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Amelioration of Salt Affected Soils for Enhancing Crop Productivity

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INTRODUCTION

Soils with high concentrations of soluble salts in their profiles such that these salts have negative impact on crop production. Majority of the salts are composed of chlorides (Cl^-), sulphates (SO_4^{2-}), carbonates (CO_3^{2-}) and bicarbonates (HCO_3^-) of calcium (Ca^{2+}), magnesium (Mg^{2+}) and sodium (Na^+). Salt-affected soils may be found on every continent and in almost every climate. In comparison to tropical areas, their distribution is comparatively more widespread in drier regions. Long-term solutions include an understanding of the underlying causes of salt-affected soils and their classification based on physical and chemical characteristics.

Extent of problem

Indian scenario

The extent and distribution of salt affected areas in India according to Central Soil Salinity Research Institute (2012) has been shown in Table 1. In India, salt stress has a detrimental impact on around 6.74 million hectares of soil. The presence of high levels of salt in the soils of many states, including Uttar Pradesh, Gujarat, and Andhra Pradesh, has a significant effect.

Table 1. Extent of salt affected soils in India

States	Saline soils	Alkali soils	Coastal saline	Total
	(ha)			
Andhra Pradesh	0	196609	77598	274207
A & N islands	0	0	77000	77000
Bihar	47301	105852	0	153153
Gujarat	1218255	541430	462315	2222000
Haryana	49157	183399	0	232556
J & k	0	17500	0	17500
Karnataka	1307	148136	586	150029
Kerala	0	0	20000	20000
Maharashtra	177093	422670	6996	606759
Madhya Pradesh	0	139720	0	139720
Orissa	0	0	147138	147138
Punjab	0	151717	0	151717
Rajasthan	195571	179371	0	374942
Tamil Nadu	0	354784	13231	368015
Uttar Pradesh	219890	1346971	0	1368960
West Bengal	0	0	441272	441272
Total	**1710673**	**3788159**	**1246136**	**6744968**

(CSSRI, 2012)

Formation of salt affected soils

Depending on the source of origin, salinity is classified as primary or secondary. The former is influenced by natural salt deposits, while the latter is mostly caused by anthropogenic causes.

Primary salinization

It is mainly due to the following:

- ✓ Rocks' weathering
- ✓ Capillary rise due to shallow groundwater
- ✓ Intermixing of sea water in coastal lines
- ✓ Salt loaded sand carried by sea winds

Secondary salinization

It is caused due to the following:

- ✓ Irrigation water of poor quality
- ✓ Industrial effluents
- ✓ Indiscriminate of basic fertilizers
- ✓ Flooding with salty water

Classification of salt affected soil

Two major groups of salt-affected soils have been identified on the basis of information about their existence, characteristics, and plant growth relations:

Saline soils - Development of most agricultural crops is hampered by the presence of neutral soluble salts in saline soil, the most common of which are sodium chloride and sodium sulphate salts. However, saline soils also have significant amounts of chlorides and sulphates salts of calcium and magnesium.

Sodic soils - Sodic soils contains sodium salts, especially, Na_2CO_3 that on alkaline hydrolysis lead to raise in pH of such soils.

Table 2. Chemical characteristics of saline and sodic soils (Indian classification)

Class	EC_e (dS m^{-1})	pH	ESP (%)	Na^+/ [Cl^-] +[SO_4^{2-}]
Saline	>4	<8.2	<15	<1
Alkali	<4	>8.2	>15	>1

Gupta and Abrol (1990)

The effects of excess salts on different properties of soil

Physical properties

High levels of exchangeable Na+ in salt-affected soils cause structural degradation, resulting in low porosity and poor soil-water and soil-air interrelationships. It also has an effect on hydraulic properties that include hydraulic conductivity and rate of infiltration in the soils, primarily as a result of aggregate breakdown. Slaking, clay swelling, and dispersion are the key processes that are involved in aggregate losses in sodic soils. Though swelling is a reversible process, dispersion is an irreversible one that can induce individual soil particles to translocate and, as a consequence, permanently obstruct water transmitting pores. Massive structure, poor aeration, and waterlogging will occur as consequences of degradation of soil structure and a decrease inability in soils to transmit water and air. Plant establishment and development are hampered by such factors.

Chemical properties

Salt-affected soils generally suffer from deficiencies of macro-nutrients such as NPK. However, higher pH reduces availability of iron, zinc, manganese, aluminum and copper Lower carbon inputs and further degradation of their physico-chemical properties result from decreased vegetation growth caused by higher salt concentration and osmotic pressure. Surface crusting is responsible for lower organic matter due to erosion. High ion concentration of sodium (Na^+) and chloride (Cl^-) results in exosmosis affecting the plant cells and growth.

Biological properties

Increased soil salinity causing osmotic stress and loss of water from microbial cells, has a negative effect on microbial activities. Additionally, there is also Na^+ toxicity along with carbonates, bicarbonates and chlorides causing deficiency of Ca^{2+} and organic matter losses due to structural degradation which are all responsible for lower microbial population and their activities in such soils.

Amelioration and management strategies

Management refers all the processes of protecting soil and improving its performances. The following are some of the methods for reclaiming salt-affected soils.:

Physical methods:

Scraping

Temporary soil reclamation process in which t he salt layer on the soil surface is mechanicall y scraped off and the lower layer of soil with l ess salt concentration is used for cultivation.

Flushing

Water is used to wash away the salts accumulating on the surface.

Leaching

The most common method of leaching is ponding fresh water on surface of the soil and allow it to penetrate. As salty drainage water is drained via subsurface drains, the leached salts are carried away from the reclamation area and leaching is considered as successful.

Chemical methods

1. **Use of soluble salts of calcium**
   - ✓ Gypsum ($CaSO_4.2H_2O$)
   - ✓ $CaCl_2$
   - ✓ Phospho-gypsum
2. **Use of sparingly soluble calcium salts - $CaCO_3$**
3. **Use of acid or acid forming materials**
   - ✓ Sulfur
   - ✓ Sulfuric acid
   - ✓ Sulfates of iron and aluminum
   - ✓ Pyrites (FeS_2)

Increasing dose of sulphur positively correlates with increasing rice yield and wheat yield. Similarly using green manures can also be used for amelioration of salt affected soils along with chemical amendments.

Advance Method of Amelioration of Salt Affected Soil

Many advance methods of amelioration of salt affected soil like as –

1. Municipal solid waste
2. Use of bio-char
3. Use of nanotechnology

Municipal solid waste (MSW): The application of anaerobically decomposed MSW improves the soil chemical properties by decreasing the pH, SAR and $CaCO_3$, and increasing the organic matter and cation exchange capacity (CEC). The ameliorative effect may probably be due to deprotonation of fulvic and humic acids, leading to formation of organic poly-anions. That can bind clay particles to form micro-aggregates by developing [(Cl-P-OM) x] y compounds, where Cl, OM and P, are clay particles, organic matter and polyvalent cations. Organic ameliorants, on the other hand, enrich the soil with stable OM with higher cation exchange capacity and aggregation, and are more efficient in removing Na^+ from the upper soil depth due to increased leaching.

Use of bio-char: In salt-affected agricultural land, biochar compost in combination with pyroligneous solution from wheat straw can be an effective choice for reducing salt stress and increasing crop productivity. Biochar has a more porous structure and a huge surface area, which can greatly increase the soil's water holding capacity. The use of biochar as the primary component of the compost can contribute to enhance the elimination of soluble salts. Furthermore, biochar-amended soil can form a blocky structure, preventing salt from moving upward with capillary water.

Use of nanotechnology: Nano-gypsum has a large surface area for exchanging adsorbed ions, which increases gypsum's ameliorative properties. Soil treated with nano-gypsum will accumulate more Ca^{2+} in the exchange complex than soil treated with traditional gypsum. Nano-major gypsum's impact may be due to its finer particle size, higher CEC and solubility.

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CONCLUSION

For reclamation of salt affected soil the new techniques can be more efficient and cost inexpensive, some of techniques are also save the environment from toxic waste material by converting into as a economic amendment. These techniques not only improve the physio-chemical properties but also increase the crop productivity, organic matter and soil fertility.

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