THE PROPERTIES OF SALT AFFECTED CLAY SOIL IN RELATION TO LEACHING TECHNIQUES

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ABSTRACT

The object of this study is to determine the most effective leaching method for removing soluble salts from the suit affected soils by using saline water. Continuous and intermittent leaching processes were conducted on heavy clay soil selected from Tina plain, The leaching processes were extended for 21 months. The results revealed that the studied two methods are effective for salt removal, with superiority for the intermittent leaching. The later one is the optimum due to its improving the soil physical properties such as wet stable aggregate, pore size distribution and infiltration rate. It is also saved more than 30% of the net applied water needed as compared to the continuous leaching method.

There was high significant correlation between salt removal and leaching water of both methods, The values of R^2 were 0.9385 and 0.9075 for both continuous and intermittent leaching methods, respectively.

Keywords: Tina plain, salt affected soils, leaching methods, saline irrigation water

INTRODUCTION

In arid and semi-arid regions the crop production is largcly dependent on the availability of water for irrigation. Egypt is one of the regions that depend on the Nile River as the main and almost only source of fresh water. Nowadays, there is still a gap between the available water resources and water needed for agriculture purposes as well as d demand for food production. Thcre is a need to get out of the old valley and to expand horizontally to increase the overall cultivated area. In the late seventies, the search for suitable extension areas led to Sinai Peninsula.

Tina Plain is a salt affected area in the North Sinai Development Project located to the cast of the Suez Canal. It was a part of the old Nilc Dclta, where an old branch of the Nile flooded this part of the Peninsula. Thc annual floods of the river formed the plain, where the fertile soil extends deeply to more than 40 km. Due to ignorance of the maintenance requirements, the old branch was gradually blocked and completely diminished, and consequently the agricultural development was stopped.

For the last two thousand years, the plain suffered from hi!~h groundwater table and high temperature that led to the salinization of the soil profile to extremely high levels. The high salinity of the groundwater table led to the formation of salt crusts and increased the soil sodium content.

This study aimcd at answcring thc qucstions raiscd on the feasibility of leaching such highly salinc-sodic soils, the appropriate method to leach these soils and bring them to acceptable limits, with improving their properties. These answers should take into consideration the limited water resources available for reclamation and the quality of water, which will be used.

MATERIALS AND METHODS

Soil site selection

In order to achieve the aims of this study a pilot area (one feddan) was selected at El Tina plain, located at the northern west part of Sinai Peninsula, Egypt. The pilot area was divided into 6 plots, with an area of 25 m^2 for each one. Each plot was surrounded by dikes and separated from the other ones by drains as shown in Fig. (1). The soils of the chosen area are characterized by a heavy clay texture (62.6 clay, 30.4 silt and 7.0 sand).

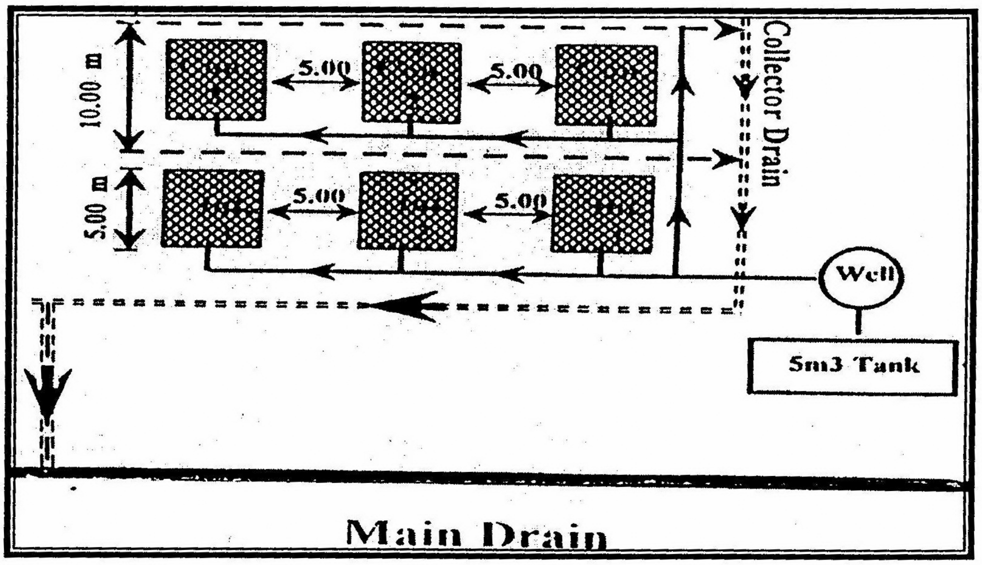

Fig. (1): Layout of the experimental field at Tina plain

Leaching Methods

The selection of leaching technique depends on soil type, soil salinity, leaching water and climate. Application of leaching water can be applied as continuous ponding, intermittent ponding, border irrigation or sprinkler irrigation. Each of the former types has advantages and disadvantages according to the surrounding and prevailing conditions. Intermittent and continuous leaching processes were selected for comparison.

Continuous pondinq is the traditional leaching method used all over the world, as it is used in surface irrigated fields. It depends on flooding the field plot, with water and allowing the water level to rise up to several centimeters above the ground surface. The water head formed by the ponding depth is the driving force that is forcing the salts to dilute and to be drained easily. It is a common practice to perform land management with this type of leaching, such as land leveling, sub-soiling and plowing (Talsma, 1967). It is considered the easiest leaching method as it does not necessitate many side activities. Rather than leveling or sub-soiling, it was applied for the other plots as shown in Fig (1).

Intermittent leaching is based on giving a set amount of water to the leaching plot and allowing this set amount to be drained completely to the drains. The idea is to give the water table the chance to draw down. Sometimes intermittent leaching is combined with mulching to improve its performance (Keren, 1990). It was applied for the first three plots as shown in Fig (1).

Field measurements

The plots under study were leached with a saline water pumped from the under ground water (EC = 10.2 dS/m). The chemical analysis of the used leaching water was determined according to Page (1982); the obtained values are presented in Table (1).

Table 1: Chemical analysis of the used leaching water

Soil pH	EC (dS/m)	TDS (ppm)	Soluble ions (me /1)							
			Ca^{+2}	Mg^{t2}	Na^{+}	K^{+}	CO_3^{2}	HCO_3^{-2}	CL^{-}	$S0_4^{-2}$
7.8	10.2	6272	7.6	13.8	81.4	0.81	--	4.2	78.2	21.21

- The quantities of irrigation water pumped to each plot either belongs to the intermittent ponding or to the continuous one were calculated as water head (m).
- Soil samples of each plot were collected among each three months at 10 cm intervals till a soil depth of 30 cm. Soil samples were chemically determined according to methods described by Page (1982) in order to follow up the soil salinity changes through the leaching process.

- Some soil physical parameters such as wet stable aggregates, pore size distribution for a depth of 0-30 cm and the infiltration rate for the surface layer of soils treated with both studied leaching methods were determined according to Kiute (1986).

- Statistical analyses were conducted to check the relation between the leaching treatments and the physical properties of the soil.

RESULTS AND DISCUSSION

Leaching of salts

Actual quantities of leaching water for both studied leaching methods are presented in Table (2).

Table 2: Actual quantities of leach in water (m depth)

Time (month)	Continuous	Intermittent
0	0.00	0.00
3	0.62	0.31
6	0.97	0.43
9	1.24	0.80
12	1.54	0.96
14	1.73	0.98
16	1.74	1.04
18	1.80	1.19
21	2.35	1.54

The data indicate that the continuous leaching consumed about 2.35 m as a head of water during the leaching time, which extended to 21 months, while the intermittent leaching consumes about 1.54 m, which represented about 0.65% the total water consumed by the continuous leaching. This means that the intermittent leaching provides about 35% less water as compared to the continuous leaching.

Figures 2, 3 and 4 represent the trend of salts leaching from the three layers of soil (0-10, 10-20 and 20-30 cm) for both studied leaching methods. Also, Table (3) represents the changes in the ECe values of the different treatments at the different time intervals.

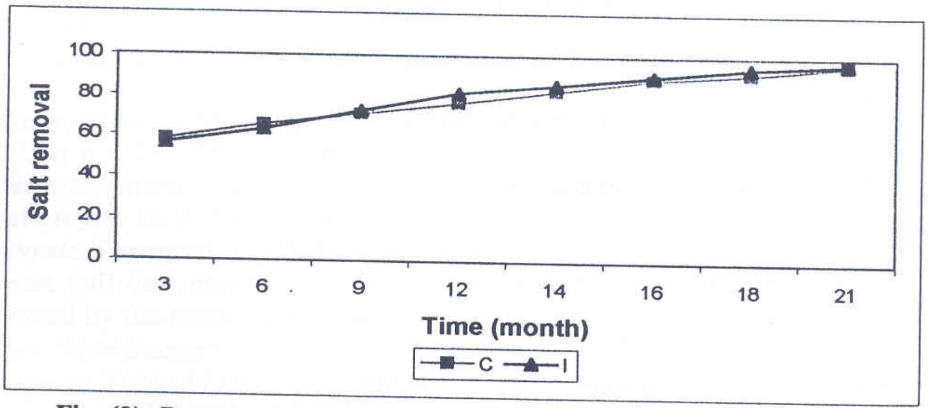

Fig. (2): Percentage of salt removal with time (soil depth 0-10 cm).

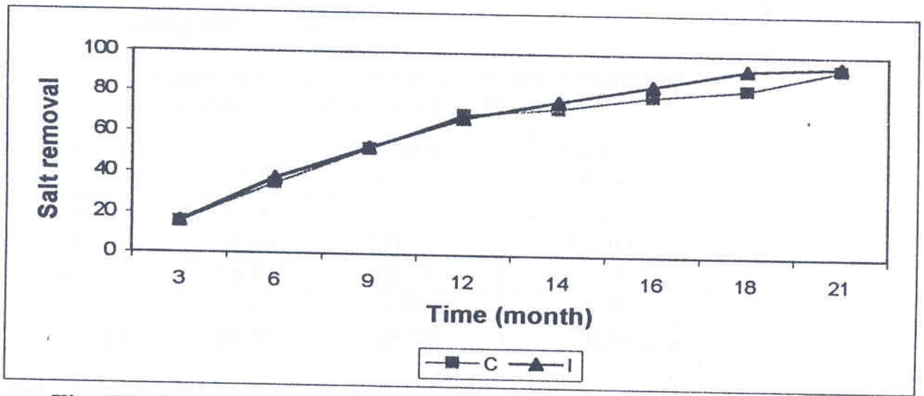

Fig. (3): Percentage of salt removal with time (soil depth 10-20cm).

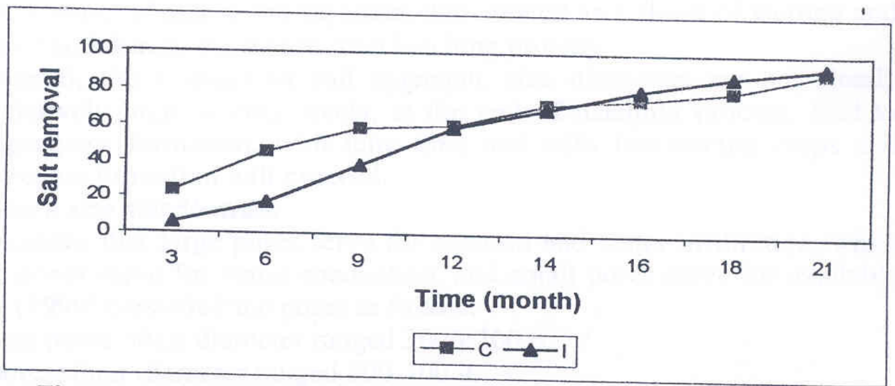

Fig.(4): Percentage of salt removal with time (soil depth 20-30 cm).

Table 3: Average of salinity changes (ECe, dS/m) during the leaching techniques

Time (month)	Leaching technique	Soil depth (cm)						
		0-10	10-20	20-30	30-40	40-50	50-60	70-60
0	Initial	354.0	195.4	177.7	119.3	80.0	118.3	117.4
3	Continuous	149.2	165.3	136.5	152.8	135.3	137.6	153.3
	Intermittent	155.6	165.0	167.8	155.2	137.9	151.6	189.2
6	Continuous	122.2	127.9	97.3	159.1	136.9	150.9	159.2
	Intermittent	130.5	122.5	147.4	144.4	134.2	129.2	171.4
9	Continuous	102.9	94.3	73.9	125.6	109.9	122.9	135.9
	Intermittent	981.0	93.2	110.1	109.8	106.6	105.3	143.5
12	Continuous	23.3	60.8	70.4	92.0	83.0	95.0	112.6
	Intermittent	65.7	63.8	72.8	75.1	79.1	81.5	115.3
14	Continuous	61.3	54.2	49.1	70.6	72.9	78.6	104.8
	Intermittent	50.1	47.3	54.1	55.6	64.8	64.0	86.2
16	Continuous	39.4	41.5	43.8	49.3	52.9	62.3	97.0
	Intermittent	34.5	30.8	35.3	36.1	40.3	46.4	56.8
18	Continuous	29.1	33.7	35.5	36.4	146.1	45.7	66.5
	Intermittent	18.9	14.4	21.2	25.7	26.3	28.9	27.4
21	Continuous	13.7	13.1	17.1	17.1	20.8	20.2	20.8
	Intermittent	10.6	10.1	12.1	17.1	12.9	12.9	12.9

From the data illustrated in the previous figures, it can be noticed that:

- More than 50% of salts were removed from the surface layer after 3 three months by both of leaching methods.
- The efficiency of continuous leaching was little bit better than that of the intermittent leaching till a time of 6 months.
- After 6 months, the trend of leaching by intermittent leaching was better. This is may attributed to the opening cracks that took place through the wetting and drying cycles and encouraged the water down-movement.
- After 21 months the EC values of the soil were coincide with that of the leaching water for both methods of leaching, Table (3).
- The percentages of salts removed from the second and third layers (10-20 and 20-30 cm) were less than that of the surface layer (0-10 cm) at the beginning of leaching time because of the salt movement from top to down.
- At the end of the leaching time the salt removal took place for both methods, but the intermittent was little bit better.

Statistical Analysis

Conducting the statistical analysis, data illustrated in Figs. (5 and 6) the following are obtained:

- The relation between salts removal and quantities of leaching was occurred as follows:
  - *As for the continuous leaching:* $R^2 = 0.9385$ and the relation is presented by the equation y = 24. 116 x + 42.622.
  - *As for the intermittent leaching:* $R^2 = 0.9075$ and the relation is presented by the equation y = 36.059 x + 47.043.

Changes in physical properties of the soil

This part will deal mainly with the improving of some physical properties of the soil associated with the leaching method.

Aggregate sizes Distribution

The data in Table (4) represent the water stable aggregates distribution at the beginning and at the end of leaching process for the 0-30 cm of the two methods. The results indicate that the amount of aggregates < 0.25 mm is the dominant amount in the initial stage. This is due to the dispersion effect owing to the high content of exchangeable sodium.

Table (4): Water stable aggregates under the continuous and intermittent leaching techniques

Aggregate size % (mm)	Initial	Continuous (final)	Intermittent (final)
<2	5.98	5.62	5.21
2.0-0.84	11.64	10.41	11.03
0.84	10.81	10.21	9.11
0.42-0.25	4.61	4.02	4.01
> 0.25	66.96	69.74	70.64

The data also reveal that there was a slight decrease in the total amounts of all diameters of soil aggregates, except that of < 0.25 for both studied leaching methods, which shows an increase. A decrease is noticed in the > 0.25 mm size group, and it is more related to the separates that created as a result of wetting and drying cycles of soil during the intermittent leaching process.

In general, the changes in soil aggregate size diameters are not clearly noticed as relatively high salinity levels, at the end of leaching process, lead to minimize aggregates formation, with long time and with introducing crops and amended aggregate formation will precede.

Changes in pore size distribution

It is known that large pores serve for aeration and water infiltration, while medium size pores serve for water conduction, and small pores serve for available water. Keren (1990) classified the pores as follow:

- Fast drainage pores, their diameter ranged 3000-300 u.
- Aeration pores, their diameter ranged 300-100 u.
- Capillary conduction pores, their diameter ranged 30-10 u.
- Storage of plant available water pores, their diameter ranged < 10 u.

The data presented in Table (5) show the changes of pore size distribution as volume percent from the total porosity of the soil for the two leaching methods. The data indicate the following:

- Concerning the continuous leaching, it is clear that there is an increase for value of the fast drainage pores (> 300 mm), which played a fundamental role during the salt leaching process. At the same time, aeration pores value (300-100 u) decreased due to the increase of the fast drainage pores, in addition to the effect of the increase of the medium and small pores.
- Concerning the intermittent leaching, it is found that there is a tendency for increasing the percentages of the fast drainage pores (> 300 mm), with a decrease for 300-100 and 30-10 mm as comparing to the values of the initial condition.
- As comparing the studied leaching methods, it is noticed that both methods ameliorate the percentage of pore size distribution, in the tendency of increasing the relatively large pores in the treated soil.

Table (5): Pore size distribution under the continuous and intermittent leaching techniques

Pore size % (μ)	Initial	Continuous (final)	Intermittent (final)
300 <	14.67	8.18	8.49
100-300	39.31	5.39	6.52
30-100	13.06	12.80	3.83
10-30	11.25	2.49	1.76
10>	21.17	8.18	12.41

Infiltration Rate (IR)

Figures (5) and (6) demonstrate the curves of IR for both methods of leaching. The curves indicate that in the case of the continuous leaching, the soil basic infiltration rate has a value of 0.11 cm/hr (0.0 26 m/day), while the value is higher in the intermittent plots, about 0.32 cm/hr, (0.0 76 m/day). This means that intermittent leaching increase the soil infiltration capacity to 2.5 times the value in the case of the continuous leaching.

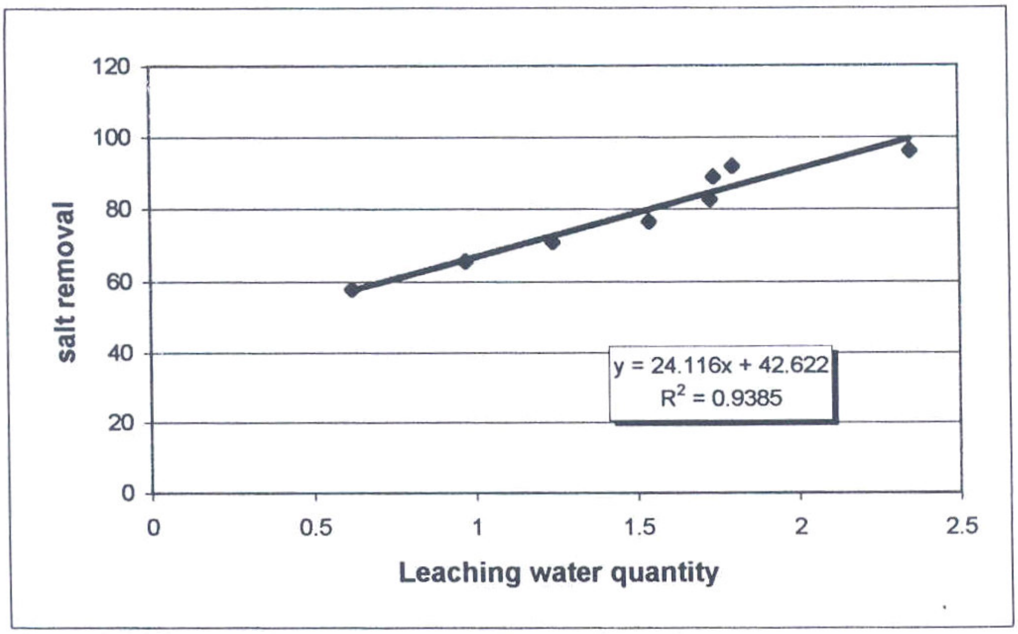

Fig. (5): Salt removal (%) and leaching water quqntity (m depth) relationship for continuous leaching technique (0-30 cm depth).

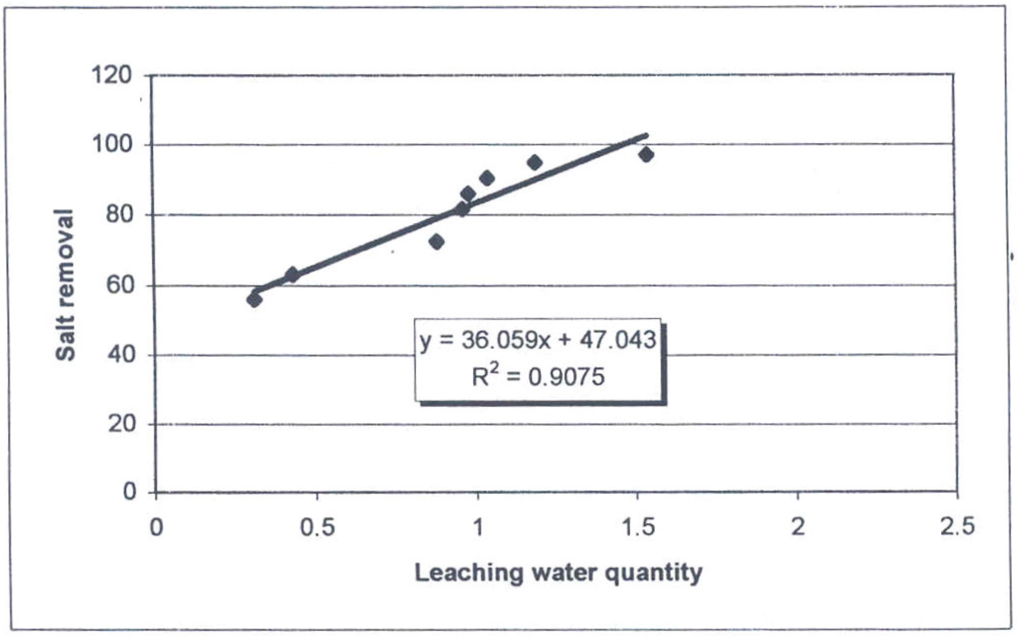

Fig. (6): Salt removal (%) and leaching water quantity (m depth) relationship for intermittent leaching technique (0-30 cm depth).

CONCLUSIONS AND RECOMMENDATION

From the previous discussions, the following can be concluded:

- Both methods of leaching decreased the salts content in the clayey soil.
- The effect of continuous leaching in salt removal is higher in the first 3-6 months while the intermittent is more effective after six months due to the improvement of some soil physical properties.
- The intermittent leaching has better impact for improving the soil physical properties such as pore size distribution and infiltration rate.
- It can be recommended that intermittent leaching is the optimum leaching method for the Tina plain condition. It saves more than 30% of the net applied water needed for the continuous leaching and improved some soil physical properties.

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