University of California
Agriculture and Natural Resources

*Making a Difference for California*

# Healthy Soils, Organics and Salts

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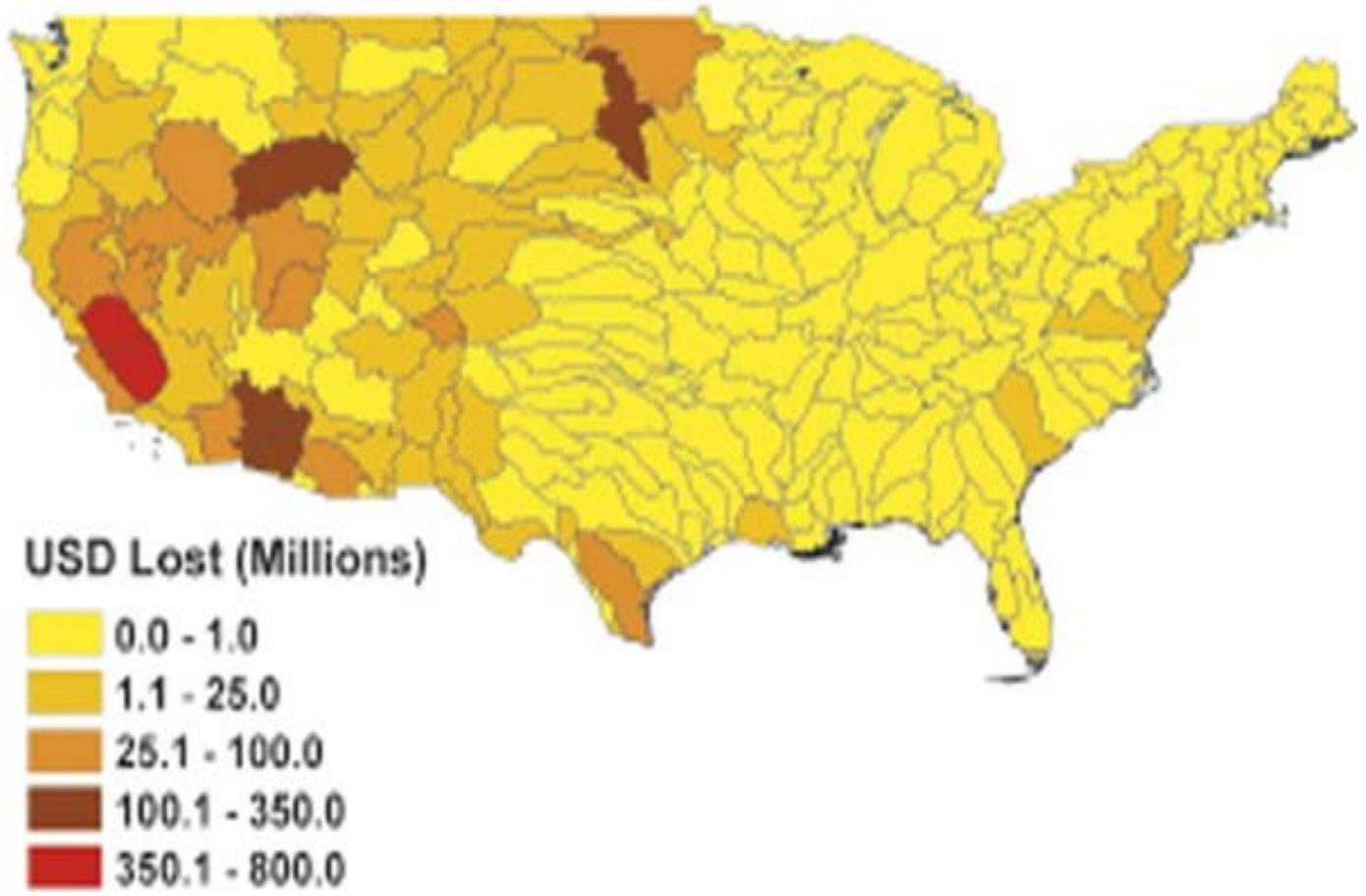
# Salts

- **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

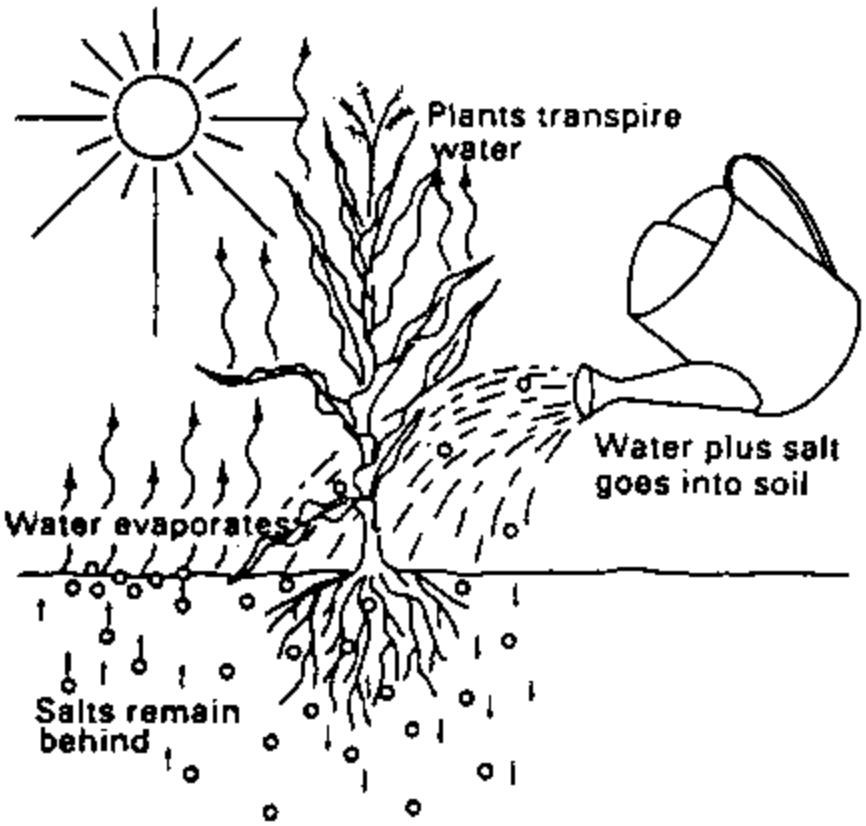
# >1.4 billion acres are degraded globally

| 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 |

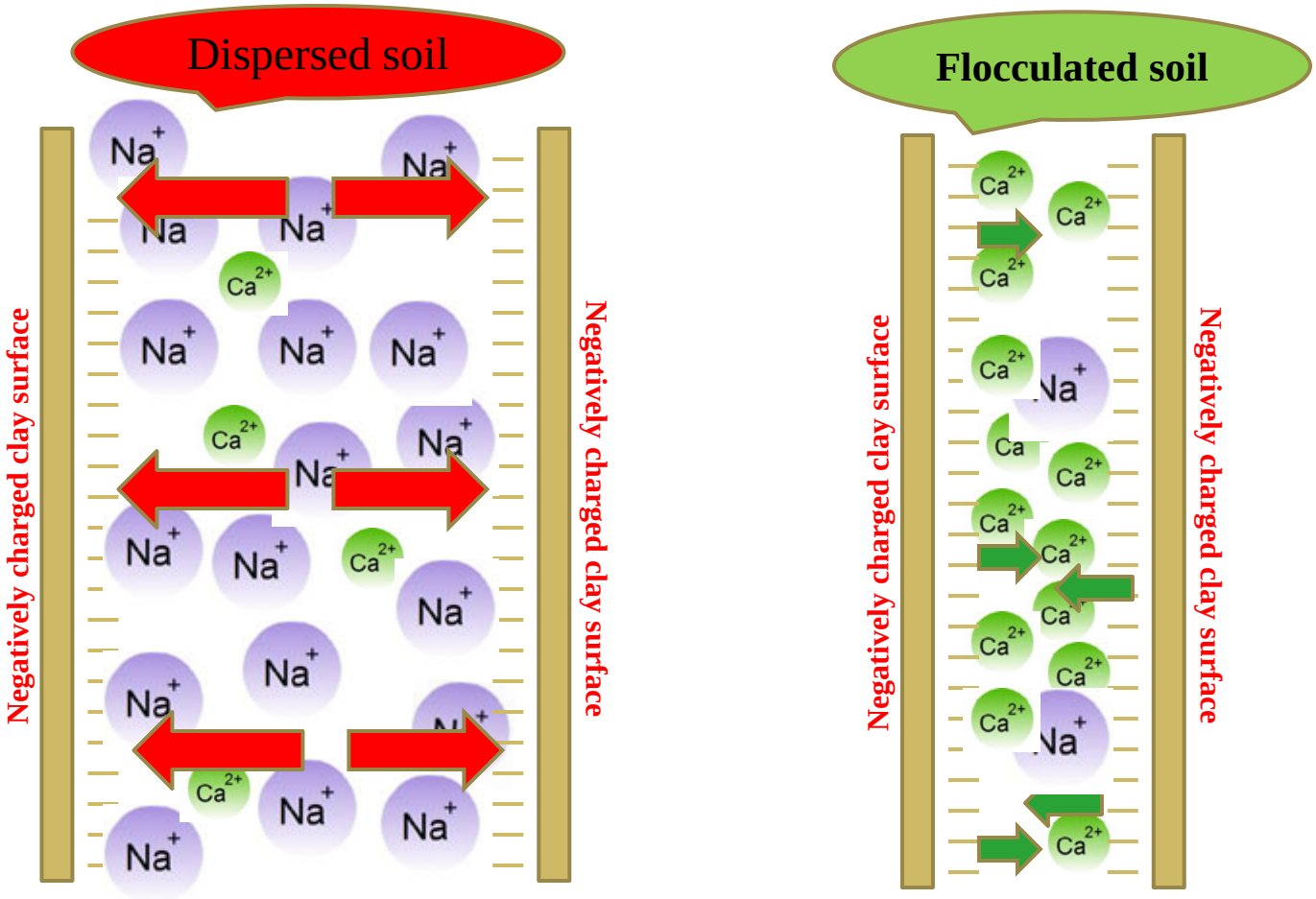
Lal 2006

# 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 |

# Questions

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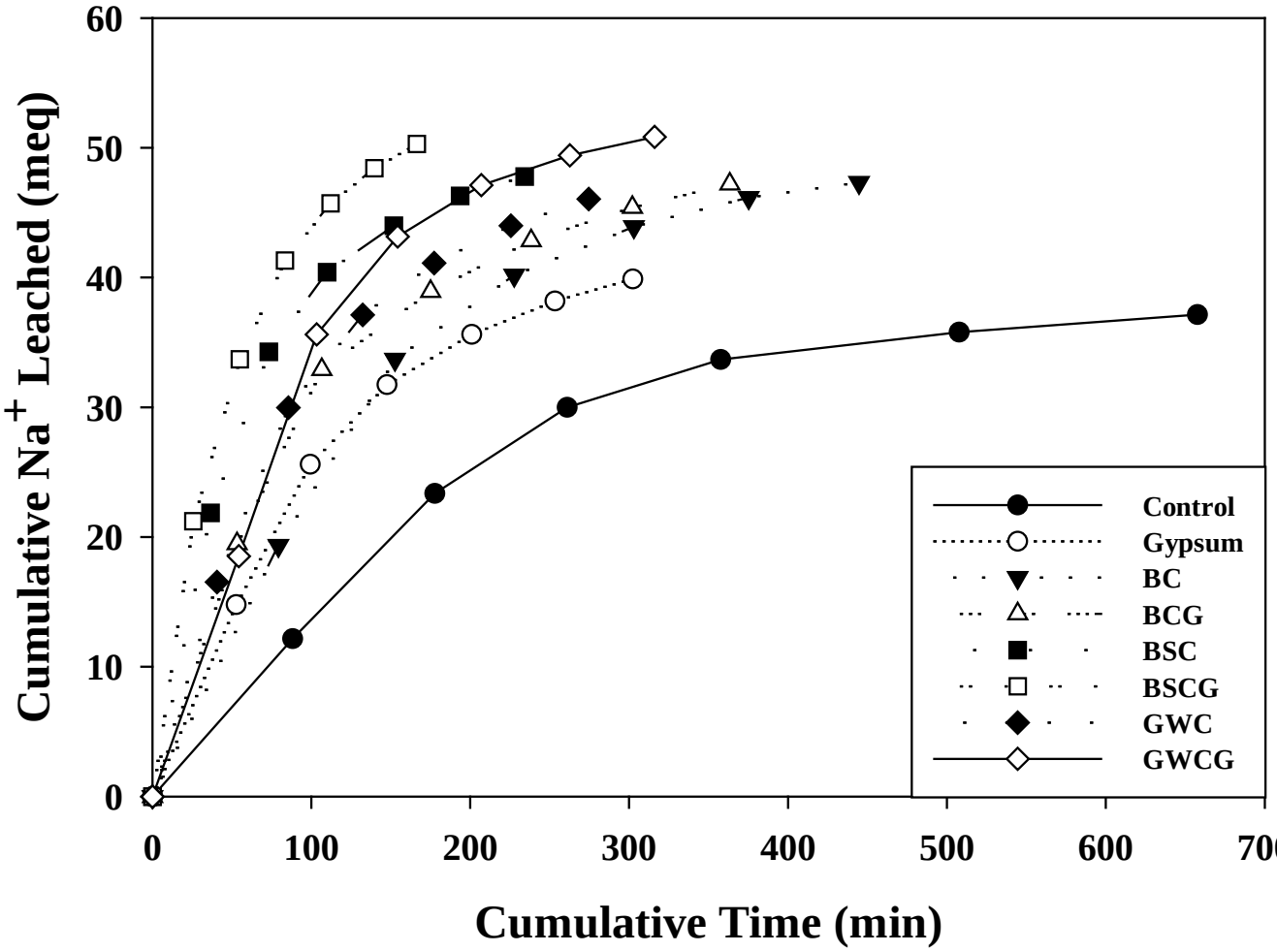
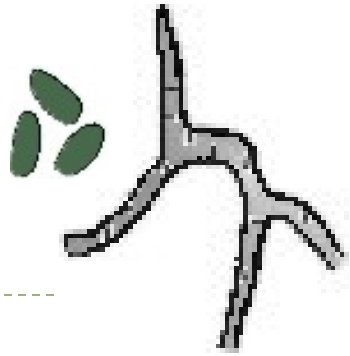
# Salinity: Gypsum accelerated performance of amendments

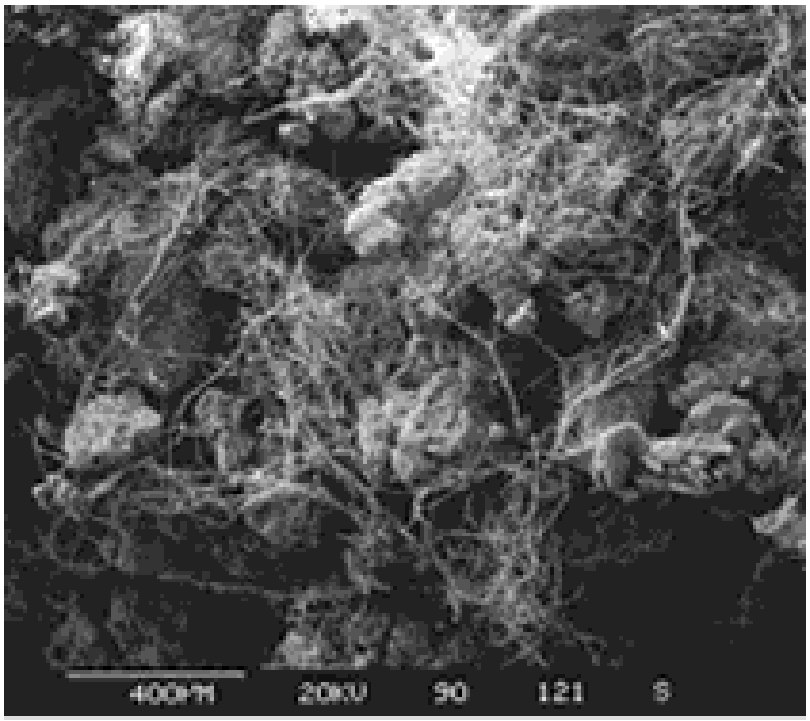



- **Control**
  soil
- **Gypsum**
  50% rate
- **BSC**:
  biosolids compost
- **BSCG**:
  biosolids compost + gypsum
- **GWC**:
  greenwaste compost
- **GWCG**:
  greenwaste compost + gypsum
- **BC**:
  biochar
- **BCG**:
  biochar + gypsum

# 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



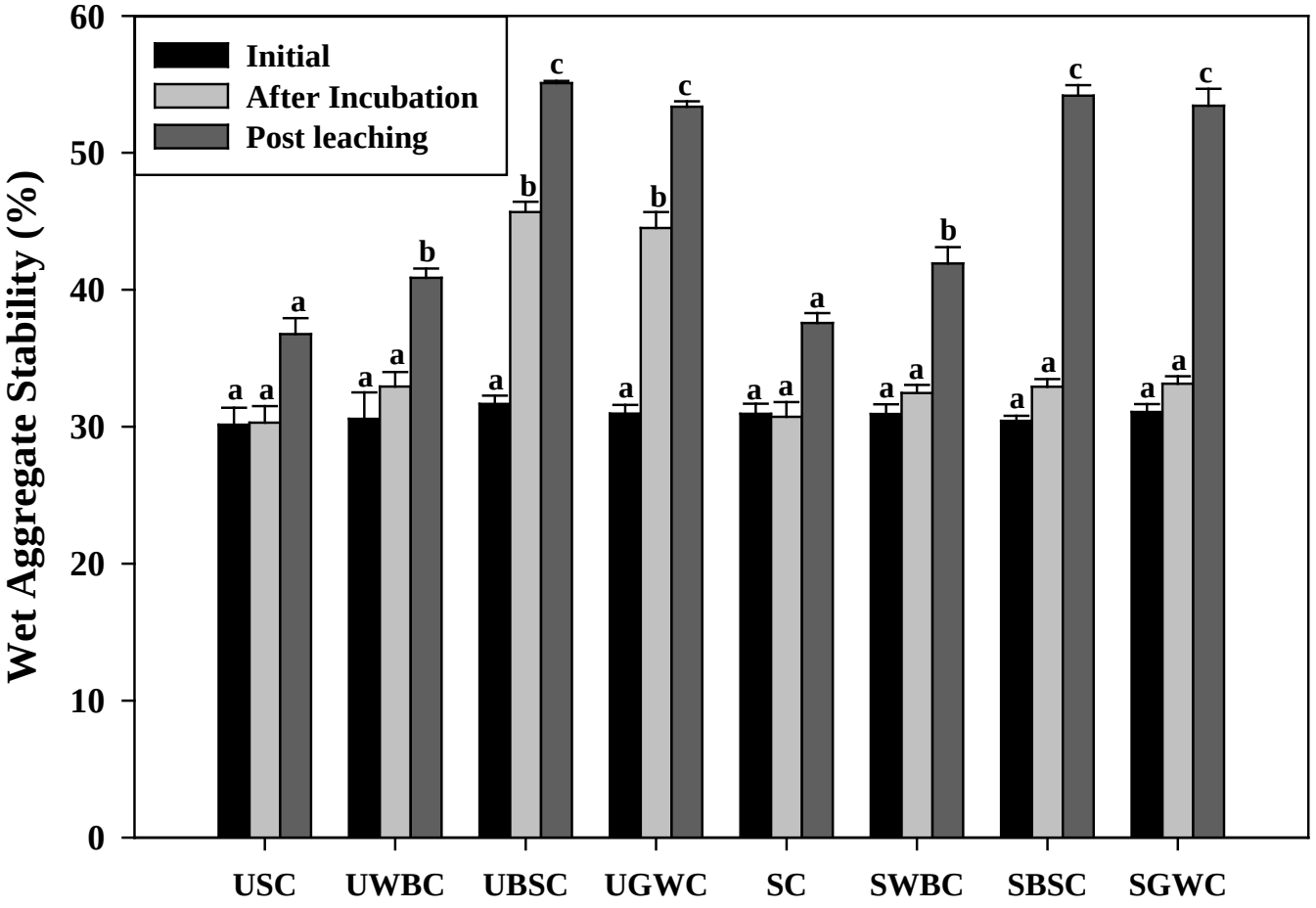


# Questions

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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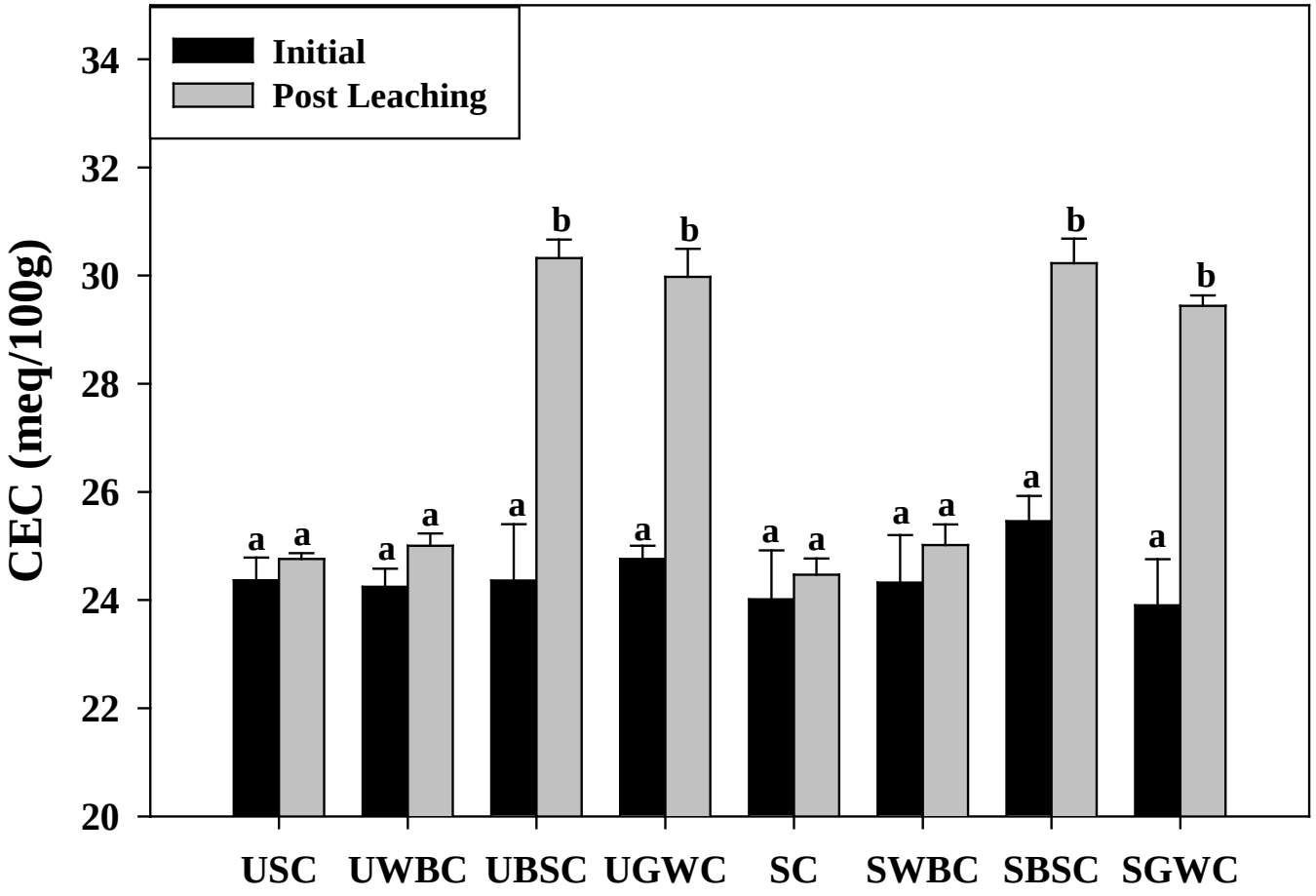
# CEC: Most improved in the composts.

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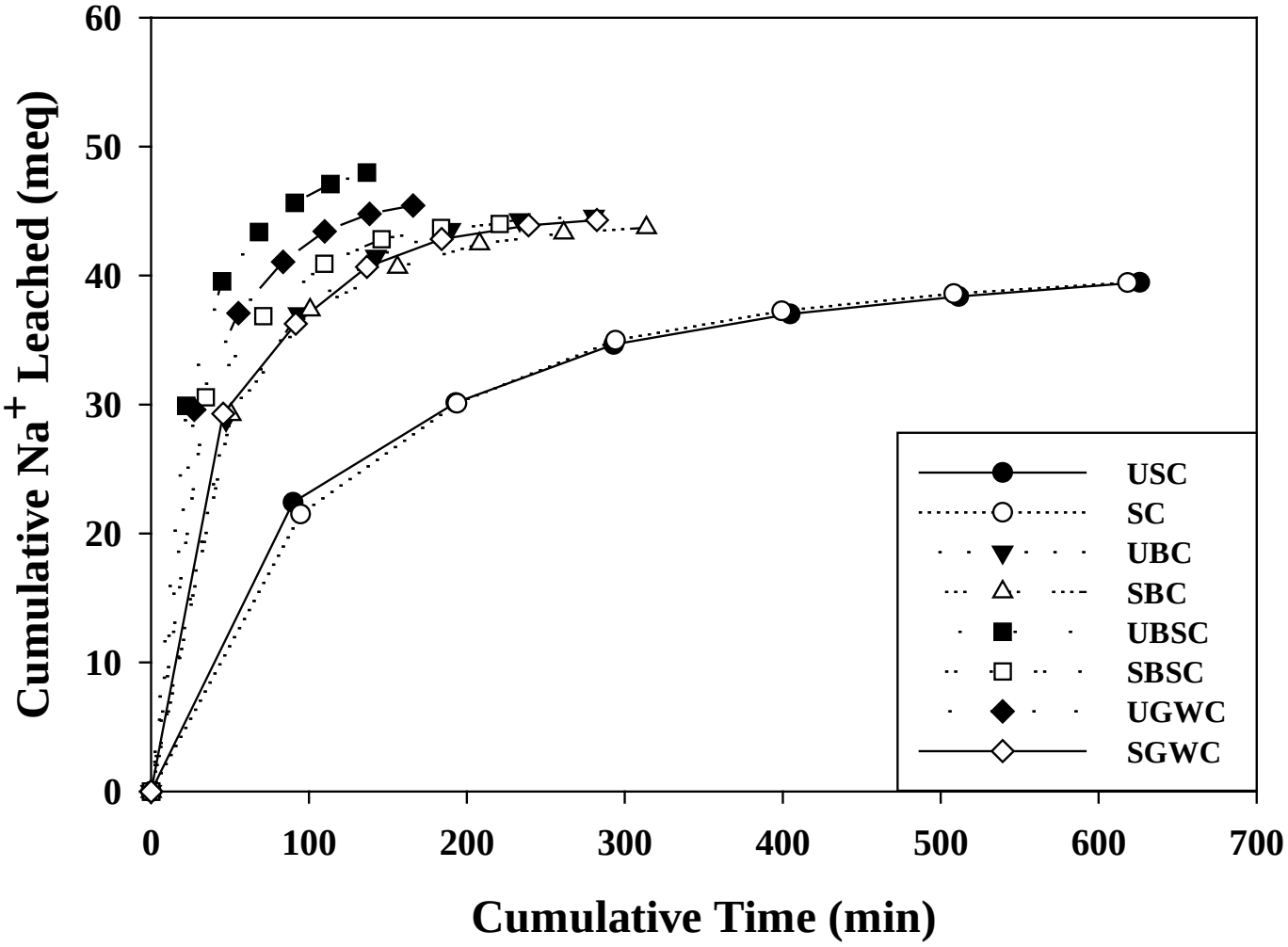
# $Na^+$: Improved fastest in unsterilized composts.

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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.**