GLOBAL SYMPOSIUM ON
SALT-AFFECTED SOILS

20 - 22
October, 2021
Virtual meeting

Soil salinity control in an era of risks and opportunities: Insights from physically-based numerical simulations of flow and transport

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Introduction

Declining water resources impose irrigation with low-quality water (LQW) .

Irrigation with LQW may have negative effects on crop, soil; hence on water & solute movement, and, eventually, on groundwater quality.

Irrigation management schemes, therefore, should consider ***soil salinity control***.

Objectives of the Presentation

(i) To assess consequences of soil salinity control based on the leaching requirement (LR) concept on crop yield and groundwater quality.

(ii) To present and analyze advanced, data-driven, irrigation management schemes for salinity control.

The Methodology

Physically based, 3-D numerical simulations of flow (RE) and transport (ADE) in variably saturated soils, are used.

Plant-soil-water-salt interactions, along with realistic features of the flow system
(*i.e.*, temporal and/or spatial variations of soil, plant, irrigation system, weather and water table) are considered.

Salinity Control - the LR Concept

It is based on a simplified, mass balance approach; the complex plant-soil-water-salt interactions are disregarded.

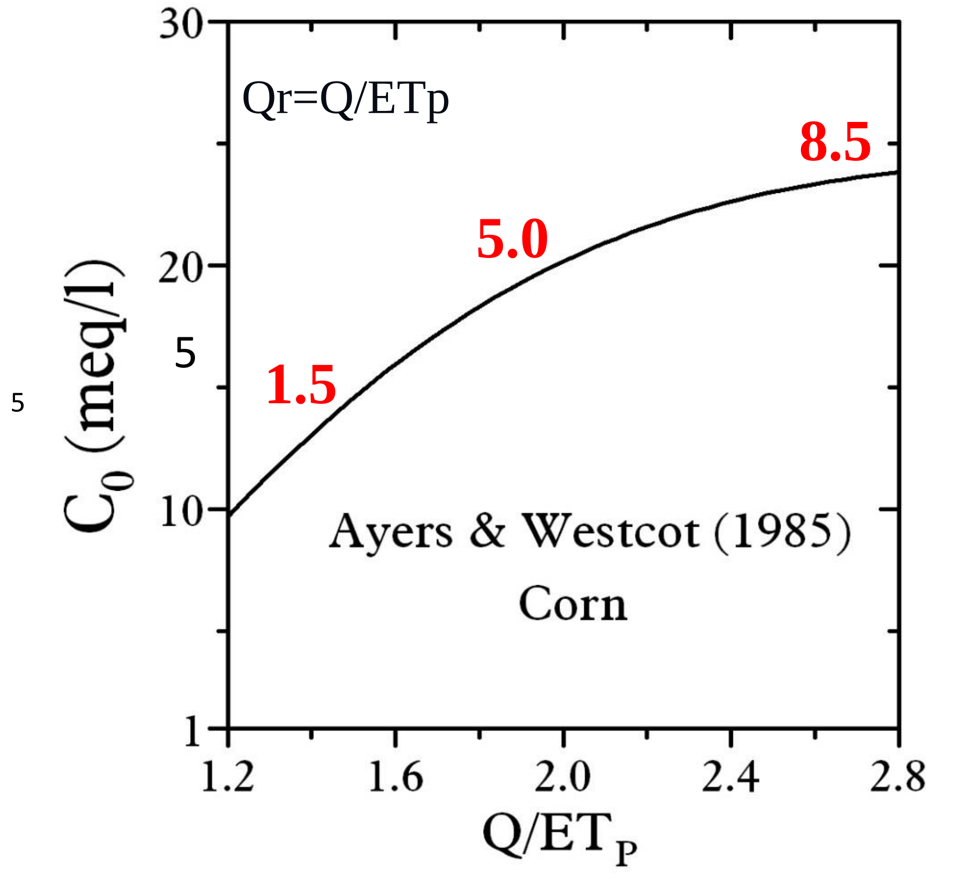
It promotes salt removal from the soil by ***applying excess amount of irrigation water.***

For a given water quality (C_0), it determines the quantity (Q) required to maintain a salinity level that allows a relatively low drop in crop yield, Y.

An example of application of the LR concept is the C_0-Q_r substitutions based on the FAO's recommendations.

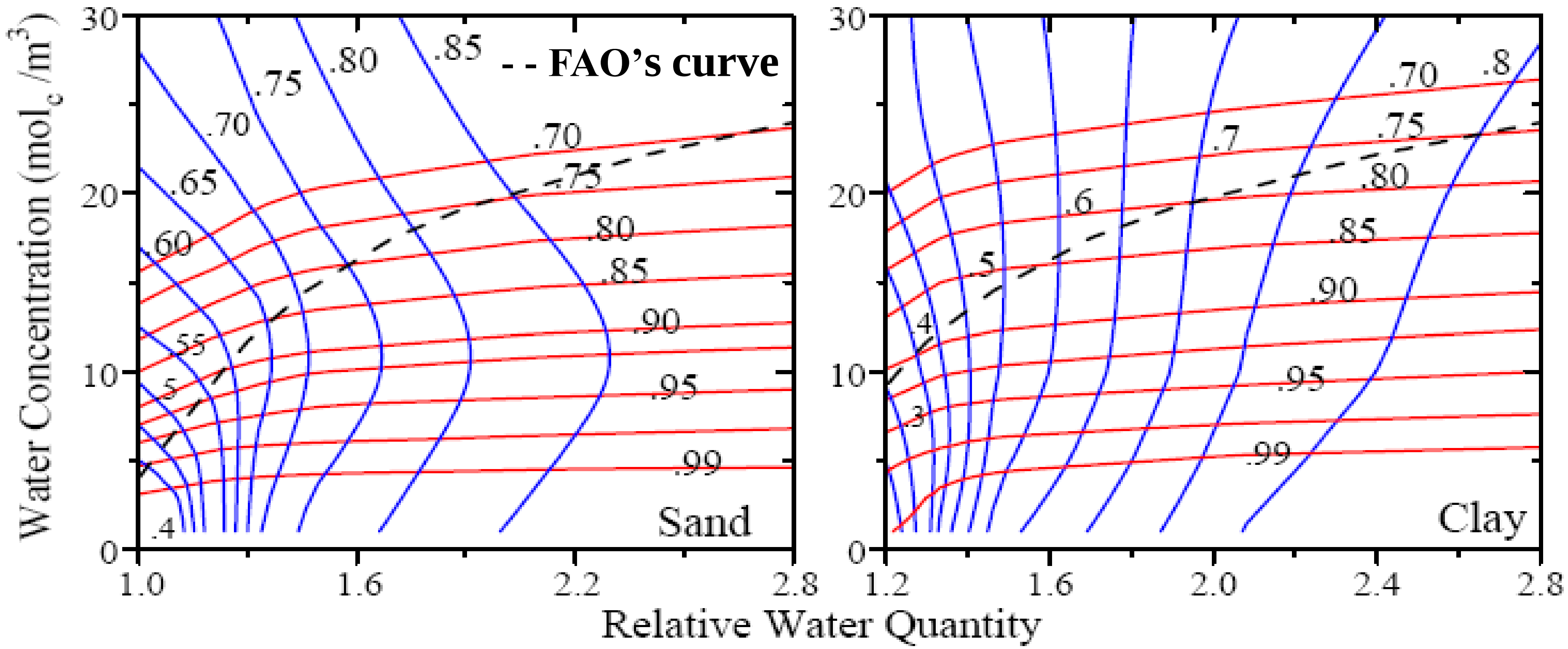
Considering irrigation with LQW, the FAO's C_0-Q_r substitutions curve may substantially increase salt leaching below the root zone, and, consequently, its load at the groundwater.

FAO's C_0-Q_r substitutions for 10% reduction in corn yield



in RED Chloride mass added by Irrigation (Ton/Ha/Yr)

Assessment of the LR Concept - Results of numerical simulations (corn under drip irrigation)



Iso-lines of relative transpiration, $T_r=T_a/T_p$ (**red**) and relative mass leached below the root zone, $L_r=M_L/M_T$ (**blue**); $M_T=M_A+M_I$; $Y_a/Y_p \approx T_a/T_p$.

Results of the simulations suggest that:

1. In contrast to the FAO's recommendations, when low-quality water is used, *the damage to the crop yield is unavoidable*, *and salt load at the groundwater increases substantially.*

2. For both soils, from both agricultural, and, particularly, environmental perspectives, ***irrigation with high-quality water is desirable***.

Irrigation with High-Quality Water (HQW)

In recent years, desalinated water (DSW) becomes a competitive source of HQW for irrigation.

This development allows a different approach for soil salinity control, namely, ***salt removal from the irrigation water prior to its application to the soil***.

Cost may restrict the use of DSW for irrigation. Efficient use of DSW for irrigation and salinity control should rely on a ***data-driven irrigation management scheme***.

Salinity Control by the ADW Scheme

The data-driven ADW scheme requires access to water of two distinct qualities, *e.g.*, treated waste water (TWW) and DSW, which may be obtained by desalinization of TWW.

The scheme's goal is to reduce the consumption of DSW, while minimizing damage to crop and environment resulting from the use of TWW.

Temporal changes in soil salinity, C=Ccl, measured by soil sensors at soil depth within the soil volume active in water uptake, Zup(t), are used to alternate irrigation water quality between TWW and DSW.

When C[Zup(t),t] exceeds a ***user-controlled, critical value,*** **Ccr**, TWW is replaced by DSW, and *vice versa*, when C[Zup(t),t] descends to a level lower than Ccr.

Notice: The ADW can be extended to account for Nitrate as well.

Results for a citrus orchard under drip irrigation, the role of the user-controlled, Ccr

C_{cr} (meq/ℓ)	F_{DW}	[1]T'_a	[1]M'_L
15	0.771	1.285	0.359
20	0.662	1.272	0.445
25	0.572	1.252	0.536
30	0.452	1.223	0.644

[1]relative to TWW after 7 years

Clearly, Ccr determines the performance of the ADW scheme, *i.e.*, the required volume fraction of DSW (F_{DW}), and the resultant improvement in crop yield (higher T_a) and groundwater quality (lower M_L).

Concluding Remarks

Unlike local sources of contamination at the soil surface, agricultural fields are distributed over large regions. Consequently, their relative contribution to groundwater contamination/salinization is profound.

Considering irrigated agriculture, therefore, from both crop production, and, particularly, groundwater quality perspectives, ***a sustainable decrease in the solutes' load at the soil surface is desirable***.

The data-driven ADW scheme, which alternates irrigation water quality considering the solutes’ concentrations in the active part of the root zone, reduces the solutes load at the soil surface, and, therefore, might have a substantial impact on groundwater quality.

Cost-performance analysis of the ADW scheme should consider *the improvement in the quality of the water drained below the root zone.*

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