Irrigation with saline water in Kuwait [1])

by Wajeeh S. Farawana [2])

1. Introduction

Kuwait is situated on the northeast corner of the Arabian Peninsula and occupies about 1,500,000 hectars. The climate is arid dry, characterised by hot dry summer and cool mild winter. The average maximum temperature of June, July, August is 44 °C; and the absolute maximum is 49 °C. The average rainfall is 50 mm per year, which is not sufficient to maintain a good plant cover, that's why the organic matter in the soil is very low and wind erosion is very active. The productivity of the soil is potentially low due to the serious climatic conditions and soil limitations.

Kuwait, seeks to increase agricultural development, must look forward to utilize any source of water available for irrigation including highly saline waters and sea water. Highly saline water has been used for many years in Kuwait by local farmers.

In order to determine if any water is suitable for agriculture or not, it is not enough to know the salinity of this water. This alone can be in many cases misleading. Crops will not grow in the irrigation water, but in the soil solution. Therefore, the water quality, the soil nature and the relationship between these two factors should be first determined as well as the kind of crop, climatic conditions, farming and irrigation practices.

2. Water Quality

This includes:

2.1. Total salinity, which can be expressed in millimhos/cm, electrical conductivity at 25 °C, or in parts per million total salt content. When the irrigation water goes into the soil it forms the soil solution, and as we know there is a close relationship between the salt concentration in the soil solution and its osmotic pressure. If the irrigation water is highly saline, the soil solution becomes concentrated and its osmotic pressure becomes very high. The plants fail to absorb their normal water requirements even when the soil is wet.

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1) Zusammenfassung einer Gastvorlesung an der OE Internationale Agrarwirtschaft der Gesamthochschule Witzenhausen.

2) Wajeeh S. Farawana, Head, Soil and Water Section, Department of Agriculture Kuwait.

2.2. The specific ion effect and the ratio between the different ions in the irrigation water: The HCO_3^- ion seems to be the most serious one followed by the Cl^- ion. Some ions when they are dominant have an antagonistic effect on other ions, like the antagonistic effect of calcium ion on potassium ion.

2.3. The poisonous effect of some ions like boron and lithium even if they are present in very small quantities.

3. Soil Nature

It is most important to study the soil to which the irrigation water is to be applied. The soil-water relationship is a well known phenomena. If a heavy clayey soil is irrigated with highly saline water, especially in hot climates, salts tend to accumulate in the upper part of the soil due to low permeability and high evaporation. Exchangeable sodium will form a serious problem in this case and the physical and chemical characteristics of the soil will change. If a hard pan exists under the soil, as in some parts of Kuwait, the salts from irrigation water will accumulate over this hard pan and form a salt layer if drainage is not applied. By capillary movement the salts will rise up. In the case of deep sandy permeable soils, salts are always leached down with irrigation water especially when flood irrigation is used.

4. Crops

It is well known that different crops differ in their tolerance to salinity. Some crops have the ability to grow in highly saline soils, and some not. The same crop can be sensitive to salinity in a certain stage of its life while tolerant in other stages.

5. Climate Conditions

In regions where enough rain falls all over the year, the salts will be always leached down, the capillary movement upwards is limited. In arid and semi-arid regions where the rain fall is scarce, the salts are not leached down. In the hot months of summer where the evaporation rate is much more than the precipitation rate, the capillary movement turns upwards, and the salts usually form a white crust on the soil surface unless artificial leaching is applied.

6. Irrigation Practices

In surface irrigation where the water is given to the soil in abundant quantities, the salts are usually leached beyond the root zone. But in the other way, the amount of water used is huge. The water losses by seepage and evaporation are considerable. With sprinkler irrigation the amount of water used is about 60% of that used in surface irrigation. But sprinkler irrigation in arid and semi-arid regions has many disadvantages, especially when highly saline water is used. The salts tend to accumulate in the upper part of the soil. In an experiment carried out

on alfalfa in Kuwait Experimental Farm, the EC · 10^3 of the saturated extract of the soil between 10—30 cm came up to 10.8 in the sprinkler irrigation compared with 4.3 in the surface irrigation after one season. The water used in the experiment was treated sewage effluent contains 1,500—2,000 ppm total salts. Also the evaporation losses in the water when sprinkler irrigation is used can be very high in summer.

The water evaporates in the air before it reaches the soil, plus the evaporation from the water which falls on the leaves and the soil surface. When highly saline water drops on the leaves of the crop and then evaporates it leaves the salts on the leaves of the plant where it causes burn spots. Some ions like Cl ion could be absorbed in big quantities into the leaves and causes leaf defoliation. Sprinkler irrigation with water containing 700 ppm Cl caused leaf defoliation of alfalfa in Kuwait Experimental Farm. 80% of a water melon field irrigated with sprinkler irrigation in Kuwait using saline water containing 2,000 ppm total salts failed to germinate or died in the early stages of growth.

Trickling irrigation can save up to 40% of the water used in sprinkler irrigation as a watermelon experiment showed in Kuwait. But the yield was very low compared with surface irrigation. Salts also tend to accumulate in the upper layer of the soil due to capillary movement. The nozzles were blocked sometimes due dirt in the water or due to salt incrustation.

Fresh water is not available for agriculture in Kuwait. It is enough only for drinking purposes and it comes from distilling the sea water. The relatively low salinity treated sewage effluent which contains 1,500—2,000 ppm total salts is prohibited for use for crop irrigation by health authorities and it is used only for afforestation.

The main source of water used for agriculture in Kuwait is the Solebyia Water Field 20 km far from Kuwait City where the water is pumped up from 200 ft. deep wells to a gathering centre and pumped again to Kuwait City. The analysis of this water shows the following:

pH	= 7.6
EC · 10^6 micromhos/cm at 25 °C	= 6,600
Total salts	= 4,560
Soluble Sodium Percentage SSP	= 40.9
Sodium Adsorption Rato SAR	= 6.2
Residual Sodium Carbonate RSC	= NIL

	m.e./L	ppm
CO_3^{--}	NIL	NIL
HCO_3^-	2.8	171
Cl^-	32.2	1,143
SO_4^{--}	31.2	1,498
Ca^{++}	23.2	464
Mg^{++}	15.6	190
Na^+	27.2	626
K^+	0.4	16

This water was used and is being successfully used for irrigation of salt tolerant crops on deep permeable sandy soil without salt accumulation in the root zone.

Some private farms have their own wells inside their farms. The salinity of the water in some of these farms exceeds 20,000 ppm total salt. One farmer has been using a water of 11,000 ppm total salt for 25 years on the same soil. There was no accumulations of salt during the croping season. This farmer used to grow tomatoes, radishes, spinach and alfalfa. The analysis of the water in this farm is as follows:

pH	= 7.6
EC · 10^6 micromhos/cm at 25 °C	= 16,000
Total salts	= 11,166
Soluble Sodium Percentage SSP	= 33.1
Sodium Absorption Ratio SAR	= 19.6
Residual Sodium Carbonate RSC	= NIL

	m.e./L	ppm
CO_3^{--}	NIL	NIL
HCO_3^-	0.6	37
Cl^-	100.8	3,578
SO_4^{--}	60.0	7,880
Ca^{+4}	38.0	760
Mg^{++}	26.6	323
Na^{++}	112.0	2,576

The texture of the soil was sandy consisting of 95 % sand, 5 % silt and clay. The EC · 10^3 of the saturation extract of the soil up to 150 cm averaged between 6—7.4 during the cropping season which, in my opinion, is not considered high salinity. The limit of 4 millimhos/cm is too low to define a saline soil, it should be raised up to 7 or 8 especially for highly permeable sandy soils.

7. Summary

The water should never be considered unsuitable for irrigation just by looking to its total salt content. Soil nature, climatic conditions, farming and irrigation practices are very important factors too, and they should also be taken into consideration.

Experiments conducted on irrigation with saline water in Kuwait proved, that excellent yield was obtained by using water of 4,000—5,000 ppm total salt. Tomatoes, radish, spinach and alfalfa grown on deep permeable sandy soils gave very good yield when irrigated with water containing 11,000 ppm total salt without salt accumulation in the root zone.