Wastewater Reuse for Irrigation and Sea Water Intrusion: Evaluation of Salinity Effects on Soils

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ABSTRACT

Climate changes and the continuous population growth increase the water demands for which, in arid and semi arid regions like the Mediterranean is considered as a limited resource. Future demands will not be met by traditional water resources like surface and ground water. In order then to handle increased water demand, the treated wastewater originating from municipal wastewater treatment plants is offered to farmers for agricultural irrigation.

Over pumping of fresh groundwater often creates sea water intrusion that causes various problems, besides others, to the quality of recycled water used for agricultural purposes. Eventual effects of the irrigated soils could be a very important and serious issue. Actual investigations were carried in land irrigated with salinity affected wastewater, and land irrigated with fresh water. Analysis of soil profiles are demonstrated and compared, posing very interesting results. Various remediation scenarios are also suggested in this study w hich was carried in the Larnaca district in Cyprus.

keywords: wastewater reuse, salinity, agricultural irrigation, SAR, Electric Conductivity

INTRODUCTION

Cyprus is located at the east Mediterranean, 75 km south of Turkey, 105 km west of Syria, 380 km north of Egypt, 380 km east of Rhodes (Greece). Cyprus is the third largest island in the Mediterranean with a population of 700,000. The average annual rainfall is about 500 mm and ranges from 300 mm in the central plain and the south-eastern parts of the island up to 1,100 mm at the top of the Troodos range and 550 mm at the top of Pentadaktylos. With many countries facing severe water shortages, reusing water for irrigation and industrial purposes is becoming more favourable [1, 2, 3].

Cyprus with a total surface area of 9250 km^2 due to its semiarid climate faces a problem of inadequacy of water for both its domestic and irrigation needs. In Cyprus there are no permanent surface water streams or lakes but until some years ago, underground water resources were adequate to meet the local water demand. However, overexploitation of the underground water leads to a gradual decrease of groundwater resources. The reuse of sewage effluents is then seriously considered as an important strategy in conserving water resources.

Currently 25 wastewater treatment stations are in operation which is producing about 20 MCM/yr. Treated wastewater is being used for watering of football fields, parks, and hotel gardens totalling to 1.5 MCM/yr, and over 3.5 MCM/yr of treated sewage is used for crop irrigation. It is estimated that by the year 2012 an amount around 30 MCM/yr of treated wastewater will be available for landscape agriculture and crop irrigation.

METHODOLOGY

It appears that due to the lower location of the town of Larnaca, saline water infiltrates into sewers and eventually affecting the quality of treated wastewater that is given to farmers for agricultural irrigation. It was then necessary to make an initial small scale evaluation of the possible effects of saline water on agricultural land. The area of the village of Dromolaxia was selected where there was ample agricultural land irrigated with treated wastewater (EC 3.75 mS/cm), originating from the Larnaca wastewater treatment plant, and agricultural land irrigated with fresh, mostly ground water. Various profile samples were taken at incremental depths to about 0.85m in both irrigation modes in order to investigate the immediate root zone of these agricultural profiles. Initially all samples taken were investigated in terms of SAR and EC. Results were plotted in a profile fashion that represents the actual layout. Figure 1 shows Electric Conductivity values at all profile increments, in red for values irrigated with treated wastewater and in blue with fresh water. In the same fashion, figure 2 presents the SAR values of the same samples (in red for values irrigated with treated wastewater and in blue with fresh water).

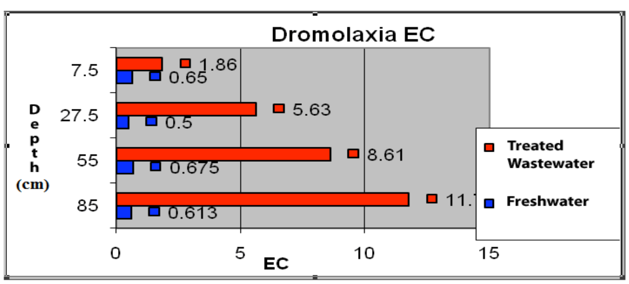

Figure 1. Electric Conductivity values of the soil profile

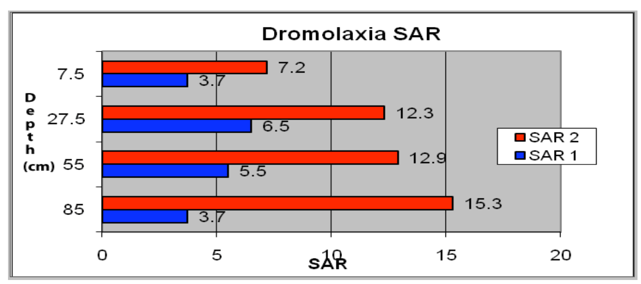

Figure 2. SAR values of the soil profile

RESULTS AND DISCUSSION

Quality of treated wastewater

This treated effluent poses danger to soils and plants when used for irrigation without appropriate management or other corrective measures. Based on our analyses, the EC in this case is very high (3.75 mS/cm), as well as the total hardness (808 mgeqv/dm^3). Very high values are also detected in sulphates, sodium, cadmium and mercury As the effects of these elements are interdependent, a risk analysis was carried based on valid EU and international standards and suggestions/ordinances with emphasis on the strictest ones [2][3]. These show serious sodium risk, chloridization risk, and possible alkalinization. The value of the Sodium absorption ratio is 6.83, even in acceptable range, still approaches danger levels. The above do not imply that this water is not suitable for irrigation. However serious irrigation management techniques and probable quality improvement measures should be taken in order to minimize long term effects on soils. It is also advisable that plants tolerant to the above water characteristics be preferred.

Effects on soils

From fig. 1, it is clear that this treated wastewater applied as irrigation to soils for the number of years irrigated, raises the EC to very high levels, compared to soils irrigated with normal fresh water. In samples irrigated with treated wastewater, the EC values range from 1.86 mS/cm at the surface layer to 11.77 mS/cm at the bottom zone. The soil irrigated with fresh water, shows minimum and maximum values ranging from 0.5 to 0.675 mS/cm.

Soils irrigated with fresh water, have salinity values within the range of 0-2 mS/cm (fig.1), and are classified as 'non saline soils' with 'salinity effects negligible' [6], [7]. When the same soil is irrigated with treated wastewater, and after evaluation of the EC of the root zone (roughly 7.0 mS/cm-fig.1), they move to the range of 'moderately saline' where 'yields of many crops are restricted', and is approaching the next range of more severe effects [6], [7].It is then clear so far, that wastewater irrigation in this area had a serious impact of the EC of soils. The EC of the soil solution extracted from a saturated example of soil can give a good indication of the salt levels.

Figure 2 shows a great increase of the SAR over our profile under investigation. Actually the increase was from an average profile value of 4.85 before irrigation, to the average profile value of 11.93 after about 10 years of irrigation with treated wastewater, and increase of 246%.

The SAR values of irrigated with treated wastewater soil, range from 7.2 at the surface to 15.3 at the bottom of our profile. When evaluation these numbers in terms of actual risks we note that [1], soils that were irrigated with fresh water are very close to the 'normal soils' category (average values SAR 4.85, EC 0.6 and pH 7.96.). Soils irrigated with treated wastewater, (average profile values SAR 11.93, EC 6.97 and pH 7.94), fall into the 'saline' category, with close proximity to the 'saline-sodic' zone. The bottom of the irrigated with treated wastewater soil profile, with an SAR of 15.3, actually falls into this 'saline-sodic zone.

CONCLUSIONS

The effects of the increase of salinity in the soils irrigated with treated wastewater as compare to the soils irrigated with fresh water is very clear in this investigation. There is a great increase of salt levels, EC and SAR in all layers of these soil profiles. If irrigation water with a high SAR is applied to a soil for years, the sodium in the water can displace the calcium and magnesium in the soil. This will causes increase of soil SAR, eventually decreasing the ability of the soil to form stable aggregates with a loss of soil structure and tilth. This also leads to a decrease in infiltration and permeability of the soil profile to water, leading to problems with crop production. If it were not for the high soil calcium levels in these soils, SAR values could have been considerably higher. The effects of the increase of salinity in the soils irrigated with treated wastewater as compare to the soils irrigated with fresh water is very clear in this investigation. There is a great increase of salt levels, EC and SAR in all layers of these soil profiles. There must be immediate action with corrective measures.

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