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28 November - 2 December 1993
Amman - Jordan

USE OF SALINE WATER FOR IRRIGATION

Prepared by

THE ARAB CENTRE FOR THE STUDIES OF ARID ZONES
AND DRY LANDS (ACSAD)

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Organized by the
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USE OF SALINE WATER FOR IRRIGATION

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ABSTRACT :

This study discusses the use of saline water for the irrigation of Alfalfa (Medicago Sativa) , Barely (Hordeum Vulgare ACSAD 176) . and Cotton (Gossypium Horstum) and growth performances of these crops in relation to level of salts and leaching fractions .

The high saline water comes from agricultural drainage water and mixed waters resulting from mixing agricultural drainage water with Euphrates river water coming from irrigation cannals . The ratios are as follows : 100 - 0 , 50 - 50 , 30 - 70 , 20 - 80 , 0 - 100 of Euphrates and agricultural drainage water respectively .

This study shows the possibility of using high saline water for irrigation of Alfalfa , Barley and Cotton at economic visibility provided that sound land management is practiced .

The study also discusses how to halt the increase of soil salinity in agricultural land irrigated with such water through applying certain amount of salt leaching water to that required by the crops . The study explains how to predict (through computer programmes) , the soil salinity increases when water of different salt levels is used for irrigation .

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INTRODUCTION :

Irrigated agriculture is dependent on an adequate water supply of usable quality . Water quality concerns have been often neglected because good quality water supplies have been plentiful and readily available . This situation is now changing in many areas in the world . Intensive use of nearly all good quality supplies means that new irrigation projects and old projects seeking new or supplemental supplies must rely on lower quality and less desirable sources . To avoid problems when using these poor quality water supplies , there must be sound planning to ensure that quality of water available is put to the best use .

In several circumstances especially during the horizontal agricultural expansion , the planners usually tend to use good quality water to irrigate development projects , while neglecting the use of low quality water , and even they pay no attention at all to such water . In order to utilize good quality water for longer period without exposing it to any kind of deterioration . It is important to mix it with high saline water . Intensive use of good quality water leads to decrease of the amount of this water and deterioration of its quality .

Most of experiences in using water of high salinity has been gained from experience in using water, and detailed study of problems that develop following use . (Abdelgawad etal , 1981) .

This saline water is being used in several places in the world (FAO , 1990) but its use requires careful management to prevent or cope with the potential problems related to the water . Often this water is the only supply available and while crop yield may not be at a maximum , they continue to provide economic return . Different research papers discuss the use of saline and high saline water in irrigation . Examples of these are ; Hoffman - etal 1983 a , Mass and Hoffman 1983 . ACSAD 1986 , 1987 , Dutt. et al 1984 . Rhoades 1984 a , b , c , 1986 , 1990 , Abdelgawad 1980 -1993 . Hazen Sawyer 1979 . FAO , 1990 , Meiri 1990 , Pasternak 1986 , Hamdy 1990 . Penkov 1990 . Szabolcs 1990 - 1992 .

There is a growing demand for fresh water for domestic , agricultural and industrial purposes and this increases the need for the use of saline water for agriculture in the Arab world , noting that the available agricultural lands which can be cultivated in the Arab world constitute 132 million hectars of which 43 millions are being cultivated (Juma , 1991) . The land under cultivation constitutes 32.58 % of the available cultivated .

The low percentage of actual cultivated land in the Arab world is the main result of the shortage of water quantity and decline in water quality .

ACSAD has initiated 8 years ago a programme for using saline water and salt affected soils for agriculture . The studies were carried out in both Qatar and Tunisia . The potential use of both saline water and salt affected soils was discussed in several ACSAD papers 1986 , 1987 , 1990 , 1991 .

The above studies focused on the use of water with salinity levels up to 2000 meq/litter 3.13 ds/m .

This research paper discusses :

(1) - The use of saline water for irrigation , which obtained from agricultural drainage water and water obtained from different mixing ratios of agriculture drainage water and good quality water . Salt levels range between (992-8890 meq/litter) with EC values 1.55-13.89 ds/m in this study .

(2) - The yields of Alfalfa (Medciago Sativa) , Barley (Hordeum Vulgare and Cotton (Gossyplum , Hirsutum) . irrigated with the above mentioned irrigation water using different leaching fractions are presented here .

(3) - The study includes also a prediction (through the use of computer) of soil salinities increases when water of different salt levels is used for irrigation , comparing it with laboratory analyses and field measurements .

Materials And Methods :

This research was carried out during 1991/1992 and 1992/1993 at ACSAD experimental station in Der El Zoor - Syria .

The water used for irrigation is from agricultural drainage water with an average ECd.w. 13.86 ds/m , (D) , mixed with the Euphrates river water from irrigation cannal (EC. RF = 1.55) . In this paper D stands for agricultural drainage water and E stands for Euphrates river water .

The ratios of mixing used for this study are:
[100 (E) -0 (D)] , [70 - 30] , [50 - 50] , [30 - 70] , [20 - 80] , [0 - 100] . The waters were mixed at different amounts in water tanks from both sources . Those mixed ratios are used to irrigate Alfalfa (Medicago Sativa) , Barley (Hordeum volgare , ACSAD 176) , and Cotton (Gossypium Hirstum) , (Der El-Zoor 22) .

The amounts of water added were based on ACSAD previous studies on crop water requirements of studied crops added to it certain amount of water to leach salts equivalent to 0 , 15 , 30 % leaching fractions . These amounts are from water mixtures .

The design of the experiments was randomized block with six replicates and plot size of 55 m2 .

The experiments were irrigated with flood irrigation system. The soils of these experiments are classified under U.S. Soil Taxonomy as Torrifluvents loamy in texture with soil PH 7.5 and ECe value of 2 ds/m , contains 15 - 25 % CaCo3 .

Plzeometers were placed in each experiment to monitor water table depth and ECs.w , every 48 hours after irrigation and at the end of one week from irrigation day .

Soil samples were collected periodically during growing seasons from barley and Cotton fields and three times a year from alfalfa fields . The following analyses were carried out on these soil samples (ECe , PH , Soluble cations and anions , CaCo3 % , CaSo4 2H2O % . Available Nitrogen , Phosphorous and Potassium . The methods of analyses were carried out according to soil chemical analyses edited by Page 1982 and ACSAD methods of soil analyses 1987 .

Yields of barley and alfalfa were presented in this paper on oven dry bases and those of Cotton were on air dry bases .

The prediction of soil salinity increases when water of different salt levels are used for irrigation carried out by Watsuit model , Rhoades 1990 , which are modified by the author 1993 .

All data presented in this paper is the mean of 12 replicates of each treatments for the growing seasons 1991/1992 and 1992/1993 .

Results and Discussion :

The mean amounts of water added to Alfalfa crop for different leaching fractions (0 , 15 , 30 %) are shown in table 1 , 2 , 3 . The mean ECs.w used for irrigation during growing seasons ranging from 1.55 to 13.2 ds/m.

Table (1) : the mean amount of water added in m^3/ha with leaching fraction zero % for Alfalfa :

Ratio of Mixing E - D	ECiw	m^3/ha E - D
100 - 0	1.55	32430 - 0
70 - 0	5.05	22701 - 9729
50 - 50	7.50	16215 - 162150
30 - 70	9.80	9729 - 22701
0 - 100		

As an example to show the amount of irrigation water from drainage water for 15 % leaching fraction is 57.49 % while from Euphrate river water is 42.51 % . Table (2) illustrates that :

Table (2) : Mean amounts of water added in m^3/ha with leaching fraction of 15 % for Alfalfa :

Ratio of mixing E - D	ECiw	m^3/ha E - D
100 - 0	1.55	37290 - 0
70 - 30	5.05	26103 - 11187
50 - 50	7.50	18645 - 18645
30 - 70	9.80	11187 - 26103
0 - 100	13.20	0 - 37290

For the 30 - 70 % of mixing ratios of Euphrates to agricultural drainage waters the amounts of water used is 19.6 % from Euphrates river water (ECiw 1.55) and 80.4 % from agricultural drainage water (ECdw 13.20).

The amounts of water for the leaching fraction 30 % is relatively very high amount , and this high amount is reflected on the reduction of yield due to leaching of soil nutrient out of the root zone .

Table (3) : Mean amount of water added in m^3/ha with leaching fraction of 30 % for ALfalfa :

E - D	ECiw	m^3/ha E - D
100 - 0	1.55	42105 - 0
70 - 30	3.05	29474 - 12631
50 - 50	7.50	21053 - 21052
30 - 70	9.80	12632 - 29474
0 - 100	13.2	0 - 42105

The high amount of water added and relatively high amount of drainage water used reflected also on an increase of salinity of soil water which caused some influence on the decrease of yield as shown on table (4) .

Table (4) : Yield of ALfalfa in Ton/ha for two years as a function of water mixing , salinity levels and leaching fraction :

Mixing ratio E - D	ECiw	Mean yield Ton/ha 0	15%	30%
100 - 0	1.55	26.2	28.75	27.00
70 - 30	5.05	23.20	24.13*	22.00
50 - 50	7.50	16.88	22.80**	18.50
30 - 70	9.80	14.30	16.20	11.40
0 - 100	13.20	5.00	5.58	3.80
Mean	-	17.24	19.5	16.54

Mean yield of six repayments for each year .

As shown in the table 4 , the mean of yield for three leaching fractions are 17.24 , 19.5 and 16.54 Tons/ha respectively for 0 , 15 , 30 % leaching fractions . As shown , the yield increases with leaching fraction then decreases . The data shows leaching fraction of 15 % has a significant effect upon increases of yield . There is a little decrease for 30 % leaching fraction yield treatments when compared with 0 % and 15 % leaching fractions . This is mainly due to leaching of soil nutrients and the increase of agricultural drainage water .

If we compare the yield of Alfalfa for 15 % leaching treatment and for 50 - 50 mixing ratios of Euphrates - drainage water we find the yield is 22.8 ton/ha which is higher than the zero and 30 % leaching fractions , as well as this yield is 87 % yield of fresh river water treatments. This yield is obtained by 57.49 % of agricultural drainage water used as mentioned before . In other statements we saved 57.49 % from fresh water . If we express this yield on the bases of water used with 15 % leaching fraction and 50 -50 mixing ratios , this yield is 79.3 % of the yield of 100 % fresh water treatment and 15 % leaching fraction . The amount of water used from fresh water is 49.7 % let us to say it is about only 50 % of the total water requirement applied from fresh water .

The mean amounts of water added to barely for the years 1991 and 1992 for the three leaching fractions are shown in the tables 5 , 6 and 7 .

Table (5) : Average amount of water added in m^3/ha for barely and its average ECiw during growing season for zero % leaching fraction :

E - D	ECiw	m^3/ha
100 - 0	1.60	3600 - 0
70 - 30	5.10	2520 - 1080
50 - 50	7.30	1800 - 1800
30 - 70	9.44	1080 - 2520
0 - 100	13.5	0 - 3600

As shown in table 5 there is slight difference from ECiw of the mixtures compared to the calculated values , however the data represented in this paper based on actual measurements of ECiw of the mixtures during each irrigation time . Table 6 shows the amount of water added to barley crop during irrigation season with 15 % leaching fraction .

Table (6) : Average amount of waters added in m^3/ha for barley with leaching fraction of 15 % :

E - D	ECiw	m^3/ha
100 - 0	1.60	4140 - 0
70 - 30	5.10	2968 - 1172
50 - 50	7.30	2070 - 2070
30 - 70	9.44	1172 - 2968
0 -100	13.5	0 - 4140

in the table 6 the amount of water used from agricultural drainage water for 15 % leaching fraction is 57.5 % of water requirement of barley practically used by farmers when they irrigated with fresh river water .

In table 7 the amount of water added to barley experiments with 30 % leaching fraction are as follows :

Table (7) :

Mixing ratio E - D	ECiw	m^3/ha E - D
100 - 0	1.60	4680 - 0
70 - 30	5.10	3276 - 1404
50 - 50	7.30	2340 - 2340
30 - 70	9.44	1404 - 3276
0 - 100	13.50	0 - 4680

Table (8) : The average grain yield of barley in Ton/ha as a function of leaching fraction and mixing ratios and salinity level :

Mixing Ratio E - D	ECiw	Tons/ha 0	15	30 %
100 - 0	1.60	4.85	4.94	4.52
70 - 30	5.10	4.21	4.24	3.74
50 - 50	7.30	3.10	3.56	3.24
30 - 70	9.44	2.40	3.10	2.51
0 - 100	13.55	1.50	1.69	1.33
Mean	-	3.2	3.5	3.1

The yield of barley shows an increase in yield as a function of leaching fraction (table 8) if we look to the mean of the data . It is 3.2. , 3.5 , 3.1 Tons/ha for 0 - 15 and 30 % leaching fractions respectively . The data also shows that with 70 % agricultural drainage water we can obtain what the state farms produce with 100 % Euphrates rivers water use . Their average yield is 2.5 ton/ha .

Our data is an average of six replicates for each year of our study let to say the yield of 3.56 ton/ha for 50 - 50 % water mixing ratio and 15 % leaching fraction is an average of 12 replicates for the two years study . The 3.56 tons/ha is obtained by 57.5 % agricultural drainage water , which means we saved 57.5 % of Euphrates river water in this experiment .

The straw yield of barely is presented in table 9 .

Table (9) : Mean yield of barley straw in ton/ha as a function of leaching fraction and water mixing ratios :

Mixing ratios E - D	ECiw	Tons / ha 0	15	30 %
100 - 0	1.60	13.4	12.0	12.7
70 - 30	5.10	12.0	12.0	10.4
50 - 50	7.30	8.9	9.7	8.7
30 - 70	4.44	6.9	7.3	6.4
0 - 100	13.55	4.0	4.3	3.6
Mean	-	9.04	9.06	8.36

The straw data shows that there is no difference in the means of 0 and 15 leaching fractions but they differ mainly from 30 % leaching fraction. Since the straw has a great value in the area as far as animal nutrition , experiments are under testing for different barley species for hay production .

The amounts of water used for irrigation of Cotton for 0 , 15 , 30 % leaching fractions are 9455 , 10872 and 12291 m3/ha with ECiw value for water mixtures ranging from 1.55 to 13.2 ds/m. The amounts of water of different mixtures with different leaching fractions could be calculated in the same manner as Alfalfa and Barley water amounts .

The yield of Cotton are presented in table 10 as a function of mixing ratios,leaching fraction and levels of salinities .

Table (10) : Cotton yield in Kg/ha as a function of mixing ratios ,leaching fractions and salinity levels :

Mixing ratios E - D	ECiw*	Kg/ha 0 (1)	15 (1)	30 % (1)
100 - 0	1.6	3364	3636 :	2727
70 - 30	5.9	2727	2909 :	2091
50 - 50	7.5	2227	2763 :	1682
30 - 70	9.8	1727	1796 :	1227
20 - 80	11.0	1227	1341 :	909
0 - 100	14.0	864	773 :	614
Mean		2023.0	2203:	1540

* Mean ECiw of irrigation water during growing seasons .
1. Mean of six replicates yield and mean of two years (Mean of 12 replicats) .

The mean of Cotton yield ranges from 2023.0 , 2203 and 1544 Kg/ha for 0 , 15 , 30 % leaching fractions respectively . There is a drastic decrease of yield for the 30 % leaching fraction , this is might be due to leaching of nutrients from root zones especially nitrogen . The soil analyses during the growing seasons clarified this phenomena .

Salinity Monitoring in Experimental Plots :

Salinity monitoring was carried out by two ways :

1. By placing 48 pizeometers in the experimental crop plots , and measuring the water table depth and its salinity [ECdw] EC of drained water which is equal to EC of soil water .
2. The other monitoring is by collection of soil samples at various soil depth during the growing seasons of tested crops .

The pizeometers study were carried out by measuring water table depth and its ECsw every 48 hours and after a week from irrigation day . These measurements were carried out during the growing seasons of Barely and Cotton and during the growing years of Alfalfa .

Table (11) : Average pizeometers reading of ECsw and depth* of water table for Alfalfa experiments as a function of water mixing ratios and leaching fraction :

Leaching fraction	E - D	ECiw*	ECsw*	W.T.D Cm
Zero %	100 - 0	1.55	3.30	196
	50 - 50	7.50	4.01	192
	20 - 80	10.54	4.40	189
15 %	100 - 0	1.55	3.10	182
	50 - 50	7.50	5.86*	188
	20 - 80	10.54	5.38	194
30 %	100 - 0	1.55	3.00	176
	50 - 50	7.50	4.83	184
	20 - 80	10.54	6.87	191

* Average for two years reading } after a week from irrigation day
W.T.D : Water table depth in Cm . } = = =

Table (11) shows the data of the pizeometers reading of Alfalfa experimental plots . The ECsw measurements are found below the assumed values of ECsw = 3 ECiw . As example to explain this in table 11 for 15 % leaching fraction treatment , the ECiw of 50 - 50 % mixing ratios is 7.5 ds/m . According to the above assumption the ECsw should be 22.5 ds/m this value is much higher than average readings of the pizeometers for two years which is 5.86 ds/m . This comparison is very astonishing to us and we found the only explanation is the dilution of ECsw from surrounding fields , the winter rainfall (about 150 m.m) and the precipitation of gypsum and lime which lower soil water salinity .

The leaching fraction has a moderate effect upon leaching of salts especially from the mixing ratios , this is due to the amount of water added from the drainage water as well as precipitation of gypsum and lime as will be shown from detailed soil studies and prediction of salt precipitation by computer model .

The pizeometer readings from Barley experimental plots are shown in table (12) :

Table (12): * Average pizeometer reading of ECsw and depth of water table for Barely experiments as function of water mixing ratios and leaching fraction :

Leaching fraction	E - D	ECiw**	ECsw**	W.T.D(1) Cm
Zero %	100 - 0	1.55	3.6	146
	50 - 50	7.50	3.7	148
	20 - 80	10.54	5.62	166
15 %	100 - 0	1.55	3.88	153
	50 - 50	7.50	5.15	182
	20 - 80	10.54	5.72	186
30%	100 - 0	1.55	4.66	158
	50 - 50	7.50	6.98	146
	20 - 80	10.54	6.70	152

E = Euphrates river water
D = Agricultural drainage water % readings
* = Average of growing seasons
**= in ds/m
1 = water table depth

The data still holds the same remarks as far as the relation between the ECiw and ECsw for 50 - 50 and 20 - 80 mixing ratio . The leaching fraction has obvious effect upon leaching of salts . The water table depth is shallower than the water table depth of Alfalfa experimental plots .

The pizeometer readings of ECsw and water table depth of Cotton experimental plots are presented in table (13) :

Table (13) : Average pizeometers reading of ECsw and water table depth for Cotton experiments as a function of water mixing ratios and leaching fraction :

Leaching fraction	E - D	ECiw(1)	ECsw(1)	W.T.D(2) Cm
Zero %	100 - 0	1.55	2.8	150
	50 - 50	7.50	3.7	142
	20 - 80	10.54	5.4	141
15 %	100 - 0	1.55	3.0	130
	50 - 50	7.50	3.6	130
	20 - 80	10.54	5.2	129
30 %	100 - 0	1.55	3.8	135
	50 - 50	7.50	5.4	138
	20 - 80	10.54	6.2	138

(1) = ds/m
(2) = water table depth (Cm)

Generally ECsw values of Cotton fields are less than Barely and Alfalfa . Still the same remarks hold for the relationship between ECiw and ECsw for the water mixing ratios of 50 - 50 and 20 -80 % . The water table depth is shallower than Barely and Alfalfa experimental plots water table depth .

The chemical analyses of irrigation water used in the computer model for prediction of soil salinity is shown in table (14) ,

Table (14) : * Chemical composition of irrigation water in meq/litter water used for the computer model :

	% 100:E	E - D 50 - 50	E - D 20 - 80	100% D
PH	7.33	7.4	7.75	7.65
EC ds/m	2.12	11.88	13.67	14.1
Ca^{++}meq/litter	11.2	23.2	21.8	24.0
Mg^{++} =	6.8	24.4	24.0	26.6
Na^{+} =	4.5	58.0	61.0	70.5
K^{+} =	0.3	0.34	0.25	0.26
Cl^{-} =	3.0	15.2	15.6	17.8
$So^{--}{}_4$ =	15.4	84.4	86.0	97.86
Hco^{-} =	4.4	6.4	5.4	5.7
$Co^{--}{}_2$ =	-	-	-	
SAR =	0.75	12.1	12.7	14.0

* = August 14.1992

We used this analyses because it contains highest concentration of ions during growing seasons .

Prediction of average soil salinities profile (ECsw) , soluble ions , gypsum and CaCo3 contents are shown in table (14) . This prediction is based on the modified watsuit model of Rhoades 1976 and 1990 . The modification is carried by (Abdelgawad 1993) .

Table (15) : Average chemical composition of soil water and caco3 , caso4 , 2H2o2 as predicated from computer model in soil profile :

Parameter	100 % E			E - D 50 - 50			E - D 20 - 30		
	0.05*	15	30	0.05	15	30	0.05	15	30
PH	7.43	7.40	7.4	7.55	7.50	7.50	7.56	7.53	7.50
EC ds/m	6.06	4.11	3.24	30.67	19.13	14.38	31.59*	19.57	14.73
Ca^{++} 1	20.50	20.6	19.5	20.5	21.2	21.8	20.3	21.0	17.0
Mg^{++}	44.2	21.6	158.6	77.6	77.6	50.7	60.0	76.4	49.9
$Na^{+}+K^{+}$	31.20	15.3	380.0	185.5	185.5	121.1	398.0	195.0	127.0
Cl^{-}	16.50	9.1	6.16	84.7	46.5	31.64	85.8	47.1	32.1
$So^{=}_{4}$	70.0	42.3	32.0	442.8	224.6	152.9	457.4	231.6	159.4
Hco^{-}_{3}	6.03	5.0	4.7	14.2	9.9	8.1	14.4	10.1	8.2
$Co^{=}_{3}$	0.73	0.70	0.70	1.20	0.87	0.78	1.2	0.9	0.8
SAR	3.93	2.82	2.22	31.4	24.0	19.4	33.3	25.41:	20.52
$Caco_3$	3.74	8.2	-	26.2	9.6	4.4	19.5	6.2	2.23
$Caso_4$	0.04	6.7	-	104.0	43.0	21.9	102.0	42.1	21.4

E = Euphrates river
* = Leaching fractions
D = Agricultural drainage water
1= meq/litter

The data of table 15 is for 0.05 , 15 , 30 % leaching fractions . The zero % leaching fraction was not possible by the model .
Instead of zero % leaching fraction we used 0.050 % leaching fraction for mixing water ratios . The average ECsw for 0.05 % leaching fraction is 31.59 ds/m for 20 - 80 mixing ratios. This value is very high for growth of plants and if this is the cause then no yield is expected , however , the obtained data of Alfalfa yield for zero % leaching fraction for the above mixing ratio is 11.0 tons/ha and the yield for 30 - 70 % mixing ratios is 14.3 tons/ha (table 4) .

This means the model predicted the worst condition of salinity accumulation (Rhoades 1990) .

The average SAR of the soil profile for 0.05 % , 15 % and 30 % leaching fractions and mixing ratios of 20 - 80 % are 33.3 , 25.42 , 20.52 respectively . These values are generally high for Euphrates soils . The yields of Alfalfa , Barely , Cotton for 0 % leaching fraction of 20 - 80 % mixing water ratio treatment are 10.0 , 1.61 and 0.9 tons/ha respectively . These values do not correspond with the high ECsw and high SAR values predicted by the model .

The model predicted high concentration of Mg relative to calcium ion .Especially for 50 - 50 % and 20 - 80 % mixing ratios this phenomena has been reflected upon Ca to Mg ratios which is lower than the recommended values which is higher than one . These Ca/Mg values of lower than one in this study may cause more damage to the dispersion of soil clays as result of aggregate breakage , and the SAR in this cause will have more effect on dispersion of clays and enhancing the formation of soil crusts .As well as nutritional problems of plants .

The model predicted the precipitation of gypsum and lime and their rate of precipitation is a function of drainage water % used and leaching fraction . Table (16) illustrates this phenomena :

Table (16) : Gypsum and lime contents in meq/litter of soil water table as a function of water mixing ratios leaching fraction and depth of soil profile :

100 % E

*Soil Depth	Gypsum 0.05	Gypsum 15	Gypsum 30	Lime 0.05	Lime 15	Lime 30
0	0.00	0.0	0.0	2.30	2.3	2.3
1	0.00	0.0	0.0	3.11	2.66	2.08
2	0.00	0.0	0.0	7.28	4.92	2.59
3	27.51	7.08	0.0	22.00	11.43	4.86
4	124.86	26.47	0.21	74.37	20.13	6.89

E - D
50 - 50 %

*Soil Depth	0.05	15	30	0.05	15	30
0	00.00	0.00	0.00	4.11	4.11	4.11
1	9.49	7.57	5.06	4.08	4.56	3.90
2	39.13	29.21	19.23	8.36	5.86	3.46
3	114.78	65.53	35.7	24.95	12.00	4.78
4	356.71	112.88	49.56	88.67	21.33	5.90

*Soil Depth	E - D 20 - 80 % 0.05	15	30	0.05	15	30
0	00.00	0.00	0.00	3.08	3.08	3.08
1	9.07	7.19	4.73	3.40	2.49	2.46
2	38.57	28.53	18.74	5.21	3.25	1.38
3	112.47	64.21	34.46	17.47	7.51	1.90
4	349.55	110.7	48.62	67.94	14.33	2.33

E = Euphrates river water
D = Agricultural drainage water
* = Soil depth as sited in FAO 1990 and Rhoades 1976 - 1990

Soil salinity monitoring by collection of soil samples and analyzing them periodically are presented in table (17) for zero % leaching fraction because we expect the highest concentration of salt , accumulation will be in this treatment .

This data presented for 100 % E , 50 - 50 % , 20 - 80 % mixing ratios .

Generally there is an increase of ECe of soil for the experimental plots irrigated with saline water , to about three times when compared with ECe of the soil before irrigation with saline water .

The relation between ECsw predicted by the model and ECsw of soil water from analyses of soils periodically shows that the ECsw predicted by the model is close to the actual measured values for 50 - 50 and 20 - 80 mixing ratios . The EC of soil water obtained from pizeometer readings is lower than the ECsw of the actual measured by soil analyses .

The ratio of Ca/Mg from table (17) soil analyses differ from Ca/Mg ratios predicted from the model and generally in both cases there is an increase of gypsum content . The SAR decreases with increase in leaching fraction and increases with increase of agricultural drainage water percentage . The SAR at the soil surfaces is higher than lower surfaces. This explains the formation of soil surface crusts in the lower Euphrates agricultural area of Syria .

Table (17) : Average soil chemical analyses of Alfalfa experimental plots for two years for zero % leaching fraction:

Soil depth cm	Mixing Ratios	PH:	EC: ds/m	Soluble ions Meq/litter							Gyps %	Lime %	SAR
	E - D			Ca	Mg	Na	K	Cl	So4	HCo2			
	100 - 0												
0 - 10		7.89	5.90	21.0	19.0	34	0.2	23.2	51.0	1.10	0.33	26.7	7.6
10 - 30		7.57	8.54	41.0	24.0	42	0.5	47.0	58.0	1.30	0.30	18.0	7.4
30 - 60		7.83	6.75	32.0	17.0	44	0.4	28.0	57.0	1.32	0.40	17.9	8.9
Mean		7.76	7.1	31.3	20	40	0.34	33.0	55.3	1.24	0.34	20.8	8.0
	50 - 50												
0 - 10		7.66	11.83	34.0	28.0	77	0.4	56	81	2.0	0.7	17.5	13.8
10 - 30		7.69	9.66	33.0	23.0	68	0.4	47	74	2.0	0.3	17.6	12.9
30 - 60		7.71	8.41	32.0	19.0	53	0.4	34	34	2.3	0.4	18.8	10.4
Mean		7.57	9.17	33.0	23.3	66	0.4	45.7	63.0	2.1	0.47	17.7	12.3
	20 - 80												
0 - 10		7.77:	13.23:	37.0:	28.0:	95:	0.4:	53:	106:	2.1:	0.6	17.5	16.6
10 - 30		7.96:	9.84:	36.0:	20.2:	59:	0.35:	40:	71:	1.97:	0.3	18.0	11.4
30 - 60		7.10:	8.10:	35.0:	20.4:	49.7:	0.30:	35:	64:	1.93:	0.4	18.1	9.4
Mean		7.6	10.4	36	22.9	67.9	0.35	42.7	80.3	2.0	0.43	17.9	12.5

1- ECe of soil saturation extract
E= Euphrtes river water
D= Agricultural drainage water

Conclusion :

In this paper the use of saline water for irrigation of Alfalaf , Barley and Cotton is discussed . The yield performance of these crops is discussed with regards to the levels of salinities and leaching fractions . As example the 87.0 % yield of Alfalfa has been obtained by 43 % of Euphrates river water 57 % agricultural drainage water , The 87 % Alfalfa yield in this cause compared with 100 % Euphrates river water yield , let us to say we saved in this study 57 % of Euphrates river water .

The monitoring of soil salinity in the experimental plots by collection of soil samples periodically and analyzing them was found to be comparable to the salinity predicated by the computer model .

The gypsum content in soil profiles increases and became close to the soil surface as an increase in agricultural drainage water percentage increases in the irrigation mixtures .

The Ca/Mg ration decreases with an increase in agricultural drainage water percentage . This might have a harmful effect upon nutrient status and nutrient up take by these crops .

The surface soil SAR has been found to increase with increases of agricultural drainage water , precipitation of calcium as calcium carbonate , gypsum at subsurfaces of the soil , and leaching of calcium and magnesium from the surfaces in all kinds of treatment in these experiments . We think this is the reason of surface soil crust formation in the area .

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