



Response of saline wastewater irrigation on sand bed culture

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THE APPLICATION OF untreated wastewater using surface irrigation methods was found to cause soil problems. Investigation performed near Cairo with surface irrigation of untreated sewage indicated a build up in trace metals in the soil (2). Laboratory experiments on the effects of Na and organic matter of effluent showed an increase in the water retention properties of the soil (1).

The present investigation deals with the response of chlorinated saline wastewater effluent to the irrigation on a Sand Bed Culture System (SBCS). Field trial on an experimental plot (25 x 50 m) were made to study the crop growth and response of sandy medium to the application of saline (3411 to 3857 mg/l) secondary treated, chlorinated wastewater on alfalfa, onions and summer squash. Physical and chemical properties of the soil were studied over three crop seasons. The groundwater-irrigation plots acted as the control. The physico-chemical properties of the wastewater and groundwater were very similar, due to the fact that the wastewater is generally derived from the untreated groundwater.

Experimental methods

An agricultural plot of 50m x 50m was developed for growing summer squash, onions and alfalfa. Other facilities include two water storage tanks (8m x 8m x 1.3m deep) for treated effluent and groundwater and an irrigation system. Sprinkle systems for groundwater and wastewater consists of pumps, a flow meter and sprinklers spaced at 3m x 3m and eight leachate wells for collection of percolating water at a depth of 30 cm below the ground surface. The plot was located on the King Fahad University of Petroleum & Minerals (KFUPM.) Campus, Dhahran close to the outlet valve of the sewer which carries secondary chlorinated effluent from the North Aramco treatment plant.



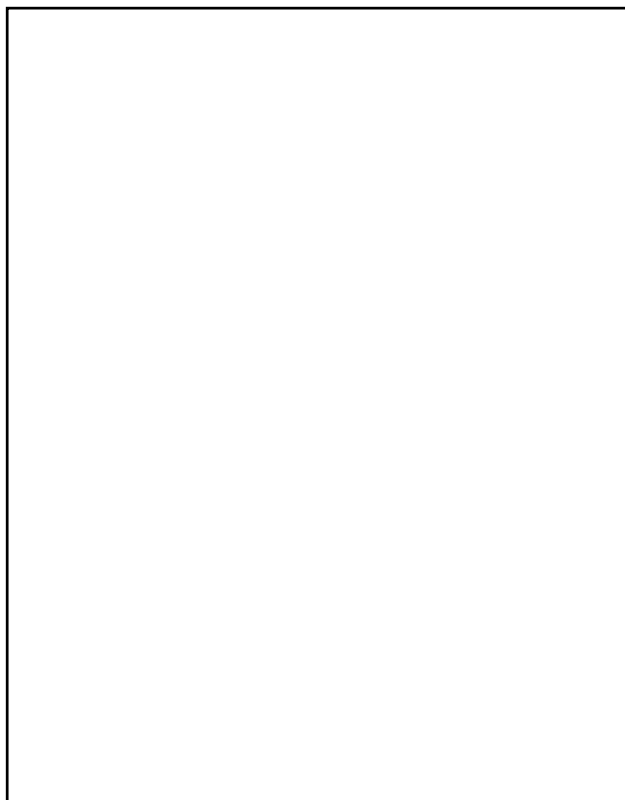
The soil in this area consists of calcified and gypsified hard sedimentary rocks overlain by wind-blown sand varying in depth from a few inches to a few feet. The soil cover is thin and devoid of any organic matter. There had been a depression at the farm site, which was filled (varying from 0.8 m to 2.2 m), with excavated material from nearby hills. Further, a layer of sand (from sand dunes) varying in thickness from 70 cm to 120 cm was laid over the earth fill. A month before the first cropping seasons, 2cm of chicken manure was spread and for the second and third cropping seasons, 2.5 cm layer of cattle manure was well mixed with the top layer. Alfalfa, onions, and summer squash were cultivated using sprinkle system for irrigation.

For the first two crop seasons, water applied was 1.5 cm/day (0.75 before sunrise and 0.75 cm after sunset). The irrigation timings were selected to avoid salt damage to the levels due to evaporation of saline water from leaf surface. In addition, once in the middle of the crop period, leaching was done with a 5 cm depth of water. In the third crop seasons, irrigation was based on the actual plant requirements measured by tensiometers installed in the rootzone, and also flooding was not carried out. The average crop yield obtained from the wastewater and groundwater plots is shown in Table-1.

The physio-chemical, bacteriological analyses of five samples of groundwater and 17 seventeen samples of wastewater collected at regular intervals during the three crop seasons were determined using an Atomic Absorption Spectrophotometer (Model 4000-Perkin Elmer). The results are summarized in Table-2.

The 1:2 water extract for chemical analysis was prepared by mixing 500g of soil sample with 1000g of distilled water and the filtrate was collected after thoroughly shaking the mixture. The soil samples were collected from wastewater and groundwater plots with fertilizer at a depth of 40 cm from four corner and the center as well. Procedures given in Standard Methods were adopted for chemical analysis. Soil samples were obtained at the start, middle and end of crop season.

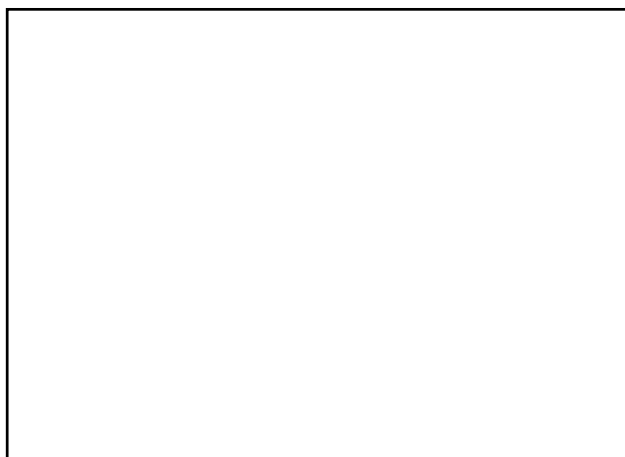
To perform the trace metal analysis of the sand media 10g of sand media was mixed with 50 ml of distilled water, 2 ml of H_2O_2 and 5 ml of HNO_3 and digested to reduce the volume to 10 ml of H_2SO_4 cooled, diluted to 100 ml and filtered. Graphite furnace was used on the Atomic Absorption Spectrophotometer for the detection of Fe, Cd, Pb, Cu and Mn and for Zn, the flame technique was used. Boron was estimated by the Carmine method.



Discussion

The quality of the effluent irrigation water was poor with TDS concentration ranging between 3,411 and 3,857 mg/l and CE 4.8 and 5.3 mmho/cm. The presence of these salts result largely from the highly saline groundwater (3,313 to 3,654 mg/l) in no-potable use at KFUMP and ARAMCO Campuses. The sodium adsorption ratio (SAR) varied from 3.85 to 11.36 presenting a moderate tendency for the irrigation water to form exchangeable Na in soil.

After two crop seasons, there was no marked difference in the physical characteristics of the sand media. In the case of hydraulic conductivity, there was a decreasing trend. However, the decrease is quite insignificant and in general it can be stated that there is no significant effect on the



hydraulic conductivity of the media due to the application of secondary treated effluent. Results are summarized in Table-3.

Soil pH₂ (pH of 1:2 water extract) is one of the main factors that affect nutrient availability and other activities of microbiota. A soil with less than 8.5 pH₂ is evaluated as "normal for most of common crops". Wastewater application on the sand bed had no significant effect as far as pH₂ is concerned due to its high permeability.

A fifty- percent of the consumptive use requirements of 1 cm/day was provided for leaching and a flooding was given once during each crop season. However, over a period of two crop seasons, the soil salinity in the wastewater irrigation plots remained more or less same as that of groundwater plots.

In the third crop season, leaching allowance of cm/day and 5 cm of flooding were withdrawn and the irrigation schedule was based on the day-to-day water requirement of crop measured through a set of tensiometers installed in the field. Though it was expected that salinity level would increase; however, there was no significant rise in the root zone salinity. This might have been due to the fact that the cultivated area has a good natural drainage and there was a rainfall of 4.83 mm, 9.65 mm, 14.20 mm, and 32.89 mm respectively for the months of January, February, March and April.

A few random samples were taken from the top 5 cm layer and analyzed. The salt concentration was found to be higher in the top layer as compared to the layer at 30 cm. This resulted from the high evaporation rate as evident from the pan evaporation values of 9.1 and 19.00 mm/day reported respectively for the months of April and May. The high salt concentration in the top layer in spite of rainfall, flooding and extra leaching could have caused germination and other growth problems during the early growth period of the plant in the subsequent crop seasons. Therefore, soil was thoroughly mixed with a rotator before each crop seasons to avoid this problem.

Table-4 presents a typical composition of soluble cations and anions in the 1:2 water extract. These salts were presents in the soil at the beginning and were further formed by the addition of irrigation water.

The SO₄ Percentage decreased from 89.39 % to 70.3 % in wastewater plot and to 41.6 % in groundwater plot. However, no sulphur deficiency symptoms were present in the plants.

The chloride percentage increased from 10.49 % to 29.3 % in wastewater plot and 53.2 % in groundwater plot. Its main function is as an osmotic pressure regulator and therefore rise in chloride does not present any problems for the yield or plant growth.

The soil used in this case can be classified as non-humic (3), since the organic content was nil. Even with the application of wastewater, there was no noticeable increase in the total organic carbon (TOC) of the soil.



Boron and Zn in the soil were present in very small traces, while in wastewater Boron ranged between 1.22 and 0.52 mg/l and Zn was below detection limit. Cadmium, Pb and Fe were in almost negligible quantities in both soil and wastewater. There was no appreciable increase in B and Zn in the soil at the end of three crop seasons. Boron, it should be noted, does not exist in toxic quantities and, therefore, does not pose any problem. It has generally been found that coarse-textured, well-grained, sandy soils are low in B; and crops with a high requirements of 34 to 56 kg/ha of borax.

In summary, Boron on sandy soil does not present any problem to crops since B deficiency occurs due to leaching, and excessive dry weather.

Conclusion

- High saline, secondary wastewater can be used on a sandy soil with natural drainage to grow fodder and salt tolerant food crops.
- No appreciable deterioration in the soil condition was noted after three crop seasons. The irrigation practice in the first two crop seasons included leaching water equal to 50 % of the consumptive use and one flooding during the crop seasons helped to reduce the salinity in the root zone.
- Trace elements like Boron in wastewater effluent did not present a serious problem for sandy, well-drained soils.
- Soil pH remained stable during the 18 months period of three crop seasons.

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