non saline soil into a saline soil. Salinity becomes a problem when enough salts accumulate in the root zone to negatively affect plant growth. Excess salts in the root zone hinder plant roots from withdrawing water from surrounding soil. This lowers the amount of water available to the plant, regardless of the amount actually in the root zone. Excess salinity in soil water can decrease plants available and cause plant stress (Hamson and Grattan, 1999).

Soil water salinity is dependent on soil type, climate, water use and irrigation routines. This is because immediately after the soil is irrigated, plant available water is at its lowest. However, as plants use soil water, the remaining water is held tighter to the soil and becomes progressively more difficult for plants to obtain. As the water is taken up b by plants through transpiration or lost to the atmosphere by evaporation, soil water salinity increases because salts become more concentrated in the remaining soil water. Thus, evapotranspirational (ET) between irrigation periods can further increase salinity (Henderson, 2001).

2.2.5 Effect of irrigation, soil Management and crop Management on soil salinity and Alkalinity.

The nature and extent of salt accumulation and degree of soil alkalinity depend on the quality of irrigation water, frequency of irrigation, soil type and its permeability, salt tolerance characteristics of the plant and climatic conditions. Generally, soils of light texture are less salinised than those of medium and heavy textured soils. The soils irrigated with waters having the same concentrations of salts develop more alkalinity with waters having higher proportion of sodium and bicarbonates ions. The presence of a hard pan of lime or clay further enhances the degree of alkalinity. The situation becomes more complex to predict when the depth of water table is high and the quality of irrigation water is poor. Under such situation, the final salt balance near the rootzone is governed by the combined effect of the quality of irrigation water, irrigation management. and climate and water transmission properties of the soil during the cropping period (Maliwal, 2001)

2.2.6 Water logging and Soil salinity.

Studies at the Land Reclamation, Irrigation and power Research Institute, Armrister, showed a rise of water table from 2.6 - 6.6 metres during the period 1986 – 1996 (Uppal, 1998). It was observed that the salt problem in high water table areas is mostly governed by the amount and intensity of rainfall. In the monsoon season when water table rises and comes near the surface. the land is temporarily waterlogged due to which salinity is reduced. But, after the rains and with the onset of winter, water is lost by evaporation and salts are deposited on the surface. During the cropping period of winter crop, crop such as lands are irrigated and the salt present in the soil profile move up and down. Consequently, the total soil salinity is controlled by the period of water logging, water transmission characteristics of the soil, the salt content of the ground water and the evaporative condition of the region. Topography of the land also modifies the ultimate soil salinity (Kovda, 2001).

2.2.7 Chemical properties of soil

The chemical properties of soil are the development of changes in the soil physical characteristics.

Salinity hazard: when the salt distribution in the soil profile becomes excessive, crop growth is deteriorated. Such soils are often recognized by the presence of a white surface crust. In saline water irrigated area, particularly in the arid regions of Rajasthan, the EC of the saturation extract of the soil is usually about three times and even more than that of irrigation water. In general, salt concentration is maximum on the surface and decreases with the increase in depth. In irrigated soils, the extent of salinity is more related to the process of salt water movement within the soil column than whether the salt are moving downwards with the leaching effect of irrigation water or are moving up by capillarity under thermal gradient. In a well drained light textured soil immediately after irrigation, the soil salinity, as measured on the basis of saturation extract of the soil sample, would be less at the surface layers and it would be more at deeper layers. On the contrary, in heavy soils accumulation of salts would always be more on the surface due to impeded drainage. Quantitatively, under similar soil condition more salinity would be observed in arid and in humid regions and in heavy textured soils than in light soils. (Maliwal, and Paliwal,2002).

2.2.8 Sodium hazard

The sodium hazard is the effect of sodium in the physical properties of soil.

In irrigated soils, the cations present in irrigation water as soluble salt take part in an exchangeable reaction with the soil. The main cation exchange which takes place is between sodium ion in the irrigation water and calcium ion in the exchangeable complex of the soil.

$Ca + 2Na+ \rightarrow Na + Ca^{++}$

According to this process a soil may not be changed into an alkali soil, depending upon the relative proportion of sodium and calcium ions in the equilibrium solution. However, the process of alkalization could be very quick and can come to an equilibrium condition if the relative proportion of Na: Ca + Mg, as expressed by the sodium adsorption ratio, is high. The exchangeable sodium percentage increases with the total salt concentration and or SAR of irrigation water or soil solution.

In arid and semi – arid regions, as the soil solution becomes concentrated through evaporation or transpiration, the solubility limits of calcium carbonates and magnesium carbonates are exceeded. As a result of these, they are precipitated with a corresponding increase in the relative proportion of sodium in the soil solution. Hence a part of exchangeable calcium and magnesium is replaced by sodium, increasing the sodium contact.This lead to the conclusion that any chemical process, in the soil causing a decrease in calcium, either in solution or exchange phase, will lead to enhancement of alkalinity. In addition to the above process, the extent of degree of sodium saturation will be governed by the chemical affinity of the ion to the soil, its replacing power in comparison to other ions and its own replaceablility by other ions.

Fortunately, amongst sodium, calcium and magnesium, the replacing power both of calcium and magnesium and their chemical affinity to a soil are more than sodium. Hence, a higher proportion of sodium is necessary in the soil solution to replace calcium. The proportion o f sodium to calcium and magnesium should be above 50 percent in the soil solution before it is adsorbed in significant amounts. Moreover, more Na is adsorbed at the same salt concentration and the same Na content when Mg is present rather than Ca, as the replaceability of mg is more than that of Ca. it may be summarized that the process of alkalization and its extent is influenced by the total salt concentration, ionic composition, relative proportion of sodium to other cations, nature and total amount of clay and their exchange characteristics.

2.2.9 Magnesium Hazard.

Sometimes more magnesium is present in irrigation water than calcium. This increases the degree of magnesium saturation which also deteriorates the soil structure Irrigation water having relatively more magnesium than calcium are likely to decrease soil productivity. About 73 percent of the 4162 samples of poor quality well waters of Rajasthan were observed to have more Mg than Ca. (Paliwal, 2002)

2.3 Development of salt affected soils.

Salt - affected soils are widely distributed throughout the World (table 1.0), the largest areas being found in Australia, Africa, Latin America, and the Near and Middle East. They are most often found in areas with precipitation – to – evaporation ratios of 0.75 or less, and in low, flat areas with high water tables that may be subject to seepage from higher elevation.

Nearly 50 million of crop land and pasture are currently affected by salinity and in some regions the area of land so affected is growing by about 10% annually.(Logan, 1995).

2.2.1 Natural salt Accumulation

Salts accumulate naturally in some surface soils of arid and semi – arid regions because there is insufficient rainfall to flush them from the upper soil layers. In the united states, about one – third of the soils in these regions suffer from some degree of salinity. The salts are primarily chlorides and sulphates of calcium, magnesium, sodium, and potassium. They may be formed during the weathering of rocks and mineral or brought to the soils through rainfall and irrigation. Other localized but important sources are fossil deposits of salt laid down during geological time in bottom of non extinct rocks or oceans or in underground saline water pools. These fossil salts can be dissolved in underground waters that moves horizontally over underlying impervious geological layers and ultimately rise to the surface of the soil in the low lying parts of the landscape, often forming saline seeps. The water then evaporates, leaving salts in place at or near the surface and creating a saline soil. In soil, The Ca^{2+} and Mg^{2+} ions dominate the exchange complex of most salt – affected soils. In some soils with greater than 15% Na saturation, the PH may rise above 8.5, and the stability of the soil aggregates may deteriorate. The soil colloids disperse and plug the soil's drainage pores, preventing the downward percolation of water. Such soils known as sodic soils are quite unproductive and are very difficult to manage. (Bhumbla,2003).

2.3.1 Development of salt affected soils

Salt – affected soils are widely distributed throughout the World (table2.0), the largest area being found in Australia, Africa, Latin America, and near Middle east. They are most often found in areas with precipitation – to – evaporation ratios of 0.75 or less, flat areas with high water tables that may be subject to seepage from higher elevation (Logan, 1995).

Table 2.1 Are . f salt – affected soils in Different Regions.

Region	Area, million ha
Africa	69.5
Near and Mddle East	53.5
Asia and Far East	19.5
Latin America	59.4
Australia	84.7
North America	16.0

2.3.2 Management of saline and sodic soils.

The first requisite for wise management of salt – affected soils is to know something about the amount and nature of soluble salts being added to and removed from the soil. In irrigated areas, this means knowing the quality of the irrigation water and status of the soil drainage.

2.3.4 Water quality considerations.

The chemical quality of water added to salt affected soils is a prime management tool. In a situation where the water is too low in salts, such as rain water, it can hasten the change from a saline – sodic soil to a sodic soil, but the impact of rain drops encourages dispersion of the soil colloids and SAR levels of irrigation water are high, the process of forming sordic soil will accelerate. A , the presence of bicarbonates in the irrigation can reduce concentrations of Ca^{2+} and Mg^{2+} in the soil solution by precipitating these ions as insoluble carbonates. Such chemical characteristics of the irrigation water can increase the SAR of the soil solution and move the soil toward the sodic class. (Ayers,and Westcot, 2003).

2.4 MEASURING SALINITY AND ALKALINITY

Plants are detrimentally affected by excess salts in some soils and by high levels of exchangeable sodium in others. the rated being detrimental to the soil both physically and chemically techniques have been developed to measure three properties that along with pH can be used to characterized salt affected and sodic soils;

i. Soil alkalinity.

ii. Exchangeable sodium percentage (ESP)

iii. The sodium absorption ratio (SAR)

2.4.1 Growth of plant on saline and sodic soil

Plants respond to different salt-affected soils in different ways. High soluble salt concentrations, through their effects on osmotic Potential, reduce plants growth on saline and sodic soils. Root cells, as they come in contact with a soil solution, that is high in salts, will lose water by osmosis to the more concentrated soil solution.The cell then collapse. The kind of salt the plant species and the rate of salinization are factors that determine the concentration at which the cell succumbs. Very limited air and water movement in some saline sodic soils also may be a factors in determining which plants can grow on these soils.

Sodic soils harm plants in five ways;

i. The caustic influence of the high pH induced by the sodium Carbonates and bicarbonates and other anions.

ii. The toxicity of the bicarbonates and other anions.

iii. The adverse effects of the active sodium ions on plants metabolism and nutrition.

iv. The low micronutrient availability due to high pH

v. Oxygen deficiency due to the breakdown of the soil structure.

2.4.2 Selective tolerance of higher plants to saline and sodic soils

Satisfactory plants growth on salty soils depend on a number of interrelated factors, including the physiological condition of the plants, its stage of growth and its rooting habits. It is interesting to note that old alfalfa plants are more tolerant to salts affected soils than young ones, and that deep rooted legumes show a greater resistance to such soils than those that are shallow-rooted.

Soil properties including the nature of the various salts, their proportionate amounts, their total concentration, and their distribution in the sodium must be considered. The structured of the soil and its drainage and aeration are also important.

2.4.2.1 Plant sensitivity

While it is difficult to forecast precisely the tolerance of crops to salty soils, numerous tests have made it possible to classify many domestic plants into four general groups based on their salinity tolerance. The relative productivity of the salinity as measured by electrical conductivity (Ece).

Note that trees, shrubs, fruits, vegetables and field crops are included in the different categories. To this list of domestic species should be added two other potential sources of plants to grow on salty soils. Wild halophytes (salt-loving plants) and salt tolerant cultivars developed by plant breeders have been found that are quite tolerant to salts and that poses qualities that could make them useful for human and/or animal consumption. Even though they may accumulate high levels of salt in their stems and leaves, the seeds are commonly not too different from domesticated ops in their content of protein and fats, for example, plant breeders have been able to develop new strains with salt tolerance greater than that possessed by convectional varieties. An example is shown by data in figure which illustrates superior performance by improved strains of barely. Plant should be one of the goals of the future to maintain or even increase food production on salt affected soils.

However, improved plants tolerance must not be viewed as a substitute for proper salinity control.

2.5. Classification of soil

2.5.1 Saline soils

Use of saline ground water:

When ground water is the only source available for irrigation, highs salinity of the irrigation water can cause a build up of salts in the root zone, particularly if the internal drainage of the soils is restricted and leaching, either due to rainfall or applied irrigation, is inadequate.

Also saline sweeps, .common in North America, Australia and other countries are the results from reduced evapotranspiration after a change in land use from a natural forest vegetation to cereal grain crop or a shift in cropping pattern such as the introduction of a fallow season in grain farming system.

2.5.2 Sodic soils

The mechanism responsible for the formation of sodium carbonates in soil which characterize sodic (alkali) standard works (Kelly, 2005) Bazilevich 2006. Groundatwre containing carbonates is one fo the chief contribution factors in the formation of sodic occur in Egypt in Wadi TUmilat, Ferhash and Wadi-El-Natrom. The soisl are reported to have formed by desalination divalent cations in some parts of the Nile Delta, by high carbonates and bicarbonates water in Wadi Tumilat and by dentrification and sulphate reduction under anaerobic conditions in Wadi-El-notrom (elgagaly, 2006)

2.5.3 Causes and processes of salt build up

The major causes for the build up salt in an irrigated area include;

a. Use of saline water for irrigation
b. Deposition of salts on soil surface from high sub soil water table.
c. Water logging and poor drainage conditions.
d. Seeping from the canals
e. Arid climate
f. Under irrigation

How do these processes results in salt build up? Two main ways through which these processes results in salt build upo are;

i. Direct Salinization by irrigation results, if there is inadequate leaching. All irrigation waters contain salt which are brought into the rootzone during irrigation. After irrigation, the water is lost by the process of evapotranspiration leaving the salt content behind in the rootzone as the salt uptake by crops is small. These salts accumulate unless there is adequate leaching by deep percolation. Inadequate leaching is cause by poor drainage conditions and climate under irrigation and use of saline water. The capillary salinization as explain by Smedema and Rycroft (2002) is thus "Evaporation of saline ground water from the soil is a common cause of soil salinization. The ground water may evaporate directly from the water table when the later occurs within the evaporation zone, or it may be drawn from deeper down as the evaporation itself will create a gradient for upward capillary flow from the water table into the evaporation zone. As the water evaporates the salt remain behind in the evaporation zone".

2.6 Chemistry of salty soils

The main process occurring in soils when irrigation with poor quality waters are;

i. Ion exchange between cations in irrigation waters and those present
ii. Dissolution and precipitation of $CaCO_3$
iii. Weathering of minerals
iv. Hydrations and dehydration of the soil as a results of fluctuation in soils as a structure
v. Leaching down of ions

vi. Upward movement of ions through capillary cavity and

vii. Mineral nutritional characteristics of the crop grown.

The clay particles have as certain deficit which is balanced by the charge of the absorbed cation taken from the soil solution. An order of replaceability of any ion present on the soil can be expressed as

$NH_4^+ > Mg^{2+} > Ca^{2+} > K^+ > Na^+$

A clay particle with sodium and calcium ions attached tends to hydrolyze. When a sodium ion is exchangeable for a hydrolyze ion, and the sodium ions combine with a molecule. of water, sodium hydroxide (NaOH) is

$$Ca\,[Clay]\,Na + H_2O \rightarrow NaOH\,[clay\ particle]\,Ca$$

When carbondioxide (Co_2) is present in the soil air, it readily reacts with the water to form hydrogen carbionates (H_2CO_3). However the sodium hydroxide (NaOH) reacts readily with the hydrogen carbonates (H_2CO_3) to form sodium hydroxide (NaOH)

$$H_2CO_3 + NaOH \rightarrow NaCO_3 + 2H_2O$$

The $NaCO_3$ is gradually removed with extensive leaching and the soil si left with hydrogen ions having replaced sodium ions. This increase of hydrogen ions is reflected in a lower pH (pH being a reciprocal index of hydrogen ion concentration).

Where soils contain is dissolved ($CaCO_3$) or gypsum, calcium is dissolved into the soil solution. This available calcium is exchangeable for sodium during the leaching process to obtain a normal soil.

Ca [clay particle] + Ca + CO_2 $NaCO_3$ + $NaCO_3$ + Ca → $NaCO_3$ + Ca [clay particle] Ca

2.6.1 SALT BALANCE

The relationship between the quantity of soluble salts brought into an area by the irrigation water and the quality removed from the area by the drainage water is called the salt balance of the area. Therefore, in an irrigation, a favorable salt balance a condition or exceeds the input must be maintained if irrigated agriculture is be permanent. The salt balance in soil is influenced by the quality and quantity of irrigation water and the effectiveness of leaching and drainage (Micheal, 1999). Any imbalance that would has adverse effect on the soil, crop growth and crop yield.

The salt balance of soils is expressed by the following relationship, (Michael, 1999).

$V_iC_i + S_m - S_p - S_c = 0$

V_i = Volume of irrigation water

C_i = Amount of dissolved from soil minerals

V_d = Volume of drainage water

C_a = Salt content of drainage water

S_p = The amount of salt precipitated over the soil surface.

S_c = Amount of salt removed by crop.

An equation expressing for a rootzone under irrigation thus: (simedema and Rycroft, 2003)

$I.C + R.Cr + G.Cg = PCp + Ds$

I = Irrigation water entering rootzone

R = Rainfall entering the rootzone C_r = Salt concentration of the rainfall

G = Capillary flow for groundwater into the rootzone

Gp = salt concentration from the rootzone.

P = Deep percolation from the root zone

Cp = Salt concentration of the water of de-percolation

Ds = Change in salt content of soil solution in the rootzone.

Cg = Salt concentration fo ground water

2.6.2 Leaching requirement

The fraction of the irrigation water that nust be leached through the rootzone to control the salinity is termed the leaching requirement. Assuming that the salt balance is in equilibrium, mathematically, LR (Micheal, 1996).

LR = Dd/Di = EG/Ecd

LR = leaching requirement, expressed as a ratio percent.

Dd = Depth of drainage water

Di = Depth of irrigation water

EG = Electrical conductivity of irrigation water

Ecd = Electrical conductivity of the drainage water.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Areas

The project study areas are the fadama land of Edozhigi in Niger State, Nigeria.

Niger State is situated in north central part of the federal Republic of Nigeria. It lies in the savanna zone of the tropics between attitude 8^0 10^1N and 11^0 30^1N longitude $3^0 30^1$E and 7030^1E.

Its climatic condition is influenced mainly by the rain-bearing south west monsoon winds from the oceans and the dry dusty or harmattan North East winds (air masses) from the Sahara Desert. Niger State has mainly the rainy and the dry seasons. The rainy seasons begins April ending and ends early ion October and the dry season states in November and ends march.

3.1.1 Edozhigi Fadama Project

Edozhigi fadama project scheme is located in a village outskirt of Bida local Government Area of Niger state.

Irrigation has been the main source of their water for dry season farming. They grew mostly Rice and sugarcane in the Area.

3.2 Materials;

The following materials was used in the collection of soil sample.

(i) Auger, Ruler, poly then bag Mortar, pestle, 3.3 Methods:

Soil was digged to a total depth of 40cm which determine the root depth of a plant.Soil samples were then collected into four different depths. Sample A was collected by digging the soil 10cm below the surface Area of the soil. Sample B was also collected by digging the soil 20cm below the surface of the soil. Sample C was collected by digging the soil 30cm below the surface of the soil. Sample D was collected by digging the soil 40cm below the soil sample.

The sample was air-dried in the laboratory after which it was crushed with pestle and then sieve to a fine powdered form. Each samples was then subject to test to determine the presence of the following;

(i) Soil PH, (ii) Exchangeable sodium percentage (iii) sodium Adsorption Ratio (iv) Determination of exchangeable Ca, Mg, K, Na, and Electrical conductivity (EC) of the soil.

3.3.1 Soil pH Determination;

3.3.1.1 Apparatus:

Glass electrode pH meter

3.3.1.2 Reagents:

(A) 0.01 M calcium chloride

(B) Distilled water

(C) 1N Potassium chloride

3.3.1.3 Procedures:

(a) Soil pH in H_2O (1:1 Soil to water ratio)

1. Weigh 20g of air – dry soil (passed 2 – mm sieve) into a 50 – ml beaker. Add 20 ml of distilled water and allow standing for 30 minutes and stirring occasionally with a glass rod.

2. Insert the electrodes of the pH into t6he partly settled suspension and measure the pH. Do not stir the suspension during measurement.

3. Report result as "soil pH measured in water".

(b) soil pH in 0.01M $CaCl_2$.

1. Prepare a 1:2 (soil: 0.01M CaCl2) suspension (10g of soil and 20ml of solution).

2. Let the suspension stand for about 30 minutes and stir occasionally with a glass rod.

3. Measure pH and report result as "soil pH measured in 0.01M $CaCl_2$"

(c) Soil ph in 1N kcl (1:1 soil to solution ratio)

1. add 20 ml of 1N kcl to 20g of soil samples and equilibrate for 30 minutes with occasional stirring.

2. Determine pH on the pH meter

3.3.2 Determination of Exchangeable Ca, Mg, K, and Na.

3.3.2.1 Apparatus:

1. Centrifuge

2. 100 – ml volumetric flask

3. Flame photometer

4. Atomic absorption spectrometer

3.3.2.2 Reagents:

(A) Acetic acid, glacial and NH_4OH, conc.

(B) Ammonium acetate solution. 1N pH 7.0

Add 58 ml of glacial acetic acid to about 600 ml of distilled water in a 2 – liter beaker. Add 70 – ml concentration NH_4OH (specific gravity 0.90). the NH_4OH is best added under a fume hood through a long stemmed glass so that it is introduced into the bottom of the acid solution. Cool this solution and adjust to pH 7.0 with acetic acid or NH_4OH using a pH meter. Transfer the solution into a 1 – liter volumetric flask and dilute to volume. Mix it in a Pyrex reagent bottle.

3.3.2.3 Procedure

1. To 5 g of sample, add 30 ml of 1N NH_4OAC and shake on a mechanical shaker for 2 hours.

2. Centrifuge (2,000 rpm for 5 – 10 min).

Carefully decant the clear supernatant into a 100 ml volumetric flask.

3. Add another 30 ml of NH_4OAC solution and shake for 30 minutes. Centrifuges and transfer the supernatant into the same volumetric flask.

4. Repeat step 3 and transfer the supernatant into the same volumetric flask.

5. Make up to mark with the NH_4OAC solution.

6. Determine k, Na, and Ca on an atomic absorption spectrometer

3.3.3 Determination of Electrical Conductivity (EC).

Weigh 10g of 2 mm sieved soil into a cup and add 25 ml of distilled water. Stir thoroughly and allow it to stand for 30 minutes

Take the reading using a conductivity meter and record the value.

3.3.4 Determination of SAR.

The Sodium adsorption ratio is determined through this formula;

$$SAR = \frac{Na^{+}}{[\{Ca2^{+} + Mg2^{+}\}/2]^{1/2}}$$

3.3.5 Determination of ESP.

The exchangeable sodium percentage was determined through this formula;

$$ESP = \frac{+100\,(0.01475SAR - 0.1126)}{0.01475SAR + 0.9874}$$

CHAPTER FOUR

4.0 Discussion of Result

Table 4.1 Determination of pH of a soil

	PH	
SAMPLE	Water	0.01 $CaCl_2$
A	4.96	3.98
B	5.07	4.05
C	4.94	3.87
D	5.14	4.05

4.1 Discussion of a result of a pH from the table above.

The ph of a soil is the measure of acidity or alkalinity of a soil. The pH of soil sample A obtained in this experiment is 4.96 – 3.98 which is slightly acidic though will not cause any harm to plant because it is within the allowable range of 6.5 – 8.4. The sample B has a pH between 4.05 - 5.07 which is also within the allowable range of 6.5 – 8.4. The pH for soil sample C is within 3.87 – 4.94 which is within the allowable range of 6.5 – 8.4 when compare to a standard. The pH for soil sample D is between 4.05 – 5.14 which is also within the allowable range of 6.5 – 8.4 when compare to a standard. The pH obtained from the experiment was slightly acidic but not too acidic to the level that will pose harm to the plants.

Table 4.2 Exchangeable bases

Sample	$Ca2^+$ (Meq/g)	$Mg2^+$ (Meq/g	Na^+ (Meq/g	K^+ (Meq/g)	SAR	ESP
A	2.88	0.32	0.308	0.609	0.308	0.876
B	9.30	0.40	0.256	0.261	0.116	- 1.101
C	5.60	1.28	0.308	.174	0.116	- 0.804
D	5.20	3.52	0.205	0.174	0.098	-1.128

4.2 Discussion of result of exchangeable bases from the table above.

Potassium is a plant nutrient necessary for plants growth. Calcium and magnesium are essential elements for tissue formation. The ratio of calcium and magnesium in soil sample A are 2.88meq/g and 0.32meq/g while that of sample B are 9.30meq/g and 0.40meq/g respectively. This gave Ca:Mg ratio greater than 5:1; this by Landon may make magnesium more increasingly unavailable to plants with increasingly Ca. this ratio is above the 3:1 – 4:1 ratio, the approximate optimum range for most plants. Though soil can remain fertile over a very range of Ca;Mg ratio. The soil sample C has a calcium and magnesium ratio of 5.60meq/g and 1.28meq/g while that of soil sample D has calcium to magnesium ratio of 5.20meq/g and 3.52meq/g. The ratio of Ca:mg in all the four samples are greater than one. This according to Westcot would not increase effect of sodium. The ratio of potassium to magnesium in soil sample A are 0.609meq/g and 0.32meq/g while that of soil sample B are 0.261meq/g and 0.40meq/g. the ratio of soil sample C are 0.174meq/g and 1.28meq/g while that of soil sample D has a potassium to magnesium ratio of

0.174meq/g and 3.52meq/g. the K: Mg in all the four sample of soil are less than 1, which is within the recommended range for crops, vegetables, sugarcane e.t.c.

The sodium has a value of 0.308meq/g for soil sample A, 0.256meq/g for soil sample B, 0.308meq/g for soil sample C, 0.205meq/g for soil sample D.

Sodium toxicity to plant is evaluated using the ESP since the ESP in all the given sample are less than 15%. there is no tendency of sodium posing harm to plants. Plants are free to be grown in the area.

The Exchangeable sodium percentage in soil sample A is 0.876 while that of B is -1.101, soil sample C has ESP value of -.804 while that of soil sample D ESP value of -1.128.sincef all the calculated value of ESP in the four soil sample are les than 15%, sodium toxicity to plants is not expected.

The Sodium adsorption ratio is the amount of sodium absorbed in a soil. The sodium adsorption ratio of soil sample A is 0.308meq/g. while that of soil sample B is 0.116; the soil sample C has a SAR of 0.116 while that of sample D has a value of 0.098.

Therefore the low salinity of the SAR values of ≤ 0.308 is put into consideration since severe problem of infiltration is expected in a long time to come.

Table 4.3 Determination of electrical conductivity

Sample	EC Determination (µs)
A	45.1
B	42.3
C	32.6
D	30.1

4.3 Discussion of result of electrical conductivity in the table above.

The EC values obtained for the four soil samples are 45.1µs, 42.3µs, 32.6µs and 30.1µs. from the resultof EC values is expected to give a yield of 100% because there is a potential reduction of for saline - sodic accumulation at the surface of soil. The calculated ESP in table 4.2 are all less than 15%. Therefore, neither the surface nor the subsurface could be said to be saline. The soils are non saline and non – sodic. The soils are also has fine textured soils, using ESP limit of 15% for fine textured soil (in accordance with Smedema, 1988) no dispersion problem is expected since the ESP of the sample are less than 15%, hence, water logging resulting from the general deterioration of the drainage characteristics is not expected.

CHAPTER FIVE

5.0 Conclu:ion and recommendation

5.1 conclusions

The irrigated land of Edozhigi has a very low salt concentration. The scheme has low saline and non – sodic. It also has no salinity environmental pollution. Salts also vary spatially within the soil profile. It carries salts along as it moves through the soil profile and due to evaporation, the concentration of some salt are high in the surface soils.

5.2 observations

The following are observed during the course of the study.

a. A small area of land is been irrigated.

B. The drainage system of Edozhigi is not properly designed

C. the Edozhigi irrigation system was not properly designed.

5.3 Recommendations

Appropriate design of Edohigi Fadama irrigation scheme should be carried out and regulalr supervision should be carried out to ensured proper maintenance of the project.

Also appropriate design of the fadama project irrigation scheme is essential to avoid the problems of water logging which would in turn lead to rise in salt content of the soil

Again, the planting of high salt tolerance crops should be adopted in the fadama land of Edozhigi.

Moreover, there should be the adoption of cultivating large areas of farm land in the fadama land of Edozhigi to control the problems of salinity.

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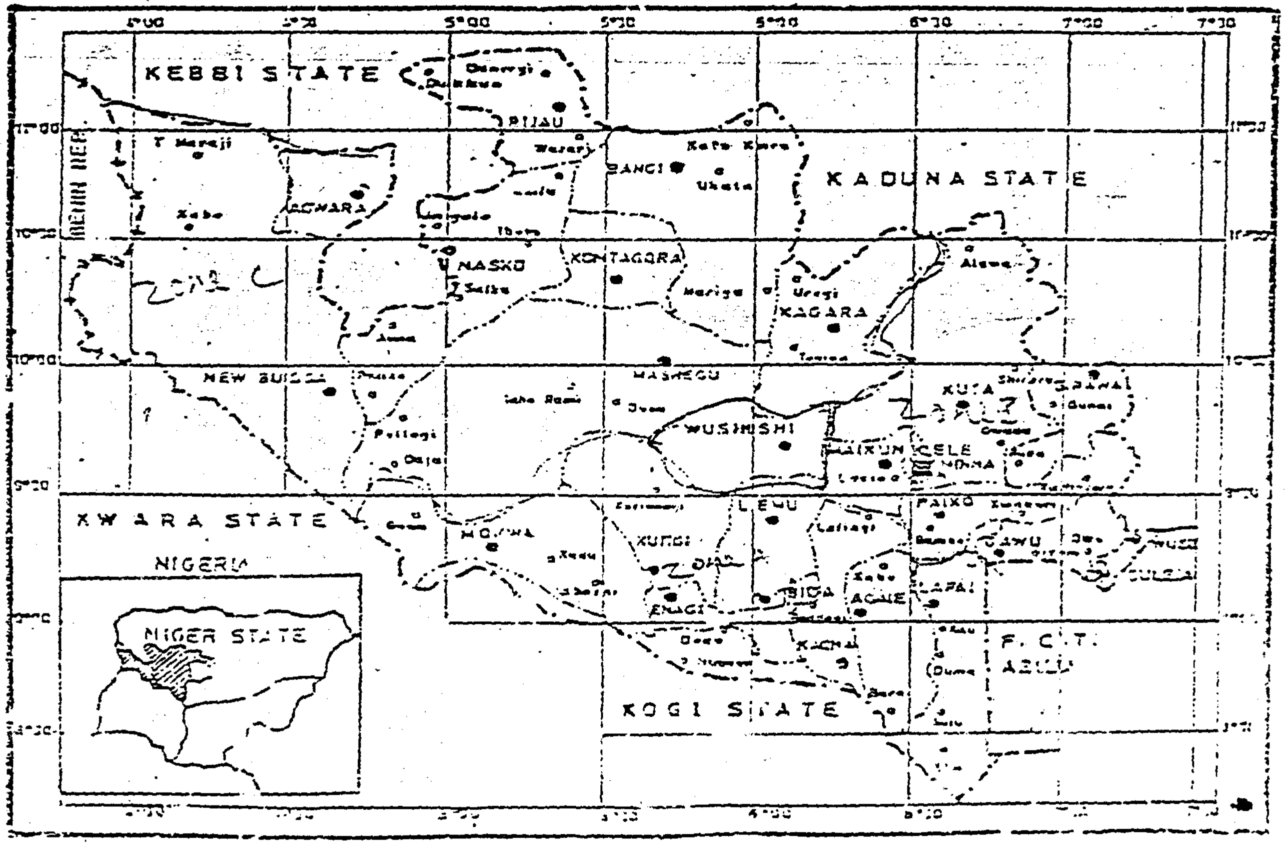

A MAP SHOWING THE LOCATION OF NIGER SATE IN NIGERIA