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Sodium Absorption Ratio

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What is SAR ?

"Sodium adsorption ratio" (SAR) is a measure of the amount of sodium (Na+) relative to calcium (Ca2+) and magnesium (Mg2+) in the water extracted from a saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

The formula for calculating the sodium adsorption ratio (SAR)

$$\mathrm{SAR} = \frac{Na^{+}}{\sqrt{\frac{1}{2}(Ca^{2+} + Mg^{2+})}}$$

where sodium, calcium, and magnesium concentrations are expressed in milliequivalents/liter.

- The sodium adsorption ratio (SAR) is a parameter related to the sodium, calcium, and magnesium concentrations in a saturated soil paste. (concentrations in meq/L or mmolc/L).
- It is also a standard diagnostic parameter for the sodicity hazard of a soil, as determined from analysis of pore water extracted from the soil.

- SAR is a widely used index for characterizing soil sodicity.
- Another index used to characterize sodicity is the exchangeable sodium percentage (ESP), related to the cation exchange capacity (CEC).
- High SAR values indicate that sodium content in a soil has the potential to result in poor physical conditions, due to crusting, water-logging, or poor permeability.
- High exchangeable sodium content can enhance clay swelling and dispersion, or disaggregation, of the soil.
- The degree of clay swelling and dispersion depends on the levels of sodium and the salinity of the soil solution and applied irrigation water

The classification of soils related to salts is shown in Table 1:

Table 1: Soil Classification

Class	EC (mmhos/cm)	SAR	ESP
Normal	< 4	< 13	< 15
Saline	> 4	< 13	< 15
Sodic	< 4	> 13	> 15
Saline-Sodic	> 4	> 13	> 15

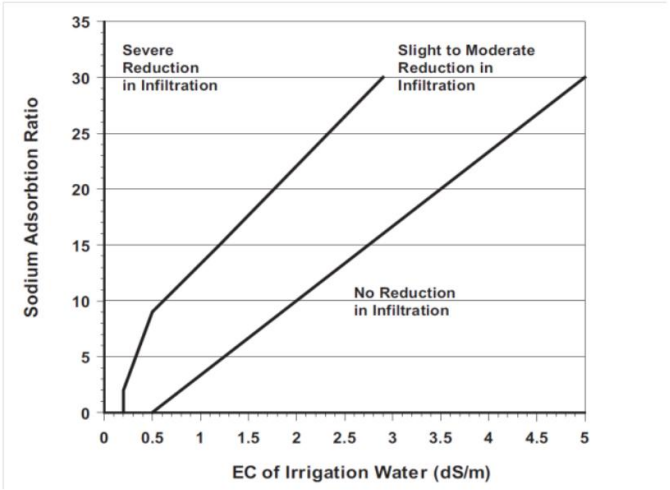
Electrical conductivity (EC) in this table refers to a saturated soil paste measurement. In this scheme, SAR and EC are presented as they relate to the classification between a saline soil (EC >4, SAR< 13), a sodic soil (EC<4, SAR> 13), and a saline-sodic soil (EC>4, SAR>13). As shown, exchangeable sodium percentage (ESP) can be substituted at 15% as a threshold value.

- For a sodic soil, a potential management activity for restoration of permeability is to amend the soil with gypsum.
- Gypsum (calcium sulfate) allows calcium to replace exchangeable sodium in the soil and subsequently mobilize the displaced sodium out of the rooting zone via leaching, which effectively increases the calcium content and lowers the SAR.
- Adding gypsum to a saline soil could increase the salt content further and aggravate the salinity problem.However, gypsum may also be a beneficial amendment for saline-sodic soils.

RELATIONSHIP BETWEEN SAR AND ELECTRICAL CONDUCTIVITY

- Examination of the SAR of a saturated soil paste is not sufficient to determine if a potential sodium problem is likely. The SAR is also related to the electrical conductivity of the irrigation water.
- The relationship between SAR and electrical conductivity of the irrigation water is a key factor in determining the potential problem of reduction in infiltration by soil sodicity.
- This concept was introduced by Ayers and Wescot, and was further developed by Oster and Schroer and Hanson, et al.

Figure 1: SAR and EC of Irrigation Water, Effect on Infiltration



Sodium hazard of irrigation water:

- High sodium ions in water affects the permeability of soil and causes infiltration problems. This is because sodium when present in the soil in exchangeable form replaces calcium and magnesium adsorbed on the soil clays and causes dispersion of soil particles (i.e. if calcium and magnesium are the predominant cations adsorbed on the soil exchange complex, the soil tends to be easily cultivated and has a permeable & granular structure).
- This dispersion results in breakdown of soil aggregates. The soil becomes hard and compact when dry and reduces infiltration rates of water and air into the soil affecting its structure.
- This problem is also related with several factors such as the salinity rate and type of soil. For example sandy soils may not get damage so easy as other heavier soils when it is irrigated with a high SAR water.

Sodium & crops:

- High sodium concentrations become a problem when the infiltration rate is reduced to such a rate that the crop does not have enough water available or when the hydraulic conductivity of the soil profile is too low to provide adequate drainage.
- Other problems to the crop caused by an excess of Na is the formation of crusting seed beds, temporary saturation of the surface soil, high pH and the increased potential for diseases, weeds, soil erosion, lack of oxygen and inadequate nutrient availability.
- Recycled water can be a source of excess Na in the soil compared with other cations (Ca, K, Mg) and therefore it should be appropriately controlled.

SAR tolerance Of irrigation water :

Tolerance	*SAR of irrigation water*	*Crop*
Very sensitive	2-8	Fruits, nuts, citrus, avocat
Sensitive	8-18	Beans
Moderately tolerant	18-46	Clover, oats, rice
Tolerant	46-102	Wheat, barley, tomatoes, beets, tall wheat grass, crested grass

Source: Extracted from the Australian Water Quality Guidelines for Fresh & Marine Waters (ANZECC)

Solutions to SAR problems in soils: The following solutions apply for SAR problems in soils:

- Change irrigation sources

- Blend irrigation water with water lower in sodium levels

- Increase aerification

- Application of sulfur, gypsum, or sulfuric acid

- Desalination with Reverse Osmosis

- Desalination installations system design

- Desalination pre-treatment

- Membrane technology

Happy reading ...