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SOIL SALINITY AND WATER LOGGING PROBLEM DUE TO IRRIGATION AND DRAINAGE PROJECT: A CASE STUDY OF CHANCHAGA IRRIGATION PROJECT.

A PROJECT REPORT

BY

ABOUBAKAR K. A.

REG. NO 95/4906

DEPARTMENT OF AGRICULTURAL ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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SUPERVISOR — DATE

MR. O. CHUKWU

Engr. Prof J. O. Ohu 29/3/2000

EXTERNAL EXAMINER — DATE

.... 1/12/2000

HEAD OF DEPARTMENT — DATE

ENGR. (DR.) M. G. YISA

DEDICATION

This is dedicated to the memory of my father Elhaji ꞁBOUBAKAR KODE died in 18th January, 1991. May the peace of God ›e upon on him. (Amen).

ACKNOWLEDGMENT

I am sincerely grateful to Almighty Allah for seeing me through all obstacles I have encountered during the period of my studies. I must confess that I have done nothing of my own strength. He actual did everything for me.

My thanks goes to my Supervisor Mr. O. Chukwu for finding time to go through this work and making useful comments and suggestions. I will not forget my appreciation to the entire lecturers, and staff of the Federal University of Technology, Minna for their selfless services.

Also I am grateful to my mother Hajiya Hadiza and my nephew Ousmane Mamani Kode for their moral and financial support.

My thanks goes also to all the succeeding government of Niger State Republic. Ever since I entered school up to this period.

Lastly my profound gratitude goes to my colleges without any distinction.

ABSTRACT

This work has based on chemical analysis of both soil and water samples of the project area. The factors determined include pH value, electrical conductivity, sodium absorption ratio, etc. From technical point of view, it has been observed that most of our water supply are of satisfactory quantity for irrigation purposes in out project area. Based on their electrical conductivity and sodium absorption ratio, the soil samples are far from being saline.

In conclusions, observation have demonstrated that the project area is not saline nor water logged. To prevent possible problem of acidity or alkalinity the pH of the irrigation water most be regularly checked. Also the use of fertilizer most be controlled because of any built-up of soluble salts.

TABLE OF CONTENTS

CHAPTER ONE

CHAPTER FOUR

CHAPTER FIVE

CHAPTER ONE

..0 INTRODUCTION

Mineral soils are derived largely from the weathering of rocks. There is an intimate relation between salts accumulation and the chemical composition of rocks from which soils are formed. Salts continue to accumulate in which soils of irrigated area where greater amounts are brought in than are removed.

The lack of percolation of water through arid-regions gives rise to accumulation on and in the soils of soluble salts that are injurious to plant life.

In arid-regions, under irrigation, drainage dicthes are necessary to remove water required for leaching undesirable salts from the soils and the disposal of excess rainfall.

.1 GENERAL INTRODUCTION

Irrigation is the artificial application of water to supplement water available from rainfall and the contribution of ground moisture for the purpose of crop production.

On the other hand, drainage is the removal of excess water at the root zone.

For permanent agriculture, there must be a favourable water supplies. In many cases, water used in irrigation contains excess salts.

By far, the most common cause of high salinity however is salinisation. i.e the accumulation of salts in the upper [illegible] of the soil from some outside sources.

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 us waterlogging. Waterlogged soils are also major factors which cause injuries to plants.

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

..2 OBJECTIVES

When an irrigation project is established or a dam constructed as reservoir to store water for irrigation purposes, or water flowing in a certain stream or river is being employed for irrigation, it is necessary to determine the quality of such water for its use in agriculture.

Therefore, the purpose of irrigation water sampling as well as soil sampling and analysis is designed to achieve the following objectives, among many others.

1. To determine the chemical composition of water of the named irrigated area, including its portability.

2. To determine the chemical composition of soil of the irrigated area.

3. To compare or correlate the chemical analysis data with FAO, UND and WHO acceptable limit.

1.3 DESCRIPTION OF THE PROJECT AREA

Chanchaga irrigation scheme is one of the multi-purpose projects being embarked upon by Niger State Ministry of Agriculture and National Resources.

The project was conceived in early 1988 but become fully operational in 1990. It covers an area of 56 hectares. It is a large and moderately fertile land area. It is situated along River Chanchaga where its derives it name, having two main tributaries within the project area.

..3.1 LOCATION

The project area is located in the North Eastern part of Chanchaga village along Minna - Paiko road bounded by Niger State Water Board and Chancahaga River. The area is located between latitude 9:00 - 10.00 North and longitude 6^0,00-7^0,00 East.

.3.2 GEOLOGY OF THE AREA

.3.2.1 RELIEF AND DRAINAGE SYSTEM

The topography of the area shows that the land is fairly undulating with many natural drains. The project area has well-drained soils with River Bakasiyasa, River Essan and River Rafingora as the major tributaries that makes up River Chanchaga. The project area is along River Chanchaga.

.3.2.2 SOILS

The soils sample carried out on the project area shows that towards River Chanchaga where irrigation is being practiced, soil is more moist than the upper part where soil is harder

The dominant soils found in this area are silty, clay, loam and clay-loam. There are also traces of sandy-loam soil especially along the River and laterite (Plinthic) soil at the upper part of the project area.

The soil of the project area can be classified as silty-clay loam which is suitable for most agricultural crops especially moderately deep rooted crops, such as maize, rice etc. The soil has water holding capacity about 145mm of water per meter depth of soil.

!.3.3 HYDROLOGY OF THE AREA

The project area being in the tropics is characterised by distinct dry and wet seasons. The rainy season seriously begins in April and ends in October.

The rainfall is heaviest and continuous between the months of July and October, while harmattan sets in shortly after the rains. During the hamattan period, mornings, evenings and nights are usually cold.

The average annual rainfall is about 1218.7mm as shows from meterorogical data. The average annual temperature ranges from 21-32^{0}c in April.

The relative humidity ranges, the highest in the month of July/August. The wind blows South-West during the harmattan.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 WHAT IS SOIL

Unlike minerals, plants, and animals, soils are not sharply distinct entities. Soils in general might be described as a borderline phenomenon of the earth's surface. They belong to the padsophere in which the lithosphere, hydrosphere and biosphere overlap and intact. It is the growing medium of higher plants and basis of life for animals and mankind.

The farmer however views the soil as an indispensable agricultural resources resource which nourishes and provide mechanical support for growing plants.

2.2 THE MAIN PURPOSE OF IRRIGATION

In many cases of the world the amount and timing of rainfall are not adequate to meet the moisture requirement of crops and irrigation is essential to grow crops necessary to meet the needs of food and jibre.

Irrigation is an age-old art, as old as civilisation. The increasing need of crop production for the growing population is causing the rapid expansion of irrigation throughout the world.

With the fifth of the world's irrigated area, India had the second largest area under irrigation. (37.640m ha) in 1969 while China irrigated (74.000m ha) in the same year (Franji and Mahajan, 1969).

2.3 EFFECT OF IRRIGATION UPON SOIL CONDITIONS AND CROPS YIELD

... leads to significant changes in soil conditions, Few studies have be made of long-term changes in soil under irrigation. Studies of changes in soil aeration have been made by Willy and Tanner (1963), Williamson (1964) and Williamson and Willy (1964) and these indicate that it takes some days for the oxygen diffusion rate of the surface soil to recover following irrigation. They also showed that surface application of water by flooding saturate the top soil and therefore impair aeration more than sprinkler methods.

Chemical and organic changes in soil conditions might also be anticipated under irrigation. In arid areas, or where water quality is poor, accumulation of salts and trace elements may present a serious problem. Bicarbonate, Sulfate, Sodium and Boron may all reach toxic levels, and careful control of application rates, moisture conditions and water quality is 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 cation exchange capacity).

Anderson et al (1972) found that levels of this rose progressively during fourteen to seventeen years of irrigation with sodium - rich water in South-West Mexico. At the same time organic matter fall. The problems of such changes are not nutritional; sodium tends to destabilise the soil structure, blocking the soil pores and inhibiting water movement.

The effects of irrigation upon crops yield are more widely appreciated, and many studies have been shown the benefits of reducing moisture stress. (Feddes and Van Wijk 1970; Evans and Neild 1981). The benefit probably derives not only from the increased supply of water and increase transpiration rate, but

... nutrient up take

EFFECTS OF WATERLOGGING

Because air and water compete for the same position in the soil, it is clear that periods of excess water lead to reduction in oxygen supply.

Greenwood (9167) also argues that toxic levels of CO_2, are unlikely in arable soil. Other gaseous products of anaerobe is respiration are more significant. Smith and Russell (1969) demonstrated that ethylene could reach toxic levels in the soil air ,or soil water under anaerobic conditions. Butyric acid, acetic acid, lactic acid and propionic acid may also be produced (Stevenson 1967) although their effects on most agricultural crops are less marked (Russell 1973).

Inorganic compounds may also similarly accumulate in waterlogged soils, and some of these, such as Manganese ions, nitrite, sulphite and sulphide may be harmful to plants. The reaction of these inorganic substances is a function of reduction processes. Under aerobic conditions, oxygen in the soil air acts as a sink for electrons released during minobial respiration. In this absences of oxygen, other compounds are exploited, and in the process are converted from a higher to a lower valency state.

Hydrogen sulphide is toxic to many plants at concentration as low as 10^{-6}m. Ethylene, for example, is produced within hours of the oxygen content failing between one percent and, in absence of free passage to the soil surface, may remain at toxic levels for many weeks there after (Dowdell et al, 1972).

In the absence of ethylene, root growth in inhabited. Anaerobic conditions might, at first sight, seem to be inimical to leaching and nutrients loss for it is generally

Thus Russell (1973) states that slow percolation through the soil when waterlogged may impoverish it faster than normal percolation under aerobic conditions.

5 THE NEED FOR AGRICULTURAL DRAINAGE

Drainage problems arise because water cannot escape rapidly enough from the soil profile. This may occur because the gravitational potential is too low. Most of the water infiltrating into these soils is affected by strong metric forces which hold the water against the surface of the particles and retard its movements through the soil pores.

During the last thirty years, the areas of land significantly. In England and Wales alone there was an increase in the annual rate of drainage (i.e the amount of drainage installed each year) between 1951 and 1971. As Trafford (1977) has shown as much as 2.63 million hectares (or 24 percent of the total agricultural area) in Britain could benefits from drainage. In addition, a further 1.74 millions ha of land is served by old drainage systems, installed mainly in the period of 1840 and 1880.

Many of these systems are now inefficient and in need of renewal.

Drainage may have an impact upon water quality. Improved drainage increases the rate of water movement through the soil and facilitates leaching of nitrate.

CHAPTER THREE

.0 METHODOLOGY

This chapter is the most important of the project. It consists of the methods or procedures used to solve the problems asked and identified in the introduction.

3.1 METHODS OF IRRIGATION IN PRACTICE

In Chanchaga irrigation project, surface irrigation method is applied. Water is applied directly to the soil surface from a main canal located at the upper reach of the field.

Water may be distributed to crops in check basin.

Check basin method of irrigation is the simplest principle of all methods. There are many variations in its use but all involves dividing the field into smaller unit areas so that each has a nearly level surface. Ridges are constructed around the areas forming basins within irrigation water irrigation water can be controlled. The basins are filled to desired depth and water is retained until it infiltrates into the soil.

MARINER engine is used to carry water from the river to the main canal. From the main canal water is distributed to the crops by same lateral canals.

Different kinds of crops are grown in sequence in the same field. i.e vegetables, and root crops like cassava.

3.2 SAMPLING MATERIALS

3.2.1 MATERIALS USED FOR WATER SAMPLING

... are used to collect water. They are labelled

Bottle are used because any contact water have no effect on its chemical composition.

3.2.2 MATERIALS USED FOR SOIL SAMPLING

- Bottle containers for collecting samples are labelled A,B,C.
- An anger and a ruler for measuring the depth.

3.3 PRE-TREATMENT PROCEDURES/PROCESSES

3.3.1 PRE-TREATMENT OF WATER SAMPLES

On the arrival from each field trip, water samples already collected in white bottle containers were kept in an air-conditioned room to maintain room temperature which did not exceed 25^0c. The idea of dong this was purposely to reduce microbial activities, as much as possible, to the barest minimum.

3.3.2 PRE-TREATMENT OF SOIL SAMPLES

After the collection of samples, they are kept in an air-conditioned room and maintained at room temperature which did not exceed 25^0c.

3.4 SAMPLES ANALYSIS

3.4.1 WATER QUALITY ANALYSIS

Although the water for irrigation from the river is considered safe for human consumption, it was still found necessary to analyse the quality of the water. Hence, the samples were analysed and the laboratory procedures used are stated below:

3.4.1.1 PH VALUE

By Palintest test method, in 10ml of water, one tablet of water testing is added and shaken manually. A change of colour

.4.1.2 CHLORIDE DETERMINATION

Chloride test method is used. The test is ranged from o to 250mg/L with the sample size of 5ml. The application of chloride test is limited on natural water, drinking water etc.

The method is to add one tablet of chloride in to the plastic container of 50ml sample of water and shake manually. At each addition of one tablet, the solution is shaken again. The process continues until the change of colour occurred.

The following formula is used to obtain the ct value in the water. (Number of tablets of chloride -1) x 20

To convert chloride ion (ct) to sodium chloride (Nacl) multiply the result by 1.64.

3.4.1.3 IRON DETERMINATION

One tablet is added in 10ml of water and shaken manually. After standing for one minute, a colour disc with a comparator are used to determine the colour of the solution with its corresponding value.

This corresponding value or reading is the equivalent to iron (Fe^{2+}) concentration in the water.

3.4.1.4 HARDNESS TEST

This test is used to determine the amount of Calcium Carbonate (CaCo3) in the water.

In a 5ml samples size, one water test tablet is added and shaken. The operation is repeated until a change of colour is obtained from blimp to blue. The observation has demonstrated

Therefore the following table is observed

SAMPLE NUMBER	ct	Nacl	PH	Fe+2
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 3 -(A)

If colour continued to develop after standing for one minutes it is indicative of more strongly bound iron complexes in the water. In such case the test solution should be allowed to stand for longer period say 10 - 15 minutes.

.4.1.5 OTHER PARAMETERS

As is the practice with any irrigation water sampling and quality control programme, a water sample analysis should be conducted to ascertain whether the existing irrigation water would have any detrimental effect on the soil or crop or not.

As is the practice with any irrigation water sampling and quality control programme, a water sample analysis should be conducted to ascertain whether the existing irrigation water would have any detrimental effect on the soil or crop or not.

As earlier on said laboratory analysis conducted was not limited to the above parameters already enumerated but included the following:

TABLE 3 - (B)

SAR	8 meg/litre
EC	980 micromtios/em
HCO^{-}_{3}	1-2 meg/litre
BORON	0.025ppm
SALT CONTENT	600ppm
Va+	25%

Where:

SAR is Sodium Absorption Ratio

EC is the Electrical Conductivity

.4.2 SOIL ANALYSIS

Within a soil, soluble salts may be crystalline (as crystals, or efflorescence). This is common in this case of weakly soluble salts. Most often the salts is in solution. This has a cationic composition which is in equilibrium with the exchangeable cations retained by absorbing complex.

The saturated paste extracts method:
This method can be used for several standardized analyses. Dried soil is mixed with distilled water and the resulting paste is taken to its liquidity limit. At least 300g of soil should be used to make the paste in order to obtain 50cm3 of liquid extract. This procedure gives a soil/water ratio which varies according to texture (e.g 50% for clayey texture and 20% for sandy sample).

The overall salinity of the saturated paste extract is determined by measuring its electrical conductivity. The electrical conductivity of a solution is the conductance of the solution measured between electrodes of 1cm2 surface area and 1cm apart.

Soluble salts are determined in the saturated paste extract. The results are presented in Table 3 - c

SAMPLE NUMBER	DEPTH CM	Ca2+	Mg2+	k+	Na+	Totals	CEC	CE	PH
A	0 -10	3.6	1.2	0.23	0.15	5.2	6.2	0.14	7
B	10-15	2.4	0.9	0.14	0.42	3.9	8.2	0.21	6.7
C	15-20	10.5	3.1	0.32	2.42	16.3	16.3	0.04	6.5

Soil sampling was carried out by taking what is Ct sample from 3 different parts of the project area by the use of an anger to the depth of:

Sodium absorption ratio fan different samples:

SAMPLE A: SAR = 0.1

SAMPLE B: SAR = 0.3

SAMPLE C: SAR = 0.9.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION OF RESULTS

The results of water analysis as well as soil analysis are tabulated in table 3 - A and 3 - B.

4.1 INTERPRETATION OF WATER ANALYSIS

The results of laboratory water analysis carried out are presented in table 3 (A) and 3 (C) on page....

4.1.1 PH VALUE (AT 25°C)

The PH value represents the concentration of hydrogen ions (H+) in water. In other word, it is the logarithm of the reciprocal of the hydrogen ion concentration. Thus a value of PH below 7 indicates acidic character while PH value is indicative of alkaline character of water, PH 7 is neutral.

However, from the results of water analysis the PH values of all the water samples were found to be within the borderline of neutral level, the highest value being 7-8 and the lowest being 7. So, generally in terms of acidity or alkalinity problem in the water samples there is no cause for alarm because all the water samples are neither acidic nor alkaline in chemical composition.

4.1.2 CHLORIDE (ct)

In terms of chloride contents, majority of the water samples are of satisfactory quality. Because the highest desirable level of chloride in any water is 200mg/litre or 200 ppm/l and all water samples were examined to contain very minute quantities of this substance. In all the water samples the ct quantities are 20mg/litre. Therefore chloride toxicity could not be a problem to the crops and soils in the field.

Iron is detected in most of the water samples. It's values are of 0.7ppm or 0.7mg/l for all the samples. But then the highest desirable level of Fe is 0.1mg/L while the maximum permissible level is 1.0mg/L.

So, some water samples in which iron concentrations are noticed can still be regarded as being satisfactory in as much as their Fe levels are still within permissible limits.

4.1.4 ELECTRICAL CONDUCTIVITY (EC X10^6 mhos/cm)

The salt concentration in any water is easily measured of electrical conductivity (EC). It measures the ability of any water to conduct electricity and is expressed in mhos/cm. EC and salt concentration are proportional to each other. The EC value mhos/cm at 250c if multiplied by 640 (a constant) can be related to salt concentration in ppm or Mg/litre (Varshney, et al, 1971). According to its EC, the water could safely be used irrigate most crops on most soils in the field with little or no likehood that soil salinity would develop.

Also this was proved when comparing the result with to the standard for irrigation water.

TABLE 4 (A)

4.1.5 CARBONATE (CO_3^{2-}) AND BICARBONATE ($HC0_3^-$)

The hardness test demonstrated that generally carbonate is not encountered it all the water samples from the results of analysis carried out. This condition therefore suggests that there is littles tendency for calcium and magnesium to form chemical precipitates except with the little quantities of free discarbonate (HCo3) which were recorded in the sample (see table 3 -(B) and 4 - (A)).

4.1.6 BORON (BO)

Boron was, found to be in little quantity in the water.

4.1.7 SODIUM ION (Na+)

Sodium is one of the undesirable elements or substances in irrigation. This is because of its ability to destroy the structure of the soil and its tendency to build-up salts in the root zone of the soil. The relative proportion of sodium, relative to others cations, is expressed by the sodium absorption ration (SAR).

The SAR is mathematically calculated as follows:

$$SAR = \frac{Na+}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}$$

TABLE 4 - A

H20 CLASS	SAR	EX X 10^6	SALT CON-TENT PPM	Na+	BOROM PPM
1	10	0 - 1000	0 - 700	60	0 - 0.5
2	10-18	1000 - 3000	700 -2000	60 - 75	0.5 - 72
3	18	3000	2000	75	72

From the above table, the classes are defined as:

(a) Class 1

H20 of this class is excellent to good, suitable for most plants under all conditions.

(b) Class 2

This water is mentioned as a good to injurious and unsatisfactory, probably harmful to most crops. It is unsuitable under most conditions.

4.2 INTERPRETATION OF SOIL ANALYSIS

The results of laboratory soil analysis carried out, are

4.2.1 ELECTRICAL CONDUCTIVITY

In terms of electrical conductivity, the majority of soil samples have low e lectrical conductivity. The values for all the samples are very less than 4. That means the soil of the project area in terms of electrical conductivity is a normal soil, because normal soils have electric conductivity less than 4.

4.2.2 SODIUM ABSORPTION RATIO (SAR)

According, to the values of their SAR, the soil samples have values very far from the abnormal soils, because the value are all less to 13.

4.2.3 PH VALUE

The PH values are not acidic, not alkaline. But we have observed that the PH decreases with the depth.

VOTE: The PH by definition is the logarithm to the base 10, of the reciprocal of the hydrogen-ion concentration of pure water. The PH of any substance is neutral when it is equal to 7. Otherwise the PH is acid when its value ranges from 0 to 7, and alkaline when it value is greater to 7 and less to 14.

Therefore PH is defined within the range $0 < PH < 14$.

4.2.4 CATIONS PERCENTAGE IN THE SOIL

The overall salinity of a sample can be expressed in terms of electrical conductivity in the saturated extract Paste. We can deduce that soil of the project does not contain excessive salt, so that the soil is normal.

It has also be observed that the quantities of cations content is higher for calcium (Ca^{2+}), followed by Magnesium (Mg^{2+}), Soils have the capacity to adsorb cations. This capacity is possessed by the negatively charge surfaces of the soil colloids which attract cations from the soil solution. It is quantified by the so-called cation exchange equilibrium which exists between the adsorbed cations and the cation in the soil solution.

As the concentration of cation 'b' in the soil solution increases relative to cation 'a', the cations from the soil solution until a new equilibrium is established (see figure).

This cation exchange process is complicated by the fact that divalent cations are adsorbed more readily than monovalent cations, whilst in addition there's also a difference in adsorption preference between cations having the same valency.

The following series gives the important cations encountered in the soil solution arranged in order of adsorption preference

$Ca^{2+} > Mg^{2+} > H^{+} > Na^{+}$

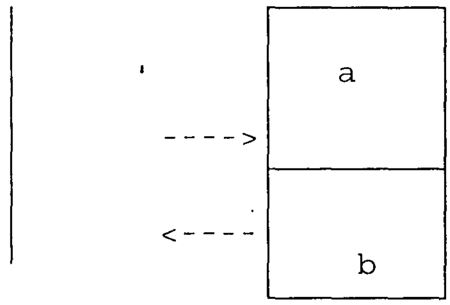
Therefore, as long as Ca2+ is the dominant cation in the soil, as it generally is in non-salty. Soils, little Na+ will be adsorbed, since it is very difficult for Na+ to displace Ca2+ on the complex. This is fortunate because a high Ca2+ occupancy of the complex is much more favourable than a high Na+ occupancy.

That means the quantity of sodium in the soils of the project area is very low, and that's why the Na+ cannot displace Ca2+.

In table 3 - (C) this sequence was proved.

Adsorption Complex (adsorbed Cation)

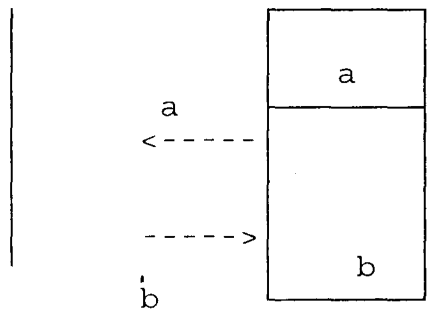
(Soil Solution) Cations in solution



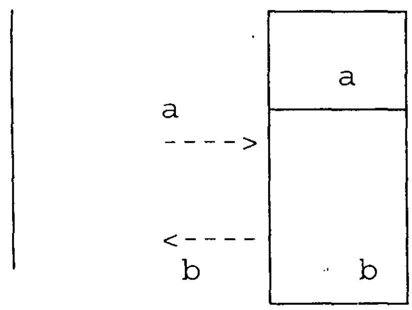
'equilibrium situation'

(preference of adsorption of cations 'a')

Adjustment by exchange of cation 'a' on the complex by cation 'b' from situation:]a+b --->] +a



Disturbed equilibrium due to relative increase of cation 'b' in the soil solution



New equilibrium

Principals of the cations exchange process

5.2.2 OBSERVATIONS IN TERMS OF WATERLOGGING PROBLEM

The project area is far from being waterlogged because of the absence of excess salts. Also, the existence of natural drains plays an important role. The alignment of big trees along the drains, the river itself plays also an important role because trees saly-up take helps to reduce salt buid-up resulting from the use of fertilisers.

5.2.3 RECOMMENDATIONS

To avoid any build-up, application of water is very important for leaching down the traces of salts brought by the use of fertilizer.

Planting of trees is also important because the trees can take-up salts from their roots.

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