

Saline and Sodic Soils

Mostly a problem in arid and semiarid regions where soils have high base saturation but soluble salts may also be high where irrigation water adds salt and drainage is poor. A high concentration of Na poses special problems because of the tendency of Na to disperse soil colloids.

Development of Saline and Sodic Soils

Natural salinity

Largely due to Ca^{2+} , Mg^{2+} , K^+ , Na^+ , Cl^- and SO_4^{2-} occurs where there is insufficient rainfall to leach naturally occurring salts from the upper profile. Especially high concentrations may occur at low positions in certain landscapes where laterally moving ground water contains heavy load of salt. Called *saline seeps*.

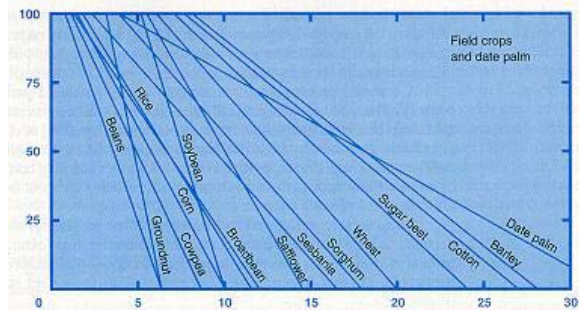
Irrigation induced salinity

Use of surface or ground water containing dissolved salts for irrigation adds salt. Evaporation from soil surface leads to accumulation of salt at or near the soil surface resulting in a *saline soil*. If the Na, though not total salt, concentration is high a *sodic soil* is formed. These problems are avoided if there is adequate drainage.

Effects of Salinity on Plant Growth

Osmotic effect

Salinity decreases soil water potential so that the plant is drought stressed at lower matric potential (or soil water content). At even lower water content (increased salt concentration), exosmosis may occur. Salinity effect is typically worse on young plant than mature plant and may inhibit seed germination. Salt tolerance varies with species.



Yield reduction of several crops as a function of the electrical conductivity (EC) of soil.

Measuring Salinity and Sodium Content

Soluble salt concentration
Exchangeable sodium percentage
Sodium adsorption ratio

Soluble salt concentration

Electrical conductivity EC of water (soil water) increases with increasing concentration of electrolytes. The EC is directly related to the ionic strength of the soil solution and the ionic strength depends on the concentration (and charge) of electrolytes. So EC is a measure of salt concentration. The units of EC are decisiemens per m (dS /m). It is measured in laboratory using a soil water extract. It can also be measured in the field, either directly or indirectly, however, less accurately.

Exchangeable Na percentage ESP

$$\text{ESP} = \left(\frac{\text{exchangeable Na}^+ \text{ cmol}_c / \text{kg}}{\text{total exchangeable cations cmol}_c / \text{kg}} \right) \times 100$$

Soils with high ESPs have high pHs

ESP = 15 % pH = 8.5
Higher ESPs pH > 10

Sodium adsorption ratio SAR

$$\text{SAR} = [\text{Na}^+] / ([\text{Ca}^{2+}] + [\text{Mg}^{2+}])^{1/2}$$

The SAR is highly correlated to ESP and since it is more easily measured than ESP, it is more often used to characterize the Na content of soils.

Classification of Saline and Sodic Soils

Type	EC	SAR
Saline	≥ 4.0	< 13
Sodic	< 4.0	≥ 13
Saline-sodic	≥ 4.0	≥ 13

Saline soils

Salt concentration as measured by EC is sufficiently high to adversely affect growth of most plants. But adsorbed Na^+ sufficiently low and Ca^{2+} and Mg^{2+} high that soil is not dispersed. *White alkali soil*

Sodic soils

Level of soluble salts is low $\text{EC} < 4.0 \text{ dS/m}$ but $\text{SAR} > 13$ and $\text{ESP} > 15\%$. Also, $\text{pH} 8.5$. The high exchangeable Na^+ disperses soil colloids and drastically reduces hydraulic conductivity. Plant growth may be affected by high level of Na^+ , HCO_3^- and CO_3^{2-} and high pH .

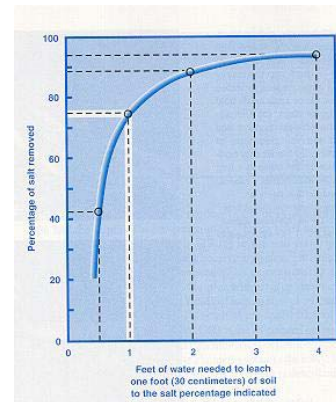
Dispersed organic colloids appear as a dark surface deposit. *Black alkali soil*

Saline-sodic soils

Characteristics of both saline and sodic soils. But high concentration of soluble salts limits the tendency of soil high in exchangeable Na^+ to disperse. However, saline-sodic soils may become sodic if the soluble salts leached.

Reclamation of Saline Soils

Flush soluble salts from soil profile. This requires irrigation water that is low in soluble salts together with good soil drainage.



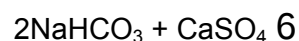
Crudely, about 30 cm of water is needed to remove about 3 / 4 of soluble salts from each 30 cm depth of salt-affected soil.

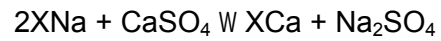
To avoid accumulation of salt in the root zone, irrigation water in excess of that needed to supply water for plant growth is added. This excess amount is called the *leaching requirement*.

Reclamation of Saline-Sodic and Sodic Soils

Cannot leach excess salts from saline-sodic soil because reduced ionic strength of soil solution in presence of high Na^+ will lead to soil dispersion. The high concentration of Na^+ must first be reduced. Sodium is replaced by Ca^{2+} or H^+ .

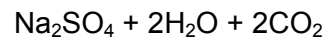
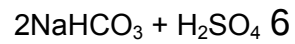
Add gypsum to reduce adsorbed Na^+ and carbonates





(where XNa, e.g., is adsorbed Na^+)

Similarly, by addition of S or H_2SO_4



Drainage is improved and hydraulic conductivity is increased. Soluble salts are then leached from the profile.