The Chemistry of Salinity in Soils

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Introduction

- Salinity concentrations in soils have profound effects on soil properties
  - Poor drainage, nutrient deficiencies, and crop toxicity
- Factors in soil salinity include:
  - Arid climates
  - Erosion of primary minerals
  - Saline irrigation and drainage waters
  - High water table
  - High potential Evapotranspiration
  - Additions of inorganic and organic fertilizers
  - Sludges and sewage effluents

"The term Salinity refers to the presence of the major dissolved inorganic solutes, essentially

Na^+, Mg^{2+}, Ca^{2+}, K^+,

Cl^-, $SO^2{}_4{}^-$, $HCO^-{}_3$, $CO^2{}_3{}^-$ "

SSSA BOOK SERIES: 5, METHODS OF SOIL ANALYSIS PT 3 – CHEMICAL METHODS.

(It could also include $NH_4{}^+$, NO_3, PO_4, and charged organic particles in aqueous (soil) samples when determined by electrical conductance)

Dissolved Solids (Salts)

- Intensity Factor – salt concentration in soil solution
- Capacity Factor – the ability of solid phases to replenish elements as it is depleted from solution

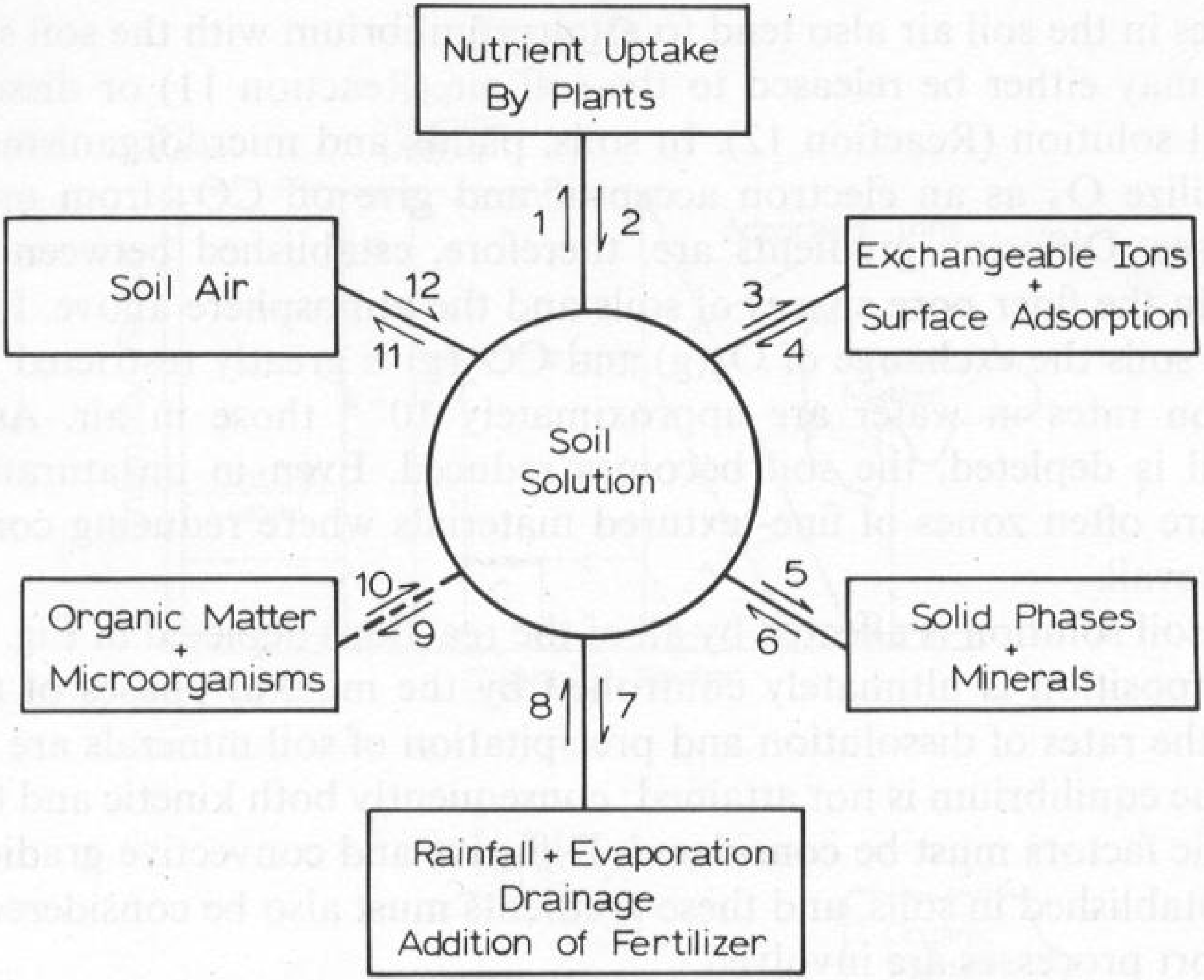


Fig. 1.1 The dynamic equilibria that occur in soils.

Salt Measurement – Intensity Factor

- Electrical Conductance – EC – Electrical current carried by a salt solution. EC increases as salt concentrations increase.

Soil Characteristics

- pH is generally below 8.5
- EC is more than 4 dS/m

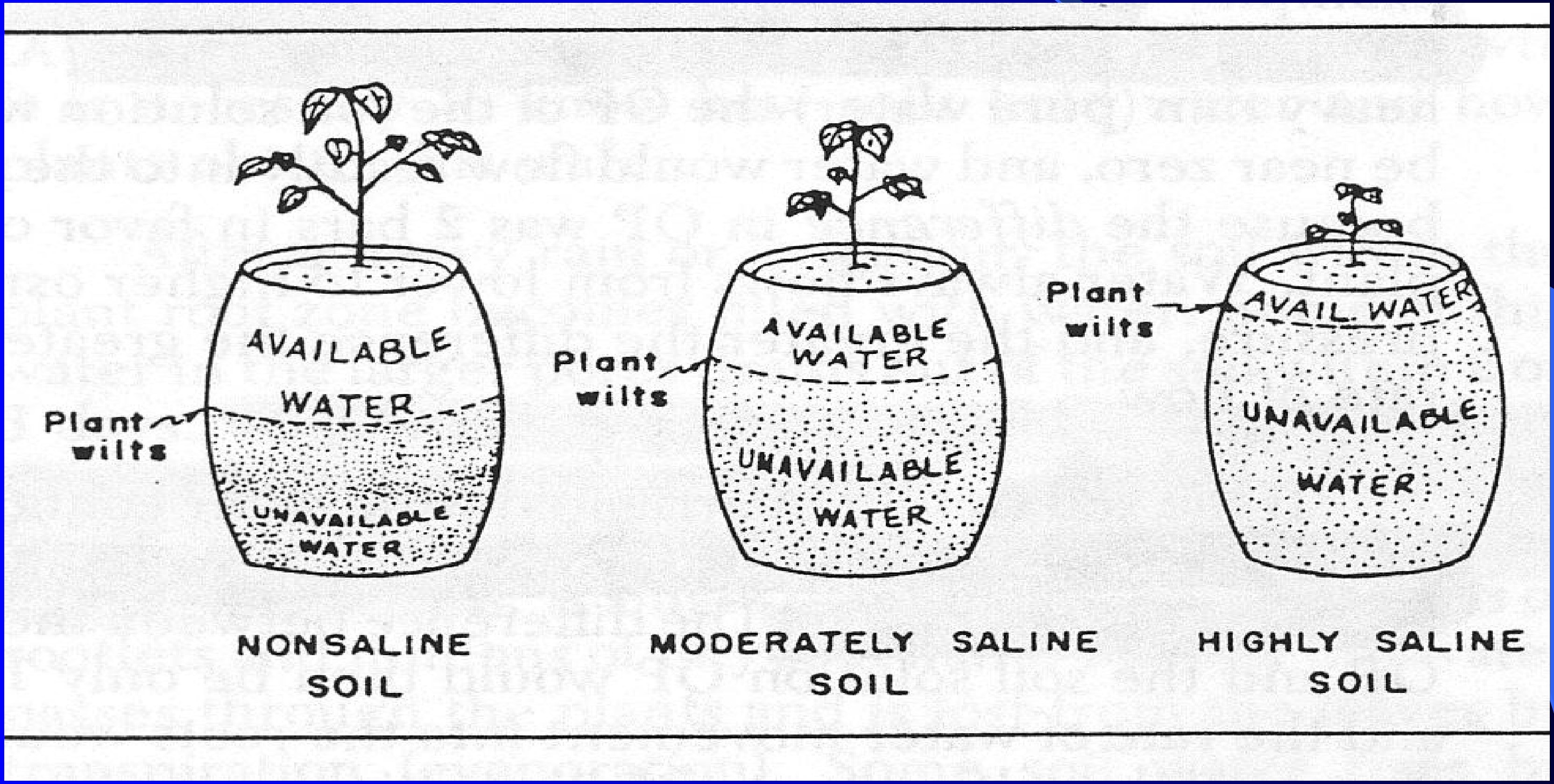
Calculations

- Total Dissolved Solids=(~640)(EC)
- Ionic Strength= (0.013)(EC)=$\Sigma c_i Z^2$
- Single-Ion Activity
  - $\alpha_j=\gamma_j m_j$ m=molar concentration
- Extended Debye Huckle Equation (estimate activity coefficients)
  - $\text{Log}\gamma=-AZ^2[(I)^{1/2}/(1+B\text{å}(I)^{1/2})]$
    - A=0.512 for water @ 25^{o}C,
    - B~0.33 in water @ 25^{o}C
    - å=adjustable parameter corresponding to ion size and charge (6)

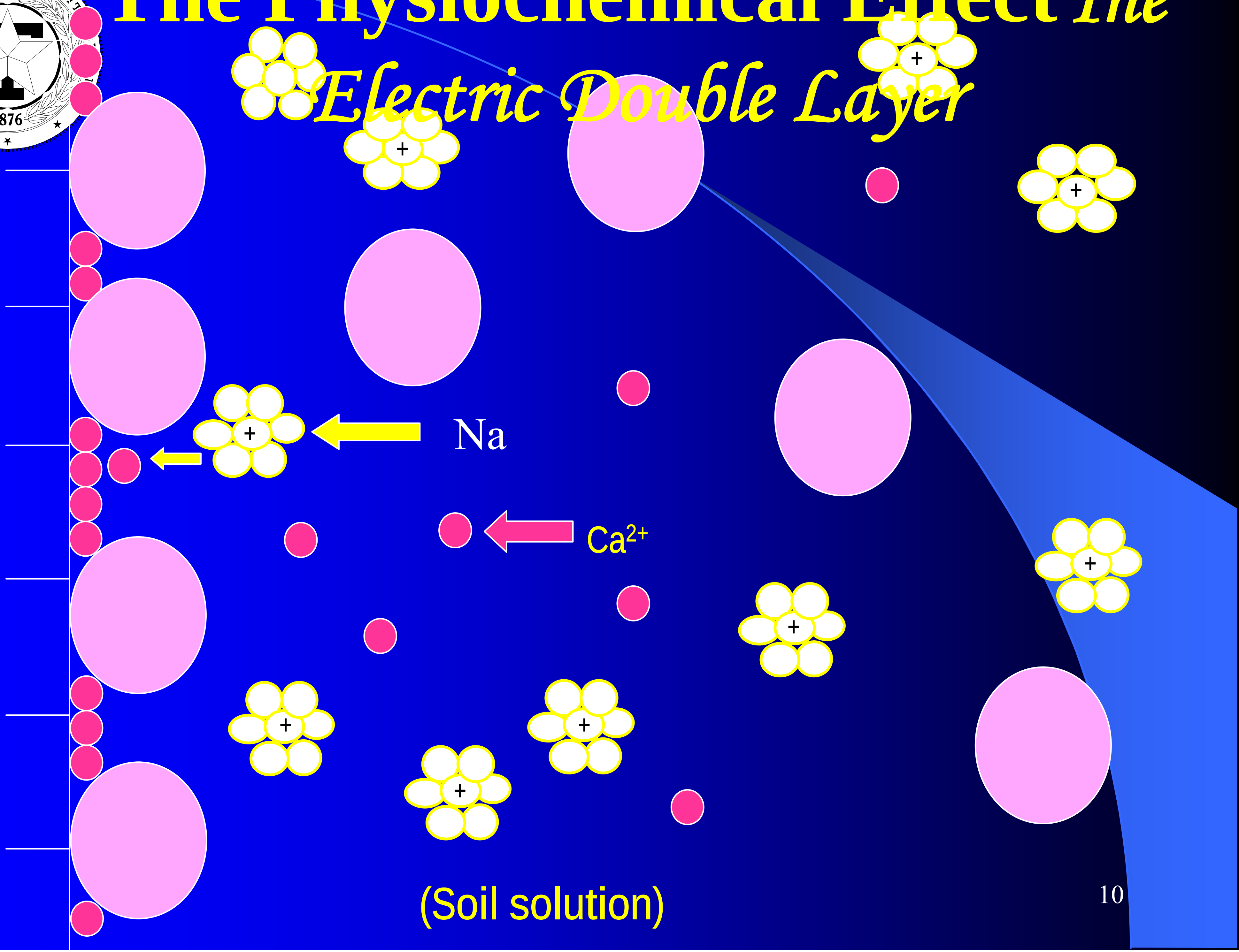
Factors Affecting Salt Dissolution

- Salt Effect or Ionic Strength Effect – Addition of an inert salt can increase the solubility of an ionic compound
  - Added NaCl can increase $CaSO_4$ dissolution
  - Increased ionic strength affects pH
- Ion pairing effect
  - Weak bonds between hydrated ions
- Common Ion Effect – a salt will be less soluble if one of its constituent ions is already present in the solution

Osmotic Potential (kPa) =40EC



The Physiochemical Effect *The Electric Double Layer*



Sodium Adsorption Ratio (SAR): Defined as being "related to the adsorption of sodium by the soil"

$$SAR = Na^{+} / (Ca^{++} + Mg^{++})/2$$

Na^{+}, Ca^{++}, and Mg^{++} in milliequivalent/L (Allison, 1954)

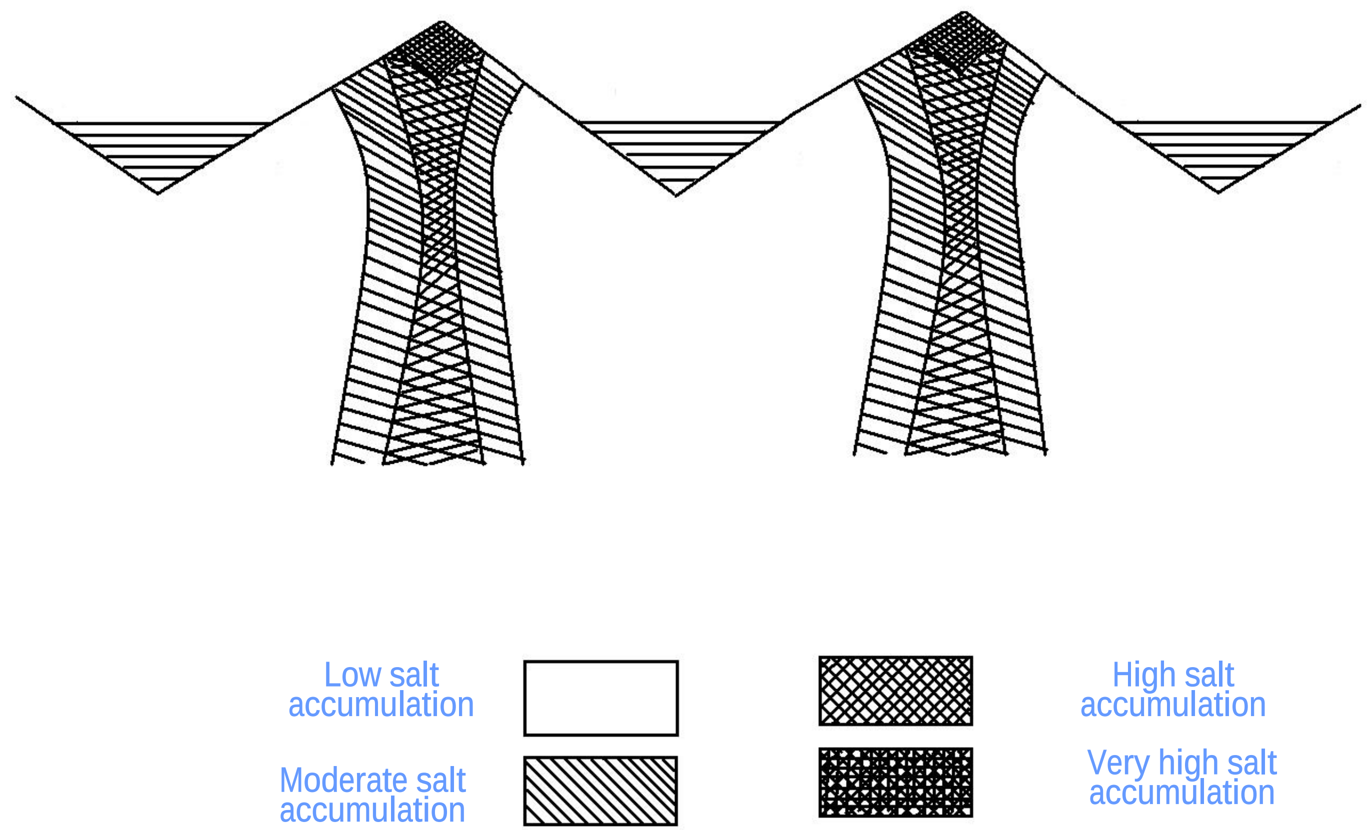
- Sodicity occurs when the ratio of sodium is much higher to that of other soluble salts.

Soil Characteristics

- pH ranges between 8.5 to 10, ESP>15
- Plastic and sticky when wet, forming hard clods and crusts
- Impermeable to all water.

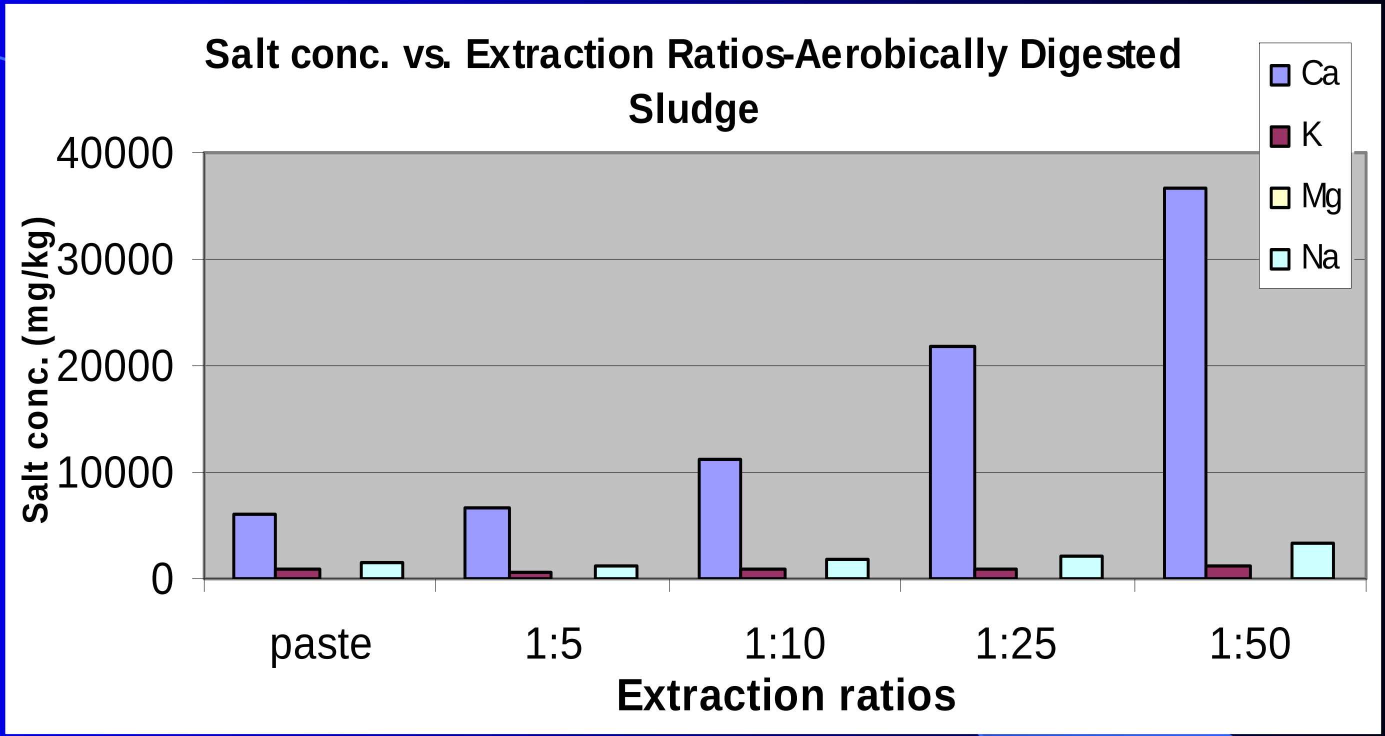
• Specific Ion Effect – Na ion can be inhibitory to certain plant processes

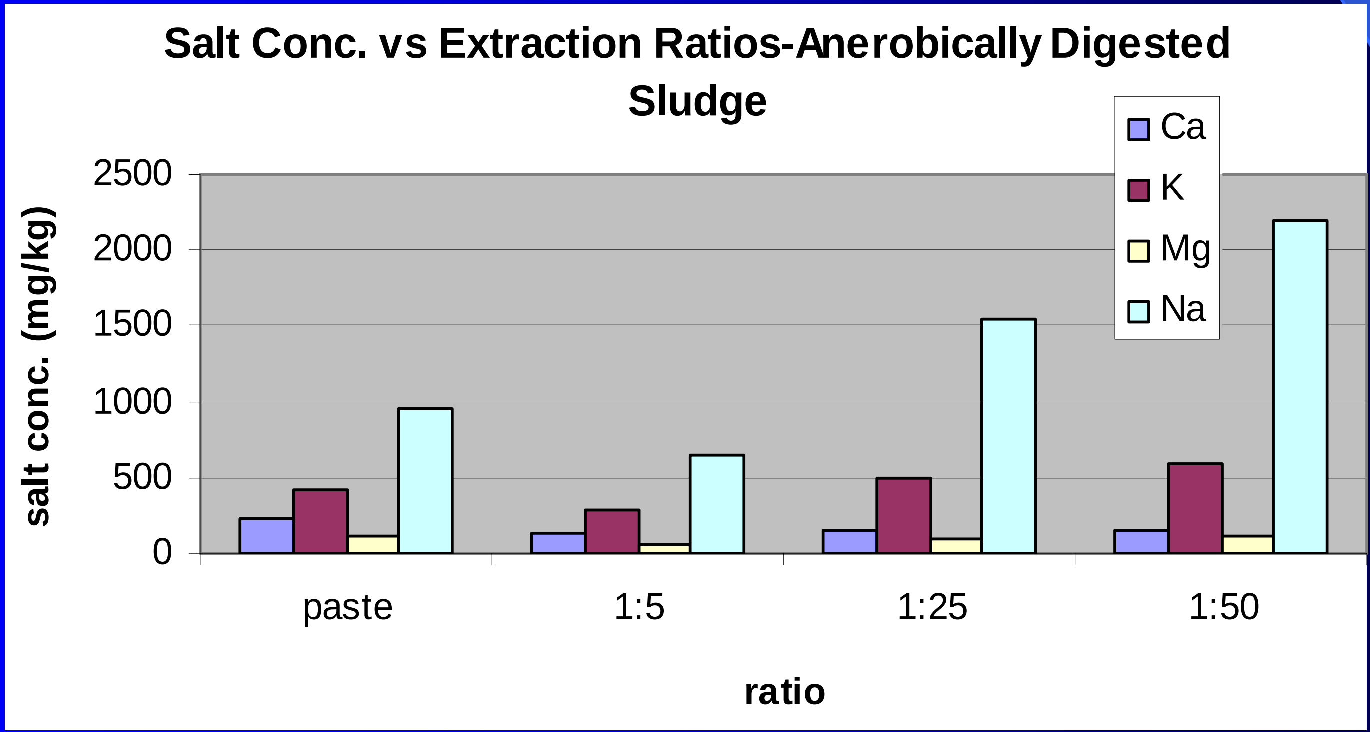
Surface Salt Pattern

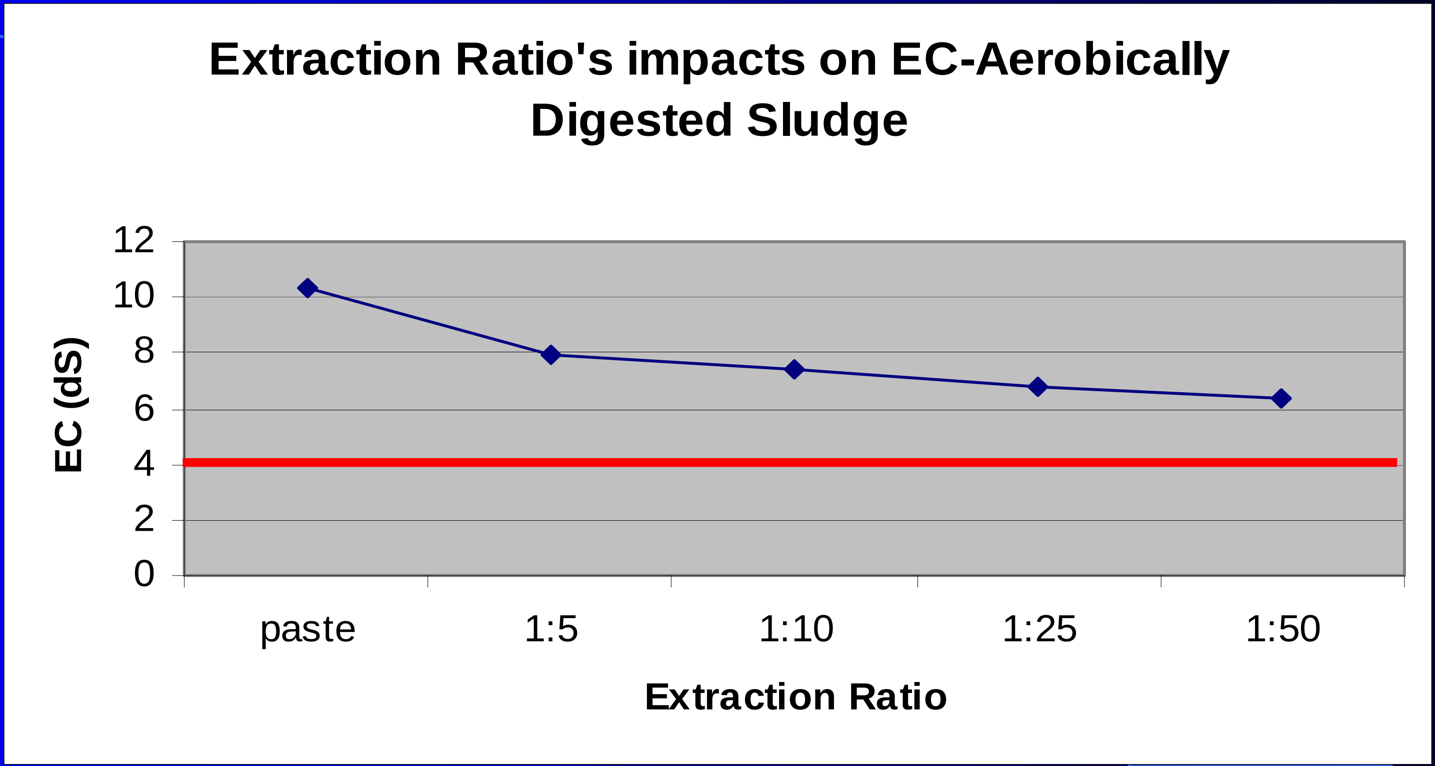


Current Research

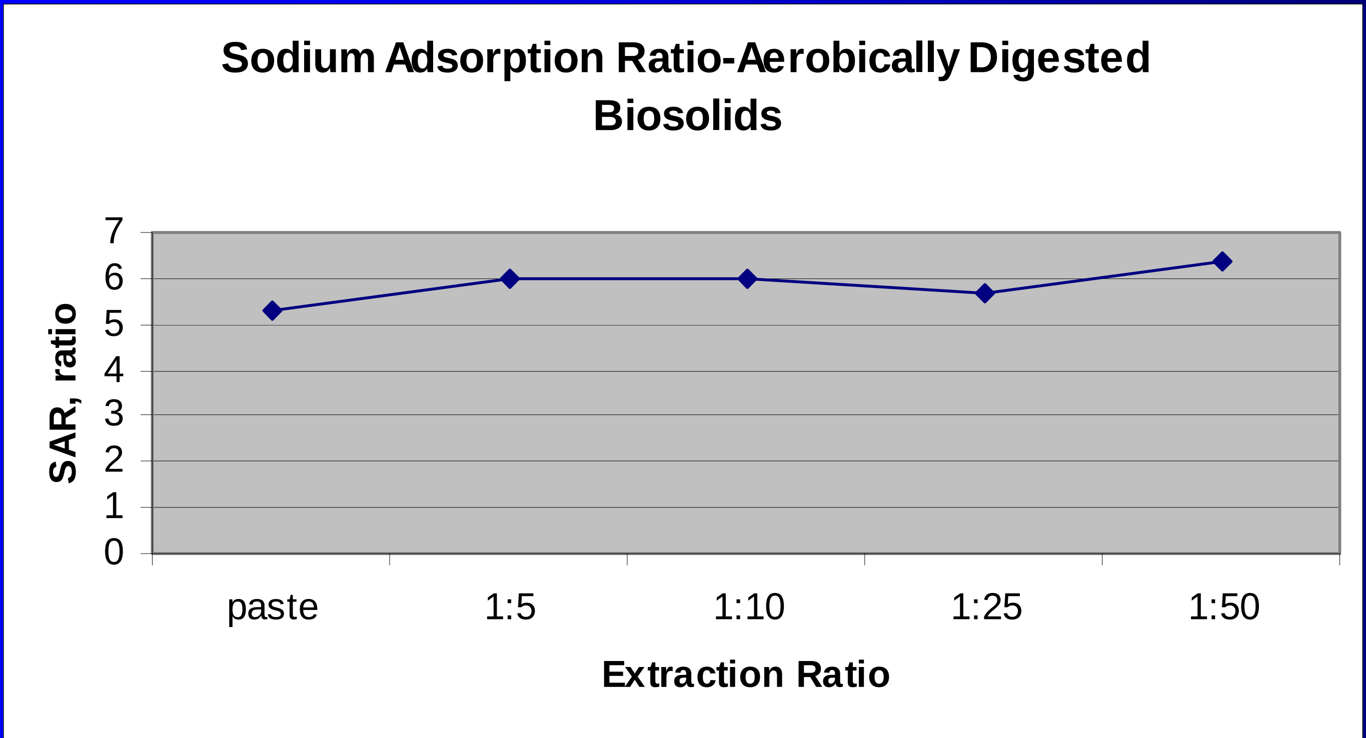
Study #1


Salt conc. vs. Extraction Ratios-Aerobically Digested Sludge
Salt conc. (mg/kg)
40000
30000
20000
10000
0
paste
1:5
1:10
1:25
1:50
Extraction ratios
Ca
K
Mg
Na


Salt Conc. vs Extraction Ratios-Anerobically Digested Sludge
salt conc. (mg/kg)
2500
2000
1500
1000
500
0
paste
1:5
1:25
1:50
ratio
Ca
K
Mg
Na

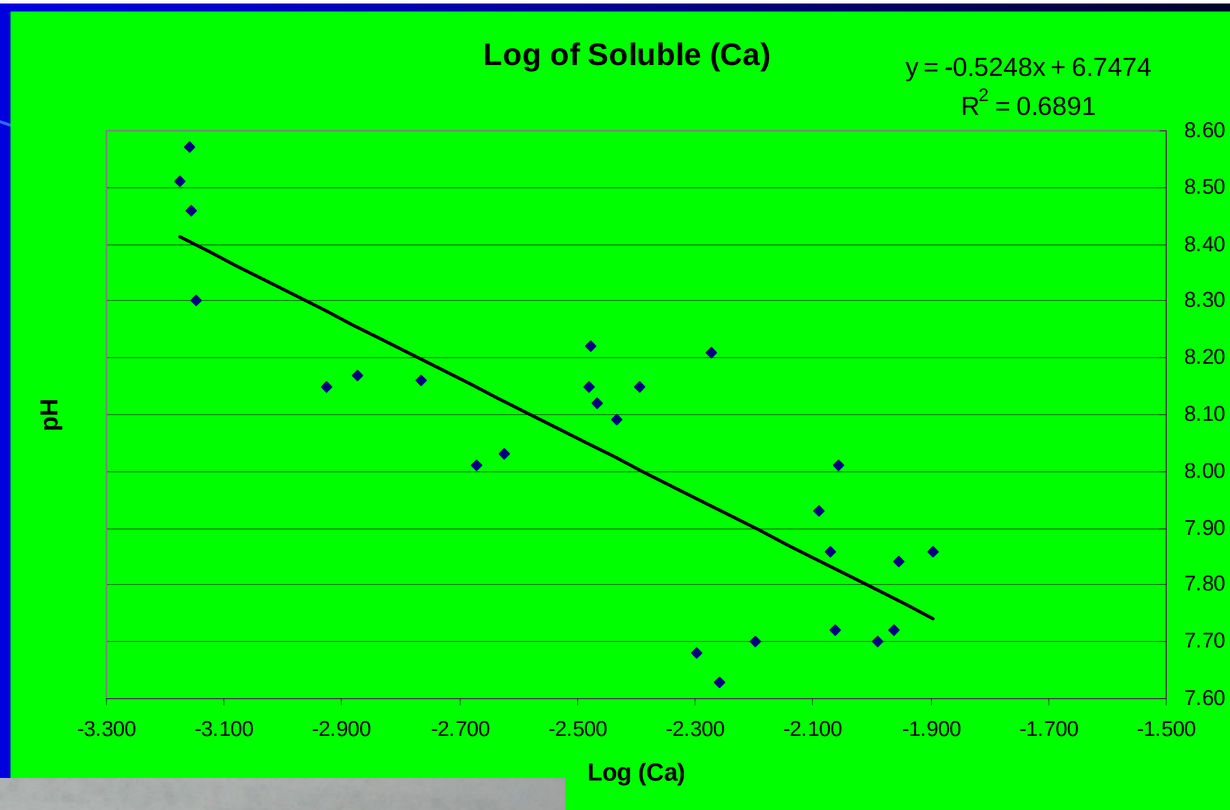


Extraction Ratio's impacts on EC-Aerobically Digested Sludge
EC (dS)
12
10
8
6
4
2
0
paste
1:5
1:10
1:25
1:50
Extraction Ratio



Sodium Adsorption Ratio-Aerobically Digested Biosolids
SAR, ratio
7
6
5
4
3
2
1
0
paste
1:5
1:10
1:25
1:50
Extraction Ratio

Study #2



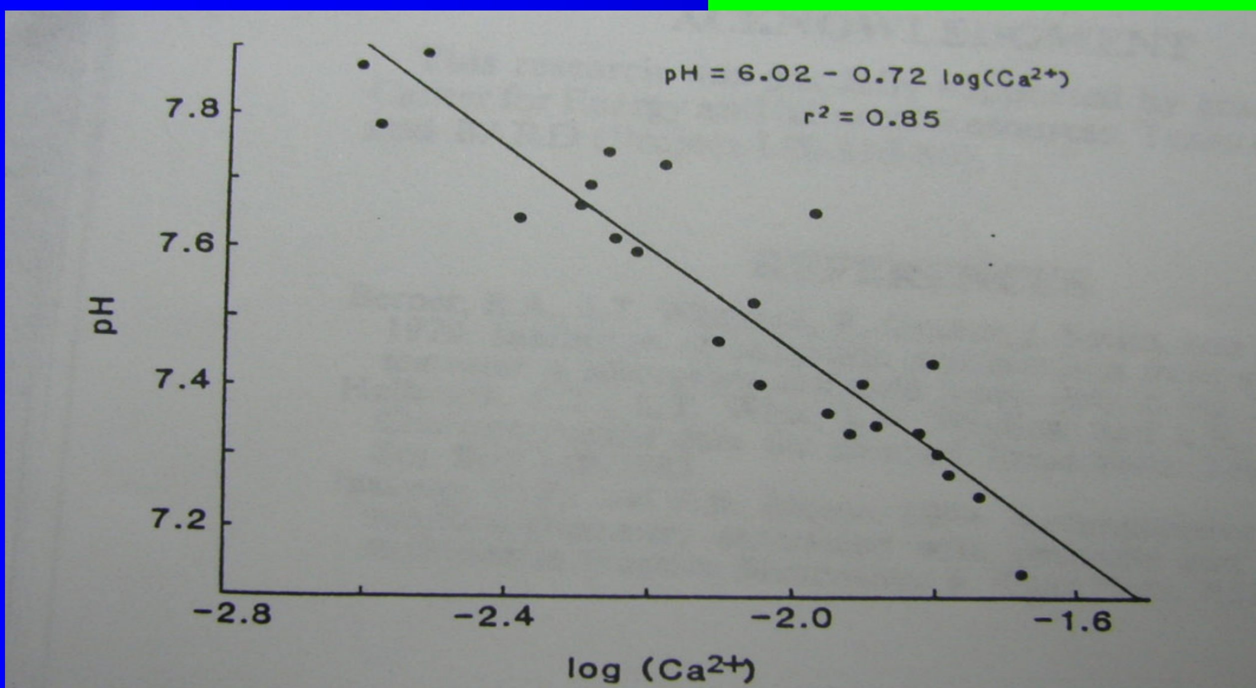


Fig. 3. Relationship between log (Ca^{2+}) and pH of extracts from suspensions of 24 calcareous soils in 1 *M* KCl.

Study #3 - Objectives

- Determine if minimum tillage is possible on irrigated soils with a high potential for salt hazard.
- Determine if biosolids remediate accumulation of salts at the soil surface.
- Evaluate the impact of ammonium on soil salinity.

Treatment Design

Tillage

- Maximum
- Minimum

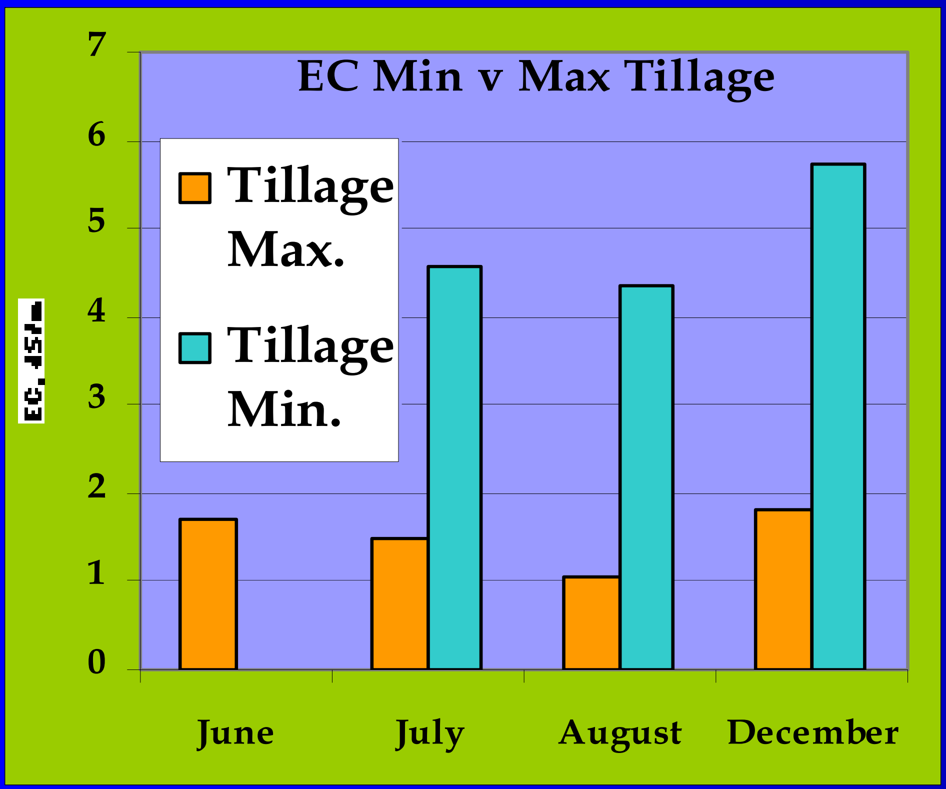
Soil Texture

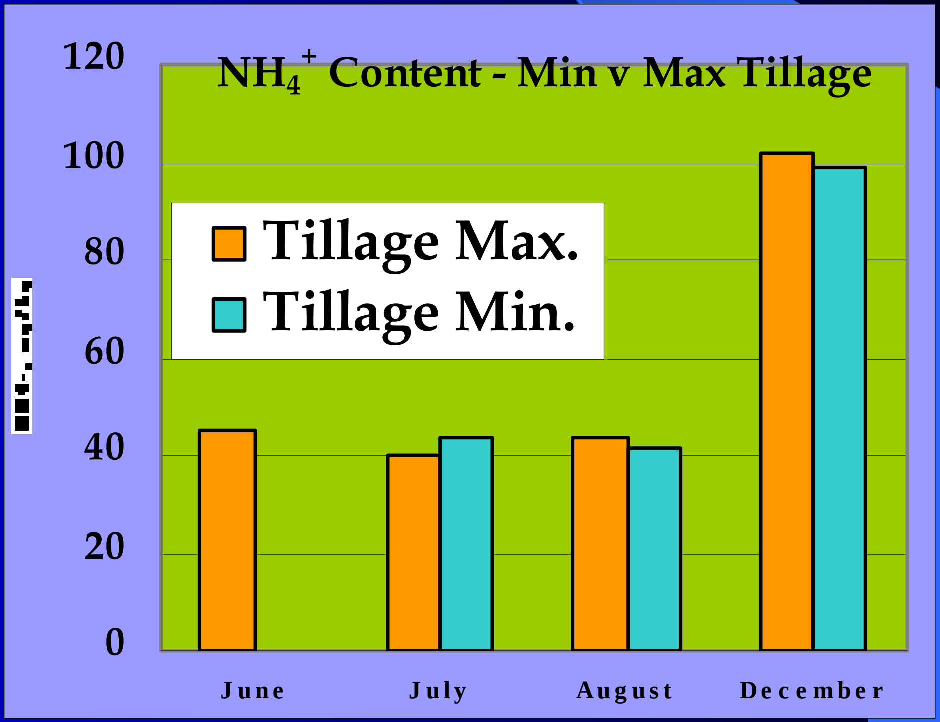
- Ge – Glendale silty clay loam.
- Gs – Glendale silty clay.
- Hs – Harkey silty clay loam.
- Tg – Tigua silty clay.

Subplots – Bed Row Position

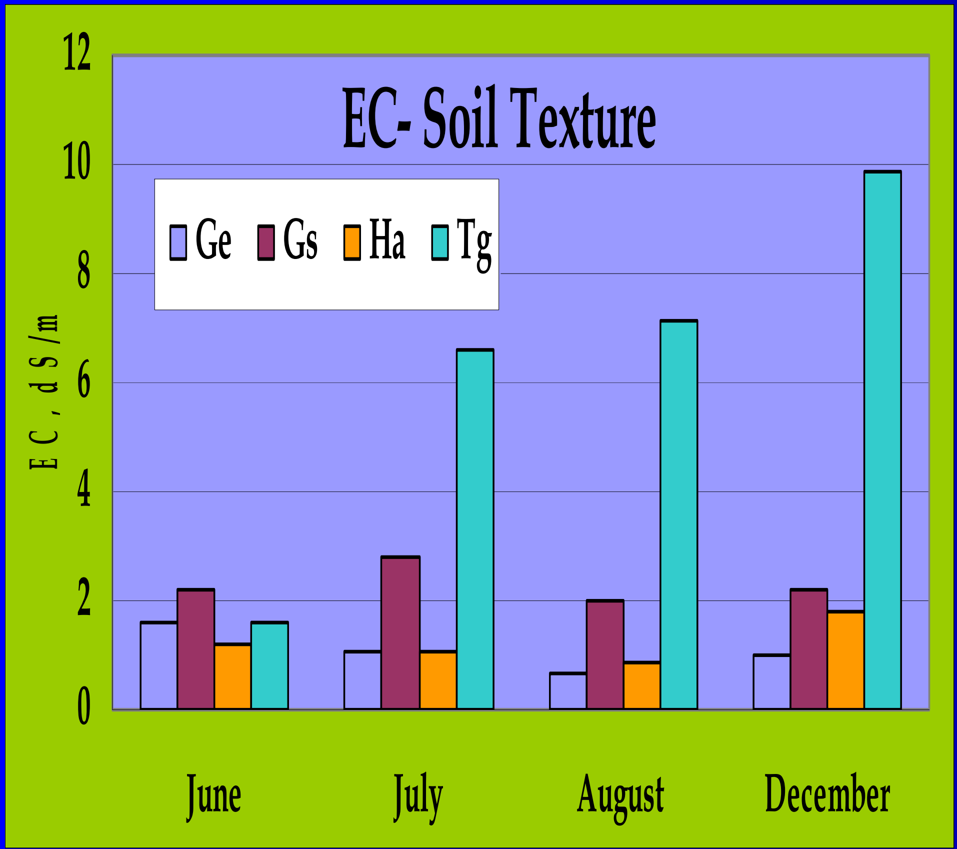
- Furrow
- Side
- Top
- Center

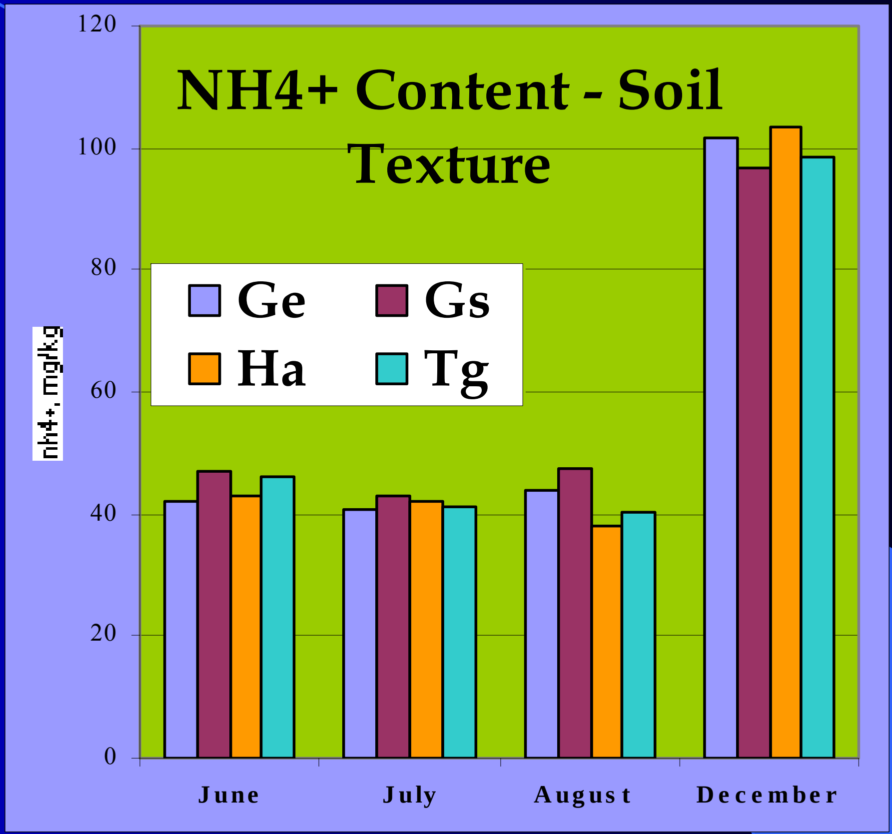
Minimum versus Maximum Tillage



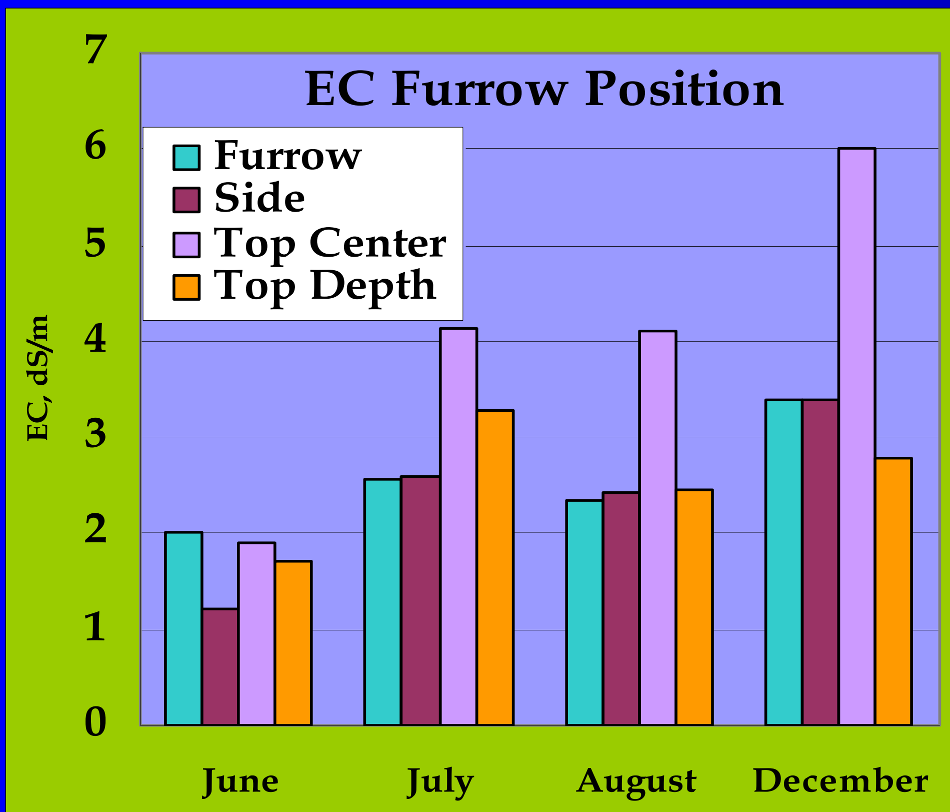


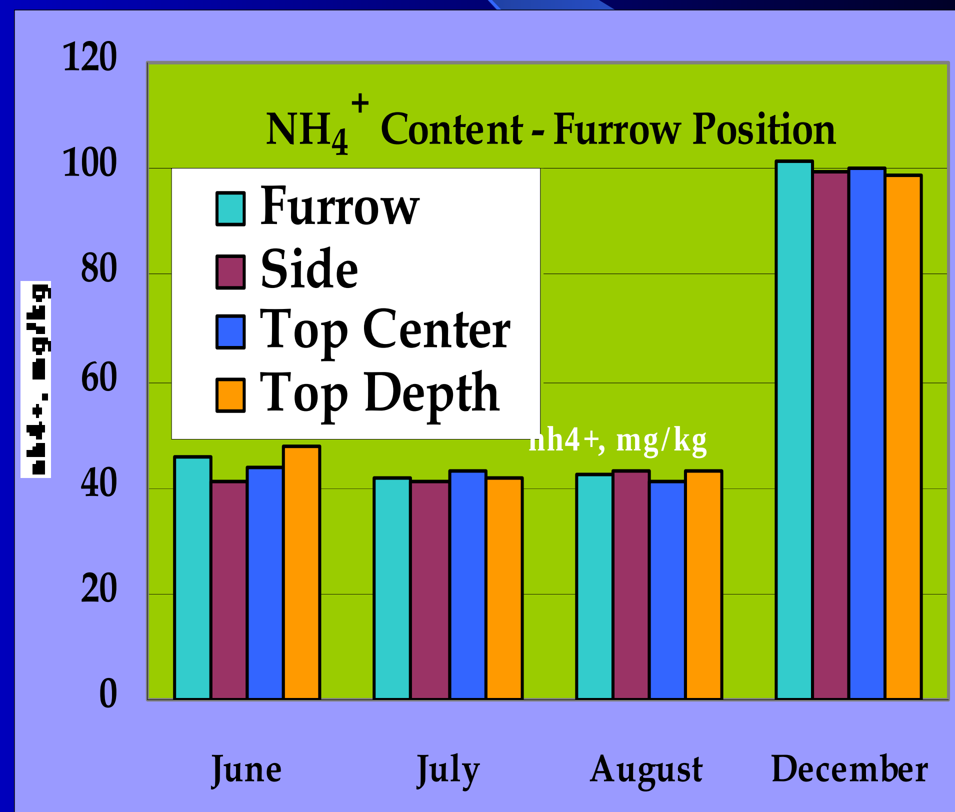
Soil Texture





Furrow Position





The Future in the Upper Rio Grande Basin

Potential Salt Management Strategies

- Develop a consistent and detailed salt monitoring program
  - Miyamoto and Iglesias
- Crop Selection – Halophytes
  - Miyamoto and USSL
- Pretreatment of alternative water sources for irrigation
  - Relatively new, site-specific
- Irrigation delivery systems
  - Enciso
- Integrated Soil Management to maintain soil structure and permeability (organic enrichment)