NEW ERA AGRICULTURE MAGAZINE

Salt affected soils - Nutrient dynamics and significant remediation measures

Manoj Kumar Mahapatra[1], Rathod Sridhar[2*] and Aruna K.[3]

Introduction:

Salt-affected soils pose a major challenge to agricultural productivity worldwide. Excessive accumulation of soluble salts and exchangeable sodium disrupts soil structure, nutrient availability, and plant growth. Understanding the nutrient dynamics in salt-affected soils and implementing effective remediation strategies are crucial for restoring soil fertility and ensuring sustainable crop production.

Types of Salt-Affected Soils

Salt-affected soils are broadly categorized into:

1. **Saline Soils**: Contain excessive soluble salts, mainly chlorides and sulfates of sodium, calcium, and magnesium. They have an electrical conductivity (EC) > 4 dS/m and pH < 8.5.
2. **Sodic Soils**: Characterized by high exchangeable sodium percentage (ESP > 15%) and a pH > 8.5, which degrades soil structure and reduces permeability.
3. **Saline-Sodic Soils**: Exhibit characteristics of both saline and sodic soils, with high soluble salts and ESP > 15%.

Nutrient Dynamics in Salt-Affected Soils

Salt stress affects the availability, mobility, and uptake of essential nutrients:

- **Macronutrients**:
  - **Nitrogen (N)**: High salt levels reduce nitrogen mineralization and microbial activity, leading to lower nitrogen availability.
  - **Phosphorus (P)**: Salinity reduces phosphorus solubility due to precipitation with calcium and magnesium, limiting plant uptake.
  - **Potassium (K)**: Competes with sodium (Na+) for uptake, often resulting in potassium deficiency in plants.
- **Micronutrients**:
  - **Iron (Fe) & Zinc (Zn)**: High pH in sodic soils reduces Fe and Zn solubility, causing deficiencies.

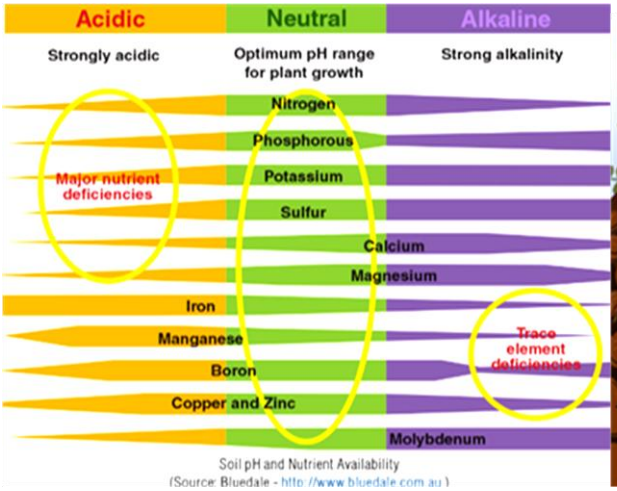
Manoj Kumar Mahapatra[1], Rathod Sridhar[2] and Aruna K.[3]*

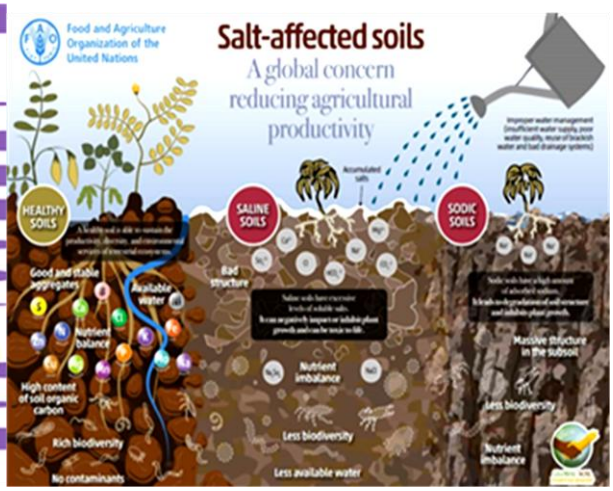
[1]Msc scholar, Department of soil science and Agricultural Chemistry, Odisha University of Agricultural and Technology

[2]Research Scholar Department of Agronomy, School of Agricultural Sciences, Nagaland University, Medziphema Campus, Dimapur (Nagaland), India-797106

[3] Professor Jayashanakar Tealnagana Agriculture University, Hyderbad

- **Boron (B)**: Excessive salinity can lead to toxic levels of boron, affecting plant growth.





The impact of salinity on nutrient availability in soils & *Microscopic images of soil aggregates in normal vs. salt-affected soils.*

Effects on Soil Structure and Microbial Activity

- **Dispersion of Soil Particles**: High sodium levels lead to poor aggregation, causing soil crusting and reduced infiltration.
- **Reduced Microbial Biomass**: Salinity negatively impacts microbial communities involved in organic matter decomposition and nutrient cycling.
- **Water Holding Capacity**: Saline and sodic soils have poor water retention, limiting plant water availability.

Remediation Measures for Salt-Affected Soils

1. **Physical Methods**

- **Leaching with Good Quality Water**: Applying excess water helps flush out soluble salts from the root zone.
- **Deep Tillage**: Improves soil aeration and breaks compacted layers, enhancing water infiltration.
- **Subsurface Drainage**: Prevents waterlogging and removes excess salts.

2. **Chemical Amendments**

- **Gypsum ($CaSO_4$)**: Replaces exchangeable sodium with calcium, improving soil structure in sodic soils.
- **Elemental Sulfur (S) and Sulfuric Acid (H_2SO_4)**: Lower soil pH and enhance nutrient solubility.
- **Lime ($CaCO_3$)**: Used in acidic saline-sodic soils to balance pH and provide calcium.

3. **Biological Approaches**

- **Salt-Tolerant Crops and Halophytes**: Growing salt-tolerant crops (e.g.,

barley, quinoa) in affected areas can improve soil health over time.

- **Green Manuring**: Incorporating organic matter enhances microbial activity and nutrient availability.
- **Microbial Inoculants**: Salt-tolerant plant growth-promoting bacteria (PGPB) enhance root growth and nutrient uptake.

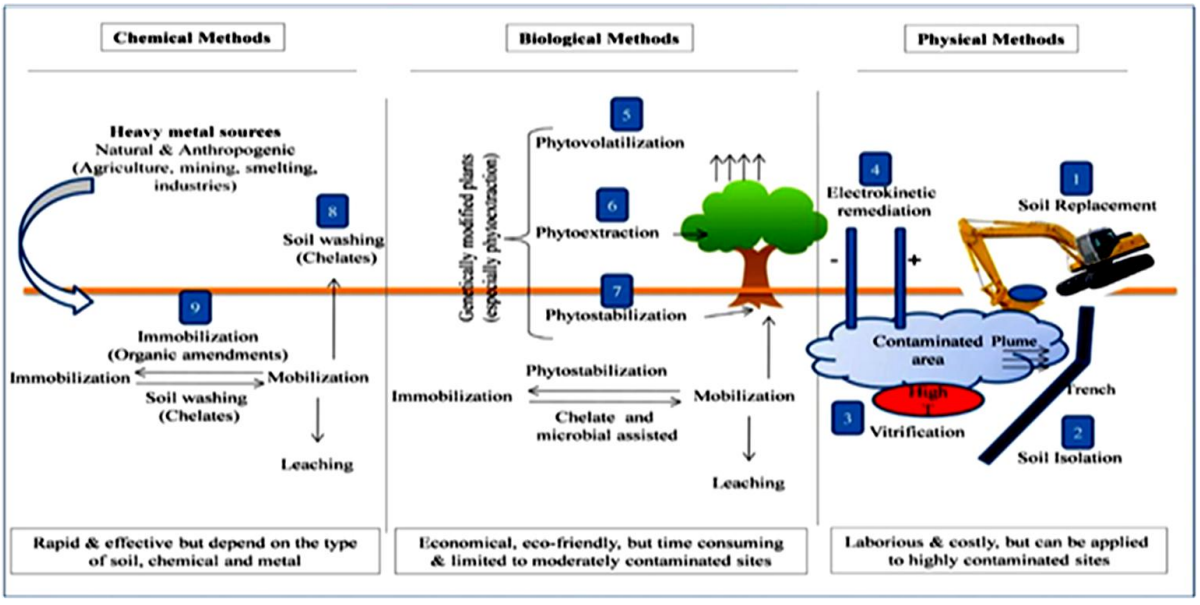
4. **Organic Amendments**
   - **Compost and Farmyard Manure (FYM)**: Improve soil organic matter, enhance microbial activity, and boost nutrient retention.
   - **Biochar Application**: Increases water holding capacity and reduces sodium accumulation.
   - **Mulching**: Reduces evaporation losses and minimizes salt concentration in the upper soil layers.

Integrated Management for Sustainable Reclamation

A combination of physical, chemical, and biological approaches ensures long-term soil health improvement. Adopting an integrated approach tailored to local conditions is key to successfully reclaiming salt-affected soils.

Conclusion

Salt-affected soils significantly impact agricultural productivity, but effective management strategies can restore soil health and improve crop yields. Understanding nutrient dynamics and applying appropriate remediation measures, including gypsum application, biological amendments, and soil conservation practices, are essential for sustainable agriculture.



References

1. Chaganti, V. N., Crohn, D. M., & Šimůnek, J. (2015). Leaching and reclamation of a biochar and compost-amended saline–sodic soil with moderate SAR reclaimed water. *Agricultural Water Management, 158*, 255-265.
2. Flowers, T. J., & Colmer, T. D. (2008). Salinity tolerance in halophytes. *New Phytologist, 179*(4), 945-963.
3. Grattan, S. R., & Grieve, C. M. (1999). Salinity–mineral nutrient relations in horticultural crops. *Scientia Horticulturae, 78*(1-4), 127-157.
4. Huang, Y., Wang, L., Wang, W., Li, T., & He, Z. (2020). Effects of sulfur application on soil properties and plant growth in saline soils: A meta-analysis. *Geoderma, 360*, 114022.
5. Mahmood, S., Abdullah, M., Wahid, F., et al. (2021). Agroforestry as a sustainable approach for mitigating soil salinity. *Environmental Science and Pollution Research, 28*(27), 35513-35530.
6. Marschner, P. (2012). *Marschner's mineral nutrition of higher plants* (3rd ed.). Academic Press.
7. Munns, R., & Tester, M. (2008). Mechanisms of salinity tolerance. *Annual Review of Plant Biology, 59*, 651-681.
8. Qadir, M., Oster, J. D., Schubert, S., Noble, A. D., & Sahrawat, K. L. (2007). Phytoremediation of sodic and saline–sodic soils. *Advances in Agronomy, 96*, 197-247.
9. Qadir, M., Quillérou, E., Nangia, V., Murtaza, G., Singh, M., Thomas, R. J., et al. (2014). Economics of salt-induced land degradation and restoration. *Natural Resources Forum, 38*(4), 282-295.
10. Rengasamy, P. (2010). Soil processes affecting crop production in salt-affected soils. *Functional Plant Biology, 37*(7), 613-620.
11. Shahid, S. A., Zaman, M., Heng, L., & Mueller, L. (2018). Soil salinity: Historical perspectives and a world overview of the problem. In *Guideline for salinity assessment, mitigation and adaptation using nuclear and related techniques* (pp. 43-53). Springer.
12. Singh, R. P., Jha, P. N., & Mishra, B. K. (2016). Microbial inoculation for reclaiming salt-affected soils: Potential benefits and risks. *Applied Soil Ecology, 105*, 163-172.