University of California
Agriculture and Natural Resources

Making a Difference for California

Healthy Soils, Organics and Salts

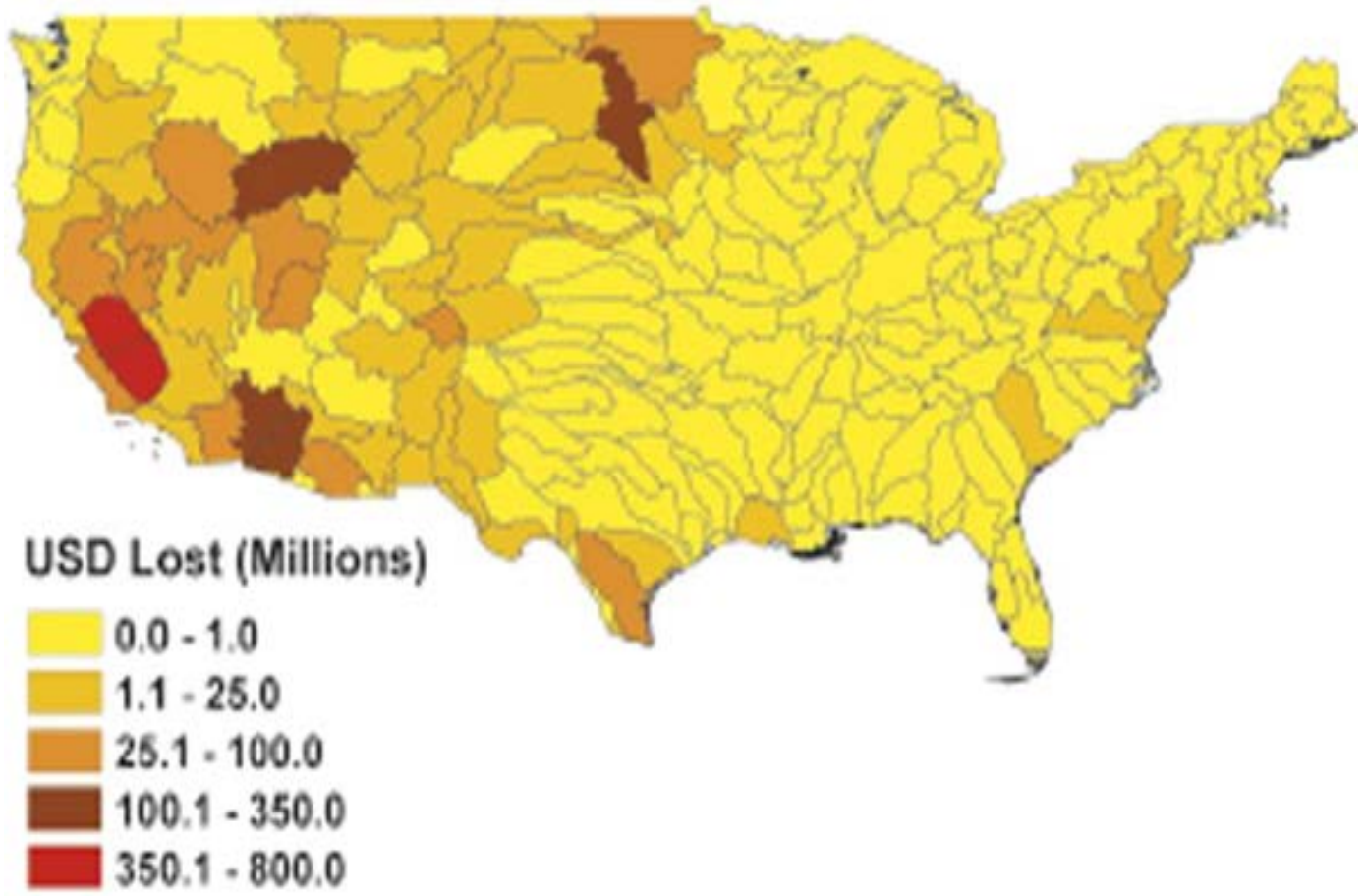
Vijaya Chaganti and David Crohn
University of California, Riverside

UC RIVERSIDE UNIVERSITY OF CALIFORNIA

Salts

- **Saline Soils:** Decrease yields by upsetting osmotic balance in the roots zone
- **Sodic Soils:** If sodium (Na^+) dominates, soil structure is lost so that water and air cannot penetrate
- **Saline-Sodic Soils:** Suffer both conditions

Soil salinization costs ≈$2.8 billion/yr



Sabo *et al.* 2010

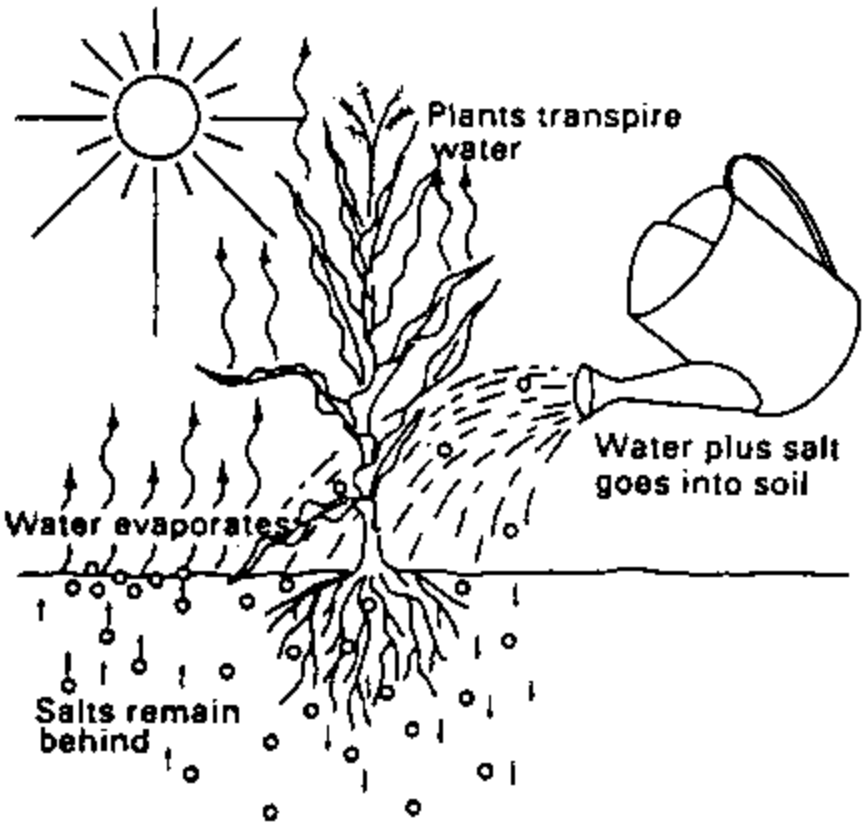
>1.4 billion acres are degraded globally

Continent	Affected Area (million acres)
North America	24
South America	143
Africa	67
Europe	57
Northern and Central Asia	297
Southern Asia	4
Australasia	840

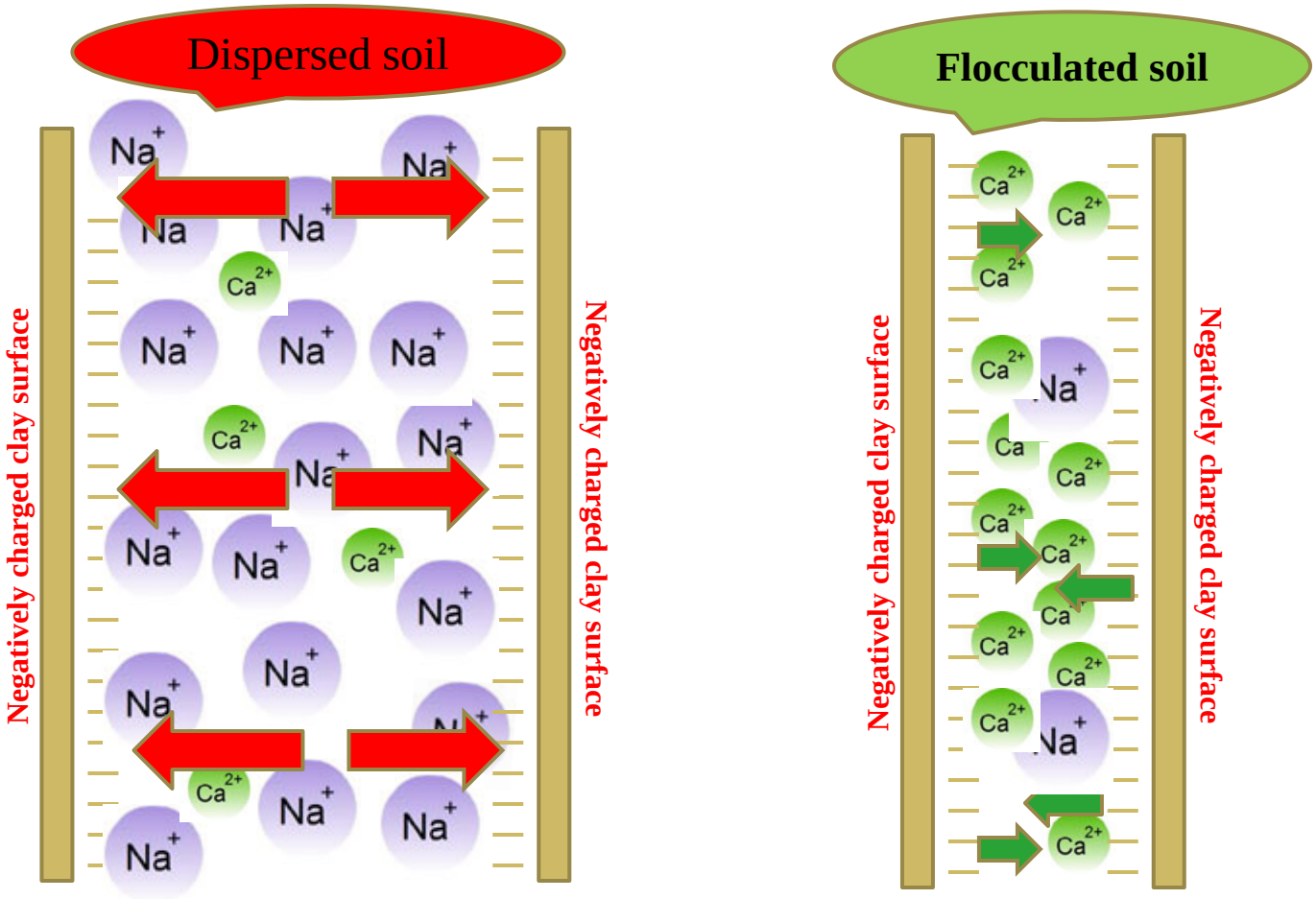
Lal 2006

Salts

- Salts are a huge concern in semi-arid and arid soils
- Salts accumulate from irrigation water
- Salts concentrate due to evapotranspiration (ET)
- Not a concern where precipitation significantly exceeds evapotranspiration



Sodium (Na) disperses soils.
Gypsum ($CaSO \cdot 2H_2O$) facilitates removal.



Rengasamy and Sumner, 1998.

Organic Amendment Characteristics

Characteristic	Woodchip Biochar	Dairy Manure Biochar	Biosolids compost	Greenwaste compost
C:N ratio	85	15	6	23
pH*	8.5	10.4	7.4	6.4
EC_5 (dS m^{-1})	2.4	30.4	12.8	2.8
Stability indicator (mg CO_2-C OM g^{-1} day^{-1})	—	—	2.3	0.66
Ca	1.68	2.99	2.84	1.47
Mg	0.41	1.46	0.48	0.37
Na	0.46	1.37	0.16	0.09

*EC and pH measurements were made on 1:5 water extracts for composts (TMECC methods) and 1: 20 extracts for biochars (IBI methods). Biochar EC_{20} was then adjusted to approximate EC_5.

Reclaimed Water Characteristics

EC_w>4 dS/m is saline
SAR>12 is sodic

Characteristic	Value
EC_w (dS m^{-1})	0.96
pH	7.2
Na^+ (meq L^{-1})	5.21
Ca^{2+} (meq L^{-1})	2.09
Mg^{2+} (meq L^{-1})	1.12
SAR	4.11
Cl^- (meq L^{-1})	5.4
SO_4^{2-} (meq L^{-1})	1.8
$HCO_3^- + CO_3^{2-}$ (meq L^{-1})	1.5

Questions

1. Can compost or biochar be used to remediate a saline-sodic soil?
2. Should gypsum be added as well?
3. Does it help that compost supports life in the soil?

Methods

- Three replicates
- Composts applied at a standard rate of 33 t/ac d/w basis
- Incubated for 30 days at room temperature
- Leached by maintaining a 2 inch constant head
- Stopped after 6 pore volumes of water pass though column

Treatments

1. Control soil
2. Gypsum (50%)
3. BSC: Biosolids compost
4. GWC: Greenwaste compost
5. WBC: Woodchip biochar
6. BSCG: Biosolids compost + gypsum
7. GWCG: Greenwaste compost + gypsum
8. WBCG: Woodchip biochar + gypsum

Soil properties	
Texture	Clay Loam
Bulk density (g/cc)	1.24
Organic Matter %	0.60
CEC (meq/100g)	27.8
pH	8.26
ECe (dS m^{-1})	23.4
SAR	31.8
ESP (%)	26.0
CCE (%)	3.85

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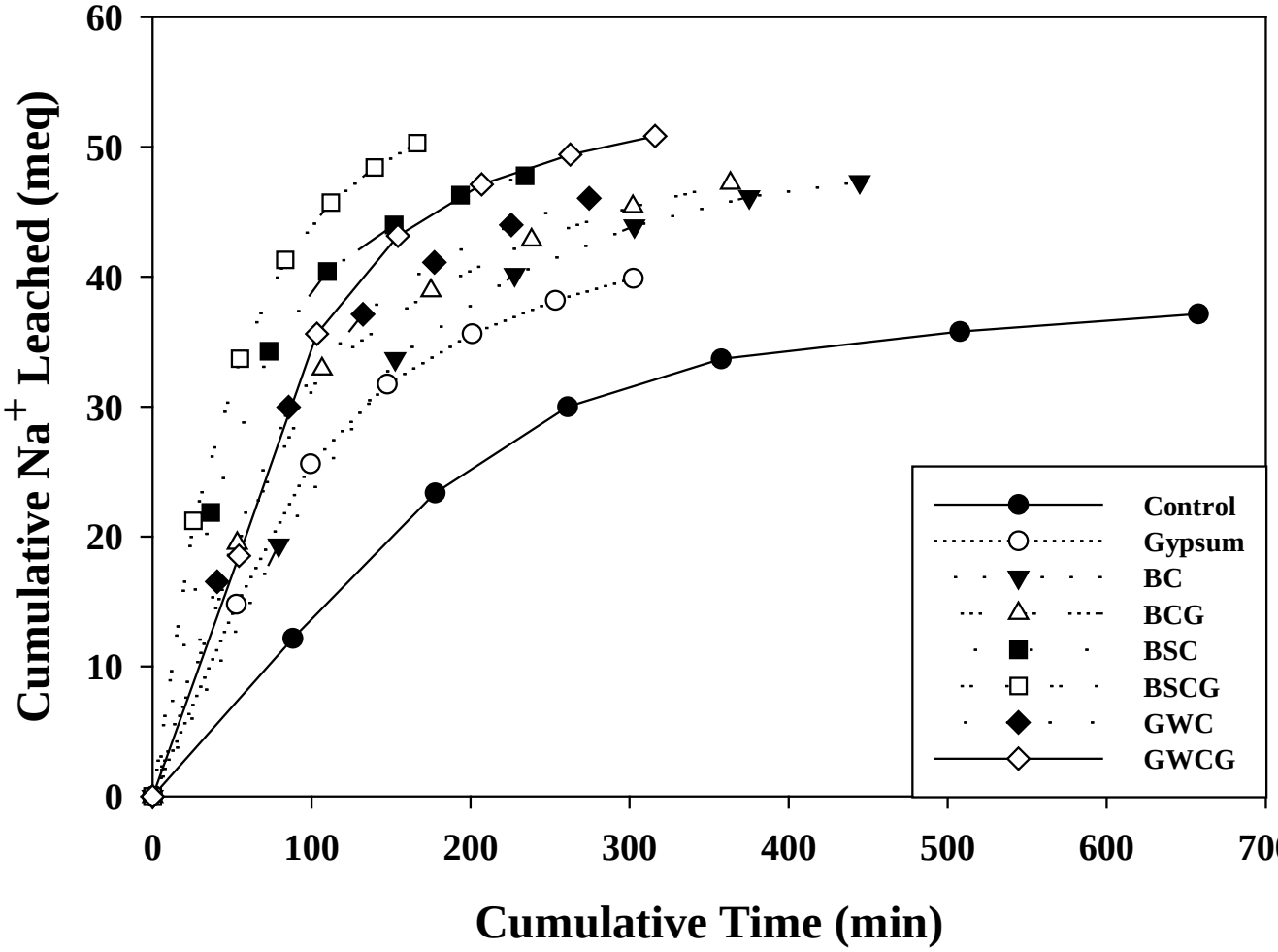
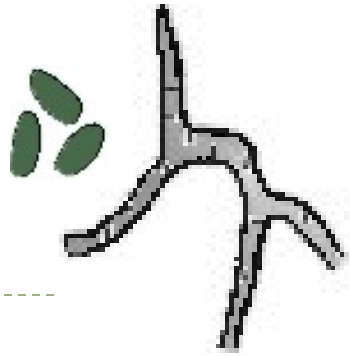
Salinity: Gypsum accelerated performance of amendments

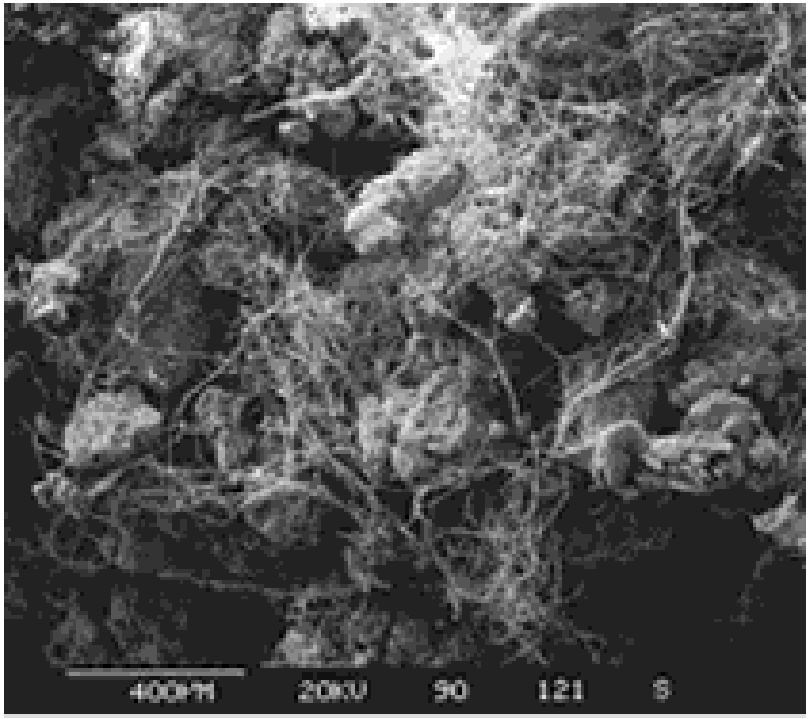


- **Control**
  soil
- **Gypsum**
  50% rate
- **BSC**:
  biosolids compost
- **BSCG**:
  biosolids compost + gypsum
- **GWC**:
  greenwaste compost
- **GWCG**:
  greenwaste compost + gypsum
- **BC**:
  biochar
- **BCG**:
  biochar + gypsum

A further benefit of compost: life

- Encourages the formation of soil aggregates
- Aggregates are soil clusters held together as a result of compost decomposition
  - Fungal hyphae bind particles together
  - Bacterial polysaccharides serve as glue
- Aggregated soils facilitate leaching for salt removal



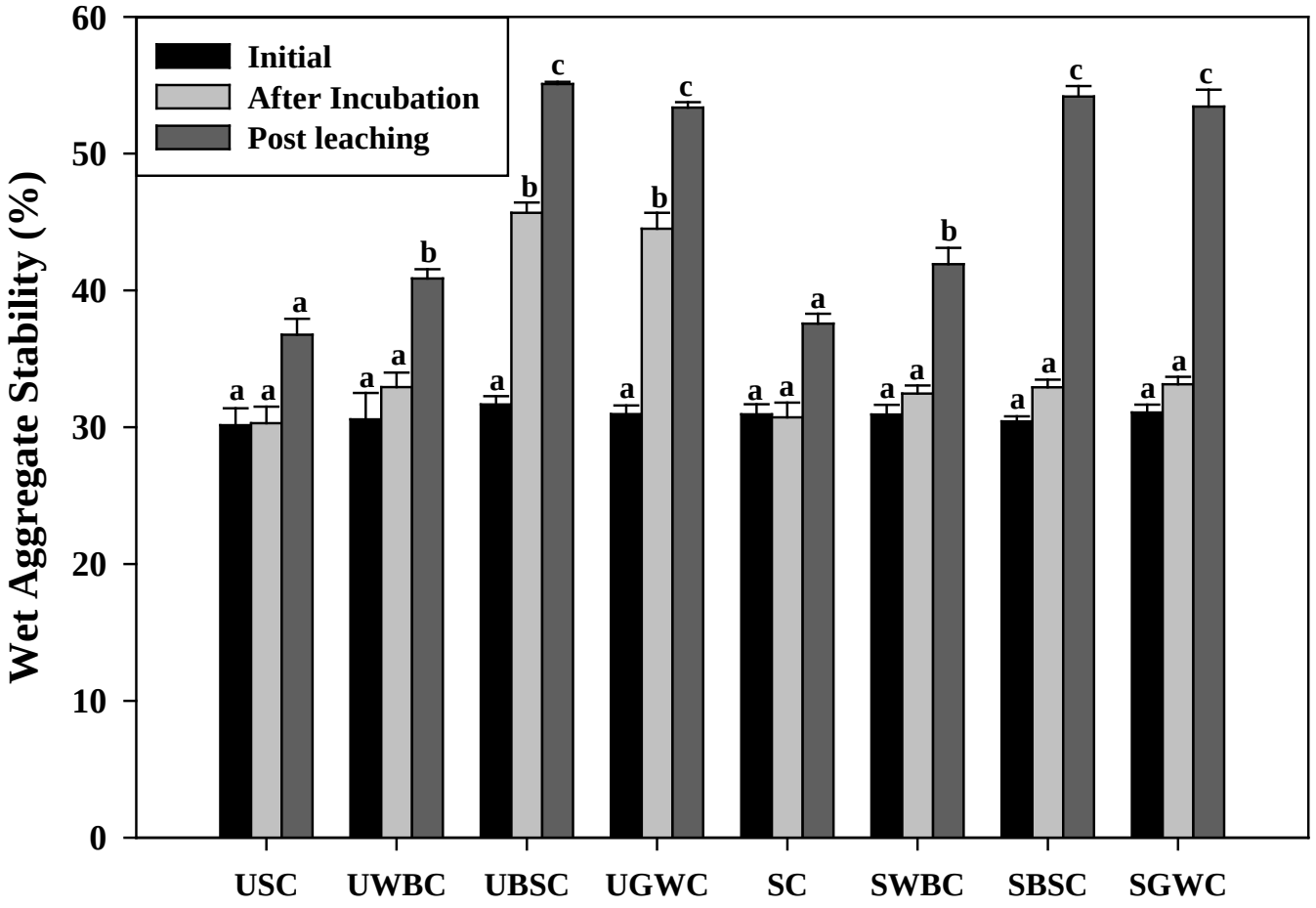


Questions

1. Can compost or biochar be used to remediate a saline-sodic soil?
2. Should gypsum be added as well?
3. Does it help that compost supports life in the soil?
    a. Soils were autoclaved
    b. Amendments were radiated

- **U: unsterilized**
- **S: sterilized**
- **SC: soil alone (control)**
- **WBC: woodchip biochar**
- **BSC: biosolids compost**
- **GWC : greenwaste compost**

Texture: Wet aggregate stability was greatest in the (unsterilized) composts.



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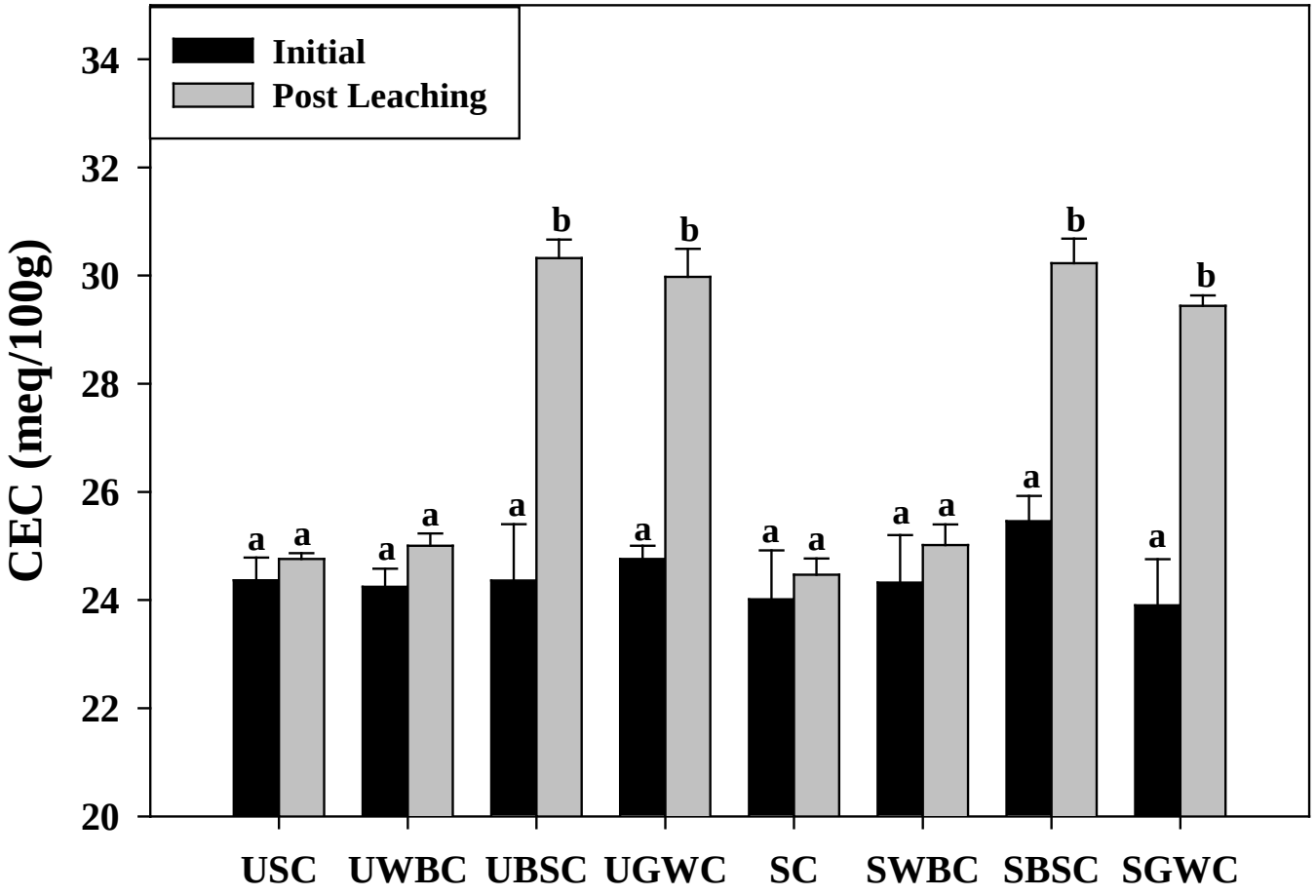
CEC: Most improved in the composts.



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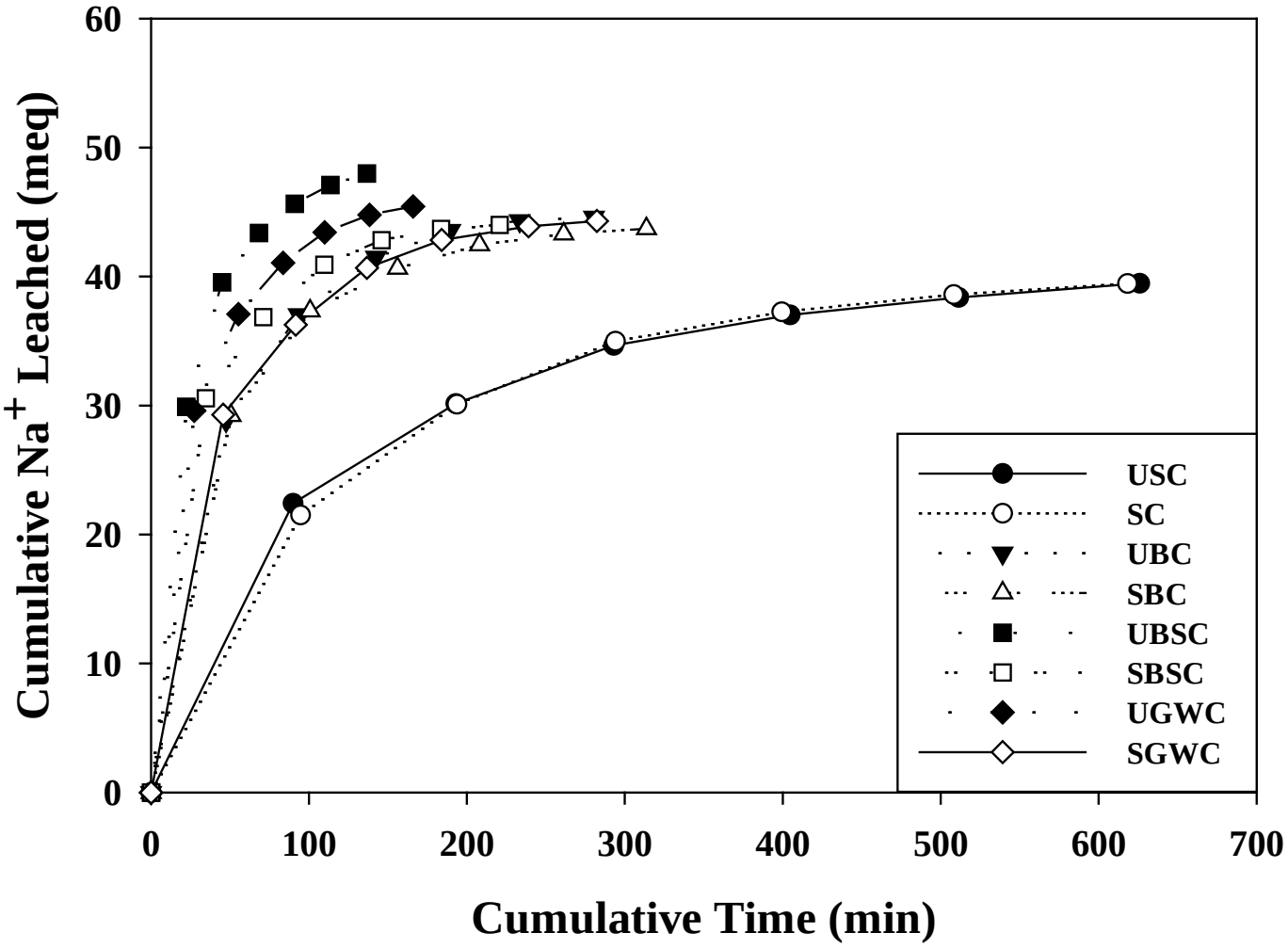
Na^+: Improved fastest in unsterilized composts.



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Overall Research Conclusions

- **Composts and biochars can be significant sources of beneficial cations like Ca^{2+} and Mg^{2+} and increase Na^{+} leaching in a salt affected soil.**
- **Biological activity is key in improving soil aggregate stability and hydraulic conductivity.**
- **Reclamation by biochar is purely physiochemical while composts provide a better and comprehensive remediation when both physiochemical and biological factors act together.**