Saline-sodic soils rehabilitation using a rubble barrier and organic amendments

Elizabeth Chávez

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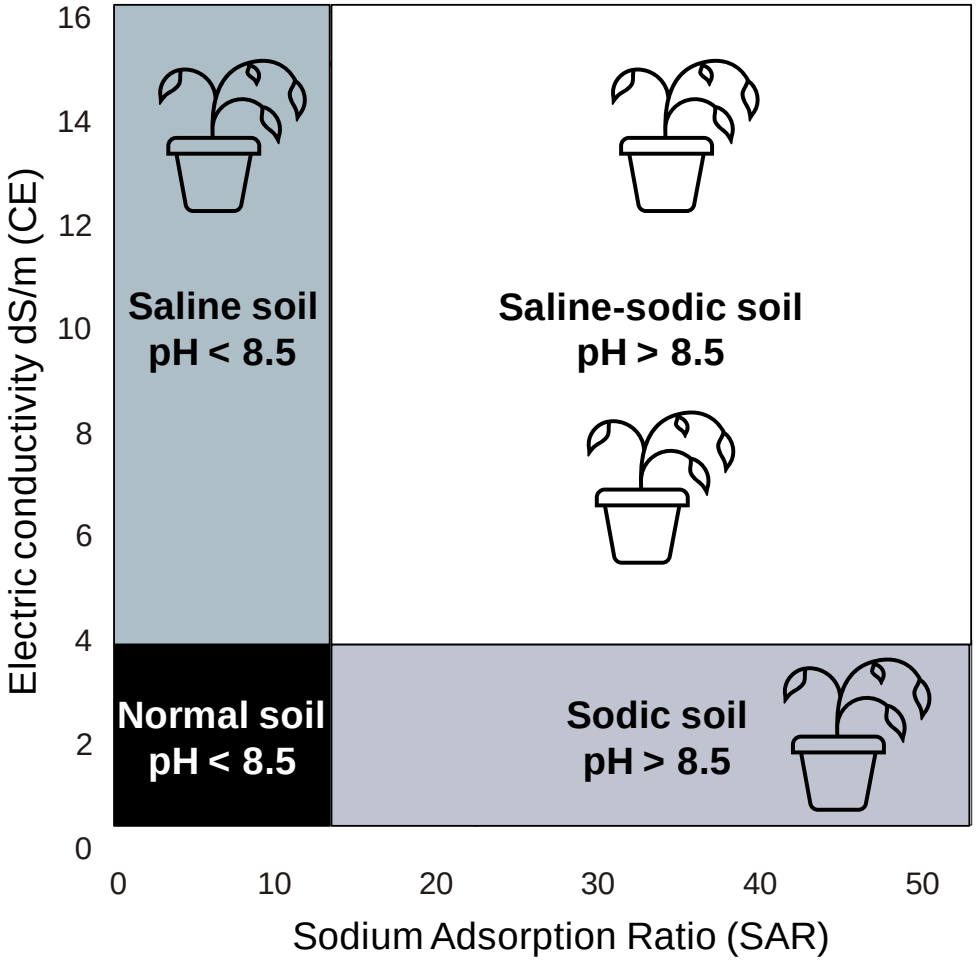
- Objectives
- Experimental design
- Results and discussion
- Conclusions

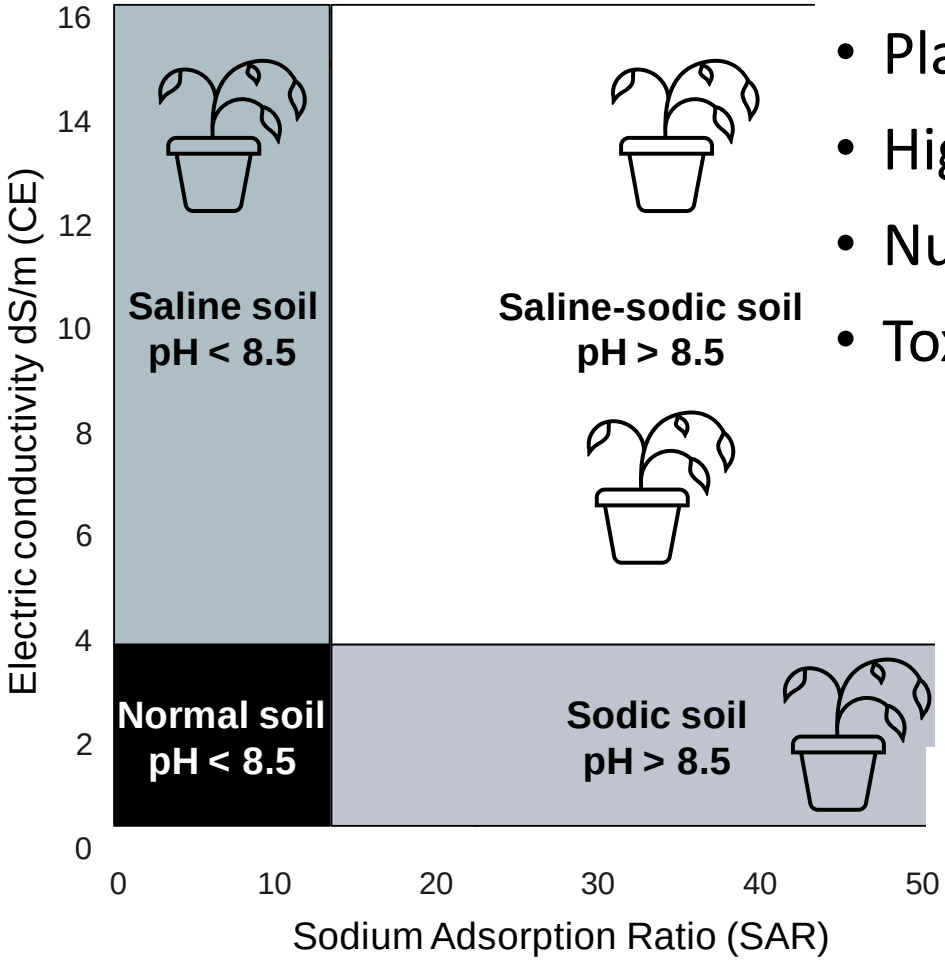
Rehabilitation of salt-affected soils

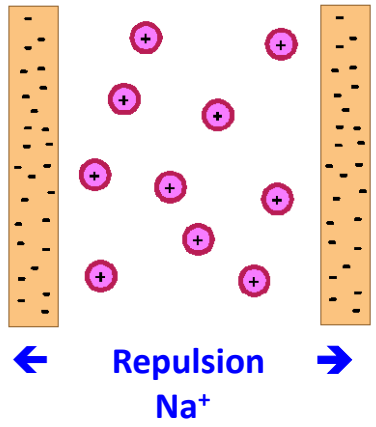


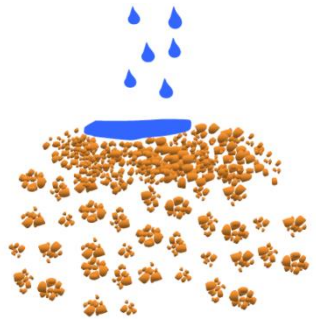
Rehabilitation of salt-affected soils

Problems due to salts and Na^+

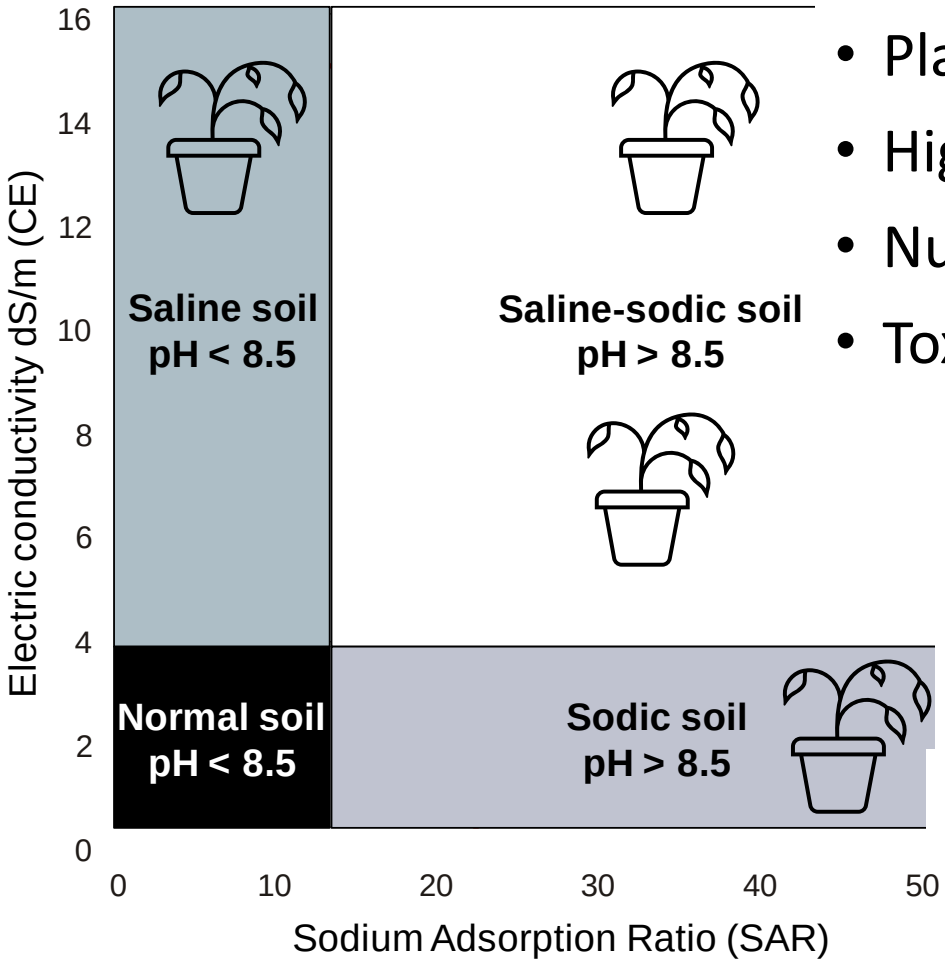
- Loss of soil structure
- Plant dehydration
- High pH
- Nutrient availability
- Toxicity (Na^+, Cl^-, OH^-)







Rehabilitation of salt-affected soils



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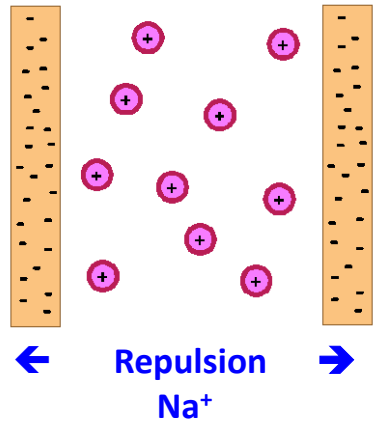
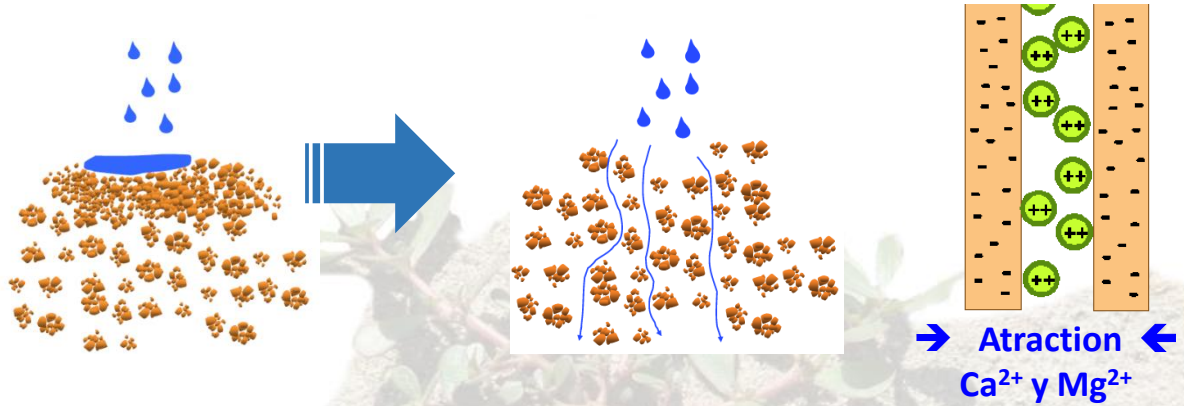


Organic matter addition

- Increase of biological activity
- Improvement of soil physical properties
- pH buffer
- Supply of nutrients
- Low cost: reuse of waste



Organic Matter

Biochar

Product of the thermochemical conversion of biomass in a O2 limited environment

Stable and complex molecules: little susceptible to decomposition

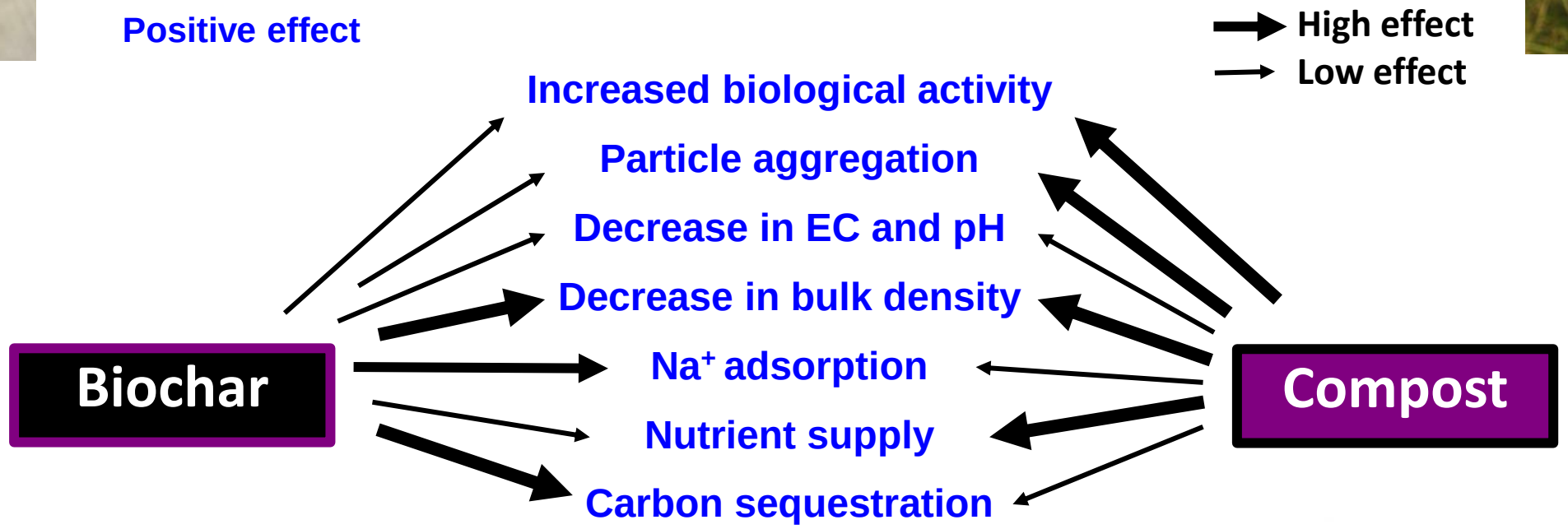
Compost

Product of the biological degradation of organic materials

Easy decomposition: increased biological activity

Lehmann, 2007; Verheijen *et al.*, 2010; Fischer & Glaser, 2012; IBI, 2015

Depending on the type of soil or amendment…



Choi & Chang, 2005; Walker & Bernal, 2008; Lakhdar *et al*., 2009, 2010; Bharadwaj *et al.,* 2011; Vaughan *et al*., 2011; Michler, 2013; Ouni *et al*., 2013; Prommer *et al*., 2014; Abrishamkesh *et al*., 2015; Buss *et al.,* 2015; Ghosh *et al*., 2015

Depending on the type of soil or amendment…

Positive effect

Negative effect

High effect

Low effect

Increased biological activity

Particle aggregation

Decrease in EC and pH

Decrease in bulk density

Biochar

Na^+ adsorption

Compost

Nutrient supply

Carbon sequestration

GHG emission

Increased salinity

Toxins supply

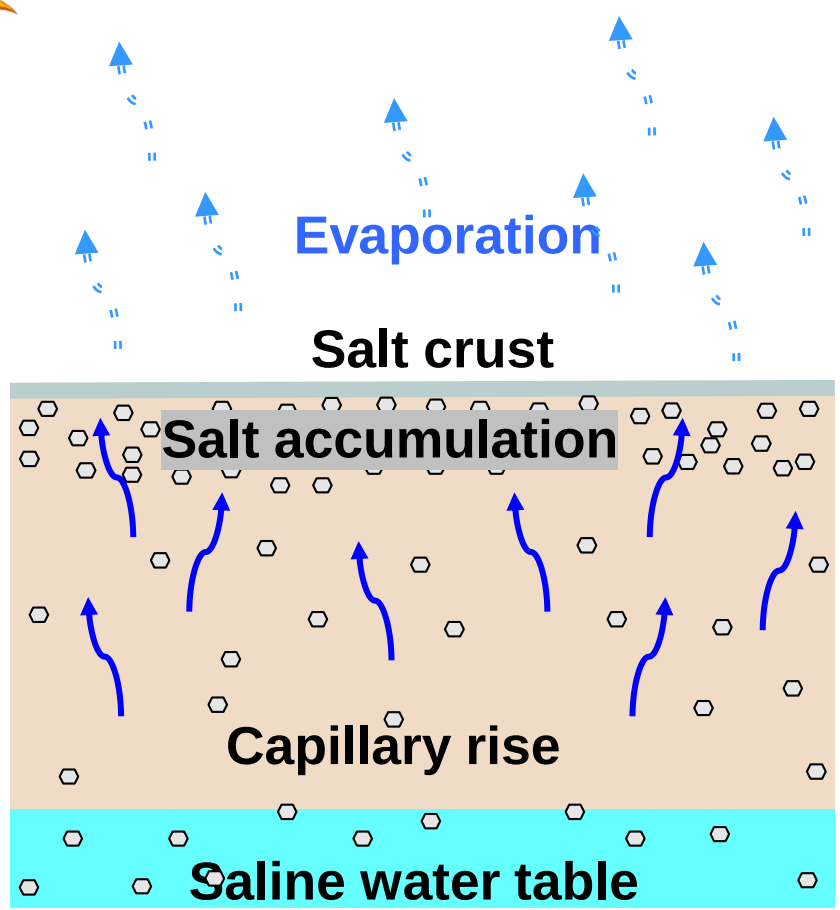
Nutrient immobilization / retention

Effect on highly saline-sodic soils ????

Choi & Chang, 2005; Walker & Bernal, 2008; Lakhdar *et al.*, 2009, 2010; Bharadwaj *et al.,* 2011; Vaughan *et al.*, 2011; Michler, 2013; Ouni *et al.*, 2013; Prommer *et al.*, 2014; Abrishamkesh *et al.*, 2015; Buss *et al.,* 2015; Ghosh *et al.*, 2015

In areas with a water table close to the surface and:

evaporation > precipitation



Stark & Redente, 1986; McFarland *et al*., 1992, 1994; Rooney *et al*., 1998; Guo *et al*., 2006; Akudago *et al*., 2009; Lee *et al*., 2014

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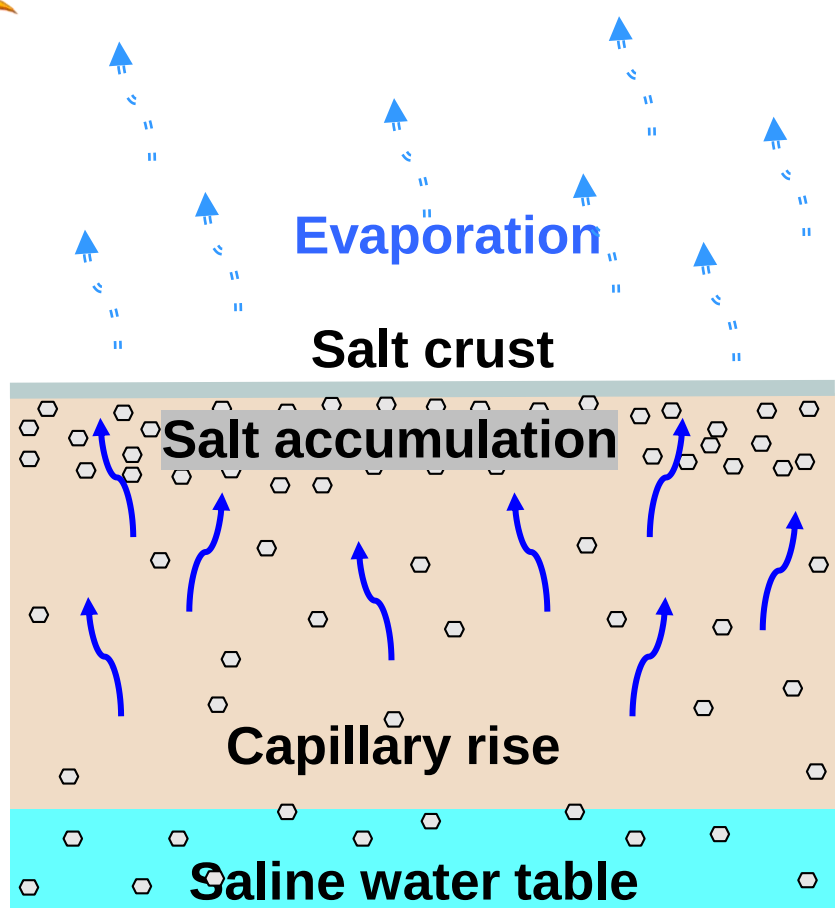
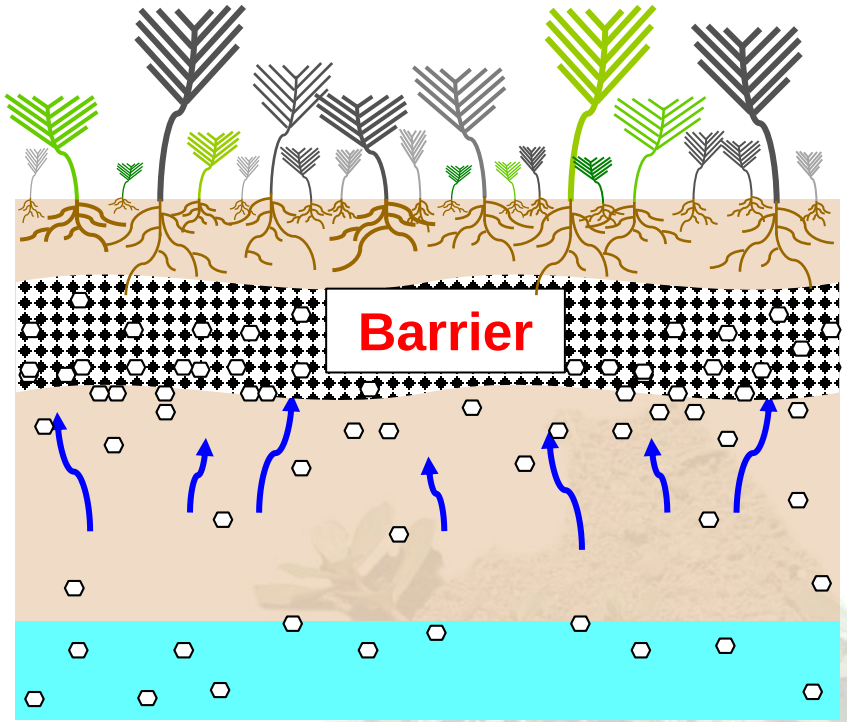


Barrier to hinder the salts accumulation in the root zone



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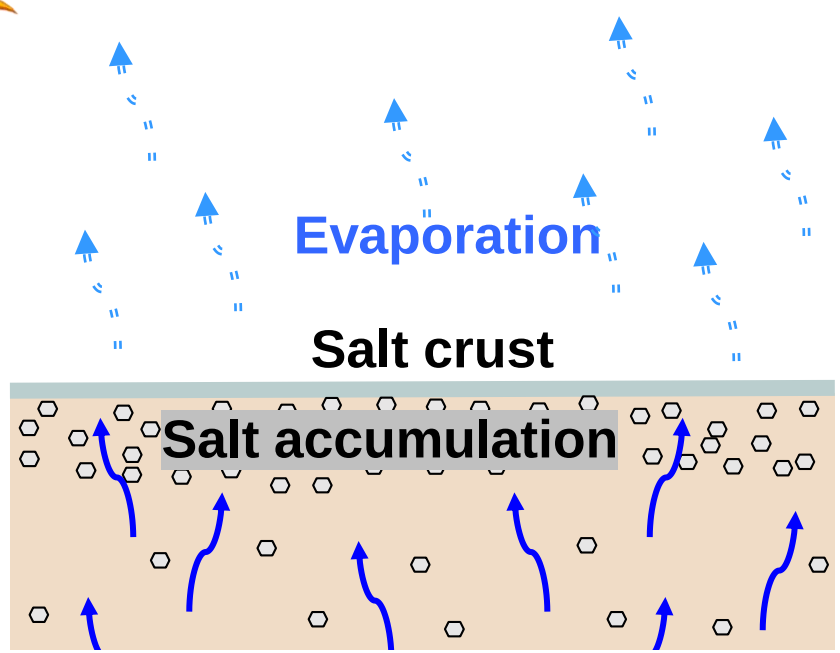

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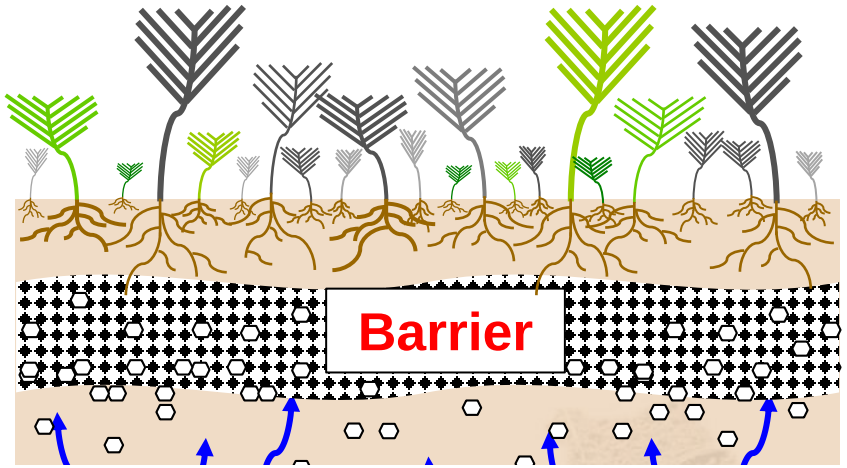


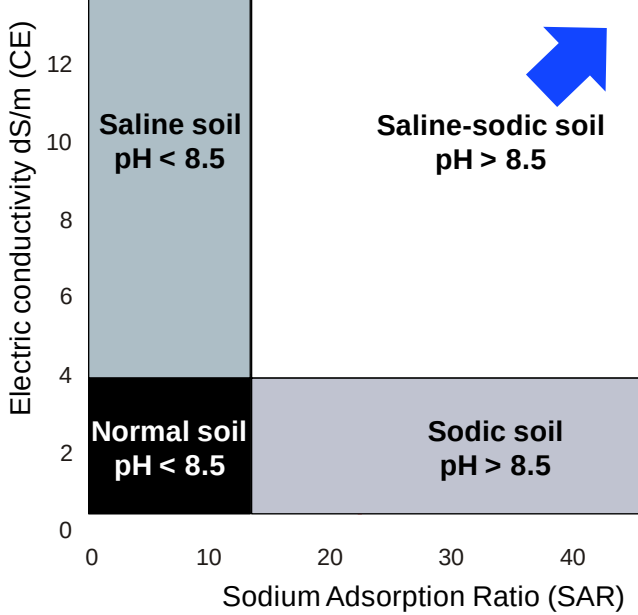
However… studies carried out *ex situ*, in non-saline soils or without the presence of vegetation

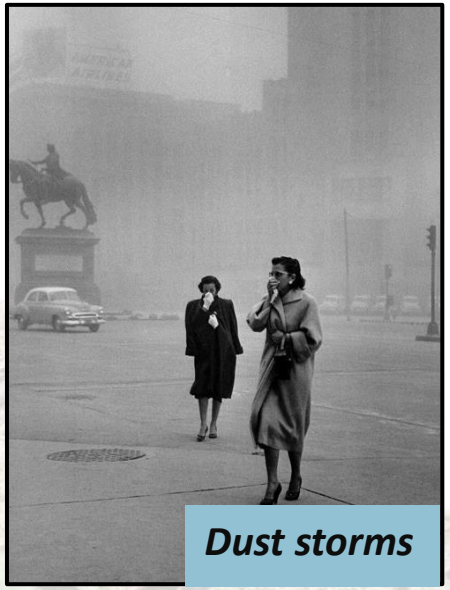
Effect on highly saline-sodic soils ?????

Stark & Redente, 1986; McFarland *et al.*, 1992, 1994; Rooney *et al.*, 1998; Guo *et al.*, 2006; Akudago *et al.*, 2009; Lee *et al.*, 2014

Former Lake of Texcoco

Highly saline-sodic soils
(>400 dS/m, SAR>300, pH > 10)





SRH, 1971; SARH,1981; García, 1988; Cruickshank, 2007

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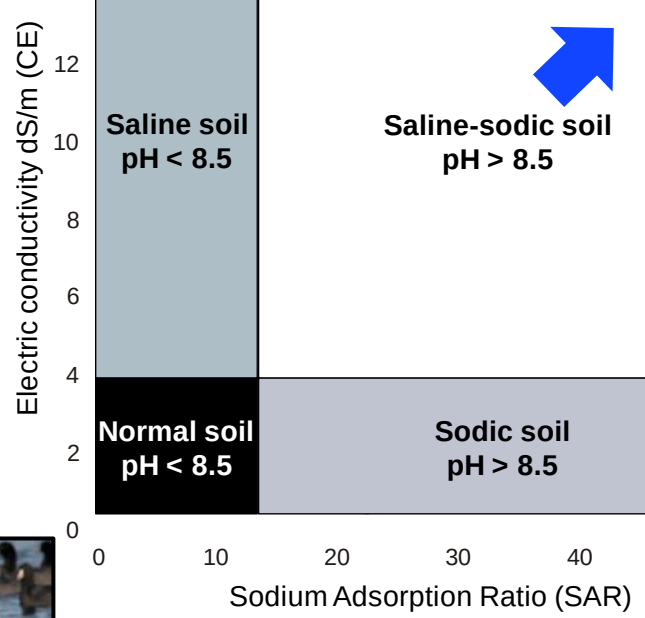
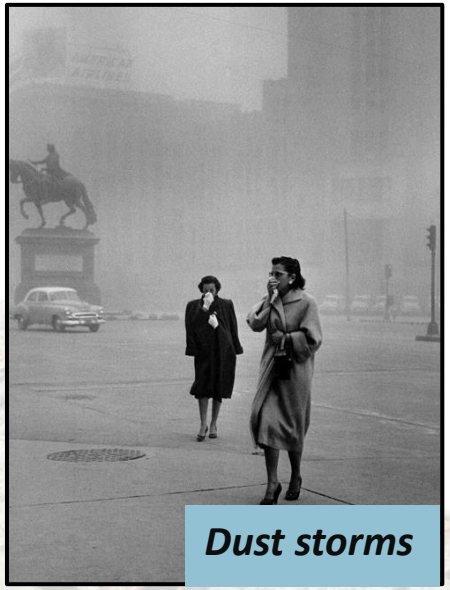



Nabor Carrillo Lake


Migrant and resident birds


Dust storms


Compost Plant


ex international airport


Distichlis spicata

GLOBAL SYMPOSIUM ON SALT-AFFECTED SOILS | 20 - 22 October, 2021

SRH, 1971; SARH,1981; García, 1988; Cruickshank, 2007

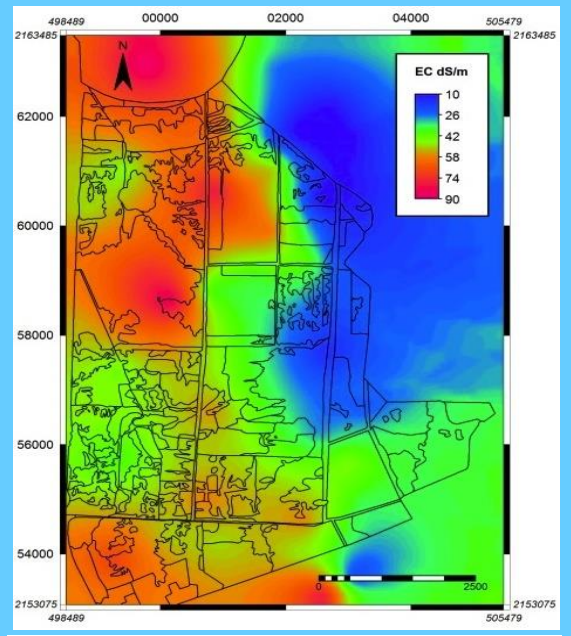
Plan Lake of Texcoco (1971)

- **Introduction of *Distichlis spicata*.**
- **Drainage pipes, salts leaching, gypsum addition.**
- **PM_{10} decreased but salinity increased.**

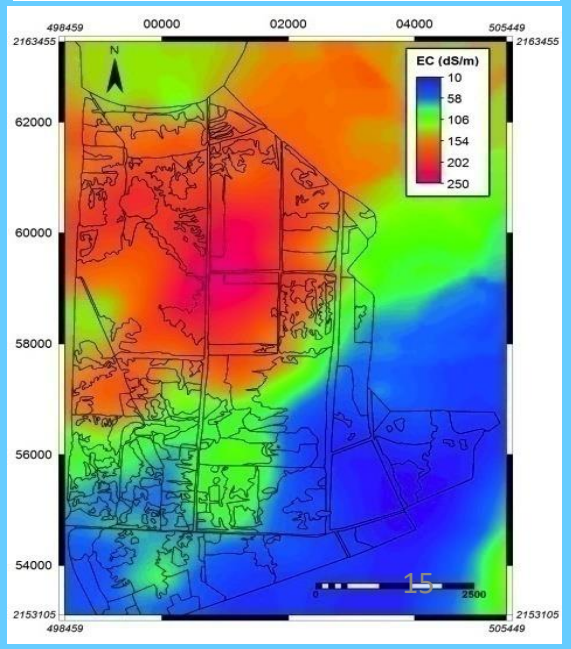
Cruickshank, 2007; Fernández-Buces et al., 2009; MCE^2, 2009; Díaz-Nigenda *et al*, 2010; SIMAT, 2011.

Soil electrical conductivity (0-30 cm)

1971



1998



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Why it does not work?

Difficult and expensive as a result of:

- **Capillary rise of saline water**
- **Lack of water to wash the salts**
- **Poor drainage**

Soil electrical conductivity (0-30 cm)

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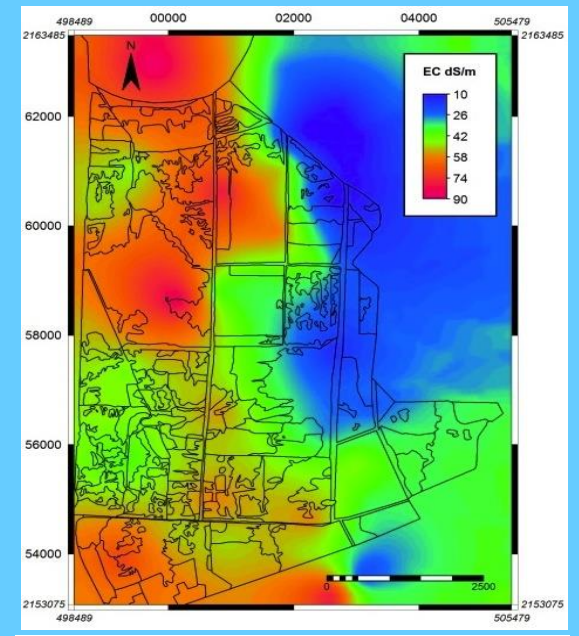

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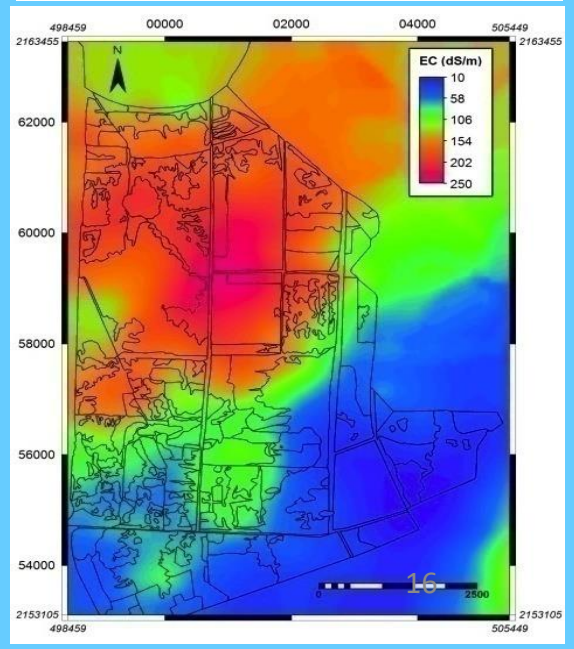

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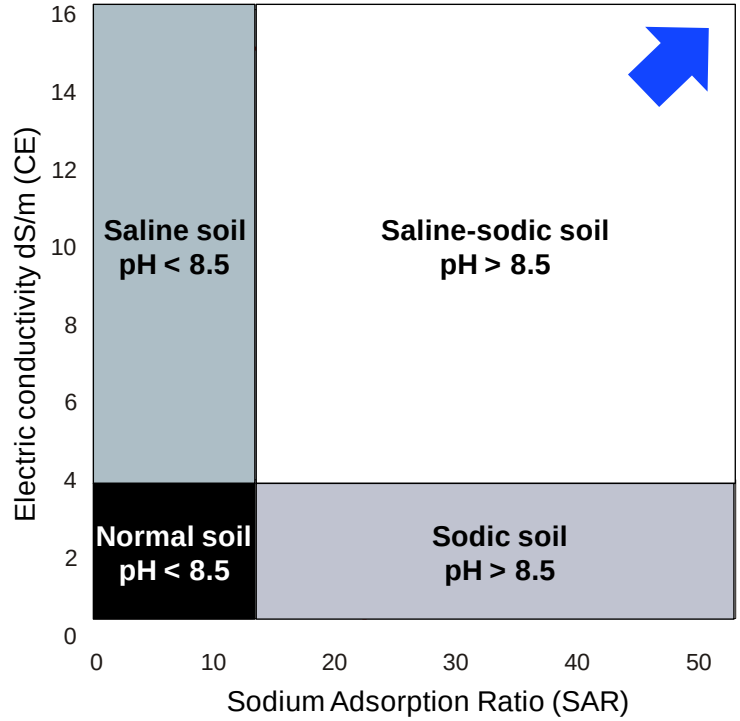
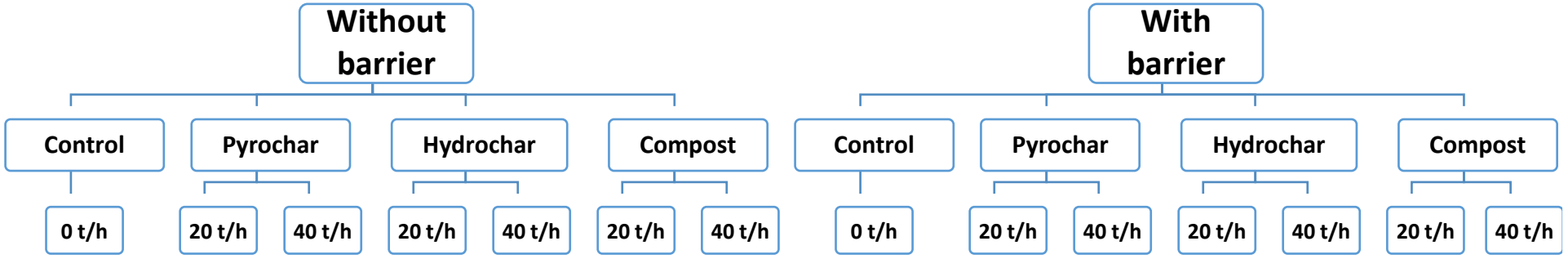
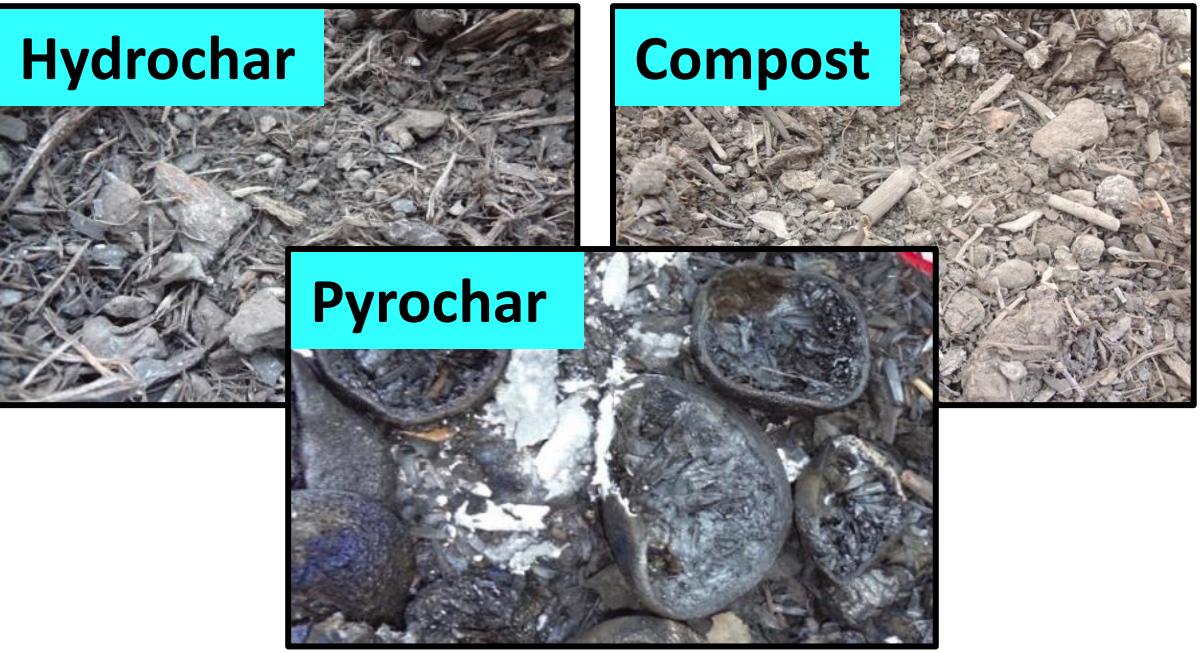


Ideal study site for:

- improvement of highly saline-sodic soils
  - establishment of a plant cover

Objective





We evaluated if the implementation of a **barrier** made with crushed rubble and the addition of **compost or biochar** mitigate the topsoil salinization and allow the development of the native grass *Distichlis spicata*.

Methodology

We evaluated *in situ* (during 24 months, 1 m^2 plots):

i) changes in soil properties (pH, electrical conductivity, sodium adsorption ratio and soil moisture)

ii) survival and development of *Distichlis spicata*

iii) greenhouse gas emissions (CO_2 NH_3)

Results and discussion

The amendments:

- did not reduce the soil salinity (too alkaline amendments or low doses?)
- improved the grass survival and plant cover (low wind erosion: better air quality?)
- decreased the topsoil moisture content (evapotranspiration and hydrophobicity?)
- increased the C and N content
- did not affect the CO_2 emissions (Carbon storage?)
- compost presented NH_3 emissions (air quality?)

Results and discussion

The barrier:

- allowed the growth of the grass (low wind erosion: better air quality?)
- decreased the topsoil salinity (capillary rise interruption)
- decreased the CO_2 and NH_3 fluxes

However:

- the soil pH increased (rubble pH?)
- the topsoil moisture decreased in the dry season (capillary rise interruption)
- but it increased during the rainy season (water infiltration delay)

Conclusions

- Higher doses or acid amendments might decrease the soil salinity.
- Biochar could improve:

  the establishment of vegetation

  the soil C content without affecting the CO_2 emissions.
- The use of compost is not recommended: NH_3.
- The barrier is effective to decrease the salinity and increase the plant cover.
- Irrigation is needed to sustain plant growth during the dry season.

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Thank you for your attention!