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PROBLEM SOILS AND THEIR MANAGEMENT

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INTRODUCTION

- Problem soils are the soils whose productivity is lowered due to inherent unfavorable soil conditions viz., salt content and soil reaction.
- In India, the extent of salt affected soils increased enormously to 6.74M ha.
- Soil salinity is one of the major problems restricting crop production in the arid and semi arid regions of the world.



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TYPES OF PROBLEMATIC SOIL

- Saline soil
- Sodic/alkaline soil
- Saline -sodic
- Acidic soils
- Other problematic soils-
 - a. acid sulphate soils
 - b. calcareous soils



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SALT AFFECTED SOIL

- **Geographical distribution in India-** 4 major tract
 - a. Semi arid indo gangatic alluvial tract
 - b. Arid tract of Rajasthan and Gujarat
 - c. Arid and semi arid tract of central and southern states
 - d. Coastal-alluvial soil

- **Area Distribution in India**
 - Saline soil- 2.96 Mha
1st Gujarat, 2nd Rajasthan
 - Sodic soil- 3.78 Mha
1st UP , 2nd Gujarat

Source: agrigyaan site



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CHARACTERISTIC

Characteristics of saline soils : Saline soils contain neutral soluble salts of chlorides and sulfates of sodium, calcium and magnesium.

- The electrical conductivity of saturated extract of the soil is more than 4 dS m^{-1} . ESP is less than 15 and pH is less than 8.5.
- Because of the presence of excess salts and low amount of Na^+ , these soils are in a flocculated state and their permeability is higher than alkali soils.
- Their physical condition is good and water can pass through them. These soils have a white crust of salts on their surface.
- Salinisation refers to the accumulation of neutral soluble salts in soils.



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- **Characteristics of alkali or sodic soils:** Most of the Na^+ is in exchangeable form.
- EC of saturated extract is less than 4 dS m^{-1} . ESP is more than 15 and Ph more than 8.5.
- Such soils are not in a good physical condition and the surface of these soils is sometimes black due to dispersion of organic matter and humus.
- Such soils if ploughed when wet, turn into slick furrow slice referred to as slick spots.



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- **Characteristics of saline - Alkali soils:** These soils have both soluble salts and exchangeable sodium. The soil reaction becomes strongly alkaline because of hydrolysis of exchangeable sodium. The physical condition of the soil is deteriorated.
- The EC of saturated extract is more than 4 dS m^{-1} , ESP is more than 15 and pH is around 8.5.
- They are transitional soils that they may be converted into saline or into sodic soils



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Comparison of characteristics of salt affected soils

Characteristic	Saline soil	Sodic soil or alkali soil	Saline – sodic soil
Soil pH	~ 8.5	>8.5	<8.5
EC	> 4 dS m ⁻¹	<4 dS m ⁻¹	> 4 dS m ⁻¹
ESP	<15	>15	>15
Content in soil	Excess soluble salts of calcium, magnesium and sodium	Presence of excess exchangeable sodium on the exchange complex	These are transition soils. They contain sodium saturation and excess soluble salts



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Reclamation of Saline soils

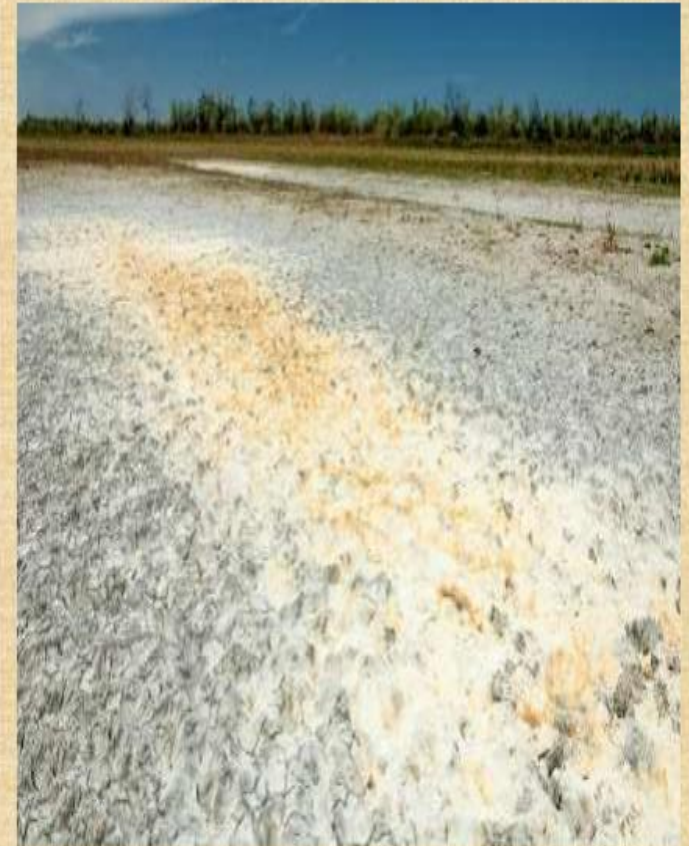
Methods of reclamation of saline soils are:

- Cultural practices
- Tolerant and sensitive crops
- Biological reclamation
- Chemical method
- Irrigation water management



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Saline soil



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I. Cultural practices

- **Scraping:** Removing the salt that have accumulated on the soil surface by mechanical means.
- **Flushing:** Washing away the surface accumulated salts by water over the surface is sometimes used to desalinize soils having surface salt crust.
- **Leaching:** Leaching is effective when the salty drainage water is discharged through subsurface drains that carry the leached salt out of the area under reclamation.
- Improving irrigation
- Land leveling
- Subsoiling
- Sanding
- Safe disposal of saline water

Leaching requirement may be defined as the fraction of irrigation water that must be leached through root zone to control soil salinity at any specific level.



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II. Tolerant and sensitive crop

- Most of the major **cereal crops exhibit high tolerance** to soil salinity, it include crops like sorghum, wheat , triticale, oats, barley etc.
- **Vegetable crops tend to fall into more sensitive** than to tolerant categories, only notable exception are asparagus and red beet under marginal condition of salinity.
- Most fruit trees are relatively sensitive to salinity. Stone fruit, citrus and avocado have all shown specific sensitivity to foliar accumulation of Cl⁻ and Na⁺.
- Chrysanthemum, carnation are considered moderately tolerant to salt stress. Aster, poinsettia, gladiolus are considered sensitive.



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III. Biological Reclamation

The decomposition of cattle manures and plant residues, in the soil liberates carbon dioxide and organic acids which help to dissolve any insoluble calcium salts in the soil solution and also neutralize the alkali present. Decomposing organic matter improves soil permeability and increases stable aggregates.

The organic amendments or improvement of saline soil are:

- **Green manuring and crop residues:** decomposition acting as solubilizing agent for Ca and neutralizing high pH of alkali soils. *Sesbania aculeata* has been found most successful on saline soils.
- **Afforestation:** The forest growth exerts ameliorative effect on the soil by loosening the subsoil and improving permeability through the action of the root system.
- **Bulky organic manures**



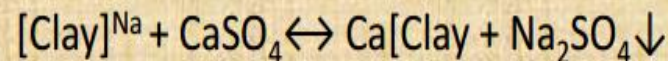
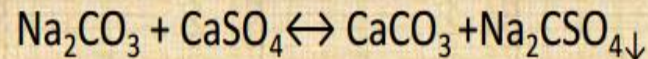
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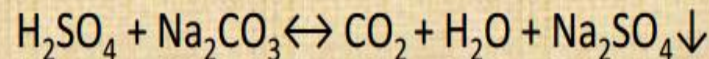
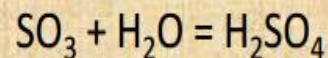
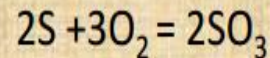
IV. Chemical method

Amendments:

- **Gypsum:** When gypsum is applied to ameliorate salt affected soils, the following reaction will take place and loss of exchangeable sodium occurs and calcium will take place of sodium on the exchange complex. Gypsum reacts with both Na_2CO_3 and the sodium adsorbed sodium as follows:



- **Sulphur:**





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V. Irrigation water management

- **irrigation frequency:** Infrequent irrigation aggravates salinity effects on growth, more frequent irrigations minimize the adverse effects of salt in the soil.
- Irrigation method can play an important role in controlling salts in the root zone. **Sprinkler irrigation is an ideal method** for irrigation frequently and with small quantities of water at a time. Leaching of soluble salts is also accomplished more efficiently when the water application rates are lower than the infiltration capacity of the soil and such a condition cannot be achieved by flood irrigation method.



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RECLAMATION OF SODIC SOIL :

Basically, reclamation or improvement of sodic soils requires the removal of part or most of the exchangeable sodium with more favourable calcium ions in the root zone.

1) CHEMICAL METHOD :

Chemical amendments for sodic soil reclamation can be broadly grouped into **three categories** :

- Water soluble calcium salts, e.g. Gypsum, Calcium chloride.
- Acid or acid forming substances, e.g. Pyrites, Sulphuric acid, iron sulphate, aluminium sulphate, lime- sulphur , sulphur etc.
- Calcium salts of low solubility, e.g. ground limestone, by product lime of sugar factory.

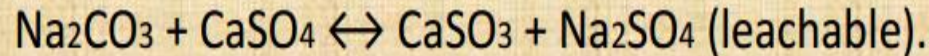


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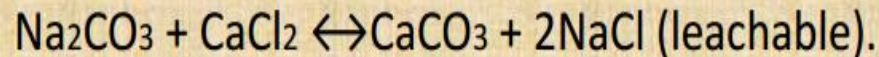
GYPSUM :

Gypsum is chemically $CaSO_4 \cdot 2H_2O$ and is a white mineral that occurs extensively in natural deposits. It must be ground before it is applied to the soil. Gypsum is soluble in water to the extent of about one-fourth of 1 percent and is, therefore, a direct source of soluble calcium. Gypsum reacts with both the Na_2CO_3 , and the adsorbed sodium as follows:



CALCIUM CHLORIDE :

Calcium chloride is chemically $CaCl_2 \cdot 2H_2O$ It is a highly soluble salt which supplies soluble calcium directly. Its reactions in sodic soil are similar to those of gypsum:





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Sodic
soil



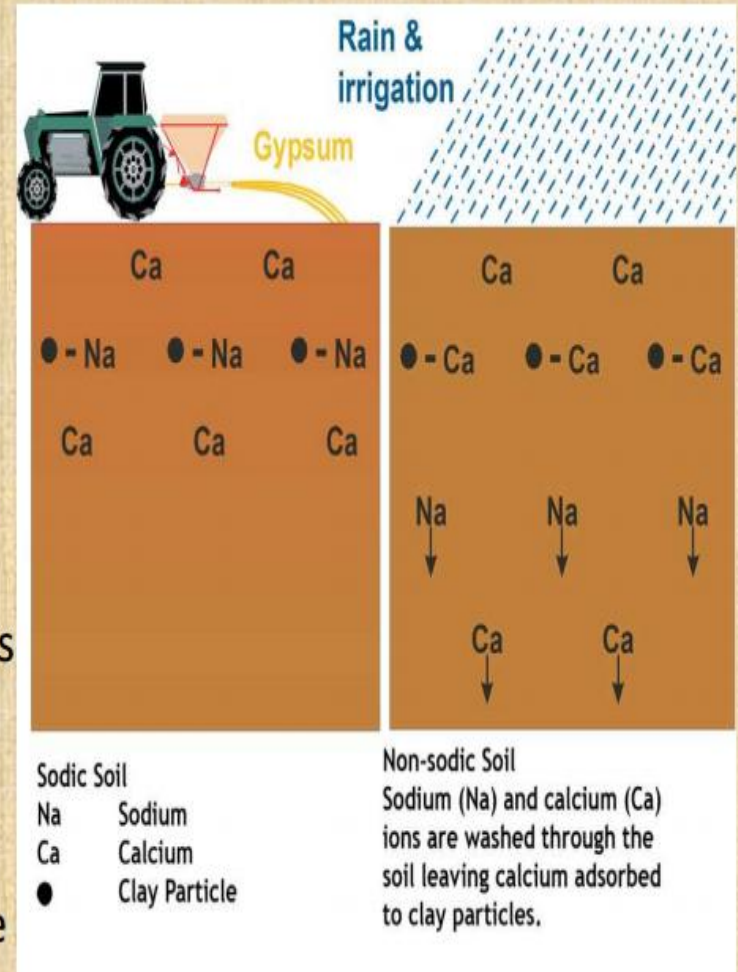
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2) CULTURAL METHOD :

Following methods are used for cultural reclamation :

- Deep ploughing
- Subsoiling
- Sanding and profile inversion
- Land levelling
- Improving planting techniques
- Scraping
- Flushing
- Leaching
- Improving irrigation/ drainage





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3) BIOLOGICAL METHOD :

- **Bulky organic manure, green manure, crop residues** application and other biological materials which produce weak organic acids that helps in creating temporarily acidic condition and help in reclamation .
- **Crop rotation** is good for sodicity problem. E.g. Rice-Dhaincha, Dhaincha- Rice -Berseem.
- **Frequent irrigation** with small quantities of water is successful irrigation management practices.
- **Tree plantation** is very useful .



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4) TOLERANT AND SENSITIVE CROPS :

- **Choice of crops** :Growing crops tolerant to excess exchangeable sodium can ensure reasonable returns during the initial phases of reclamation.
- Rice and Dhaincha appear to be tolerant to sodic conditions , wheat and bajra are only moderately tolerant and legume crops like mash and lentil are relatively sensitive to excess exchangeable sodium.
- Crops like wheat, cotton, barley, tomatoes, etc. were rated as tolerant.
- Crops that are able to withstand excess moisture conditions resulting in short-term oxygen deficiencies are also more tolerant of sodic conditions.



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5) IRRIGATION WATER MANAGEMENT :

- Leaching with water of good quality
- Continued use of quality irrigation water, good irrigation methods, and cropping practices further displaces adsorbed sodium.
- In some cases, it may be necessary to restore the soil to greater depths to obtain adequate drainage and root penetration.



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Reclaiming saline-sodic soil

- this type of soil can be reclaimed by replacing the exchangeable Na with Calcium.
- This is commonly accomplished by adding **gypsum**, since it is relatively soluble and inexpensive.
- However if the soil is naturally high in Calcium carbonate(lime), then **elemental S or sulphuric acid** can be applied.
- Saline sodic soil should be leached with a good quality (low-sodium)**water treatment** with calcium bearing amendment or sulfur.



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Acidic soils

- The soil having pH less than 7 is called acidic soil.
- They contain excessive amounts of dissolved ions of Al, Fe, Mn and Cu.
- Acid soils are deficient in Ca and Mg .
- Acid sulphate soils are rich in pyrite which on oxidation form sulphuric acid .These soils have pH <3.5.
- Crops on these soils suffer mainly due to Al toxicity and nutrient deficiency



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Distribution of acid soils in India

- Total area – 92 million ha.
- Among states M.P. is 1st and Maharashtra is 2nd
- Acid soils comprise about 28% of total geographical area
- 9.3% area has pH < 5.5 ,
18.9% area has pH range 5.5-6.5





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Formation of Acid soils

- 1) Parent materials (Granite- acidic)
- 2) Acid rain (High pollution area, US-CANADA)
- 3) Acid forming fertilizers – $(\text{NH}_4)_2\text{SO}_4$
- 4) High rainfall area (basic salts leach down – remain Al^{3+})
- 5) Highly weathered soil (Laterite soil- it has Fe and Al)



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Kinds of soil acidity

- 1) Active acidity / Solution acidity-** It is due to dissolved H^+ and Al^{3+} ions in solution . It measured by pH.
- 2) Exchangeable acidity** - It is due to adsorbed Al^{3+} , H^+ at clay surface , replaced by neutral salts.
- 3) Reserve acidity / residual acidity** – Acidity remaining after liming .

Total acidity= (active acidity + exchangeable acidity + reserve acidity)



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RECLAMATION OF ACID SOILS

A) Liming

- Application of lime is recommended for reclaiming acid soils.
- Burnt lime - CaO , Hydrated lime- Ca(OH)_2 , Basic slag - CaSiO_3 , Dolomite- $\text{CaCO}_3 \cdot \text{MgCO}_3$, Calcite.
- It improves the base saturation, inactivates iron, manganese and aluminium in soil solution
- Lime should be applied once in five years depending on soil pH.



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• **B) Choice of crops**

- Rice is relatively tolerant to soil acidity, since flooding the field raise soil pH to near neutrality.
- Millets and oats among cereals, groundnut among the legumes, tea and potato among others can be grown on acid soils.

C) Soil fertility management

- Leaching losses of nitrogen fertilisers can be reduced by split by split applications.
- Use of completely water soluble sources like SSP ,TSP,DAP should be avoided.
- Potassium sulphate is preferred over murate of potash



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Problems associated with over liming

- 1) Deficiency of Fe, Cu, Mn, Zn
- 2) Phosphorus availability reduce
- 3) Incidence of diseases like Scab in root crops increases.
- 4) Boron deficiency is seen , it adsorbed on $\text{Al}(\text{OH})_3$
- 5) Root tip swelling due to high cons. of OH^- ion



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Other problematic soils-

Acid Sulphate soils (Kari soils)

Area-

- Kottayam & Alleppey of kerala, Coastal Odisha, Sundarbans of West Bengal

Characteristics-

- Acid sulphate soils are rich in pyrites(FeS_2) which on oxidation form sulphuric acid These soils have $\text{pH} < 3.5$.
- Occur in humid region where frequent tides comes
- Sulphide(FeS_2) \rightarrow oxidation \rightarrow Sulphates(H_2SO_4)



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Management of Acid sulphate soils-

- 1) Crops- Paddy (Pokkali variety)
- 2) Keeping the area flooded , so frequent oxidation- reduction avoided.
- 3) Liming & leaching
- 4) Controlling water table
- 5) Allowing soil to dry for a long time the leaching with water , so that sulphide minerals are oxidized to sulfates and washed off.



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Calcareous Soils

- Found in arid or semi arid area , when high amount of CaCO_3 dominates .
- Characterised by the presence of CaCO_3 in the parent material and by a Calcic horizon
- pH- 7-8.5
- CaCO_3 precipitates at pH-8.5
- Calcareous soils to be low in O.M. and available N.
- Deficient in P and Mo.



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Degraded alkali soils

Characteristics-

- 1) Formed in highly irrigated /areas with extensive leaching.
- 2) Top soil – Acidic, Sub-surface soil- Sodic(black in colour)

Formation-

