GLOWA Jordan River

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Jordan River

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Soil property changes under treated wastewater irrigation

Bernd Marschner, Karsten Schacht, Elisabeth Jüschke (RUB)
Yona Chen, Jorge Tarchitzky, Edo Guttman (HUJI)

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The Problem of Treated Wastewater (TWW)

Generally elevated concentrations of

- nutrients (esp. N and P)

but also

- salts
- dissolved and particulate organic matter (≈ BOD)
- inorganic and organic pollutants

- Irrigation can cause adverse effects on physical, chemical and biological soil properties
- Site-specific evaluation of the soil suitability for irrigation with TWW and a local risk assessment required

Materials and Methods

Three Soils

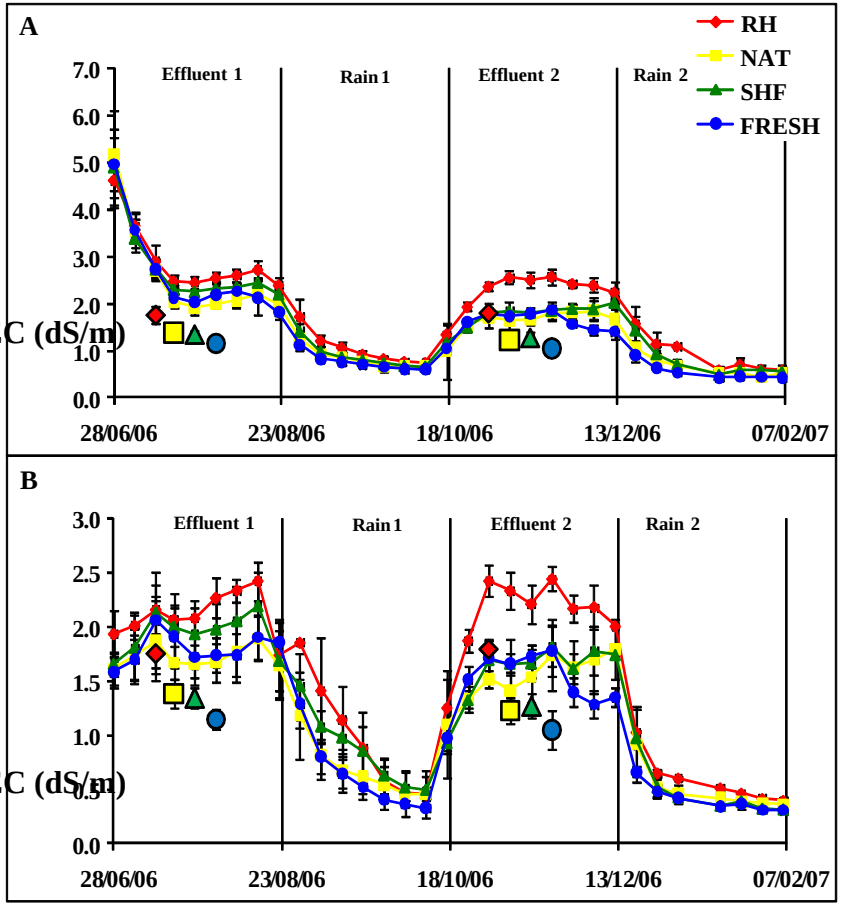
- Grumosol - Banana plantation in Ga'aton (clay-rich)
- Loess - vinyard in Tel Arad (sandy loam)
- Hamra soil - citrus orchard in Bazra (sand)

Four Water qualities

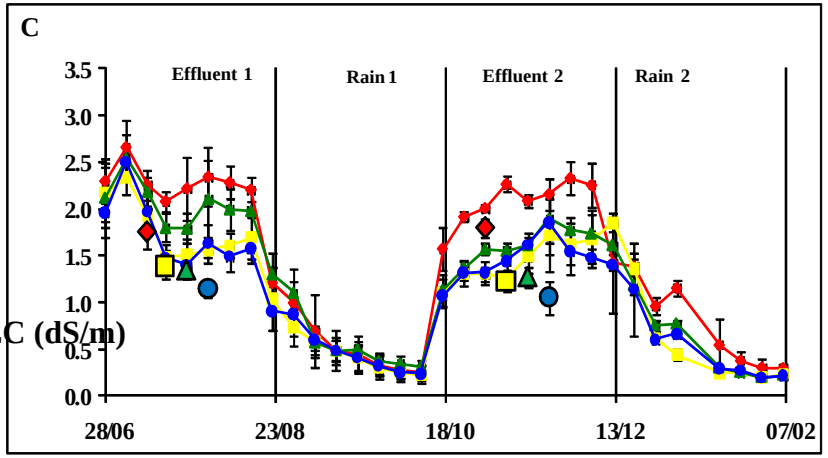
- **RH** (Ramat Hakovesh): secondary TWW (low level). Aerobic and anaerobic pond, filtration and chlorination
- **NAT** (Netanya): secondary TWW (activated sludge)
- **SHF** (Shafdan): tertiary treatment. Activated sludge and soil-aquifer treatment process.
- **FRESH** (Potable water - Bet Dagan): tap water in the experimental greenhouse (control)

Electrical Conductivity (EC) in drainage water

Grumosol



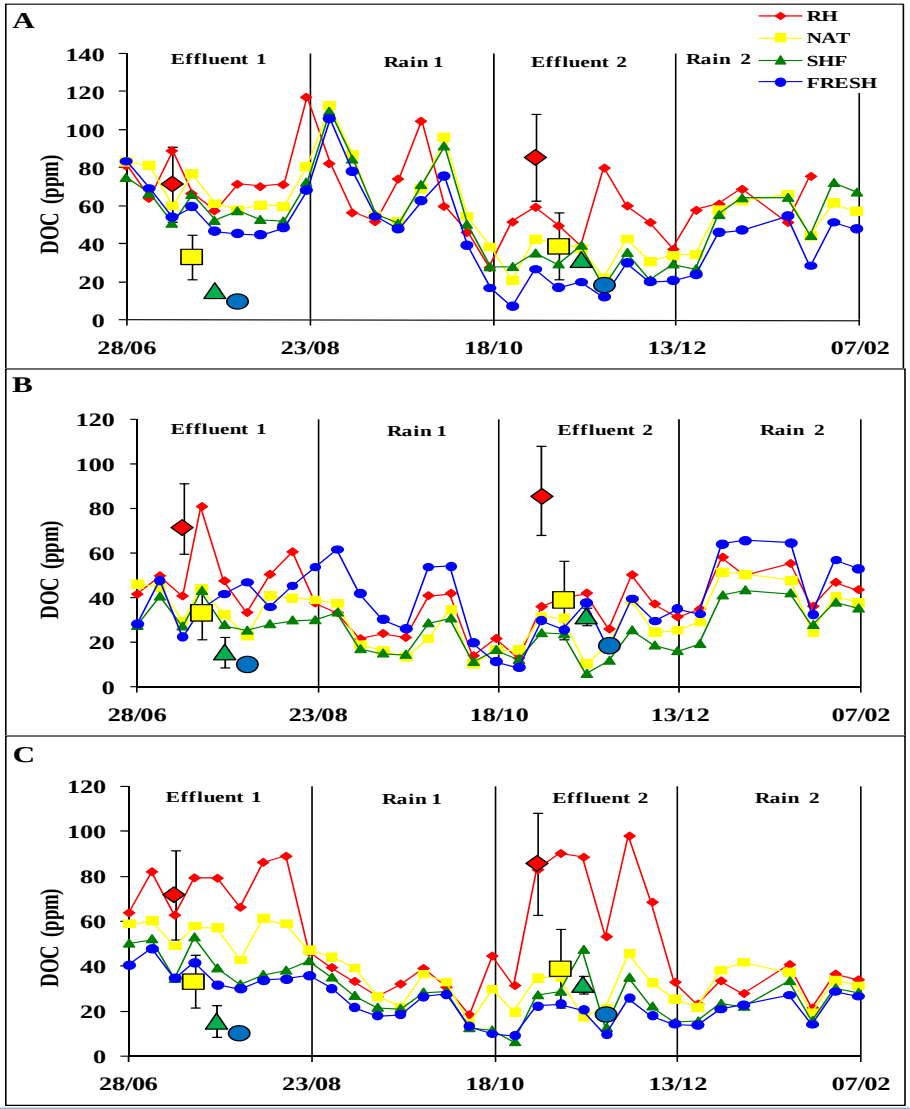
Hamra



- EC initially highest in Grumosol
- High salinity irrigation water (RH) causes highest EC in drainage
- During rain period, salts are completely leached from all soils

Loess

Dissolved Organic Carbon (DOC)



Grumosol

Loess

Hamra

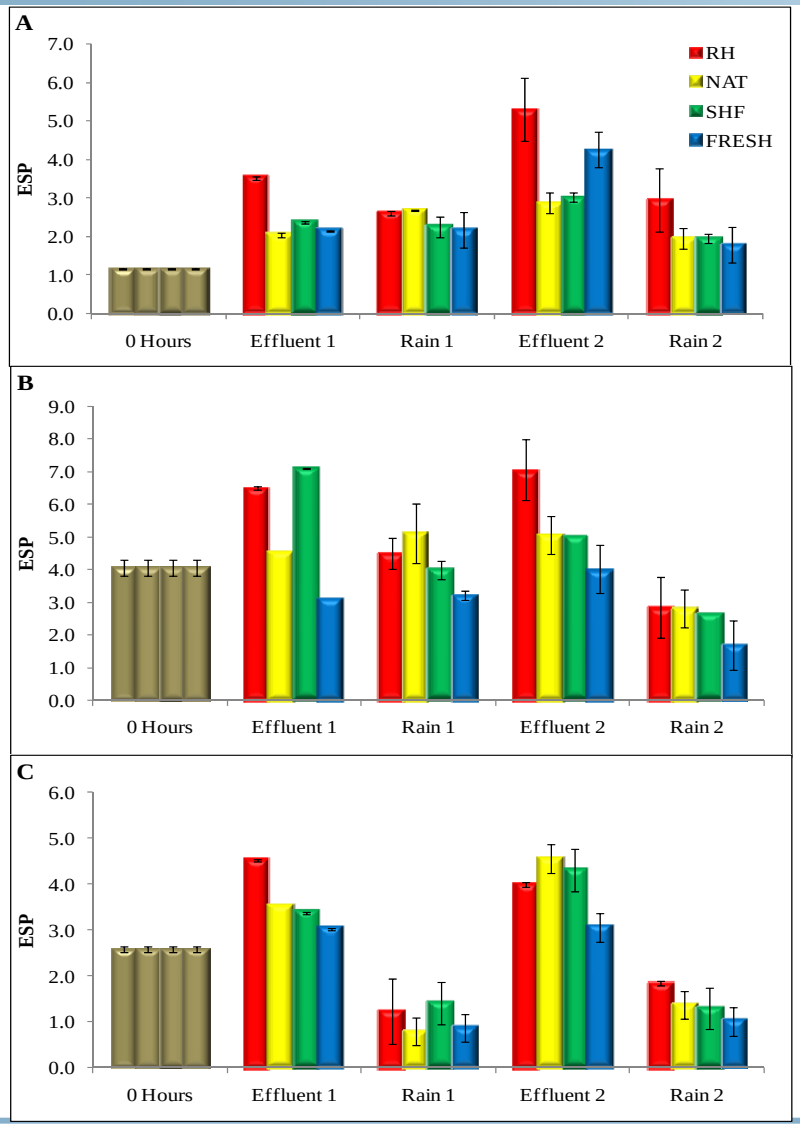
- In Grumosol and Loess, no effect of water quality on DOC in drainage

➔ DOC is efficiently retained by sorption

- In Hamra, DOC from **RH**-water is easily leached

➔ high risk of DOC-associated transport of contaminants

Exchangeable Sodium % (ESP) in soil



Grumosol

Loess

Hamra

- In Grumosol, sodicity increases with time, especially with **RH** irrigation.

  ➔ high risk of soil sodization

- In Loess and Hamra, a low ESP is restored after rain periods.

  ➔ salts are easily exchanged and leached

Water Repellency Effects on Infiltration

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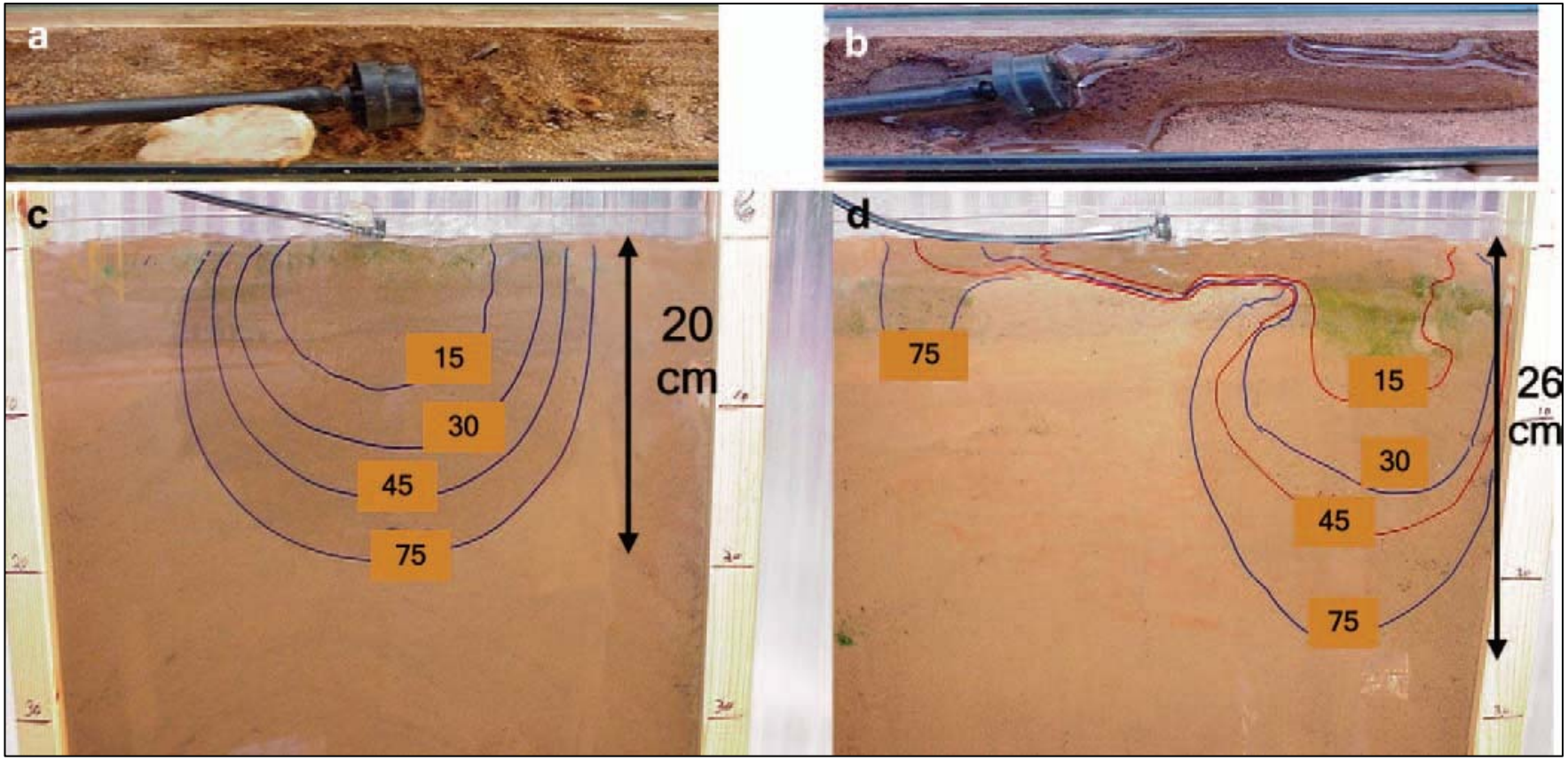
freshwater **treated wastewater**

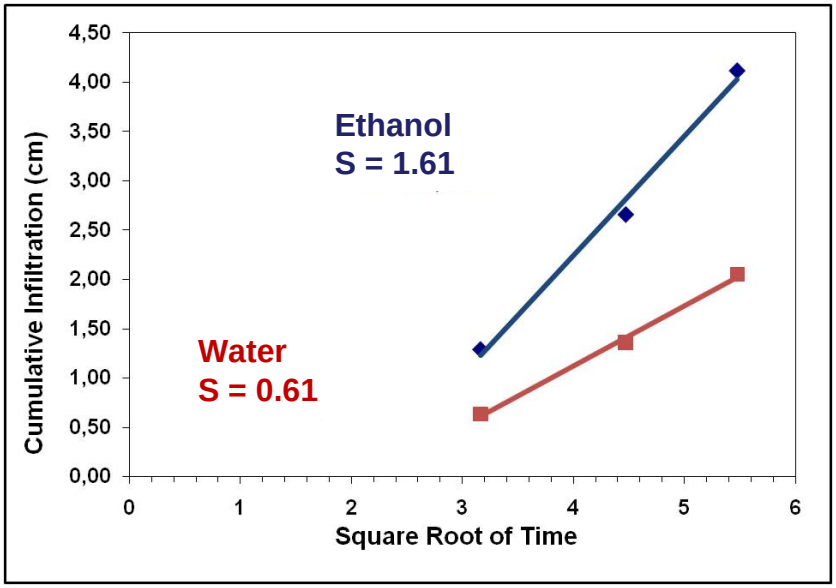


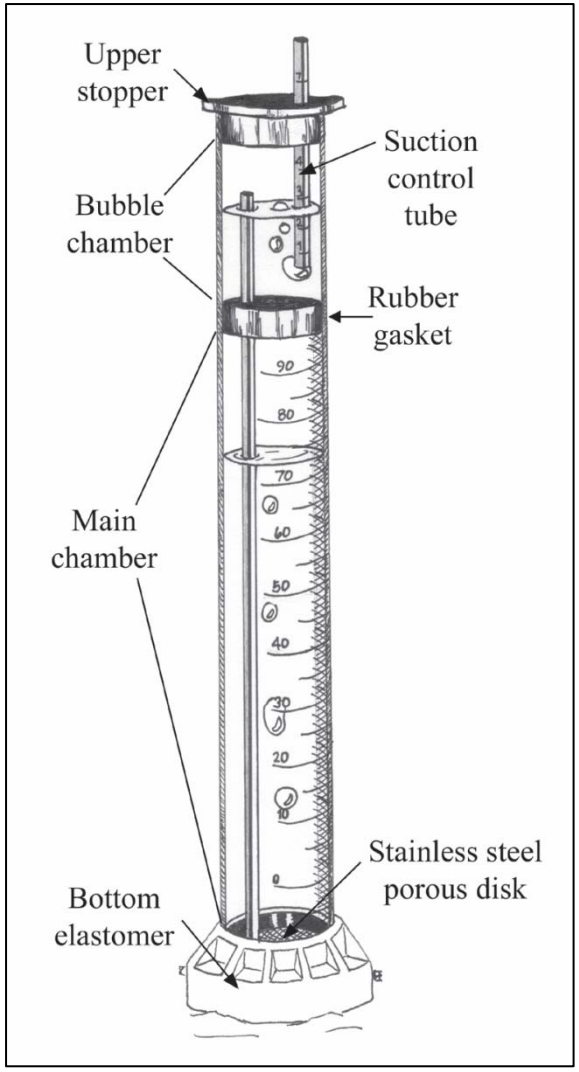
Water Repellency Index (R)

Mini-Disk Infiltrometer (MDI)

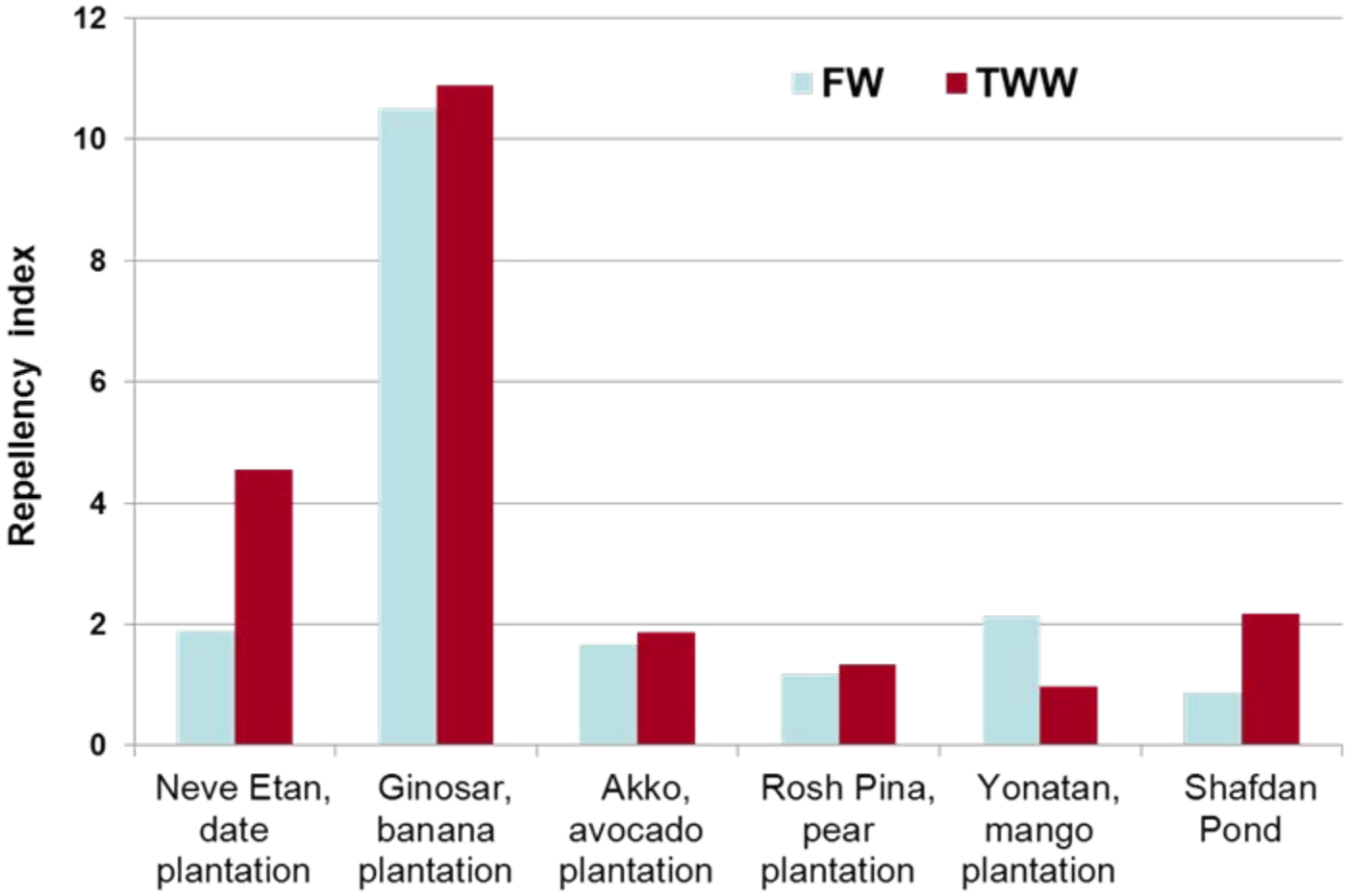
- Determination of infiltration rates of water and ethanol

$$R = 1.95\left(\frac{S_{\text{ethanol}}}{S_{\text{water}}}\right)$$





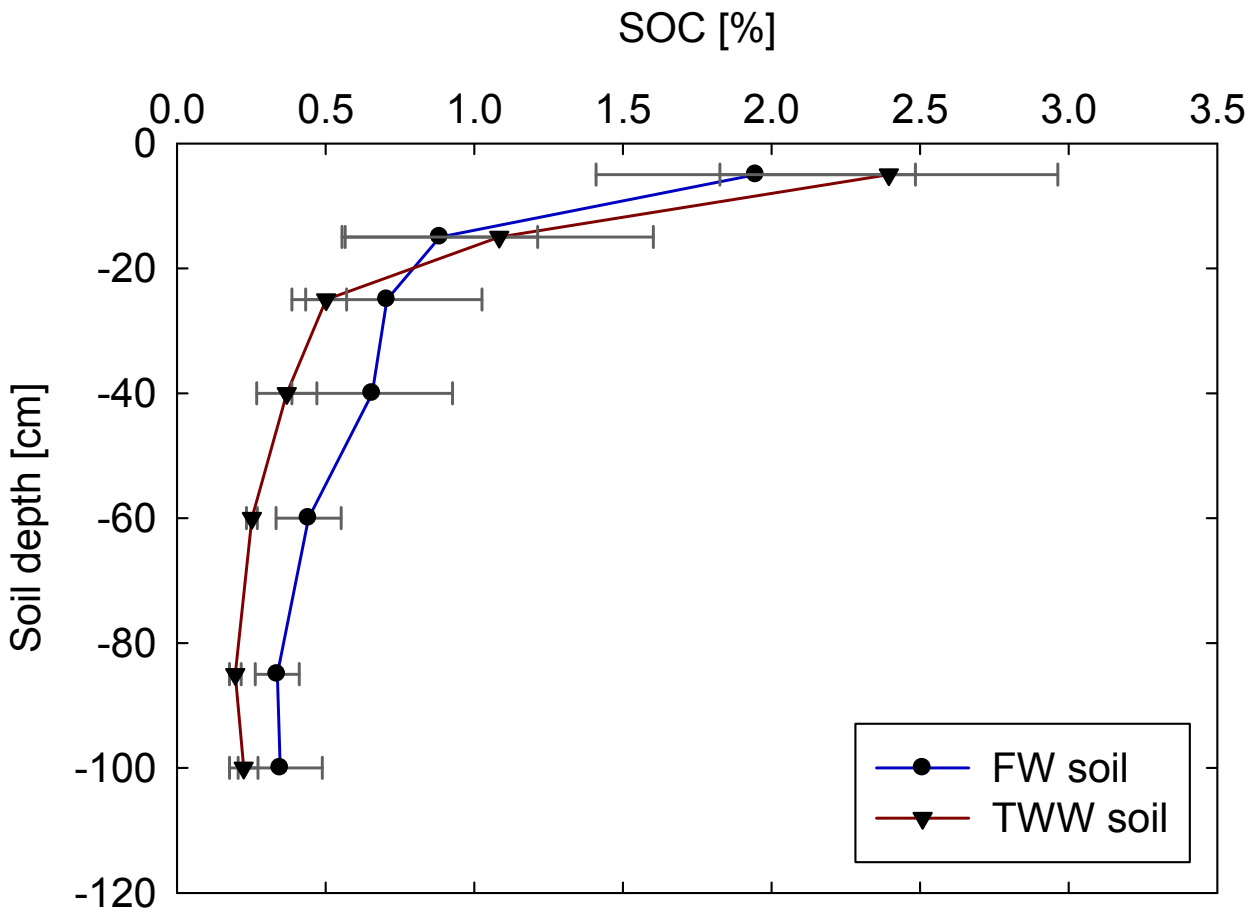
Water Repellency Index (R)



$$R = 1.95\left(\frac{S_{\text{ethanol}}}{S_{\text{water}}}\right)$$

- R is generally higher in soils irrigated with TWW

Soil Organic Carbon (SOC)



- Soils under TWW irrigation generally contain more SOC in the topsoil but less SOC in the subsoil
- Overall TWW induced SOC losses amount to 12-30 t/ha
- Based on duration of TWW irrigation, annual losses are about 1 t/ha

Microbiological Parameters

Three soil profiles in Bazra, Acco and Wadi Fara

Soil depth [cm]	α-glu	ß-Xyl	N-acet	ß-glucoro	ß-cello	ß-glu	pho	Leu	Tyr	Arg
0-10		+	++	+	++	++	+ -	++	+++	++
10-20	+	+		+	+	+	+	++	+	+
20-30		+		+	++	++	++	++	+	++
30-50	+ -	+ -	+ -		+	+	++	+	+ -	++
50-70		+ -	+ -	-		+ -	+	++ -	-	+ -
70-100	-	-	-		-	-	-	-	-	+ -

Bazra, Acco and Wadi Fara

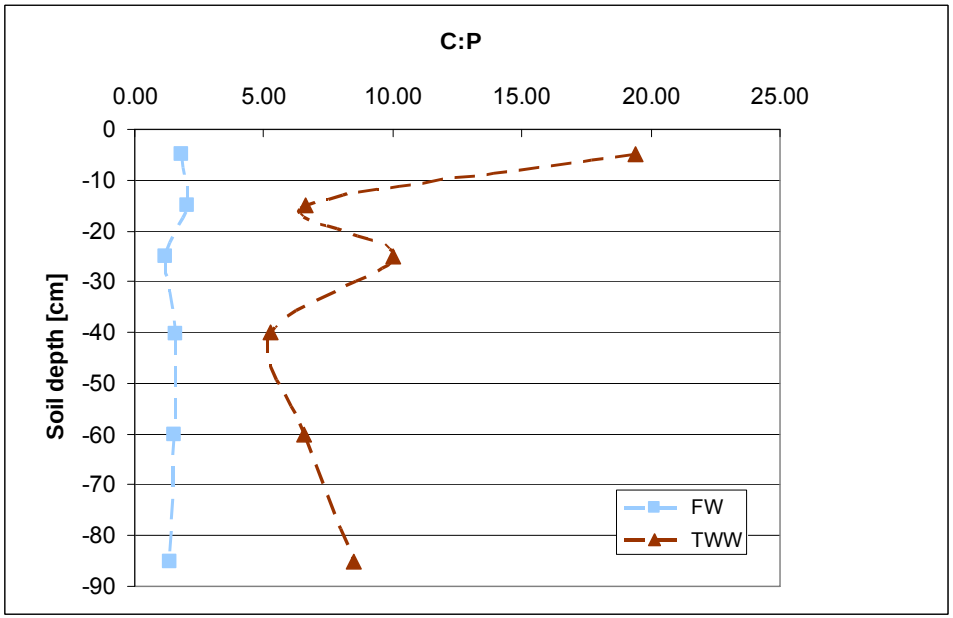
	no difference between TWW and FW
- - -	TWW < FW (three sampling sites)
- -	TWW < FW (two sampling sites)
-	TWW < FW (one sampling site)
+ - -	TWW < FW (two sampling sites) and TWW > FW (one sampling site)
+ -	TWW < FW (one sampling site) and TWW > FW (one sampling site)
++ -	TWW < FW (one sampling site) and TWW > FW (two sampling sites)
+	TWW > FW (one sampling site)
++	TWW > FW (two sampling sites)
+++	TWW > FW (three sampling sites)

Student t-Test p<0.05

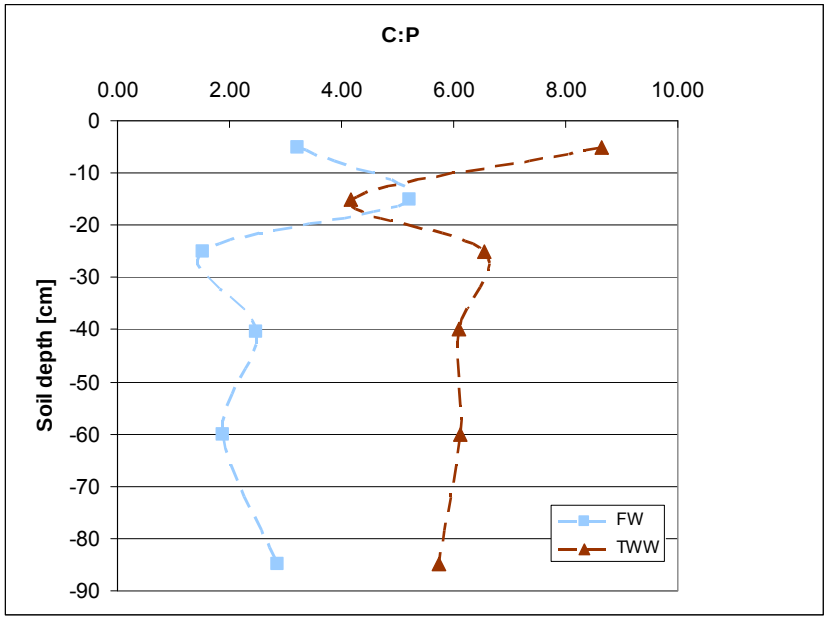
(2) - only two of three sampling sites showed significant differences between control and treated sample, therefore only these values were calculated

Ratio of Enzyme Activities from C & P Cycle

Acco



Bazra



- With TWW irrigation, ratio of C:P enzyme activities is higher throughout the soil profiles
- Due to high P-inputs with TWW, plants and microorganisms need less enzymes for P-nutrition

Conclusions – TWW Irrigation

- In clay-rich soils the risk of salinization, sodicity increases and hydraulic conductivity reduces, thus posing a risk for soil degradation
- In sandy soils, salts and DOC are easily leached, enhancing the risk for groundwater pollution.
- In sandy soils, water repellency can be induced and preferential fowpaths can be promoted, thus reducing water use efficiency and enhancing solute leaching.
- In most investigated soils, microbial activity is stimulated and SOC in the subsoils decreases.
- Soil enzyme activities indicate an adaptation of soil microbiota and plant roots to the increased nutrient and carbon inputs under TWW irrigation.

Thank you