25.

Genesis, Characteristics, and Reclamation of sodic soils

Learning objectives

To study the genesis, characteristics and reclamation of sodic soils

Sodic soils - Definition

Alkali or sodic soil is defined as a soil having a conductivity of the saturation extract less than 4 dS m^{-1} and an exchangeable sodium percentage greater than 15. The pH is usually between 8.5 – 10.0.

Most alkali soils, particularly in the arid and semi-arid regions, contain $CaCO_3$ in the profile in some form and constant hydrolysis of $CaCO_3$ sustains the release of OH^- ions in soil solution. The OH^- ions so released result in the maintenance of higher pH in calcareous alkali soils than that in non – calcareous alkali soils.

Expected loss of soil productivity due to ESP in different soils

ESP	Loss in productivity (%)	
	Alluvium derived soils (Inceptisols / Alfisols)	**Black soils (Vertisols)**
Up to 5	Nil	Up to 10
5-15	<10	10-25
15-40	10-25	25-50
>40	25-50	>50

Formation

Soil colloids adsorb and retain cations on their surfaces. Cation adsorption occurs as a consequence of the electrical charges at the surface of the soil colloids. While adsorbed cations are combined chemically with the soil colloids, they may be replaced by other cations that occur in the soil solution. Calcium and Magnesium are the principal cations found in the soil solution and on the exchange complex of normal soils in arid regions. When excess soluble salts accumulate in these soils, sodium frequently becomes the dominant cation in the soil solution resulting alkali or sodic soils.

Major production constraints

Excess exchangeable sodium in alkali soils affects both the physical and chemical properties of soils.

a) Dispersion of soil colloids

b) Specific ion effect

Reclamation of alkali / sodic soils

Physical Amelioration

This is not actually removes sodium from exchange complex but improve physical condition of soil through improvement in infiltration and aeration. The commonly followed physical methods include

- Deep ploughing is adopted to break the hard pan developed at subsurface due to sodium and improving free-movement water. This also helps in improvement of aeration.
- Providing drainage is also practiced to improve aeration and to remove further accumulation of salts at root zone.
- Sand filling which reduces heaviness of the soil and increases capillary movements of water.
- Profile inversion – Inverting the soil benefits in improvement of physical condition of soil as that of deep ploughing.

Chemical Amelioration

Reclamation of alkali / sodic soils requires neutralization of alkalinity and replacement of most of the sodium ions from the soil – exchange complex by the more favourable calcium ions. This can be accomplished by the application of chemical amendments (the materials that directly or indirectly furnish or mobilize divalent cations, usually Ca^{2+} for the replacement of sodium from the exchange complex of the soil) followed by leaching to remove soluble salts and other reaction products. The chemical amendments can be broadly grouped as follows:

- **Direct Ca suppliers**: Gypsum, calcium carbonate, phospho-gypsum, etc.

- **Indirect Ca suppliers**: Elemental Sulphur, sulphuric acid, pyrites, $FeSO_4$, etc.

Among them gypsum is, by far, the most commonly used chemical amendment. Calcium carbonate is insoluble in nature which of no use in calcareous sodic soils (have already precipitated $CaCO_3$) but can be used in non calcareous sodic soils (do not have precipitated $CaCO_3$) since pH of this soils are low at surface and favouring solubilisation of $CaCO_3$. Some of indirect suppliers of Ca *viz.* Elemental sulphur, sulphuric acid, iron sulphate are also used for calcareous sodic soils. These materials on application solubilise the precipitated $CaCO_3$ in sodic soils and releases Ca for reclamation.

Other sources

Distillery spent wash

Distillery spent wash is acidic (pH 3.8-4.2) with considerable quantity of magnesium. About 2 lakh litres of distillery spent wash can be added to an acre of sodic soil in summer months. Natural oxidation is induced for a period of six weeks with intermittent ploughing once in a month. In the second month (after 45-60 days) fresh water may be irrigated and drained. Such a treatment reduces the pH and exchangeable sodium percentage and increases the productivity of the sodic soil.

Distillery effluent

Distillery effluent contains both macro and micronutrients. Because of its high salt content, it can be used for one time application to fallow lands, About 20 to 40 tonnes per ha of distillery effluent can be sprayed uniformly on the fallow land. It should not be allowed for complete drying over a period of 20 to 30 days. The effluent applied field has to be thoroughly ploughed two times for the oxidation and mineralization of organic matter. Then the crops can be cultivated in the effluent applied fields by conventional methods.

Pulp and paper mill effluents

Pulp and paper effluents contain lot of dissolved solids and stabilized organic matter. The properly treated matter can safely be used for irrigation with appropriate amendments *viz.* pressmud @ 5 tonnes ha^{-1}, fortified pressmud @ 2.5 tonne ha^{-1} or daincha as in situ green manure.

The following crops and varieties were found to be suitable for cultivation in Tamil Nadu along with recommended doses of amendments *viz.* pressmud @ 5 tonnes ha^{-1}, fortified pressmud @ 2.5 tonnes ha^{-1} or daincha as in situ green manure (6.25 tonnes ha^{-1}).

Rice	IR 20, TRY 1, CO 43
Maize	CO 1
Sunflower	CO 2
Groundnut	TMV 2, TMV 7
Soybean	CO 1
Sugarcane	COC 92061,COC 671, COC 6304, COC 91064
Fodder crops	Cumbu-Napier hybrid, Paragrass,Guinea grass

Certain oil seed crops like gingelly and castor, pulses like greengram and blackgram were found to be sensitive for effluent irrigation.

Benefits

- Application of gypsum, pressmud and pyrite increases the grain yield of rice grown in a sodic soil by 79, 81 and 69 % over control respectively. Pyrite was as effective as one third of gypsum, when applied on total S content basis.
- Gypsum alone enhanced the grain yield significantly by > 50 % over control. When the manures (Green manures, FYM) were added with gypsum further improvement in yield (15 %) was observed.
- An average yield improvement of > 50 % could be possible according to severity of the problem.

Crop choice

Rice is preferred as first crop in alkali / sodic soil as it can grow under submergence, can tolerate fair extent of ESP and can influence several microbial processes in the soil. Rice-Wheat / Barley – *Sesbania*, rice-berseem are some of the rice based cropping sequences recommended for sodic soils during reclamation. Some of the lands where aerable cropping after reclamation is not economically feasible can be brought under different agroforestry systems like silviculture, silvipasture *etc.* which can improve the physical and chemical properties of the soil along with additional return on long-term basis. Some grasses like *Bracharia mutica* (Para grass) and *Cynodon dactylon* (Bermuda grass) *etc.* had been reported to produce 50% yield at ESP level above 30.

The sodicity tolerance ratings of different crops is as follows

Relative tolerance of crops to sodicity

ESP (range*)	Crop
2-10	Deciduous fruits, nuts, citrus, avocado
10-15	Safflower, blackgram, peas, lentil, pigeonpea
16-20	Chichpea, soybean
20-25	Clover, groundnut, cowpea, pearl millet
25-30	Linseed, garlic, clusterbean
30-50	Oats, mustard, cotton, wheat, tomatoes
50-60	Beets, barley, sesbania
60-70	Rice

*Relative yields are only 50% of the potential in respective sodicity ranges.

Relative tolerance of fruit trees to sodicity

Tolerance to sodicity	ESP	Trees
High	40-50	Ber, tamarind, sapota, wood apple, date palm
Medium	30-40	Pomegranate
Low	20-30	Guava, lemon, grape
Sensitive	20	Mango, jack fruit, banana

Benefits

Sodic soil reclamation through afforestation is a slow process measuring about 20-30 % during 9 years with a better efficacy of *A. indica* than *Pongamia pinnata.*

Saline-alkali/ sodic soils

Saline-alkali / sodic soil is defined as a soil having a conductivity of the saturation extract greater than 4 dS m^{-1} and an exchangeable sodium percentage greater than 15. The pH is variable and usually above 8.5 depending on the relative amounts of exchangeable sodium and soluble salts. When soils dominated by exchangeable sodium, the pH will be more than 8.5 and when soils dominated by soluble salts, the pH will be less than 8.5.

Formation

These soils form as a result of the combined processes of salinizaiton and alkalization. If the excess soluble salts of these soils are leached downward, the properties of these soils may change markedly and become similar to those of sodic soil.

Management of saline alkali soils

The reclamation / management practices recommended for the reclamation of sodic soil can be followed for the management of saline – sodic soil.

Occurrence in India:

Extent and distribution of sodic soils in India

Sr. No.	**State**	**Alkali soils (ha)**
1	Andhra Pradesh	196609
2	Bihar	105852
3	Gujarat	541430
4	Haryana	183399
5	J & K*	17500
6	Karnataka	148136
7	Maharashtra	422670
8	Madhya Pradesh	139720
9	Punjab	151717
10	Rajasthan	179371
11	Tamil Nadu	354784
12	Uttar Pradesh	1346971
	Total	**3788159**

Source : www.cssri.org

References

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Nyle C. Brady (1996).The Nature and Properties of soils. Tenth edition. Prentice hall of India Pvt.Ltd,New Delhi.

Questions to Ponder

1)What is the relationship between salts and electrical conductivity?

2)What is the fate of leached ouyt salt during saline soil reclamation?

3)What is the nutrient management in saline soil?

4)Where is saline soil predominant in India?Why? ?

5)What are halophytes?