Humid Region Salt Accumulation in Soils at Penn State’s Living Filter

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Introduction

Reuse of municipal waste water effluent conserves freshwater resources and avoids direct discharge into surface waters. Since the early 1960s, Penn State has used treated waste water to irrigate cropped, grassed and forested lands at its “Living Filter” site (Fig. 1). Effluent is currently applied at a rate of 258 cm per year. This site also receives over 96 cm of precipitation resulting in the site filtering ~354 cm of water per year.

Salt accumulation is generally considered solely an issue for arid regions. However, at the Living Filter, effluent concentrations of sodium (Na^+), magnesium (Mg^{2+}), and calcium (Ca^{2+}) have all increased over the years, with large recent increases in Na^+ due to the extensive installation of water softeners on campus.

As a result, an increase in wastewater Sodium Adsorption Ratio (SAR) and total salt concentration (Fig. 4a & 4b) has occurred. Application of high SAR water can result in reduced hydraulic conductivity (Goncalves et al., 2007). The higher the SAR and the lower the electrical conductivity (EC), the greater the potential is for decreasing hydraulic conductivities (Ayers and Westcot, 1989).

Fig. 1- Penn State’s Living filter Astronomy site.

Fig. 2- Cores were taken from summits and depressions in the Living Filter.

Fig. 3- Giddings hydraulic soil sampler used to extract soil cores.

Objective

The objective of this research was to determine the extent to which the soils at the Living Filter reflect wastewater increases in SAR and EC.

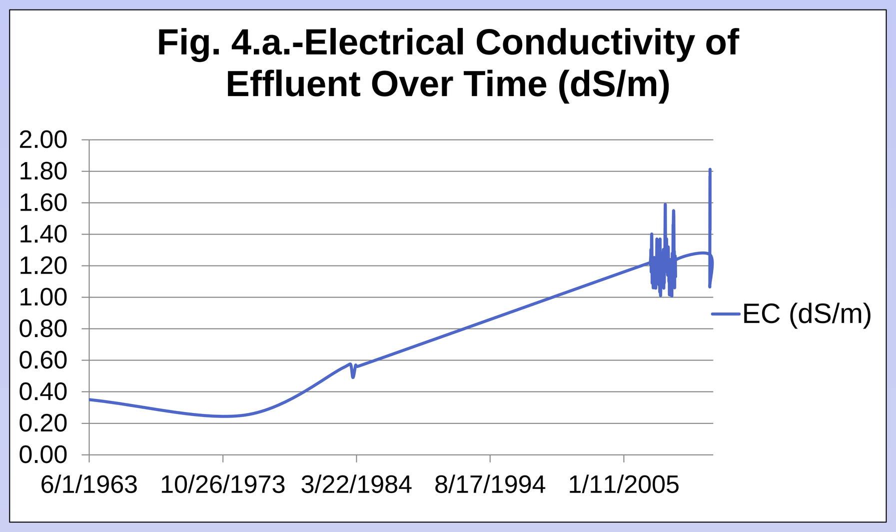

Fig. 4.a.-Electrical Conductivity of Effluent Over Time (dS/m)

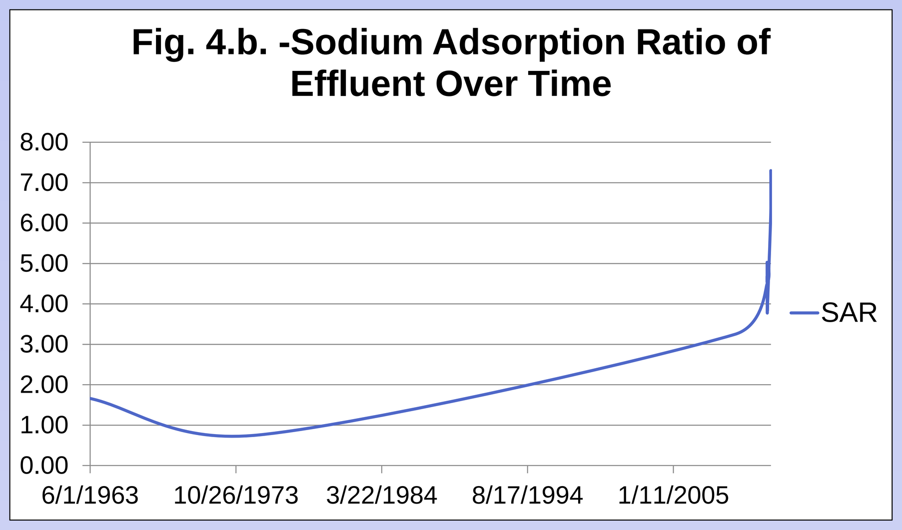

Fig. 4.b. -Sodium Adsorption Ratio of Effluent Over Time

Materials and methods

HYDRUS 1-D was used to model the expected distribution of sodium, calcium and magnesium throughout the soil profile, as a result of increased concentrations in the wastewater used to irrigate the site. The simulation was conducted to cover a period of 5 years, considering two different scenarios. We used mean wastewater quality from (A) 1963 – 1975 and also from (B) 1975 – 2009, as shown in Fig. 4a & 4b.

Soil sampling was conducted during July 2012. 120 cm long cores were collected from 18 sites representing irrigated **summits** and **depressions** (Fig. 2 & 3), as well as from an adjacent non-irrigated site for comparison. All samples were collected in plastic sleeves and stored a walk-in freezer with end caps secured until analyzed.

The 120 cm soil cores were separated into six segments in 20 cm increments. The gravimetric water contents were determined, and 1:2 soil water extracts were analyzed for major cations - Ca, Mg, Na, K, using an ICP. The EC of the extract was estimated by summing the major cations and dividing by 320. The **SARs and ECs of the soil solutions** were then estimated using the gravimetric water contents.

Results

The **initial modeling** with Hydrus 1-D demonstrated the likelihood that the **SAR** of the soil solution **has increased significantly** over time (Fig. 5). **Soil samples** from the site indicate that **irrigated** locations have a higher concentration of the major cations (Fig. 6) and a **higher SAR** (Fig. 7).

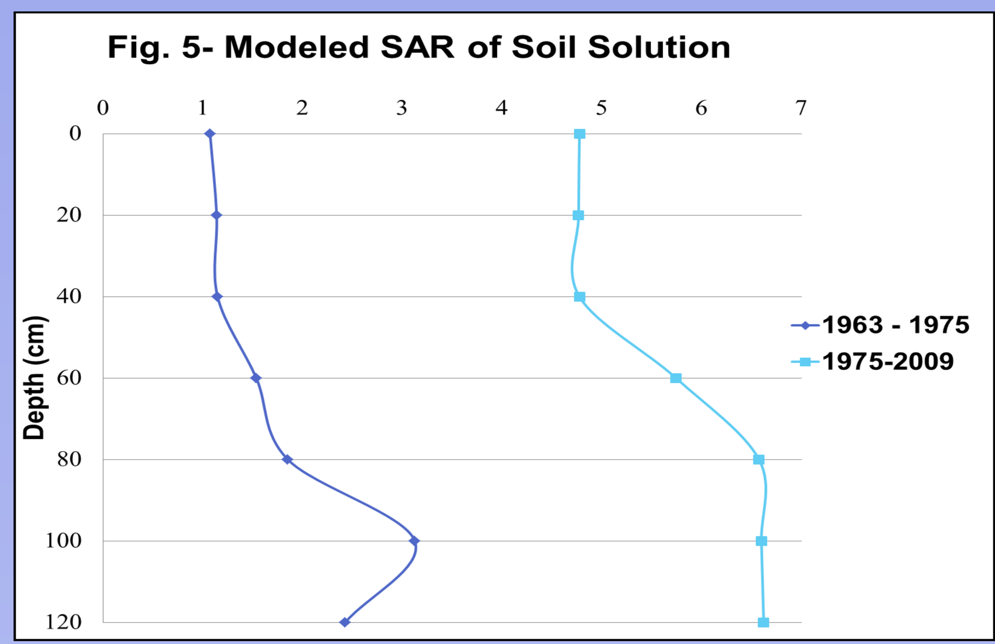

Fig. 5- Modeled SAR of Soil Solution

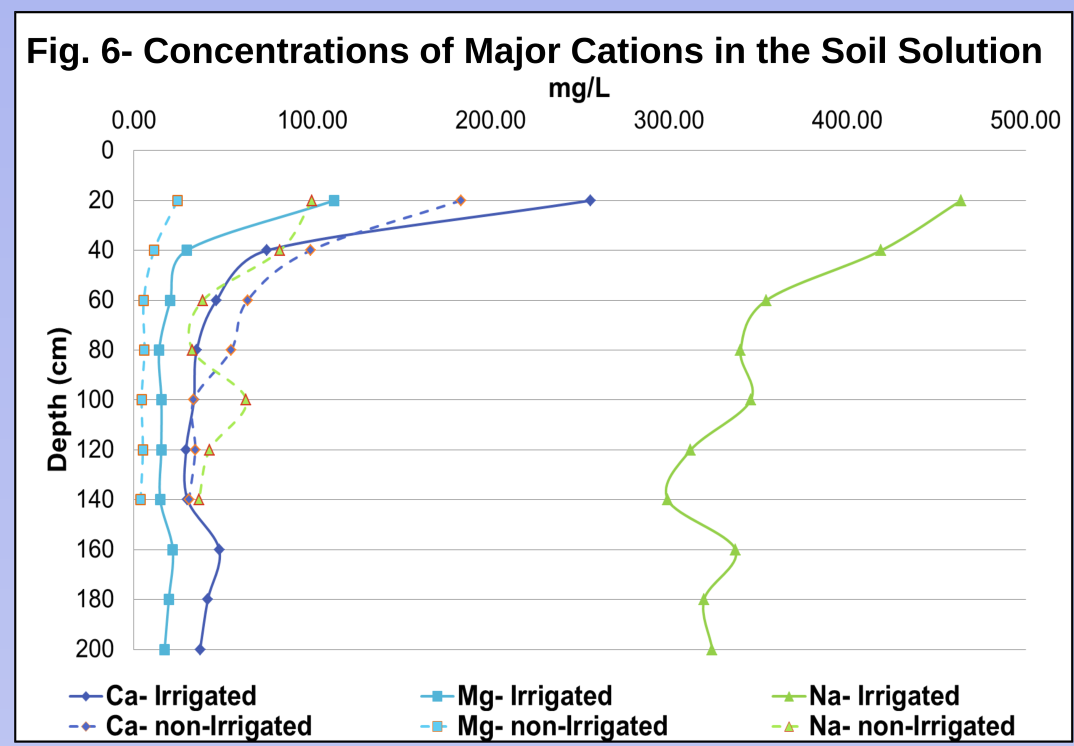

Fig. 6- Concentrations of Major Cations in the Soil Solution

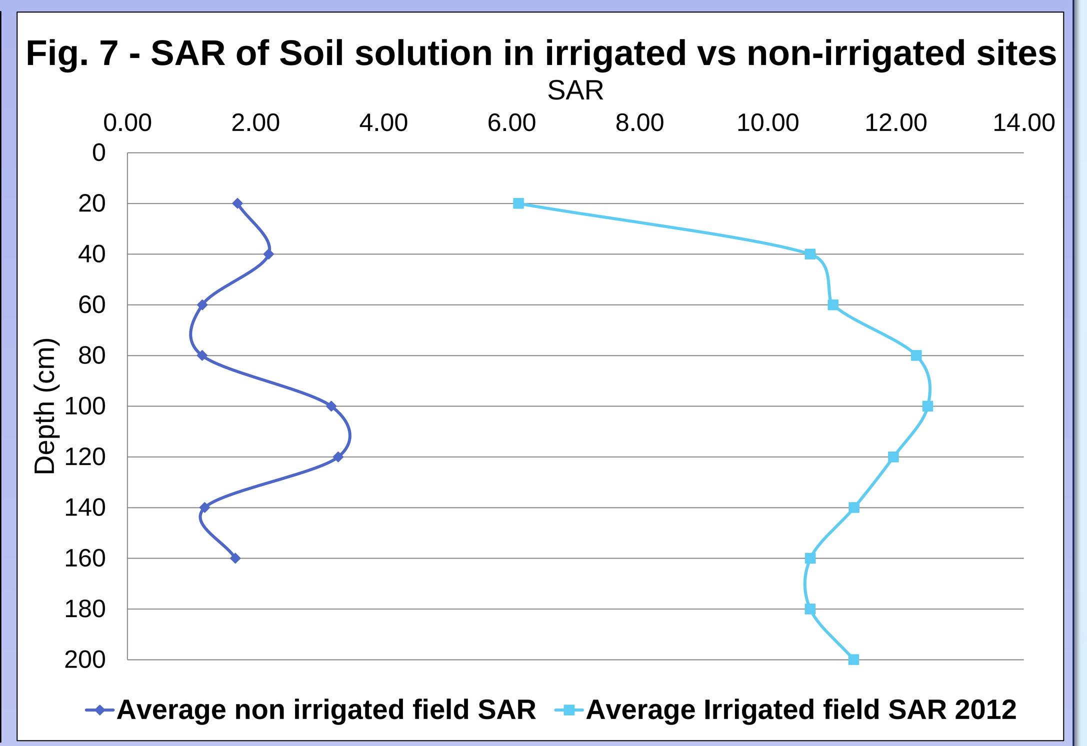

Fig. 7 - SAR of Soil solution in irrigated vs non-irrigated sites

Summary

Modified from Ayres and Westcot (1989), Fig. 8, serves as a guideline for irrigation water use where salts are an issue. It demonstrates a relationship between SAR, EC, and the extent of expected reduction in infiltration. Plotted are effluent and soil solution values.

Fig. 8 suggests that use of the **effluent has increased the soil solution SAR** values such that **a reduction in hydraulic conductivity may occur**, especially at depth. These conclusions warrant further research into the relationship between SAR, EC, and Ksat within these humid region soils.

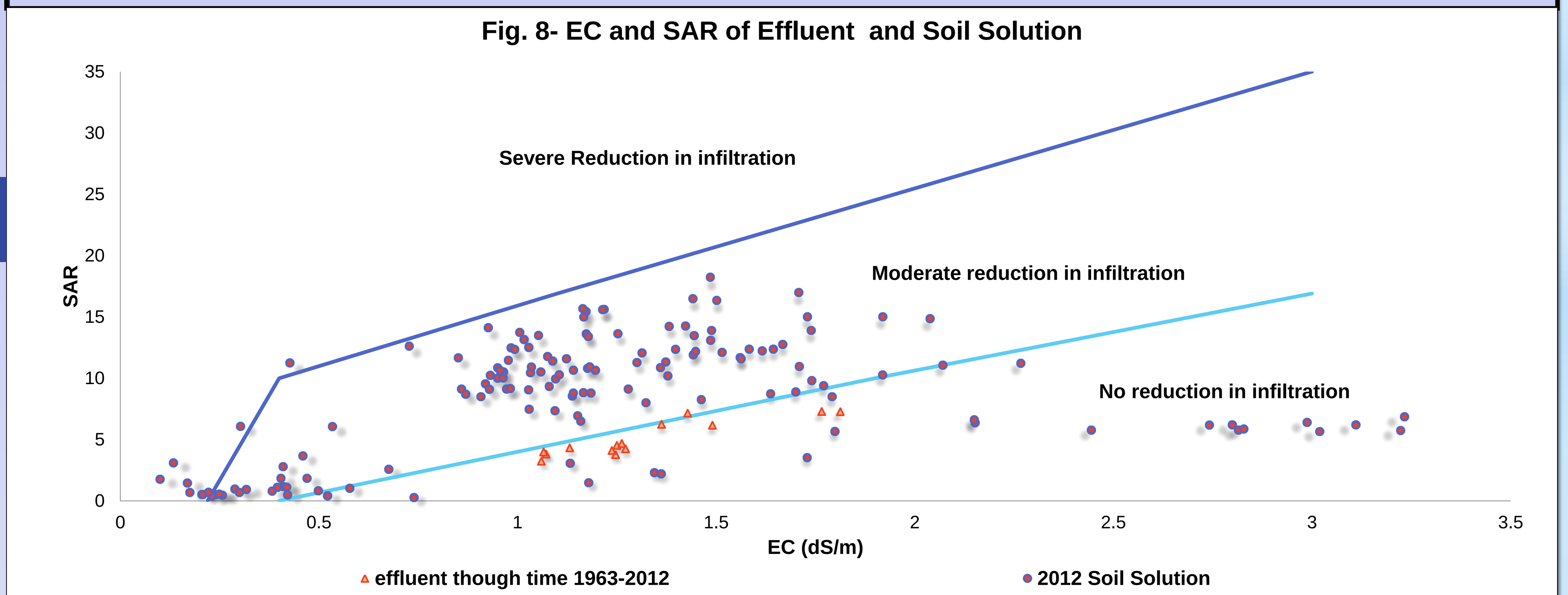

Fig. 8- EC and SAR of Effluent and Soil Solution

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For further information

Please contact *tdr148@psu.edu*. More information on this and related projects can be obtained at : http://ecosystems.psu.edu/research/labs/soil-water-quality

Literature cited

1. Ayers, R. S., and D. W. Westcot. 1989 “Water Quality for Agriculture.” Rep. no. 29. 1st ed. Rome: Food and Agriculture Organization of the United Nations. Print.
2. Goncalves, R.A.B., M.V. Folegatti, T.V. Gloaguen, P.L. Libardi, C.R. Montes, Y. Lucas, C.T.S. Dias, and A.J. Melfi. 2007. “Hydraulic conductivity of a soil irrigated with treated sewage effluent.” Geoderma 139:241-248.