J. Agric. Sci. Mansoura Univ., 34 (6): 7115 - 7127, 2009

SOIL WATER INFILTRATION AND SALT REDISTRIBUTION IN SOIL OF EL-TINA PLAIN AREA USING WATER OF VARIOUS SALINITY

El-Kharbotly, A. A.; S. A. Mohamed; A. Y. Genead and H. M. Abdou
Soils and Water Department, Faculty of Agriculture, Suez Canal University, Ismailia 41522, Egypt.
E-mail: ahmed_kh_38@yahoo.com

ABSTRACT

Soil infiltration is a key factor to water movement in soil and subsequently leaching of saline soils. A laboratory column experiment was conducted to examine the rate of water flow during the downward movement of various types of infiltrated water for El-Tina plain soil. Transparent perspex columns, 10.4 cm in diameter and 100 cm in length were used in this experiment. The treatments included the use of the River Nile water, and two water mixtures between the Suez Canal and the River Nile water of 1:15 and 1:1. The redistribution of salts after water infiltration was also assessed, and the changes in selected soil properties were evaluated. Results showed that the accumulated water intake (cm) were higher when infiltrating with the 1:1 water mixture as compared to both the River Nile and the 1:15 water mixture. The elapsed time required for the wet front to reach the bottom of the soil column with the 1:1 water mixture was only half of the time required using the River Nile water. Alkalinity build-up occurred during infiltration with the River Nile water, even in the presence of the gypsum requirements in the upper 15 cm soil layer. Salt redistribution showed that infiltration with low salinity water caused more accumulation of salt at the lower soil layers. pH values decreased as the salt content increased in the lower soil layers. Sodium was found to be the major cation, followed by magnesium and calcium. Magnesium concentrations were extremely higher in the lower soil layers as compared to the upper soil layers. Chloride was the dominant anion followed by sulfate.

Keywords: Infiltration, Wet front, Salt redistribution, El-Tina plain.

INTRODUCTION

In Egypt, land and water resources are very limited. The total area of salt affected soils in Egypt is approximately 35% of the agricultural lands, 1 Mha, GARE (1992). El-Mowellhey, (1998) reported that the reasons for the presence of such saline soils in Egypt are different and probably related to soil formation, Mediterranean sea-water intrusion, use of low quality irrigation water, and poor drainage. However, due to the large expansion in Egyptian population, agriculture progress should be made horizontally and vertically. One of the major horizontal agriculture expansions is the development of about 620,000 feddan in the El-Salam Canal agriculture national project. Most of this area lies east of the Suez Canal. El-Tina plain area, which is approximately 50,000 feddan, lies within this area. Its soils are rather highly saline and alkali, Bayoumy (1998) and Farag (1999). Consequently, leaching practices should be carefully evaluated and implemented in order to utilize this area in agriculture. Moreover, most of the soils in El-Tina plain are heavy in texture, a condition that will further complicate leaching processes.

Among the most important physical properties determining the efficiency of the leaching process is the rate of the downward water flow through the soil surface. The infiltration process is dynamic and varies with soil, vegetation, and climatic parameters. Initially, soil infiltration capacity is high and tends to decrease with time until it approaches a steady state infiltration rate, Scott (2000).

Soil infiltration depends on the EC of the applied water and soil ESP value. Increasing the EC of the applied water will increase soil infiltration. This is attributed to the prevention of colloids from free swelling by reducing the equality of cations and anions concentrations at their medial plane, as well as to the osmotic and hydrostatic pressure differences. As a result, the soil pores remain open and infiltration is encouraged, Kamel (1999). On the other hand, Bethune and Batey (2002) reported that soil exchangeable sodium has an adverse effect on infiltration process. In part, it is attributed to the effect of clay particles dispersion. Structure instability of sodic soil, and low electrolyte concentration of infiltrated water, lead to aggregates breakdown and dispersion of colloids producing low steady state infiltration rates, Levy and Mamedov (2002). Generally, runoff increases with low soil EC and high ESP values due to aggregates dispersion, and the degree of dispersion differs among clay minerals and soil types, Buckland et al. (2002).

The objectives of the current research were to: (1) determine the rate of water flow during the downward movement of various types of infiltrated water; (2) examine the salt redistribution process during water infiltration; and (3) evaluate the changes in selected soil properties after infiltration with water of various levels of salinity.

MATERIALS AND METHODS

The selected soil profile is a deep fine texture soil with water table ≥ 100 cm. Its soil unit covers about 27,918 feddan (i.e., about 67% of the total El-Tina plain area, 41,391 feddan). Samples were collected separately from each soil layer. The total depth of samples was 75 cm. The 75 cm soil profile consisted of 2 layers. All samples were air dried, crushed with a wooden hammer and sieved through a 2.0 mm sieve holes. All soil layers of the soil profile are extremely saline alkali as indicated by the electrical conductivities of the saturation paste extracts (ECe), and from the pH values of soil water suspension. Some properties of the investigated soil are listed in Table (1). According to the Soil Survey Staff, (2006), the soil profile is classified as *Typic Haplosalids*,

Three transparent perspex columns, 10.4 cm in diameter and 100 cm in length were used in this experiment. The end of the columns was covered with cheesecloth and the columns were placed on a steel frame. The soil layers were packed in the columns having similar depths as those in the field to a total depth of 75 cm. They consisted of 2 successive soil layers. The bulk densities of the two packed soil layers were 1.25 Mg m^{-3}. Incremental packing of the soil samples involved the use of five centimeters soil depths packed in each column. Each soil depth was packed using a powder funnel with a plastic extension tube in order to reach deep down in the column. The extension tube was gradually raised to minimize particles segregation as packing proceeded, Bellini *et al.* (1996). At the bottom of the column, a layer of 2 cm in thickness of pre-washed coarse sand, having particles diameter between (2.0 and 1.0 mm), was packed. A wooden rod with a studded surface was used during the successive packing of each 5 cm soil section to bring the soil bulk density to the desired value and to prevent partial particles layering within each soil section.

Table (1): Some properties of the investigated soil and the infiltrated waters.

	Soil layers		Water types		
parameters	**0-25**	**25-100**	**River Nile**	**1:15****	**1:1*****
Physical properties					
Soil particles distribution (%)					
Coarse Sand	0.66	0.12			
Fine Sand	24.94	14.29			
Silt	42.55	52.10			
Clay	31.85	33.49			
Texture class	Clay loam	Silty clay loam			
Chemical properties					
ECe (dSm^{-1})	114.5	144.9	0.336	5.02	32.1
Total dissolves salts TDS (g l^{-1})	197.8	263.0	0.215	3.00	23.900
pH	8.19*	8.18*	7.30	8.26	8.19
Gypsum %	2.79	0.31			
Calcium carbonate $CaCO_3$ %	0.58	0.44			
Organic matter %	1.26	1.79			
CEC (meq / 100 g soil)	32.83	37.62			
ESP %	54.05	64.69			
Soluble cations (meq l^{-1})					
Ca^{++}	24.1	16.3	0.8	1.5	6.1
Mg^{++}	220.5	180.9	0.7	8.2	39.8
K^{+}	8.8	10.0	0.6	1.4	8.1
Na^{+}	891.5	1241.8	1.2	39.1	267.0
Soluble anions (meq l^{-1})					
CO_3^{--}	N.D	N.D	N.D	N.D	N.D
HCO_3^{-}	2.1	1.8	1.3	2.1	2.3
Cl^{-}	731.4	1103.2	1.2	30.5	193.9
SO_4^{--}	411.5	344.0	0.8	17.5	124.8
SAR	80.6	125.1	1.4	17.7	55.7

N.D not detected. * Soil: water suspension (1:2.5)
**** 1:15 mixture of Suez Canal and River Nile Water.**
***** 1:1 mixture of Suez Canal and River Nile Water.**

Agricultural trade gypsum was added to one soil column. The rate of application was 50 ton ha^{-1} as suggested by Ashworth *et al.* (1999). Its amount was incorporated with the top 15 cm soil section before packing. The infiltrated water was obtained by diluting the Suez Canal water with River Nile water. The treatments included River Nile, a mixture of 1:15 (Suez Canal: River Nile water), and a mixture of 1:1. Table (1) shows the total salt concentration and some chemical properties of the infiltrated water. The gypsum amended soil column was treated by the River Nile water. Gypsum was not added to the other two soil columns. One soil column was treated by the 1:15 water mixture, and the last soil column was treated by the 1:1 water mixture. During infiltration, 10 cm head of the chosen type of water was allowed to drop 1 cm due to the downward water movement, then the 10 cm head was restored with the same type of added water. The depths of infiltrated water and their elapsed times as well as the advance of wet fronts were recorded. Downward water movement in the soil column that was treated by the River Nile water completely stopped after certain time. Therefore, few drops of Phenol-Phethalin indicator (Ph.Ph) were added to the water head, Tanji (1990), and the pink color formed indicated that alkalinity was building. Consequently, 1.4 ml of 1N HNO_3 was applied to the water head until its pink color disappeared. Afterwards, water movement was regained and the infiltration test continued. The application of acid was made when the wetting front reached 23.1 cm after 20.2 hrs. Additional two applications of 1.4 ml of 1N HNO_3 were added when the depth of wet fronts reached 36.0 and 56.5 cm at 88.75 and 573.3 hrs, respectively.

When the wet front reached the end of the soil column, the head of water was immediately removed and the soil was quickly dissected into 10 cm sections. All soil sections were analyzed for EC, pH, major cations and anions concentrations, and salt and water contents.

RESULTS AND DISCUSSION

The infiltration tests were terminated just when the wetting front reached the bottom of each soil column. The relationship between the elapsed time (hr) of the River Nile infiltrating water and its accumulated intake (cm) is given in Table (2) and presented in Figure (1). The data reveal that, as time progressed, the accumulated water intake increased. The derived formula for such function is as follows:

$$D = 3.429T^{0.309} \quad R^2 = 0.9966 \quad (1)$$

Where D is the accumulated water intake (cm) and T is the elapsed times (hr).

Water intake rates (I) were calculated from the obtained data for the accumulated intake (cm) divided by the elapsed times (hr). The results are presented in Figure (2). The derived formula for this function is as follows:

$$I = 3.429T^{-0.691} \quad R^2 = 0.9993 \quad (2)$$

Where *I* is the water intake rate ($cmhr^{-1}$) and T is the elapsed time (hr).

These forms of equations align with those reported by Israelsen and Hansen (1962), Kirkham and Powers (1971), and Scott (2000). It should be noted that, if the intake rate (I) was obtained from the derivative of the accumulated water intake (D) the formula for (I) according to Israelsen and Hansen (1962) should be :

$$I = 1.0596T^{-0.691} \quad (3)$$

Where I is the water intake rate ($cmhr^{-1}$) and T is the elapsed time (hr).

Table (2): River Nile infiltrating water intake rates and advancing wet front through El-Tina plain 75 cm soil treated with gypsum in the upper 15 cm depth.

Elapsed Time (hr)	Accumulated Water Intake (cm)	Intake Rate (cm hr^{-1})	Depth to wet Front (cm)	Rate of Advancing Wet Front (cm hr^{-1})
0.020	1.0	50.7614	1.6	81.2183
0.250	2.0	8.0000	4.5	18.0000
0.817	3.0	3.6733	7.3	8.9384
1.717	4.0	2.3301	10.1	5.8834
3.567	5.0	1.4017	13.2	3.7006
5.967	6.0	1.0055	15.7	2.6311
8.583	7.0	0.8156	17.6	2.0506
13.867	8.0	0.5769	20.2	1.4567
20.167	9.0	0.4463	23.1	1.1454
27.500	10.0	0.3636	25.6	0.9309
41.167	11.6	0.2818	28.8	0.6996
53.000	12.6	0.2377	31.0	0.5849
66.667	13.6	0.2040	33.0	0.4950
88.750	14.8	0.1668	36.0	0.4056
115.000	15.8	0.1374	38.9	0.3383
144.000	16.8	0.1167	41.0	0.2847
180.867	17.8	0.0984	43.4	0.2400
243.000	18.8	0.0774	45.7	0.1881
329.033	19.9	0.0605	48.4	0.1471
387.667	20.9	0.0539	50.5	0.1303
457.417	22.4	0.0490	53.8	0.1176
573.267	23.6	0.0412	56.5	0.0986
664.750	24.6	0.0370	58.7	0.0883
768.750	25.9	0.0337	62.1	0.0808
908.750	26.9	0.0296	65.0	0.0715
1035.000	28.2	0.0272	68.0	0.0657
1176.250	29.2	0.0248	70.7	0.0601
1387.833	30.5	0.0220	73.7	0.0531
1460.000	31.2	0.0214	75.0	0.0514

It is clearly shown from Equations (2) and (3) that the rate of change, slope of the lines, between the calculated I and derived I were constant. Moreover, the difference between the formulae coefficients was small.

The obtained trends for the intake rate ($cmhr^{-1}$) and the rate of advancing wet front ($cmhr^{-1}$) almost coincide with each other, Table (2). Moreover, the rate of advancing wet front always decreased due to the proportionality between the hydraulic gradient (H) and soil depth (L) according to Darcy's law as stated by Richards (1954). It is interestingly noticed that, there are three zones for the obtained values of the advancing wet front. The upper zone dealt with soil depth treated with gypsum, 15cm, where the obtained rates sharply decreased from 81.22 to 2.63 $cmhr^{-1}$ and the depth to the wet front reached 15.7 cm. The second zone dealt with the advancing wet front for the remaining top soil layers, from 15 to 25 cm. It decreased from 2.05 to 0.93 $cmhr^{-1}$, and the depth of wet front reached 25.6 cm. The third zone for the calculated advancing wet front of the silt clay loam soil layer, from 25 to 75 cm, decreased from 0.7 to 0.05 $cmhr^{-1}$, and the wet front reached the bottom of the soil column. These results indicate that the decrease in the rate of advancing wet front for the lower soil layer sharply diminished and became almost constant as compared to its decrease in the upper soil layer.

The salinity levels of infiltrating water mixtures used in this experiment were 32.1 and 5.02 dSm^{-1}, for a mixing ratio between the Suez Canal and River Nile water of 1:1 and 1:15, respectively, Table (1). The relationship between the elapsed time of the 1:15 infiltrating water mixture and its accumulated water intake for the fine texture soil is given in Table (3), and presented in Figure (1). The results show similar trends as that obtained for the use of the River Nile water, however, the accumulated intake was in general lower than that obtained with the River Nile water. The derived formula representing the relationship is as follows:

Table (3): Mixed infiltrating water (1: 15 mixture of Suez Canal and River Nile water) intake rates and its advancing wet front through El-Tina plain 75 cm soil depth.

Elapsed Time (hr)	Accumulated Water Intake (cm)	Intake Rate (cm hr^{-1})	Depth to wet Front (cm)	Rate of Advancing Wet Front (cm hr^{-1})
0.086	1.0	11.6550	2.4	27.9720
0.533	2.0	3.7502	5.4	10.1256
1.733	3.0	1.7308	8.2	4.7309
4.050	4.0	0.9877	10.9	2.6914
7.933	5.0	0.6303	13.6	1.7143
12.267	5.8	0.4728	15.8	1.2880
22.183	7.1	0.3201	19.2	0.8655
32.767	8.1	0.2472	22.1	0.6745
46.350	9.3	0.2006	25.5	0.5502
59.433	10.2	0.1716	27.6	0.4644
79.767	11.3	0.1417	30.0	0.3761
102.267	12.3	0.1203	32.2	0.3149
150.933	13.8	0.0914	36.0	0.2385
226.683	15.6	0.0688	40.5	0.1787
309.433	17.1	0.0553	44.8	0.1448
386.933	18.4	0.0476	48.1	0.1243
467.017	19.4	0.0415	50.6	0.1083
539.267	20.2	0.0375	53.1	0.0985
634.350	21.2	0.0334	56.5	0.0891
734.517	22.3	0.0304	60.0	0.0817
851.183	23.3	0.0274	62.5	0.0734
970.183	24.4	0.0251	66.5	0.0685
1113.017	25.5	0.0229	69.7	0.0626
1226.267	26.6	0.0217	72.4	0.0590
1345.017	27.6	0.0205	75.0	0.0558

$$D = 2.4734T^{0.3364} \qquad R^2 = 0.999 \quad (4)$$

Where D is the accumulated water intake (cm) and T is the elapsed times in (hr). The obtained trends for 1:15 infiltrating water mixture intake rate and the rate of advancing wet front were approximately similar to those obtained for River Nile infiltrating water. However, the magnitudes of the initial values for both variables were higher upon the use of River Nile water than for the use of 1:15 infiltrating water mixture. Nevertheless, their final values were almost similar to each other. The relationship between the 1:15 infiltrating water mixture intake rate and its elapsed time is presented in Figure (2). The derived formula is as follows:

$$I = 2.4734T^{-0.6633} \quad R^2 = 0.9997 \quad (5)$$

Where *I* is the intake rate ($cmhr^{-1}$) and T is the elapsed time (hr).

The obtained results for the use of 1:1 mixture infiltrating water with the fine texture soil are given in Table (4). The relationship between the elapsed time of the infiltrating water and accumulated water intake clearly shows higher accumulated intake as compared to infiltration using both the River Nile water and 1:1 water mixture, Figure (1). On the other hand, the time required to wet the entire 75 cm soil depth was 1460 hrs upon the use of River Nile water, while it only required 820.4 hrs upon the use of the 1:1 water mixture. Hence, using such saline water in infiltration decreased the time of wetting for the 75 cm soil column into half that is required when infiltrating using the River Nile water. The relationship between the elapsed time of the 1:1 water mixture and its accumulated water intake is presented in Figure (1). The derived formula for the relationship is as follows:

$$D = 3.0296T^{0.3367} \quad R^2 = 0.9981 \quad (6)$$

Where D is the accumulated water intake (cm) and T is the elapsed times in (hr).

The trends for the intake rate and rate of advancing wet front calculated after the use of the 1:1 water mixture were similar to those calculated for the use of River Nile water. The magnitudes of the initial rates were low for the use of 1:1 mixed water compared to the use of River Nile water, Figure (2). Nevertheless, their final values were lower for the use of River Nile water. The relationship between the elapsed time of the 1:1 water mixture and its intake rate is presented in Figure (2), and the derived formula is as follows:

$$I = 3.0296T^{-0.6633} \quad R^2 = 0.9995 \quad (7)$$

Where I is the intake rate ($cmhr^{-1}$) and T is the elapsed time (hr).

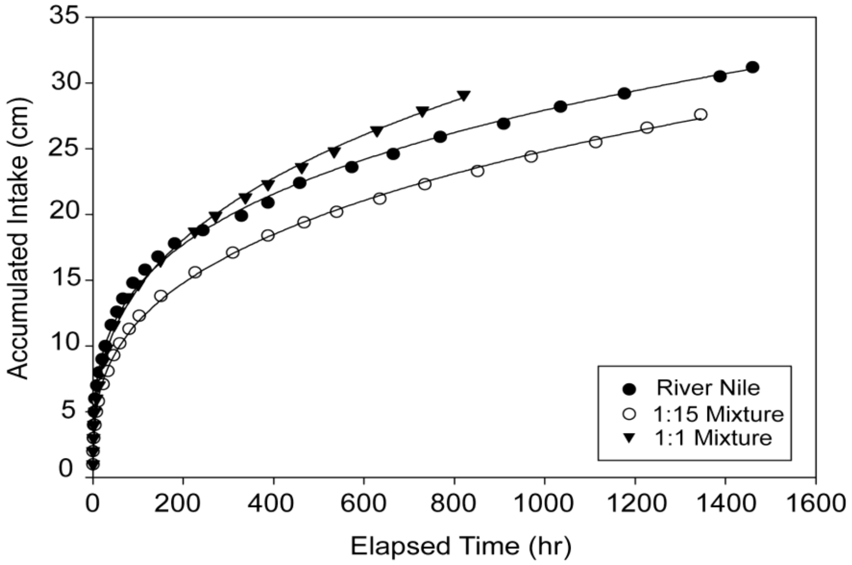

Figure (1): The relationship between the elapsed times of the infiltrated water and their accumulated intake for El-Tina plain soil.

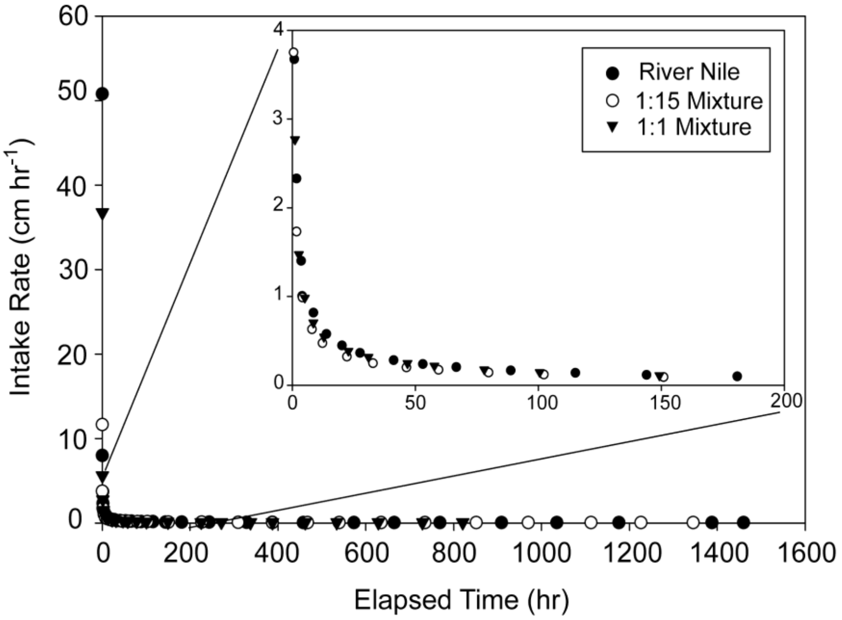

Figure (2): The relationship between the elapsed times of the infiltrated water and the intake rate for El-Tina plain soil.

Table (4): Mixed infiltrating water (1: 1 mixture of Suez Canal and River Nile water) intake rate and advancing wet front through El-Tina plain 75 cm soil depth.

Elapsed Time (hr)	Accumulated Water Intake (cm)	Intake Rate (cm hr^{-1})	Depth to wet Front (cm)	Rate of Advancing Wet Front (cm hr^{-1})
0.027	1.0	36.7350	1.5	55.1025
0.358	2.0	5.5814	4.8	13.3954
1.083	3.0	2.7692	7.0	6.4616
2.717	4.0	1.4724	10.2	3.7546
5.083	5.0	0.9836	12.9	2.5377
8.517	6.0	0.7045	15.4	1.8082
12.867	7.0	0.5440	17.7	1.3756
22.817	8.8	0.3857	22.0	0.9642
30.900	9.8	0.3172	24.6	0.7961
46.850	11.6	0.2476	28.8	0.6147
57.733	12.6	0.2182	31.5	0.5456
78.067	13.7	0.1755	34.2	0.4381
100.567	14.7	0.1462	37.0	0.3679
149.233	16.5	0.1106	41.9	0.2808
224.983	18.7	0.0831	47.8	0.2125
271.233	19.9	0.0734	50.5	0.1862
336.983	21.3	0.0632	54.8	0.1626
387.733	22.3	0.0575	57.0	0.1470
461.983	23.6	0.0511	60.5	0.1310
534.150	24.8	0.0464	63.1	0.1181
628.233	26.4	0.0420	67.8	0.1079
729.400	27.9	0.0383	71.8	0.0984
820.400	29.1	0.0355	75.0	0.0914

Initial soil porosities were determined for the two soil layers present in the field, by means of determining moisture content after saturating specific volume of soil having 1.25 Mgm^{-3} bulk densities. The values varied among the two soil layers, and the calculated weighted average total soil porosity for the entire 75 cm soil column was 58.844 %. Therefore, the corresponding total pore volume was 3748.92 cm^3. On the other hand, the total depth of applied infiltrating water was 31.2, 27.6, and 29.1 cm for River Nile, the 1:15, and the 1:1 water mixtures, respectively. The depth of the added water resulted in a total water volumes of 2650.32, 2344.51, 2471.93 cm^3, respectively. These values prove that drainage did not occur, and the soils were not completely saturated. These results are supported by the soil moisture contents values, which showed gradual decrease with increasing soil depth, Tables (5 to 7). The initial distribution of salt contents for the 0 to 15 and 15 to 25 soil sections were 200.906 and 133.937g, respectively. Moreover, salt content for every 10 cm soil depth in the remaining 25 to 75cm soil section was 187.745g. Consequently, the soil column total salt content was 1273.568g.

The data presented in Tables (5 to 7) show the redistribution of salt contents throughout the soil columns at the end of the infiltration process.

Kharbotly, A. A.

5-6-7

Evidently, the EC values and the salt contents tremendously increased as soil depth increased. Such increase was prominent as the salinity of infiltrated water was low (i.e. infiltrating with the River Nile water). Nevertheless, the total salt content for the various soil columns using the previously mentioned types of water were 1273.71, 1280.79, and 1332.24g, after infiltrating with the River Nile water, the 1:15 water mixture, and the 1:1 water mixture, respectively. Consequently, the amounts of salt added after infiltration with the various types of water were 0.142, 7.222, and 58.669g, respectively. The increased amount in the salt content was loaded with the applied infiltrating water.

In general, pH values decreased as the salt content increased in the lower soil layers. This was evident by pH values less than 8.5 at 65, 45, and 45 cm soil depth, after infiltrating with the River Nile water, the 1:15 water mixture, and the 1:1 water mixture, respectively. Nevertheless, the obtained data of the pH values after infiltration generally indicate that all soil layers could be classified as saline-alkali. In this respect, Richards (1954) stated that for saline-alkali soils, under conditions of excess salts, the soil pH are seldom higher than 8.50. However, he also reported that when the soil solution (or infiltrated water) is having SAR value higher than 11.0, and EC value are higher than 2.25 dSm^{-1}, then alkalinity hazard will be very high. Ion concentrations were determined from the saturation past extracts, and sodium was found to be the major cation, followed by magnesium and calcium. Magnesium concentrations were extremely higher in the lower soil layers as compared to the upper soil layers, Tables (5 to 7). Chloride was the dominant anion followed by sulfate. Apparently, the trend for SAR values somewhat coincide with sodium ion concentrations. An exception was found for the lowest soil section, which exhibited low SAR value due to the very high magnesium concentration.

Summary and Conclusions

The current experiment showed that infiltrating the saline soils in El-Tina plain with low salinity water (i.e. River Nile) required much longer time for the advancing wet front to reach the bottom of soil columns, and increased the risk for alkalinity build-up, with its subsequent effect on the slow downward water movement. The accumulation of salts at lower layers upon water infiltration greatly decreased with both the 1:15 and 1:1 water mixtures as compared to the River Nile water. This could help to obtain a more uniform leaching of excessive salts and enhance the long-term leaching efficiency. El-Salam canal water with its moderate salinity levels could provide a good source of water to leach the high saline soils in El-Tina plain area, assuming soil alkalinity will be monitored and controlled using soil amendments.

REFERENCES

Ashworth, J.; D. Keyes and J. M. Crepin (1999). A comparison of methods for gypsum requirement of brine-contaminated soils. Can. J. Soil Sci. 79: 449-455.

Bayoumy, M.R. (1998). Soil resources and their agricultural potentiality in Sinai. In project of development of Sinai: nitrogen fixing leucaena trees, Cairo Univ. Publications ISBN.

Bellini, G.; M. E. Sumner; D. E. Radcliffe and N. P. Qafoku (1996). Anion transport through columns of highly weathered acid soil: Adsorption and retardation. Soil Sci. Soc. Am. J. 60: 132-137.

Bethune, M.G. and T. J. Batey (2002). Impact on soil hydraulic properties resulting from irrigating sline-sodic soils with low salinity water. Aus. J. Exp. Agri. (3): 273-279.

Buckland, G. D.; D. R. Bennett; D. E. Mikalson; C. Chang and E. de. Jong (2002). Soil salinization and sodification from alternate irrigation with saline-sodic water and simulated rain. Canadian J. of Soil Sci. 82(3): 297-309.

El-Mowellhey N. (1998). "Opening Ceremony". Proceeding of the international symposium on sustainable management of salt affected soils in the arid ecosystem and FAO- workshop on integrated management of sustainable use of salt affected soils, Cairo, Egypt, 21-26 September, 1997. pp1.

Farag, F.M. (1999). Soils of El-Salam canal basin and their agricultural suitability. Annal of Agric. Sc. Moshtohor, 37 (2):1435-1553.

Government of Arab Republic of Egypt (GARE) (1992). Environmental action plan, Egypt. pp. 5-29.

Israelsen, O.W. and V.E. Hansen (1962). Irrigation Principles and Practices. John Wiley and Sons Inc., New York and London.

Kamel, M. R. (1999). Studies of salinity effects on some soil properties and plant growth. MSc. Thesis, Fac. Agric. Cairo Univ. Egypt.

Kirkham, D. and W.L. Powers (1971). Advanced Soil Physics. Wiley Interscience. A division of John Wiley and Sons. Inc., New York.

Levy, G. and A. I. Mamedov (2002). High-energy-moisture- characteristic aggregate stability as a predictor for seal formation. Soil Sci. Soci. Am. J. 66(5): 1603-1609.

Richards, L. A. (ed) (1954). Diagnosis and Improvement of Saline and Alkali Soils. U.S. Dep. Agric. Handbook No. 60 U.S. Gov. Print of Washington DC.

Scott, H. D. (2000). Soil Physics, Agricultural and environmental application. Iowa state university press/Ames.

Soil survey staff (2006). Key to Soil Taxonomy. United states department of agriculture. Tenth edition.

Tanji, K. K. (ed) (1990). Agriculture Salinity Assessment and Management. ASCE Manuals and Reports on Engineering Practice No. 71. American Society of Civil Engineers, New York, N. Y. 10017.

تأثر رشح التربة للماء وإعادة توزيع الأملاح في أراضي سهل الطينة باستخدام مياه مختلفة الملوحة.

احمد عبد العليم عبد الطيف الخربوطلي ، سمير علي محمد ، علي يوسف جنيد و هشام محمد عبده
قسم الأراضي و المياه- كلية الزراعة - جامعة قناة السويس

تم دراسة معدلات رشح التربة للماء و إعادة توزيع أملاح التربة بعد عملية الرشح. وقد استخدم لهذه الدراسة أعمده شفافة من زجاج البرسبكس طولها ١ متر وقطرها ١٠,٤ سنتيمتر. تم تعبئة التربة في هذه الأعمدة حتى عمق ٧٥ سنتيمتر بنفس التتابع الطبقي الموجود في الحقل. كانت الكثافة الظاهرية المستخدمة في التعبئة هي ١,٢٥ طن/م^{٣} لطبقتي التربة. تم تخصيص ثلاث أعمده. وقد تم إضافة الجبس الزراعي للعمود الأول بمعدل ٥٠ طن للهكتار. تم خلط الجبس في طبقة الـ ١٥ سنتيمتر العليا أثناء التعبئة. وضع ضاغط من ماء النيل بسمك ١٠ سنتيمترات علي سطح هذا العمود. الأعمدة الأخرى وغير المعاملة بالجبس تم وضع الضاغط المائي لها بنفس العمق ولكن من مخلوط من ماء قناة السويس وماء النيل بنسبة ١:١ لأحدي العمودين و الأخر من مخلوط من ماء قناة السويس وماء النيل بنسبة ١٥:١. كان يسمح للضاغط المائي بالانخفاض ١ سنتيمتر ثم يعاد إلي عمقه الأصل بنفس نوع الماء المستخدم مرة أخري. تم تسجيل الزمن المنقضي و عمق الماء المترشح إلي التربة وعمق جبهة الابتلال. تم إنهاء عملية الرشح مباشرة بعد وصول جبهة الابتلال إلي قاع عمود التربة. حيث تم تقسيم العمود إلي أجزاء واستخدمت التربة التي بها في تقدير المحتوي الرطوبي و المحتوي الملحي و التركيز الأيوني للمحلول الأرضي ورقم الحموضة للتربة. ظهر من النتائج أن بزيادة ملوحة الماء المترشح يزداد معدل الرشح كما يقل الزمن اللازم لوصول جبهة الابتلال إلي قاع العمود. تم تتبع جبهة البلل بوضوح كما تم الحصول علي نظام متجانس من انخفاض المحتوي الرطوبي مع العمق. ظهر من نتائج تقدير المحتوي الملحي لأجزاء التربة بعد انتهاء عملية الرشح حدوث عملية غسيل شديد للأملاح من الطبقات السطحية. تراكمت هذه الملاح في الأجزاء السفلية من التربة و التي أظهرت اعلي محتويات ملحية.

Table (5): El-Tina plain soil properties after infiltration with River Nile Water.

Soil depth (cm)	EC_e (dSm^{-1})	pH	Ɵm	Salt content, g /layer	Ion Concentration (meq l^{-1})							SAR
					Ca^{++}	Mg^{++}	Na^+	K^+	HCO_3^- *	Cl^-	SO_4^{--}	
0-15	4.97	8.84	0.6250	9.175	18.1	6.2	23.3	2.1	2.1	7.2	40.4	4.1
15-25	9.25	9.04	0.5114	9.431	19.2	19.2	52.7	1.5	2.0	53.8	36.7	126.7
25-35	9.87	9.22	0.4422	11.027	8.3	8.9	79.6	1.8	2.2	23.8	72.7	190.3
35-45	37.10	9.20	0.4156	37.245	8.2	15.1	344.2	3.5	1.7	120.8	248.4	194.3
45-55	>200	9.12	0.2600	344.594	13.3	126.1	3045.2	21.7	2.4	2751.8	452.0	191.5
55-65	>200	8.62	0.2500	361.790	12.8	551.4	2782.2	19.9	2.4	2559.1	804.7	632.1
65-75	>200	8.39	0.2227	500.445	6.0	1167.7	3298.5	26.5	3.3	3614.5	880.9	326.7

*** CO_3^{--} Not detected**

Table (6): El-Tina plain soil properties after infiltration with 1:15 Suez Canal and River Nile Water mixture.

Soil depth (cm)	EC_e (dSm^{-1})	pH	Ɵm	Salt content, g /layer	Ion Concentration(meq l^{-1})							SAR
					Ca^{++}	Mg^{++}	Na^+	K^+	HCO_3^- *	Cl^-	SO_4^{--}	
0-15	6.95	8.73	0.6023	7.240	13.7	12.7	38.8	4.2	2.2	26.4	40.8	10.7
15-25	8.50	8.91	0.4306	5.953	11.2	8.0	62.1	3.7	2.3	26.7	56.0	20.0
25-35	48.80	8.99	0.4276	74.115	15.9	14.9	447.0	10.2	3.0	258.3	226.7	113.9
35-45	>200	8.52	0.2903	261.12	12.6	249.8	3524.6	61.8	1.4	3676.1	171.2	307.7
45-55	>200	8.33	0.2600	268.243	16.7	66.1	3823.8	47.1	1.6	3939.4	12.7	594.1
55-65	>200	8.18	0.2492	293.347	4.4	1154.3	3096.4	68.6	1.8	4186.7	135.2	128.6
65-75	>200	8.11	0.1876	370.775	5.1	2319.9	3056.2	83.7	5.1	4865.2	594.7	89.6

*** CO_3^{--} Not detected**

Table (7): El-Tina plain fine texture soil properties after infiltration with 1:1 Suez Canal and River Nile Water mixture.

Soil depth (cm)	EC_e (dSm^{-1})	pH	Ɵm	Salt content, g /layer	Ion Concentration (meq l^{-1})							SAR
					Ca^{++}	Mg^{++}	Na^+	K^+	HCO_3^- *	Cl^-	SO_4^{--}	
0-15	32.1	8.60	0.6322	27.091	31.1	42.8	238.9	8.1	3.9	194.7	122.4	39.3
15-25	33	9.05	0.4302	18.288	32.4	20.7	267.8	9.1	3.1	202.9	124.0	52.0
25-35	180.9	9.10	0.4005	151.366	29.7	24.7	1735.4	19.3	2.4	1599.9	206.7	332.9
35-45	>200	8.73	0.3826	254.775	7.0	80.1	3847.5	62.9	1.6	3640.4	355.5	582.9
45-55	>200	8.48	0.2579	258.758	17.5	191.2	3778.5	72.8	2.7	3610.3	447.1	369.9
55-65	>200	8.30	0.2572	267.84	6.9	1065.3	3064.6	65.7	2.6	3821.4	378.5	132.4
65-75	>200	8.25	0.1916	354.119	8.9	2471.4	2995.9	80.2	6.4	5045.4	504.4	85.1

*** CO_3^{--} Not detected**