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# Drainage Engineering (BTAI3103)

## Module 2 Drainage for Salt Control (Lecture-03: Salt problem in Soil and Water\_1)

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# Introduction

- ✓ **Salinity** refers to the amount of soluble salts in soil
- ✓ **Sodicity** refers to the amount of sodium in soils
- ✓ 80 m-ha affected by salinity around the world (@3ha/min)
- ✓ World area of saline and sodic soil soils are about 394 and 434 m-ha, respectively
- ✓ Extend and distribution of salt affected soils in India is 6.7 m-ha (CSSRI)



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# Introduction

- Certain chemical substances beyond permissible limits either in soil or irrigation water affects crop growth.
- Most salt affected soils are found in arid and semi-arid regions on the world
- In irrigated agriculture, water evaporates leaving the salts in the rootzone during crop growth.
- High water tables at some locations could bring the salts to the surface.
- Groundwater may contents large amount of salts and use of such water for irrigation could increase salt content in the soil profile.



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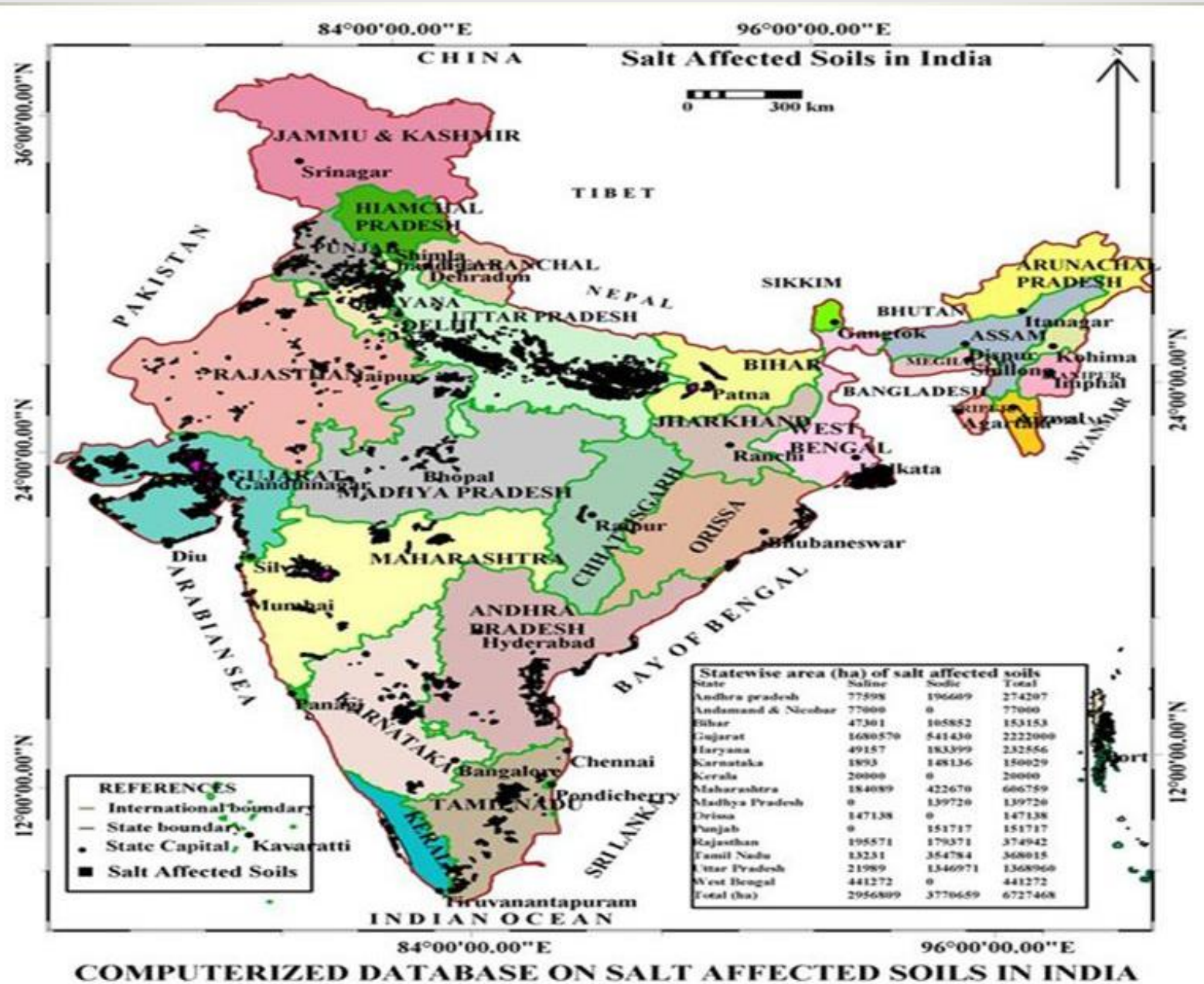
# Introduction

- High concentration of soluble salt increases the solution suction and thus reduces the availability of soil water to plants
- Salts like sodium carbonate, soluble borates etc. increase the soil pH and makes unavailable nutrients such as P, Mg, and Zn to plants.
- High conc. of exchangeable Na produce a soil structure breakdown which reduces permeability, aeration, infiltration rate and soil workability.
- Soluble salts can be removed by leaching and subsequent drainage.
- Soluble salt concentration and exchangeable sodium content, are most important parameters, which affects plant growth and soil condition.



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Source: CSSRI, 2012. (<http://www.cssri.org/index>)



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# Measurement of soluble salt concentration

- A soil sample is brought to saturation by stirring in distilled water until a characteristic end point is reached, where the soil glistens and flows slightly without free water standing on the surface. This solution is called saturation extract.
- Sometimes soil water extracts 1:1 (100gm of water per 100gm of dry sample) is used for analysis.
- The solution is extracted by placing the sample in a funnel with filter paper and applying suction.
- The total soluble salt concentration is estimated by measuring electrical conductivity (EC) of the saturation extract.



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# Salinity Units

- ✓ Total salt content of the soil solution or irrigation water is expressed as **electrical conductivity at 25°C**
- ✓ Common units: decisiemens/meter (ds/m) or mmohs/cm
- ✓ Total salinity of irrigation water (in ppm or mg/L),

$$C_{iw} = 640 \times EC_{iw}$$

where  $EC_{iw}$  is the electrical conductivity of irrigation water (ds/m)

- ✓ Standard measurement for soil salinity is expressed as saturated paste extract salinity,  $EC_e$



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# Important Terminology

**Cation Exchange:** It is the interchange of cation in solution with the help of some other cations.

**Cation Exchange Capacity (CEC):** It is defined as the amount of calcium absorbed by the soil through cation exchange process. Unit- milli-equivalent per 100 gm soil.

**Equivalent Weight:** It is the weight of an ion or compound, which combines with or replaces 1gm of Hydrogen ion.

**Milli Equivalent Weight:** It is the equivalent weight per thousands; expressed as meq.





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# Important Terminology

**Equivalent per Million:** It is defined as the ratio of weight of ion (ppm) to its equivalent weight.

**Milli Equivalent per Liter:** It is the milli-equivalent of an ion or compound in one liter of solution, expressed as meq/l.

**Electrical conductivity (EC):** It is defined as the reciprocal of electrical resistivity, expressed as mhos/cm.

When temperature is greater than 25°C:

$$\text{Actual EC} = \text{Observed EC} - 2\% \text{ of EC}/1^\circ\text{C}$$

When temperature is lesser than 25°C:

$$\text{Actual EC} = \text{Observed EC} + 2\% \text{ of EC}/1^\circ\text{C}$$



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# Important Terminology

**Sodium Adsorption Ratio (SAR):** It is an index, used for assessing the sodium hazard. It is calculated as

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

**Exchangeable Sodium percentage:** It is empirically calculated as

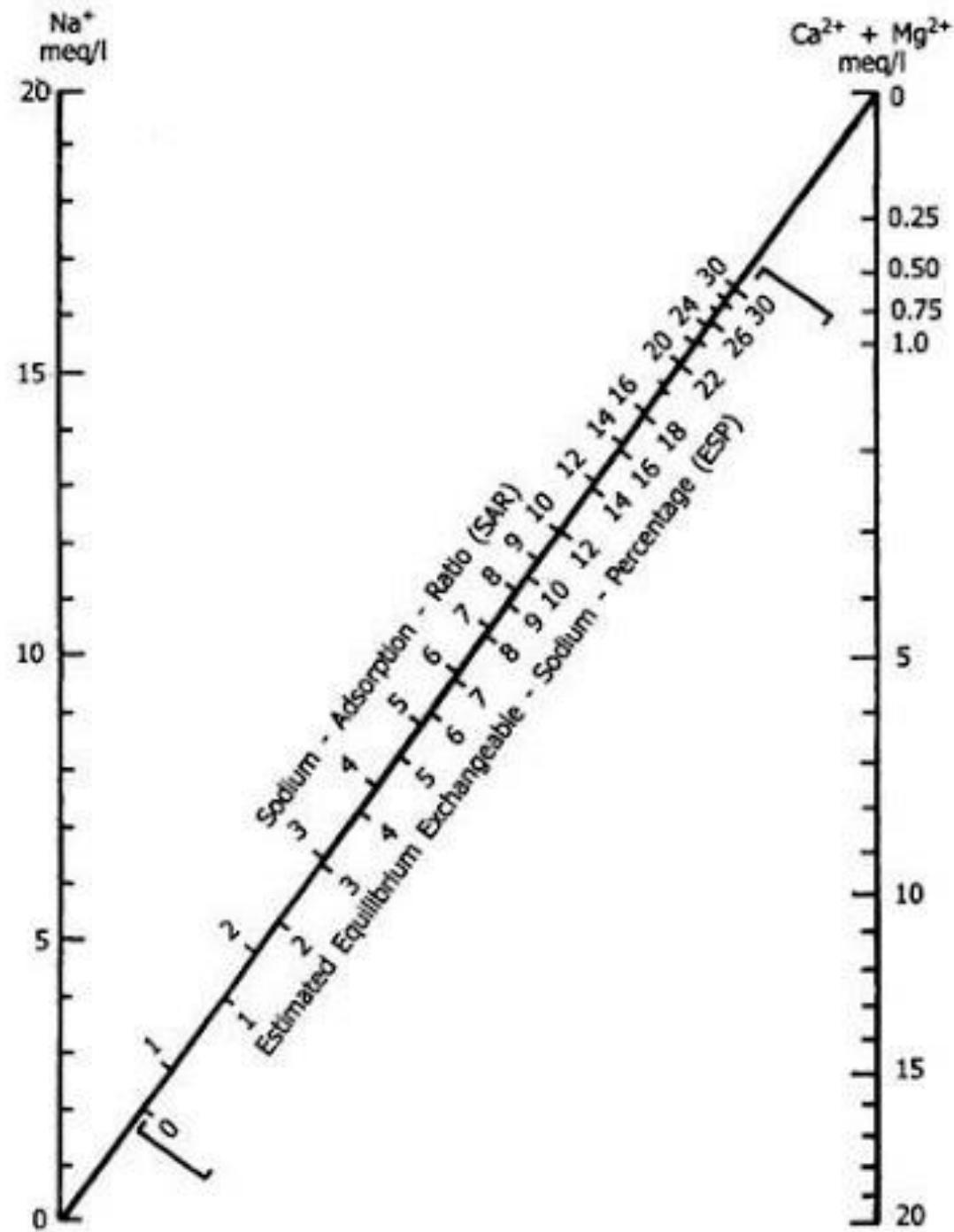
$$ESP = \frac{100(-0.0126 + 0.01475SAR)}{1 + (-0.0126 + 0.01475SAR)}$$

Nomogram can be used for determining SAR of a saturation extract and corresponding ESP value.



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**Fig. 16.2.** Nomogram for determining the SAR value of irrigation water and for estimating the corresponding ESP value of a soil that is at equilibrium with the water (USSL, 1969).



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# Osmotic Potential Energy in Soil

- ✓ Water with a higher concentration of salts has a lower energy (more negative) than water with a lower concentration of salts
- ✓ Water is driven toward the higher salinity region; therefore, plant has difficulty pulling water from the high saline soils.
- ✓ The osmotic potential energy in saturated soils:

$$\Psi_o = -3.6 \times EC_e$$

Where  $EC_e$  is the electrical conductivity of the saturated paste extract, dS/m;  $\Psi_o$  is the osmotic potential, m.



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# Osmotic Potential Energy in Soil

✓ As the soil dries, the salinity increases. The osmotic potential as a function of water content is

$$\Psi_o = -3.6 \times EC_e \times \frac{\theta_s}{\theta}$$

Where  $\theta_s$  is the saturated water content (by volume);  $\theta$  is the actual water content (by volume)



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## Example

Calculate osmotic potential in the soil at 25% water content if  $EC_e = 1$  dS/m, and water content is 50%.

## Solution

The osmotic potential as a function of water content is

$$\Psi_o = -3.6 \times EC_e \times \frac{\theta_s}{\theta}$$

$$\Psi_o = -3.6 \times 1 \times \frac{100}{50}$$

$$\Psi_o = -7.2 \text{ m}$$

$$\Psi_o = -0.72 \text{ atmospheres}$$



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