Agricultural Journal 3 (6): 469-471, 2008
ISSN: 1816-9155


# Soil Salinity and Water Logging Problem Due to Irrigation and Drainage: A Case Study of Chanchaga Irrigation Project

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**Abstract:** In the arid region, drainage ditches are necessary to remove water required for leaching undesirable salts from the soil and the disposal of excess rainfall. Chemical and organic changes in soil conditions are anticipated under irrigation. Several methods are used to irrigate farm lands throughout, the world but the method used in this study area is, the surface irrigation method. Sterilized bottle containers were used to collect water and soil samples from the study area. The samples were given a pre-treatment of being stored in an air conditioned room with temperature not more than 25°C to reduce microbial activities. The 5 samples had a constant chloride ion ($Cl^-$) of 20 mg $L^{-1}$, Sodium Chloride (NaCl) of 32.8 mg $L^{-1}$, iron ($Fe^{+2}$) of 0.7 mg $L^{-1}$ and pH of 7. The pH of the water samples was found to be within the borderline, which implies that the water used for irrigation in the study area was neither acidic nor alkaline.

**Key words:** Acidic, alkalinity, irrigation, salt, soil, water

## INTRODUCTION

Irrigation is the artificial application of water to a farm to supplement rainfall and the contribution of ground moisture for the purpose of crop production, while drainage is the removal of excess water at the root zone. For good agricultural practice there must be a favourable water supply (Todd, 2006).

Mineral soils are derived largely from the weathering of rocks. There is an intimate relationship between salt accumulation and chemical composition of rocks from, which soils are formed. Salts continue to accumulate in soils of irrigated area, where greater amounts are brought in than are removed. The lack of percolation of water through and arid regions give rise to accumulation of soluble salts which are injurious to plant life.

In the arid region, drainage ditches are necessary to remove water required for leaching undesirable salts from the soil and the disposal of excess rainfall (Michael, 1998). The chemical composition of soils and the kind of water must be necessarily known for normal plant growth. The salts added to soils in irrigation water must be balanced before planning any irrigation project. The presence of excess water at the root zone is referred to water logging which is also a major factor which causes injuries to plants.

The elevation of the sources of water and the land surface between the water surface and the area to be irrigation, the different plants of the farm area and the drainage outlets must be known to properly plan a farm irrigation system.

Irrigation leads to significant changes in soil conditions, some of which are long-lasting and not all of which may be beneficial in agricultural terms. Studies of changes in soil aeration have been made which indicate that it takes some days for the oxygen diffusion rate of the surface soil to recover following irrigation (Willy and Tanner, 1963; Greenwood and Goodman, 1971).

Chemical and organic changes in soil conditions are anticipated under irrigation. In areas, where water quality is poor, accumulation of salts and trace elements may present a serious problem. Bicarbonates, sulphates, sodium and boron may all reach toxic levels and careful control of application rates, moisture conditions and water quality are essential to remove these by leaching. One of the main indications of soil chemical conditions under irrigation is the exchangeable sodium percentage (the accumulation of sodium cation as percentage of the same position in the soil); it is clear that periods of excess water lead to reduction in oxygen supply. Greenwood and Goodman (1971), argued that toxic levels of carbon dioxide are unlikely in arable soil. Other gaseous products of anaerobic respiration are more significant. Smith and

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Russell (1969), demonstrated that ethylene could reach toxic levels in the soil-air or soil-water under anaerobic conditions. Butyric, acetic, lactic and propionic acids may also be produced (Stevenson, 1967), although their effects on most agricultural crops are less (Russell, 1973).

The study area is located in the West-Eastern part of Chanchaga village along Minna-Paiko road bounded by Niger State Water Board and Chanchaga River, in Niger State, Nigeria. The area is located between latitude 9-10° North and longitude 6-7° East.

The objectives of this study, were to determine the chemical compositions of water and soil of the irrigated area and to compare the chemical analysis with the FAO and WHO acceptable limits.

## MATERIALS AND METHODS

Several methods are used to irrigate farm lands throughout, the world but the method used in this study area is, the surface irrigation method. Water is applied directly to the soil surface from a main canal located at the upper reach of the field. Water is distributed to crops in check basin.

Sterilized bottle containers were used to collect water and soil samples from the study area. The samples were given a pre-treatment of being stored in an air conditioned room with temperature not more than 25°C which to reduce microbial activities.

The palintest test method was used to determine the pH value of the sample of water collected. The dayside and Iron test was used to determine the quantity of chlorine present within the samples collected. Hardness test was carried out to determine the amount of calcium carbonate ($CaCO_3$) in the water.

The chemical analysis of the soil samples were carried out. The dried soil was mixed with distilled water and the resulting paste was taken to its liquidity limit. This procedure gave a soil-water ratio which varies according to the texture of the soil. The salinity of the saturated paste extract was determined by measuring its electrical conductivity.

## RESULTS AND DISCUSSION

Comprehensive soil studies are essential for the successful management of irrigated farm areas. Periodic soil test needs to be undertaken to confirm what is available in the soil in terms of nutrients and what is required as supplement to meet the nutritional requirements of specific crops. This approach ensures that residual nutrient after plant up-take is enhanced with an equal reduction in concentration that eventually contaminates the environment.

It is important to evaluate irrigation water quality together with soil to be irrigated because low quality irrigation water might be hazardous on heavy, clayey soils like that which we have at the study area, while the same water could be used satisfactorily on sandy and/or permeable soils. An increase in the salinity of the groundwater is often associated with water logging; therefore, an appropriate and well-maintained drainage network will help to alleviate such undesirable effects.

**Soil salinity:** There are 4 main reasons for an increase in soil salinity on an irrigation scheme:

- Salts carried in the irrigation water are liable to build up in the soil profile as water is removed by plants and the atmosphere at a much faster rate than salts. The salt concentration of incoming flows may increase in time with development activities upstream and if rising demand leads to drain water reuse.
- Solutes applied to the soil in the form of artificial and natural fertilizers as well as some pesticides will not all be utilized by the crop.
- Salts which occur naturally in soil may move into solution or may already be in solution in the form of saline groundwater. This problem is often severe in deserts or arid areas where natural flushing of salts (leaching) does not occur. Where, the groundwater level is both high and saline, water will rise by capillary action and then evaporate, leaving salts on the surface and in the upper layers of the soil.
- The transfer from rain fed to irrigation of a single crop, or the transfer from single to double irrigation may create a humidity/salinity bridge in the soil, between a deep saline groundwater and the (so far) salt-free surface layers of the soil. Careful soil monitoring is highly recommended whenever the irrigated regime is intensified, even though the saline layers might be far below the soil surface and the irrigation water applied is of high quality.

On waterlogged soils, normal cultivation operations such as tilling, ploughing, ridging and harrowing cannot be carried out. In some cases, the free water may rise above the surface of the land, making the cultivation operations impossible; thus, such lands become swampy in nature.

Since, the plant roots happen to come within the capillary fringe, water is continuously evaporated by capillarity. Thus, a continuous upward flow of water from the water table to the land surface gets established. With this upward flow, the salts which are present in the water also rise towards the surface, resulting in the deposition

Table 1: Chemical analysis of the water samples

| Sample No. | Chloride ion (mg $L^{-1}$) | Sodium chloride (mg $L^{-1}$) | pH | $Fe^{+2}$ (mg $L^{-1}$) |
|---|---|---|---|---|
| | (Cl-) | (NaCl) | 7 | 0.7 |
| A | 20 | 32.8 | 7 | 0.7 |
| B | 20 | 32.8 | 7 | 0.7 |
| C | 20 | 32.8 | 7 | 0.7 |
| D | 20 | 32.8 | 7 | 0.7 |
| E | 20 | 32.8 | 7 | 0.7 |

Table 2: Chemical analysis of the soil sample

| Sample No | Depth (cm) | $Ca^{2+}$ | $Mg^{2+}$ | $K^+$ | $Na^+$ | CEC | EC | PH | SAR |
|---|---|---|---|---|---|---|---|---|---|
| A | 0-10 | 3.6 | 1.2 | 0.23 | 0.15 | 6.2 | 0.14 | 7.0 | 0.1 |
| B | 10-15 | 2.4 | 0.9 | 0.14 | 0.42 | 8.2 | 0.21 | 6.7 | 0.3 |
| C | 15-20 | 10.5 | 3.1 | 0.32 | 2.42 | 16.3 | 0.04 | 6.5 | 0.9 |

of salts in the root zone of the crops. The concentration of these salts present in the root zone of crops has a corroding effect on the roots, which reduces the osmotic activity of the plants and checks plant growth.

The results of the water analysis shown in Table 1 indicate that all the 5 samples had a constant chloride ion ($Cl^-$) of 20 mg $L^{-1}$, sodium chloride (NaCl) of 32.8 mg $L^{-1}$, iron (II) ion ($Fe^{+2}$) of 0.7 mg $L^{-1}$ and pH of 7. It was discovered that the pH of the water samples was within the borderline (neutral) which implies that water used for irrigation in the area was neither acidic nor alkaline.

The chloride content of the water samples is of satisfactory quality because the highest desirable level of chloride in any water used for irrigation should be 200 mg $L^{-1}$. This therefore, indicates that the chloride ion will not be toxic to the plants grown in the area. Iron (II) ion, $Fe^{+2}$ was detected in all the water samples which and is within the permissible range of 0.1-1.0 mg $L^{-1}$ for irrigation purposes.

The electriccal conductivity of the salt content in the water sample was carried out and a value of 980 mhos $cm^{-1}$ at 25°C was obtained and sodium absorption ration was 8 $\mu L^{-1}$. The hardness test showed that generally carbonate was not encountered in all the water samples. The salt content was obtained as 600 ppm.

Table 2 shows the chemical analysis of the soil samples obtained from the study area. Three samples of soil were collected at depths between 0 and 20 cm. The electrical conductivity (EC) of each of the soil samples collected was low as the values obtained were <4. This is an indication that the soil of the study area is normal when EC is considered. The sodium absorption ratio (SAR) value obtained ranged between 0.1 and 0.9 which is less when compared with the standards. The pH value ranged from 6.5-7.

It was observed that the content for calcium ($Ca^{2+}$) ions was higher and is closely followed by magnesium ($mg^{2+}$), Sodium ($Na^+$) and Potassium ($K^+$). As long as $Ca^{2+}$ is dominant in the soil, little sodium present in the soil will be absorbed since, it is difficult for $Na^+$ to replace $Ca^{2+}$. This means that the quantity of sodium present in the soil of the study area is very low.

In general, the purer the water, the more valuable and useful it is for riverine ecology and for abstractions to meet human demands such as irrigation, drinking and industry. Conversely, the more polluted the water, the more expensive it is to treat to satisfactory levels. As soil salinity levels rise above plant tolerance levels, both crops and natural vegetation are affected. This leads to disruption of natural food chains and the loss of agricultural production.

## CONCLUSION

It can therefore, be concluded from the chemical analysis carried out on the water samples that most of the surface water supplies for irrigation purposes are of satisfactory quality. The results also showed that the study area is not subjected to any problem of salinity which has removed the fear of water logging of the farm land. Regular soil and water analysis should be conducted as done in this study, to be able to check the rate of salt build up within the soil and consequently the water.

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