

RECLAMATION OF SODIC SOILS USING EDTA

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ABSTRACT

When Ethylene diamine tetra acidic acid (H_4EDTA) is added to a sodic soil having even small amount of $CaCO_3$, $CaEDTA^{-2}$ is the predominant species at all pH levels based on the stability constant of Ca, Mg, Na and H species formed with EDTA. This being the case, where H_4EDTA will act as a strong acid resulting in dissolution of three moles of calcite per mole of H_4EDTA . Two thirds of the released Ca^{2+} is available for exchange with exchangeable Na, while one-third will be present as $CaEDTA^{-2}$. This hypothesis was tested in a replicated column experiment whereas powdered H_4EDTA was added to a sodic soil at a rate of 1.5 and 2.0 times the exchangeable Na. Intermittent ponding technique was used at a rate of 4 fold of field capacity every 15 days using distilled water. The obtained data proved that H_4EDTA is an effective and quick amendment on reclaiming sodicity within 30 days without need for any other mutual amendments. The ESP was decreased to 5 instead of 25.3 in the initial soil in addition to improving all physical and chemical properties of the studied soil. Applying this technique according to the high expense of EDTA could be useful when the need of fast result is urgent. For example, formation of sodicity in the root zone of many orchards especially mango and citrus trees irrigated with water rich in bicarbonates and carbonates (Nile water) or rich in sodium (wells and wastewater). Also adding H_4EDTA could be useful with the sodic patches formed beside irrigation canals and on the poor drained areas before its expanding to the rest of the fields. H_4EDTA is the only

known acid that can be applied to the soil as a powder, so, it could be applied to the subsoil layers. All other liquid acids used for reclamation are applied only to the soil surface. Another useful application of H_4EDTA in irrigated agriculture would be to inject the powder into drip irrigation lines as a cleaning agent. It would dissolve precipitated calcite within the lines and emitters.

Key words: H_4EDTA , reclamation, sodic soil.

1. INTRODUCTION

One of the most important soil problems in arid and semi arid regions is the high level of exchangeable sodium. It is commonly believed that a soil with an ESP more than 15 and a high percentage of expandable clay minerals will be adversely affected by poor aeration, poor water infiltration, and structure that resist cultivation. Coarse structured soils with ESP values more than 15, may also be adversely affected by low salinity and high SAR of irrigation water (Shainberg and Letey, 1984). These poor physical properties can be attributed to dispersion and slaking of aggregates. In some soils the plugging of pores by dispersed clay particles is the major cause of reduced hydraulic conductivity (Frankel *et al.*, 1978). In addition, infiltration rate decreased with decreasing soil salinity and with increasing exchangeable sodium (Mcneal and Coleman, 1966; Oster, 1993, and Oster *et al.*, 1979). Infiltration rate is more strongly affected by low soil salinity and high ESP than hydraulic conductivity because of the mechanical impact and stirring action of the applied water (Flehender *et al.*, 1974; Cass and Sumner, 1982 and Abu-Sharar *et al.*, 1987). As a result, during reclamation farmers must maintain adequate infiltration rate and hydraulic conductivity through various combinations of crop, soil amendment, tillage practice, and adequate drainage (either natural or artificial) to remove excess salts and exchangeable sodium from the root zone (Oster, 1993, and Cass and Sumner, 1974).

This work is a trial to find out a quick method to reclaim sodic soils or sodic conditions in cultivated land. Many cases of formation of sodic conditions in the root zone of productive orchards (especially mango and citrus as sensitive species to sodicity conditions) occur as a result of using irrigation water rich in bicarbonates (Nile water) or rich

in sodium (wells and re-used water). Furthermore the sodic patches formed close to irrigation canals and poorly drained areas need to be controlled before expanding to the rest of the fields. This condition needs to be reclaimed by safe and quick methods. Using the acid form of EDTA (H_4EDTA) which is known as a chelate material and the only strong acid that can be applied to the soil as a powder could achieve this work. H_4EDTA has a capacity to dissolve three moles of soil calcite for each mole of H_4EDTA . Two thirds of the released Ca will be available for exchange with exchangeable Na. This could shorten the time needed for reclamation.

2. MATERIALS AND METHODS

The soil used in this study was a sodic soil containing 11.6 % of $CaCO_3$, with an exchangeable sodium percentage (ESP) of 25.3 (Table 1). It was obtained from El-Mansour area, Kafr El-Sheikh Governorate north of Delta, Egypt. The soil was air dried, ground, sieved (< 2-mm), and analyzed for $CaCO_3$ content, cations, pH, and electrical conductivity (EC) in the saturated-soil extract according to the recommended methods of FAO 1970. Particle size distribution, determined by hydrometer (Gee and Bauder, 1986), included 35 % clay, 38 % silt, and 27 % sand.

Table (1): Some chosen properties of the studied soil.

PH	EC dS/m	Soluble ions (mmole/l)					CEC Meq/100	ESP	ECaP	EMgP	EKP
		Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	SAR					
8.31	4.50	32.2	0.72	2.73	2.00	20.9	30.40	25.30	46.50	25.50	2.70

Rectangular shaped, corrugated plastic columns (35-cm height) filled with 2 Kg of soil were used in this study. The dimensions of the columns were: 10 X 10 cm at the top and 8 X 8 cm at the bottom. Three layers of cheesecloth were attached to the bottom of each column to retain the soil. Air dried soil was mixed with powdered H_4EDTA and packed into the column through a glass tube, which was gradually raised as the soil filled the lower 25 cm of the column.

The soil columns were slowly saturated from below by setting the columns into container filled with distilled water. Then water was applied at a rate of 4 fold the field capacity every 15 days using

intermittent ponding technique. The columns were covered to minimize evaporation. The effluent was collected daily and analyzed for pH, EC, soluble cations and anions. Following the experiment, the soil was separated into 4 layers, (0-5), (6-13), (14-20), and (21-25) cm, and extracts from saturated soil pastes were obtained and analyzed.

The experiment included three treatments: 2 rates of H_4EDTA , (1.5 and 2.0 times the exchangeable sodium) and a control. Intermittent leaching was used in this experiment.

Milliequivalent of H_4EDTA requirement for reclaiming the sodic soil was supposed to be equal the milliequivalent of exchangeable sodium. But, according to the expected reaction between H_4EDTA and polyvalent cations in the soil, H_4EDTA was added in a dose as high as 1.5 and 2 times the exchangeable sodium. For that reason also the experiment was started without any calcium amendment addition to force the hydrogen EDTA to dissolve soil calcite and the released Ca^{2+} can replace exchangeable Na^+ , and that sodium could leach out of the soil easily as di-sodium EDTA due to its high dissolution.

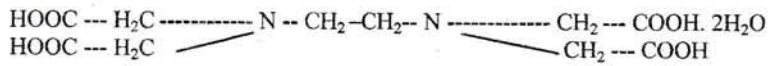
Thirty days after the beginning of the experiment, (to make sure that all added H_4EDTA was leached out of the soil column), a daily additions of 500 ml of saturated gypsum solution (1 g / 500 ml water) was added to each soil column of the EDTA and control treatments for another 15 days.

Accordingly, the used treatments were:

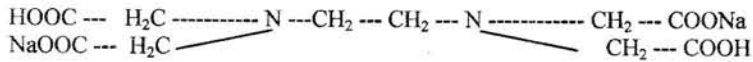
- 1- Intermittent leaching + H_4EDTA at a rate of 1.5 times the exchangeable Na for 30 days.
- 2- Intermittent leaching + H_4EDTA at a rate of 2.0 times the exchangeable Na for 30 days
- 3- Intermittent leaching + H_4EDTA at a rate of 1.5 times the exchangeable Na for 30 days followed by a daily addition of 500 ml saturated gypsum solution for another 15 days.
- 4- Intermittent leaching + H_4EDTA at a rate of 2.0 times the exchangeable Na for 30 days followed by a daily addition of 500 ml saturated gypsum solution for another 15 days.
- 5- Intermittent leaching for 30 days.
- 6- Intermittent leaching for 30 days followed by a daily addition of 500 ml saturated gypsum solution for another 15 days.

2.1 Chemical composition of the used material

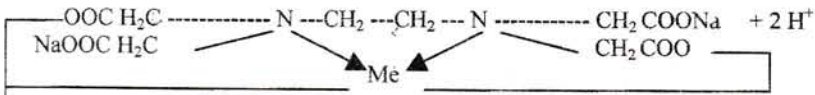
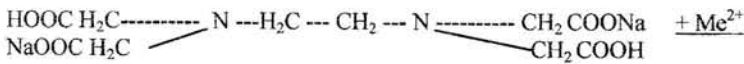
Ethylene diamine tetra acetic acid (H_4EDTA) is one of the most commonly known complexes. It is known commercially as Versinate or trilon B. Its molecular weight is 328.3 and the structure formula is -



The di-sodium salt (Na_2EDTA) form has a molecular weight of 372.3 and a gram equivalent of 168.15 with a structural formula of -



EDTA, like other complexes, forms very stable soluble internal complex salts with many metals. The metal replaces hydrogen atoms as the COOH groups and is also linked by coordinate bonds to Nitrogen atoms as the following structural formula, (Alexeyev, 1979): -



The very low instability constants of such complexes, ranging from 10^{-9} to 10^{-22} , indicate that these internal complex salts are highly stable. In particular K_{inst} of the Ca^{2+} complex is 2.7×10^{-11} and that of the Mg^{2+} complex is 2×10^{-9} , and for Na^+ $10^{-1.7}$. These constants indicate that, for EDTA solutions that contain equal molar concentrations of Ca^{2+} , Mg^{2+} , and Na^+ , the Ca^{2+} and Mg^{2+} complexes with EDTA are 7 to 8 orders of magnitude greater in concentration than the Na^+ complexes with EDTA.

In case of treating some precipitates such as CaC_2O_4 , CaSO_4 or BaSO_4 with EDTA solutions, the precipitates dissolve (Alexeyev, 1979). This occurs because the respective cations are combined into complexes.



The precipitates are dissolved only in alkaline solutions. When the solutions are acidified, the complexes are decomposed and CaSO_4 are again precipitated. The explanation is that, as the above equation shows, the formation of complexes with EDTA is accompanied by accumulation of acid in the solutions. Consequently, if H^+ ions combine with OH^- ions from an alkali, the equilibrium shifts to the right, favoring complex formation; conversely, if the solution is acidified the reaction equilibrium shifts to the left and the complex decomposes. This could explain the idea of using EDTA to reclaim alkali soil or alkali conditions. EDTA could dissolve the Ca precipitates producing extra amount of acids could dissolve more soil Ca precipitates and at the same time reduces the alkalinity condition and soil pH.

Many references stated that the ability of EDTA to chelate Fe^{2+} , Mn^{2+} , Zn^{2+} , and Cu^{2+} was limited because Ca^{2+} ions competed effectively with these ions for the chelate legend, (Wallace and Lunt, 1956; Lunt *et al.*, 1956, and Norvell, 1972).

3.RESULTS AND DISCUSSION

The obtained data of the different treatments could be discussed under two main headings, leachate analyses and soils analyses.

3.1. Leachate analyses

Data in Table (2) and Fig. (1) show the leachate analysis under different reclamation treatments.

3.1.1. Cumulative water discharge

Cumulative water discharge reflected high improvement of infiltration rate and soil permeability of the studied soil under EDTA treatments. Improving such properties is necessary to aid the leach out of the reaction products during reclamation process (usually Na_2SO_4 and Na_2CO_3). High rate of EDTA (before adding the gypsum solution) increased the water discharge about 20 % more than the low rate of EDTA and 1008 % more than the control. Adding gypsum solution after 30 days of the beginning of the experiment to the EDTA

treatments did not significantly improve the water discharge. These rates were 72.6% and 62% from the total added water to each soil column, became 80 and 63 % after gypsum additions. This means that the improvement of the soil physical properties during reclamation has mainly happened by the effect of H₄EDTA.

Table(2):Leachate analysis of different treatments during reclamation.

Time after (day)	Cumulative discharge (L)	PH	EC dS/m	Ions recovery meq.				Remaining Na % of initial
				Na	K	Ca	Mg	
EDTA (1.5 time the exchangeable Na)								
1	9.50	8.00	11.70	62.58	2.27	112.68	28.64	68.54
10	1.25	8.10	4.50	104.00	4.00	205.00	46.00	47.72
20	2.40	8.13	2.55	124.00	5.00	243.00	49.00	37.7
30	3.08	8.21	1.00	130.00	5.00	246.00	50.00	34.56
40	4.57	8.65	2.55	145.00	7.00	272.00	57.00	27.27
50	6.93	8.60	2.30	158.00	21.00	363.00	84.00	20.57
EDTA (twice the exchangeable Na)								
1	0.59	8.30	9.70	54.74	2.24	125.40	19.20	72.48
10	1.50	8.30	6.85	109.00	5.00	297.00	39.00	45.4
20	3.63	8.00	4.10	142.00	7.00	406.00	48.00	28.83
30	3.63	8.20	0.90	142.00	7.00	406.00	48.00	25.83
40	6.35	8.60	2.30	159.00	10.00	488.00	63.00	20.09
50	10.13	8.55	2.35	173.00	14.00	595.00	85.00	13.18
Control								
1	0.00	-----	-----	-----	-----	-----	-----	100.00
10	0.10	8.70	37.80	19.00	1.00	1.00	1.00	90.69
20	0.27	8.70	7.32	32.00	2.00	2.00	2.00	83.83
30	0.36	9.30	5.15	36.00	2.50	2.00	2.00	79.50
40	1.06	9.30	5.50	50.00	4.00	3.00	3.00	72.55
50	1.28	9.50	4.30	60.00	6.00	3.00	3.00	69.65

3.1.2. Electrical conductivity (EC) and soil reaction (pH)

The electrical conductivity of the EDTA treatments decreased sharply among the first two weeks due to the high volume of the water discharge from the soil column compared with high EC and low volume of water discharge in the control treatment. A slight increase in the EC value of the leachate in the EDTA treatment was observed after addition of saturated gypsum solution due to the increase of SO₄²⁻ and Ca²⁺ recovery in the leachate.

The pH values of the leachate showed high pH values in the control treatment compared with the EDTA treatments. A slight increase in the pH values of the leachate of all treatments was

observed after adding the gypsum solution due to increase of bicarbonate and sodium ions accumulated in the deep layers of the soil column is going on under the effect of gypsum addition.

3.1.3. Sodium and potassium recovery

H₄EDTA showed an outstanding effect in removing sodium from the sodic soil in relatively short time that did not exceed 30 days. About 72% and 63% of the total initial sodium were removed from the soil column under high and low rates of EDTA treatments, respectively compared with 16% only in the control. The total initial sodium (198.9 meq) includes the exchangeable and soluble sodium was calculated as follows: -

$$\begin{aligned} \text{meq. of exchangeable Na/soil column} &= \text{ESP}/100 \times \text{CECX} \times 10 \times \text{weight of} \\ &\quad \text{soil column (kg ---meq./100g--- --meq/kg)} \\ &= 25.3/100 \times 30.4 \times 10 \times 2 = \underline{153.82} \\ \text{meq. of soluble Na}^+/\text{soil column} &= \text{Soluble Na meq/l} \times \text{SP} \times \text{weight of} \\ &\quad \text{soil column(kg)} \\ &= 32.2 \times 0.70 \times 2 = \underline{45.8} \\ \text{The total initial Na}^+/\text{soil column} &= 153.82 + 45.80 = \underline{199.62 \text{ meq/soil}} \\ &\quad \text{column} \end{aligned}$$

After addition of the saturated gypsum solution for 15 days, the amount of Na recovery from the soil column was slightly increased to 87%, 79.5% and 31% from the initial in the high, low rate of EDTA and control, respectively. These data mean that about 82% and 79% from the total Na recovery were removed under H₄EDTA effect within 30 days without any Ca²⁺ amendments. Consequently, the reclamation of sodic soils can be achieved with H₄EDTA only without need for other mutual Ca²⁺ amendments.

Potassium recovery in the leachate showed a good effect of the EDTA in saving the potassium from leaching during reclamation. Data show that only 7 and 5 meq. K⁺ were removed during the first 30 days of the EDTA treatments. Adding of gypsum to the soil column after that period increased the K⁺ recovery to 14 and 21 meq. in only 15 days, which proves that EDTA reacts with the polyvalent metals than

mono-valent. High rate of EDTA addition saves the K^+ removal from the soil more than the low rate.

3.1.4. Calcium and Magnesium

The amount of calcium recovery under H_4EDTA effect before addition of gypsum solution recorded the highest amount of ions recovery, Table (2). It reached 3 and 9 times more than the amount of Na and Mg recovery, respectively in the high rate of EDTA treatments. However, these amounts were 2 and 5 times more than Na and Mg, respectively under the low rate of EDTA. The amount of the released Ca^{2+} in the leachate under the high rate of EDTA after 30 days of the beginning of the experiment was 406 meq. exceeded the summation of initial soluble and exchangeable Ca^{2+} , even though all this amounts could be leached out.

$$\begin{aligned} \text{meq of exchangeable Ca/soil column} &= ECaP/100 \times CEC \times 10 \times \text{weight of soil} \\ &= 50/100 \times 30.4 \times 10 \times 2 \\ &= 300.4 \text{ meq} \end{aligned}$$

$$\begin{aligned} \text{meq. of soluble Ca/soil column} &= \text{Soluble Ca (meq/l)} \times SP \times \text{weight of soil} \\ &= 2.78/2 \times 0.70 \times 2 \\ &= 1.95 \text{ meq} \end{aligned}$$

$$\begin{aligned} \text{Total initial Ca/soil column} &= 300.4 + 1.95 \\ &= 302.35 \text{ meq/ soil column} \end{aligned}$$

This observation means that the H_4EDTA has a good effect in dissolving some insoluble or slightly soluble calcium forms in the soil such as $CaCO_3$ and $CaSO_4$, Alexeyve, 1979; Martell and Smith, 1974; and Strumm and Morgan, 1981. In addition, Norvell, 1972; and Norvell and Lindsay, 1969 and 1972; demonstrated that excess concentration of EDTA in the sodic soil not combined with Fe, Zn, Cu and Mn were assumed to be in the form of "Ca-chelates", because the competition of these cations to Ca is not significant in alkali soils.

The amount of the dissolved $CaCO_3$ during reclamation could be calculated as follows:

the initial $CaCO_3$ was 11.55 %, decreased to 9.8 % and 10.37 % in the high and low rates of EDTA treatments, respectively. Thus, the dissolved $CaCO_3 = (\text{initial } CaCO_3 - \text{final } CaCO_3) / 100 \times \text{weight of soil column}$

$$\begin{aligned} \text{Treatment of 2 } H_4EDTA &= (11.55 - 9.80) / 100 \times 2000 \\ &= 35 \text{ grams which equal} \\ &= 35 \times 1000 / 50 = 700 \text{ meq. } Ca^{2+} / \text{soil column} \end{aligned}$$

$$\begin{aligned} \text{Treatment of } 1.5 \text{ H}_4\text{EDTA} &= (11.55 - 10.37)/100 \times 2000 \\ &= 23.6 \text{ grams which equal} \\ &= 23.6 \times 1000/50 = 472 \text{ meq. Ca / soil column} \end{aligned}$$

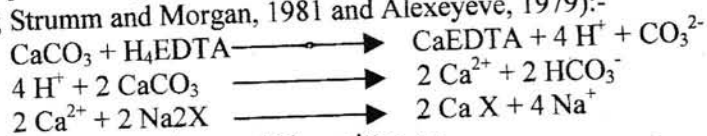
The amount of removed Ca^{2+} during the first 30 days of the experiment was 406 and 246 meq. in 2.00 H_4EDTA and 1.50 H_4EDTA treatments, respectively. Thus the remainder of soluble Ca^{2+} ions in the soil column were, $700 - 406 = 294$ meq.; and $472 - 246 = 226$ meq. in the same treatments, respectively. The remainder of Ca^{2+} ions in the soil column of the EDTA treatments exceeded the amount of the initial sodium (Exchangeable and soluble) which were 153.8 meq. Na / soil column. Accordingly, using H_4EDTA (without any amendment addition) in reclaiming sodic soils will be effective and quick method could solve many of urgent needs in relatively short time.

Magnesium recovery, Table (3), showed that most of Mg recovery under EDTA treatments occurred during the first 10 days followed by stable condition and increased again after gypsum addition, which reflects the capability of Ca^{2+} in replacing exchangeable Mg^{2+} .

3.2. Soil analyses

Chemical analyses of the studied soil after reclamation are presented in Table (3).

The data showed that the soil had been reclaimed during 30 days only under H_4EDTA treatments without need for gypsum additions. The ESP decreased to about 5 instead of 25.3 in the initial, Table (1) compared with average of 21 in the control. These values decreased again to about 1.50 and 19 in the EDTA treatment and control, respectively after addition of gypsum solution for another 15 days. The data also showed the predominance of bicarbonates and calcium in the EDTA treatment which proved the effect of EDTA in dissolving CaCO_3 according to the following equations (after Martell and Smith, 1974; Strumm and Morgan, 1981 and Alexeyev, 1979):-

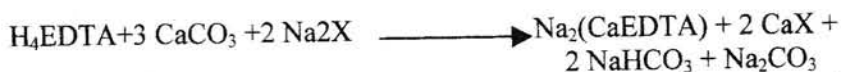


So, the overall reaction could be written as: -

Table (3): Chemical analyses of soil saturated paste extract in different reclamation treatments.

Layer depth (cm)	pH	EC dS/m	Meq/l								ESP	CaCO ₃ %Av
			Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	SAR		
After 30 days before additions of gypsum												
1.50 EDTA												
0-5	7.60	0.60	2.98	0.82	4.83	0.30	6.85	0.10	0.42	3.50	4.91	10.3
6-13	7.70	0.70	3.21	0.77	5.66	0.29	7.34	0.08	0.51	4.02	5.59	
14-20	7.80	0.80	4.15	1.02	5.95	0.33	8.60	0.07	0.70	3.70	5.18	
21-25	8.00	1.00	13.60	1.17	8.60	0.51	19.68	0.21	1.53	3.17	4.46	
2.00 EDTA												
0-5	7.50	0.50	3.91	0.67	3.38	0.25	7.24	0.08	0.51	2.23	3.19	9.80
6-13	7.50	0.50	6.15	0.72	3.83	0.29	10.30	0.10	0.33	2.06	2.96	
14-20	7.60	2.40	30.14	5.55	10.01	0.94	45.33	0.10	0.73	2.37	3.38	
21-25	7.70	4.50	30.15	18.13	17.57	1.47	70.54	0.10	1.78	3.58	4.04	
Control												
0-5	8.20	1.12	0.80	0.80	8.80	0.78	10.00	0.18	1.07	9.84	18.90	11.50
6-13	8.20	1.34	0.70	0.30	12.10	0.62	12.43	0.30	1.02	17.11	20.23	
14-20	8.20	1.49	0.50	0.20	14.00	0.53	13.46	0.27	1.18	23.66	22.57	
21-25	8.30	1.84	0.60	0.30	17.20	0.48	16.72	0.24	1.76	25.64	24.50	
After 30 days followed by 15 days of gypsum additions (total 45 days)												
1.50 EDTA												
0-5	7.10	2.40	14.19	3.69	3.11	0.84	3.45	1.14	17.17	1.04	1.50	
6-13	7.20	1.80	11.00	4.51	2.44	0.87	3.27	0.66	14.90	0.88	1.27	
14-20	7.20	1.70	9.33	4.33	3.32	0.90	2.16	0.64	15.05	1.27	1.84	
21-25	7.25	1.75	10.78	4.60	3.52	0.91	3.48	0.65	15.69	1.27	1.84	
2.00 EDTA												
0-5	7.10	2.60	15.00	4.30	3.11	0.85	4.41	1.06	17.41	1.00	1.46	
6-13	7.10	1.70	10.77	4.05	2.27	0.83	3.61	0.61	13.51	0.83	1.21	
14-20	7.20	1.65	9.46	3.97	2.98	0.89	2.11	0.60	14.59	1.15	1.67	
21-25	7.20	1.75	9.79	4.50	3.44	0.95	2.36	0.67	15.66	1.29	1.86	
Control												
0-5	8.10	1.20	1.20	1.00	9.00	0.49	6.25	0.11	0.67	8.58	16.98	
6-13	8.10	1.43	1.00	0.50	12.00	0.39	7.77	0.19	0.64	13.86	17.86	
14-20	8.10	1.54	0.70	0.30	14.10	0.33	8.41	0.17	0.74	19.94	20.62	
21-25	8.30	1.96	1.01	0.50	18.30	0.30	10.45	0.15	1.10	21.06	22.30	

Note: The concentration of metal-EDTA in its solution does not follow the relation between EC and concentration of ions on its solution (EC X 10 or 12.5 or 8).



This could explain the reason of the accumulation of bicarbonates in the deep layers of the soil column. In addition, Wallace and Lunt, (1956) reported that the form of CaEDTA can be adsorbed as a metal-chelate by the soil particles. As a result, CaEDTA can easily

replace exchangeable Na on the exchangeable complex. On other hand $\text{Na}_2(\text{CaEDTA})$ could leach out easily according to its high solubility.

The accumulation of the soluble bicarbonate ions associated with soluble Ca^{2+} and Na^+ ions, reflects the need of soil treated with EDTA for either more time of leaching or contribution of cations to enhance the leach out of Na^+ and HCO_3^- from the deep layers. However, adding gypsum solution removed completely both bicarbonates and sodium from the deep layers associated with changing the predominance of Ca^{2+} and SO_4^{2-} . Consequently, the pH values decreased to about 7.15 and The EC values increased.

The changes in the exchangeable cations could be summarized as shown in Table (4):

Table (4): Initial and final exchangeable cations under different reclamation treatments.

Treatment	ESP	ECaP	EmgP	EKP
Initial	25.30	48.00	23.50	3.20
30 days under EDTA effect				
1.5 EDTA	5.00	82.50	9.50	3.00
2.0 EDTA	3.40	76.70	15.90	3.00
CONTROL	21.00	59.00	17.00	3.00
30 days + 15 days adding gypsum solution				
1.5 EDTA	1.60	85.00	11.40	2.00
2.0 EDTA	1.06	81.20	15.74	2.00
CONTROL	18.70	61.30	18.00	2.00

3.2.1. Conclusion and Applying

H_4EDTA acts as a strong acid when mixed with sodic soils contains some calcite. The zone of effectiveness would be directly linked to the depth of incorporation. It is the only known acid that can be applied to a soil as a powder. Acids such as sulphuric when used for reclamation are usually applied to the soil surface only. Another possible application in irrigated agriculture for H_4EDTA would be to inject the powder into drip irrigation lines as a cleaning agent. It dissolves precipitated calcite within the lines and emitters. Applying this technique according to the expense of EDTA could be useful under urgent needs. For example, formation of sodicity in the root zone of many orchards especially mango and citrus trees irrigated with water rich in bicarbonates and carbonates (Nile water) or rich in sodium (wells and wastewater). Also adding H_4EDTA could be useful

with the sodic patches formed beside irrigation canals and poor drained areas before its expanding to the rest of the fields. EDTA could also be added to the calcareous soil to dissolve the calich crust, which prevents and resists the germination of the seeds in these soils.

3.2.2. Economic study for spot reclamation using EDTA:

Supposing that there is a sodic patch or a sodic subsoil area under Mango tree has a thickness of 20 cm and a dimension of 1m X 1m. The ESP is 25, and the CEC is 32 meq./100 g soil, so:

$$\begin{aligned} \text{The meq of exchangeable Na} &= \text{CEC} \times \text{ESP}/100 \\ &= 32 \times 25/100 = 8 \text{ meq}/100\text{g soil} \end{aligned}$$

According to this study, this amount of exchangeable Na needs a meq of EDTA as high as 1.5 to 2.0 times the exchangeable Na, which equals 12 to 16 meq of EDTA to be reclaimed.

The weight of EDTA = meq of EDTA X equivalent weight/1000

The molecular weight of H_4EDTA is 328.3 with a 4 H^+ atom available to be replaced, so the equivalent weight is: $328.3 / 4 = 82.075$.

Under low rate of EDTA = $12 \times 82.075/1000 = 0.98 \text{ g}/100 \text{ g soil}$, and

Under high rate of EDTA = $16 \times 82.075/1000 = 1.31 \text{ g}/100\text{g soil}$

Thus $0.98 \text{ g}/100 \text{ g soil}$ equals $9.8 \text{ g}/1 \text{ kg soil}$, or $9.8 \text{ kg}/\text{ton soil}$, under low rate of EDTA, while it will be equal $13.1 \text{ kg EDTA}/\text{ton soil}$ under the high rate of EDTA applications.

The weight of sodic layer = area X depth X bulk density

$$= 1 \times 1 \times 0.2 \times 1.5$$

$$= 0.30 \text{ ton, This needs to:}$$

Under low rate of EDTA = $0.3 \times 9.8 = 2.94 \text{ kg EDTA}$, and Under high rate of EDTA = $0.3 \times 13.1 = 3.93 \text{ kg EDTA}$.

Supposing that, a feddan has 100 patches or a 100 mango trees under a spacing of (7m X 7m). These need 294 and 393 kg of EDTA under low and high rate additions, respectively.

The price of a ton of the commercial mass of EDTA is 20.000 LE, so the price of 1 Kg is 20 Egyptian pounds (not in a small package), thus the cost of reclamation will be: -

Under low rate of EDTA = $294 \times 20 = 5,880 \text{ LE}/\text{feddan}$, and Under high rate of EDTA = $393 \times 20 = 7,860 \text{ LE}/\text{feddan}$.

These costs are not considered expensive when we know that, the official expected cost of reclamation of El-Salam zone is 20,000

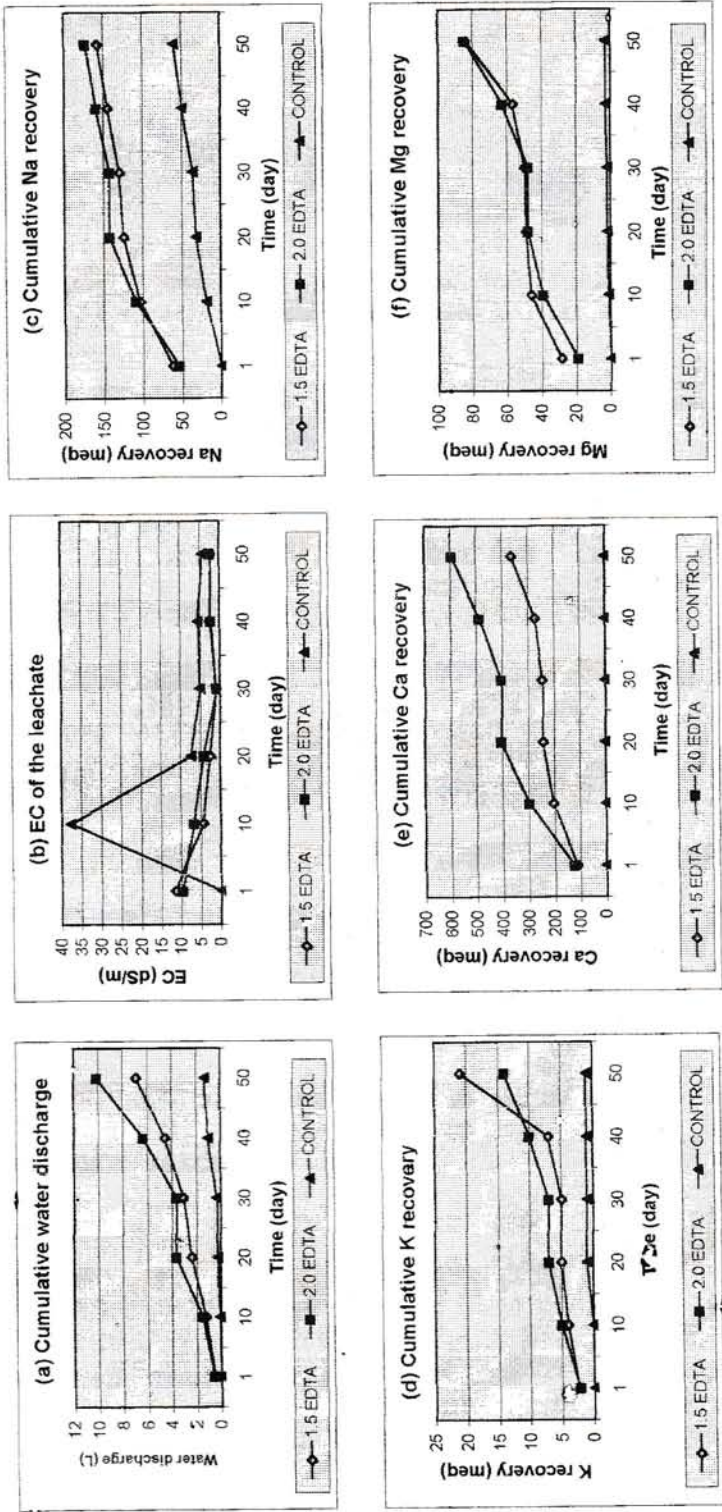


Fig (1): Changes in some reclamation parameters in the leachate .

LE/feddan, and in Tushky area in upper Egypt is 30,000 LE/feddan. In addition, reclamation of alluvial soils will have more beneficial return income than that in case of reclaiming sandy or desert soil. Moreover, using EDTA in reclamation shortens the time needed for reclamation to only 30 days instead of 3 – 5 years for the sandy or desert soil to be economically productive. The time saved under reclamation by EDTA will return back the cost of reclamation or may be more.

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إستصلاح سريع للأراضى القلوية باستخدام المركب المخلبى EDTA

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ملخص

من الثابت علميا أنه بإضافة الصورة الحامضية للمركب المخلبى إيثيلين داي أمين تترا أسيتك أسيد والمعروف تجاريا بأسم الفرسين أو السترايلون (ب) أو EDTA ، للأراضى القلوية التى تحتوى على نسب ولو قليلة من كربونات الكالسيوم فإن المركب الكالسيومى للمادة المخلبية هو الذى يسود فى جميع درجات الحموضة (pH) متفوقا على صور المركب الأخرى مع المغنسيوم والصوديوم. وبإضافة هذا المركب المخلبى فى صورته الحامضية H_4EDTA فإنه يسلك سلوك الأحماض القوية، وبالتالي يتفاعل مع كربونات الكالسيوم الموجودة فى التربة منتجا ثلاثة مولات من الكالسيوم الذائب لكل مول من المركب المخلبى. تلتى هذه الكمية من الكالسيوم تكون ميسرة للتبادل مع الصوديوم على مركب التبادل والإحلال محلها، بينما التلت الباقي سوف يتواجد على صورة المركب الكالسيومى للمادة المخلبية.

اختبرت هذه النظرية معمليا فى تجربة أعمدة بلاستيكية مخشنة تحتوى على 2 كيلو جرام من التربة القلوية فى ثلاث مكررات حيث أضيفت المادة المخلبية على صورة بودرة وخلطت مع التربة القلوية بمعدل مرة ونصف ومرتين مثل ملليمكافئات كمية الصوديوم المتبادل . أتبع نظام الغسيل المتقطع بمعدل أربعة أضعاف السعة الحقلية للتربة كل 15 يوما باستخدام الماء المقطر. وكانت النتائج المتحصل عليها مشجعة جدا حيث ثبت أن الصورة الحامضية للمركب المخلبى EDTA ذات فعالية كبيرة وسريعة جدا فى إستصلاح الأرض القلوية عند استخدامه كمصلح، حيث انخفضت نسبة الصوديوم المتبادل الى 5 % فقط بدلا من 25.3% فى التربة الأصلية خلال ثلاثين يوما فقط مع تحسن كامل لجميع الخواص الطبيعية والكيميائية للتربة فى كلتا المعاملتين بينما لم يحدث أى تحسن ملحوظ مع تجربة المقارنة بدون إضافة المركب المخلبى. وعلى الرغم من ارتفاع أسعار المركب المخلبى EDTA حيث يصل السعر التجارى للطن السائب منها

20.000 جنية مصرى وبالتالي يكون سعر الكيلوجرام 20جنيها، فإن تكاليف استصلاح للقدان الذى يحتوى على مائة شجرة أو مائة بقعة قلوية مساحة البقعة الواحدة متر مربع وبعمق 20 سم، لم تتجاوز خمسة الى ثمانية آلاف جنيها مصريا وهى تكاليف ليست بالمرتفعة إذا علمنا أن التكاليف المقدرة لإستصلاح القدان فى زمام أراضى ترعة السلام تبلغ 20 ألف جنية ، بينما تصل الى 30.000 فى أراضى جنوب الوادى. ويمكن أن يقتصر استخدام هذه المادة المخيلية فى الإصلاح على الحالات التى تتطلب تدخلا سريعا للحصول على نتائج سريعة دون تأخير. مثال ذلك حدوث قلوية فى منطقة الجذور لأشجار الفاكهة المثمرة والتى تحدث بكثرة خاصة مع أشجار المانجو والموايح المزروعة فى الأراضى الرسوبية السوداء والتى تروى بنوعية من المياه غنية فى البيكربونات (مياه نهر النيل) أو غنية فى الصوديوم (مياه الآبار ومياه الصرف الصحى والصناعى والصرف الزراعى). وتكون هذه الطريقة فعالة أيضا فى معالجة البقع القلوية ذات المساحات المحدودة خاصة المتكونة بجوار قنوات الري أو فى المناطق الضعيفة الصرف والتى تكون على شكل بقع قلوية قبل امتدادها الى باقى أجزاء الحقل. وتعتبر مادة H_4EDTA هى الحامض القوى الوحيد الممكن إضافته للتربة على صورة بودرة وليس سائلا مثل باقى الأحماض التى تستخدم فى الإصلاح وبذلك يمكن إضافته للطبقات تحت السطحية للترية ضمنا لحدوث استصلاح كامل لطبقات التربة السطحية وتحت السطحية بعكس الأحماض السائلة التى تضاف للطبقة السطحية فقط. ويمكن أيضا استغلال إمكانية إذابة هذه المادة المخيلية لكربونات الكالسيوم بضعها داخل خراطيم شبكات الري بالتنقيط لإذابة كربونات الكالسيوم المترسبة بداخلها وكذا المترسبة حول النقاطات وبالتالي نضمن عدم انسدادها وزيادة كفاءة شبكة الري. ويمكن أيضا دراسة إمكانية إضافتها للطبقة السطحية من الترب الجيرية لتحسين معدل إنبات البذور بها وذلك لإمكانية إذابتها للقشرة الكلسية التى تعوق الإنبات فى مثل هذه الأراضى.