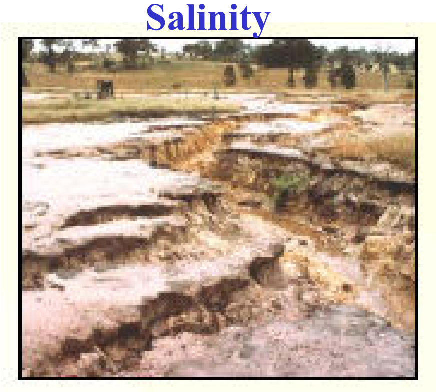
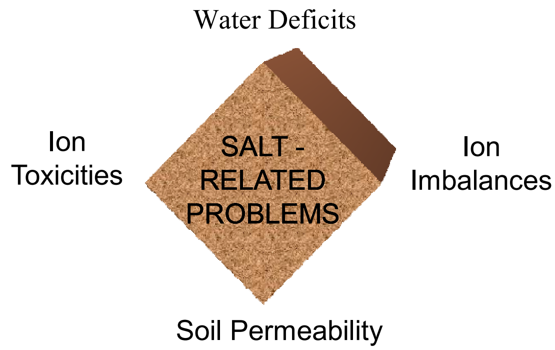
Salinity





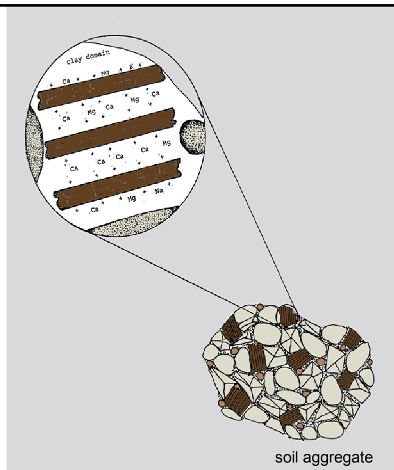
Water deficits reflect **salinity** problems from salt concentrations

Salinity -A measure of the salt concentration of water

Soil permeability reflects **sodicity** problems from sodium concentrations

Common Salt Ions

Ca^{2+}	K^{+}	NO_3^{-}
Mg^{2+}	Cl^{-}	HCO_3^{-}
Na^{+}	SO_4^{2-}	CO_3^{2-}



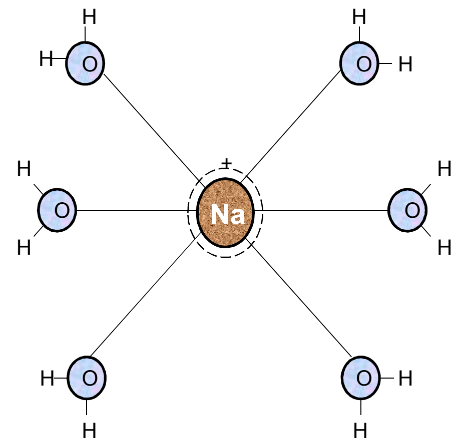


Table 1. Common salt compounds.			
Salts are ionic crystalline compounds consisting of a cation and an anion.			
Salt compound	**Cation (+)**	**Anion (-)**	**Common name**
NaCl	sodium	chloride	halite (table salt)
Na_2SO_4	sodium	sulfate	Glauber's salt
$MgSO_4$	magnesium	sulfate	epsom salts
$NaHCO_3$	sodium	bicarbonate	baking soda
Na_2CO_3	sodium	carbonate	sal soda
$CaSO_4$	calcium	sulfate	gypsum
$CaCO_3$	calcium	carbonate	calcite (lime)

Salinity is defined as the presence of excessive amounts of soluble salts in the soil (usually measured as electrical conductivity, EC). Na, Ca, Mg, Cl, and SO_4 are the major ions involved. Effects of salinity plant growth are as follows:

- Osmotic effects (water stress)
- Toxic ionic effects of excess Na and Cl uptake
- Reduction in nutrient uptake (K, Ca) because of antagonistic effects

Examples of salt-affected soils include:

- •saline coastal soils (widespread along coasts in many countries)
- •saline acid sulfate soils
- •neutral to alkaline saline, saline-sodic, and sodic inland soils (e.g., India, Pakistan, Bangladesh)
- •acid sandy saline soils

Salinity and Yields

- •Affects respiration and photosynthesis processes
- •decreased biological N2 fixation

- •affected leaves with white tips
- •some leaves with chlorotic patches
- •stunting
- •reduced tillering
- •patchy field growth

Type of hazards

- •pH
- • Salinity hazard
- • Sodium hazard
- • Carbonate and bicarbonates as they relate to calcium and magnesium content
- • Elements that may be toxic to plants

Salinity hazard factors

Figure 1 Model showing recharge, transmission and discharge zones

zones. For salinity to occur, there must be an increase in water movement through the recharge zone. This may then cause groundwater levels to rise in the discharge zone to a point where it is close to the land surface or discharges to surface water systems. Groundwater may seep onto the surface or rise to the surface by capillary action. Evaporation of groundwater causes salts to concentrate in the upper layers and on the land surface.

In areas with shallow water tables, water containing dissolved salts may move upward into the rooting zone. This occurs by capillary action (similar to the way a wick works), where evaporation serves as the suction of water up through the soil

Soil Types

The Salinity Laboratory breaks salt affected soils into three classes:

1. Saline Soil - contains sufficient soluble salts to interfere with plant growth

2. Saline-Sodic Soil - contains sufficient sodium to interfere with plant growth

3. Sodic Soil - contains sufficient soluble salts and sodium to interfere with plant growth

Range and Rating for salinity Hazard indicators

Ground water salinity (mg/l)	Rating
0-500	1
500-1500	3
1500-3000	8
>3000	10
Vegitation	
Forest	10
Wood land	9
Low wood land	8
Tall & shrub land	6
Low open shrrub	3
Grass land	1

Aquifer yield (l/s)	
0-0.5	10
0.5-5	5
>5	1
Laterite	
Present	10
Absent	1
Rain fall	
<400mm	1
400-600	4
600-800	6
800-1200	10
1200-1400	6
1400-1600	4
>1600	1

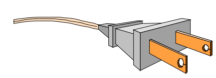
Salt-affected soils

•Saline soils are the easiest to correct;

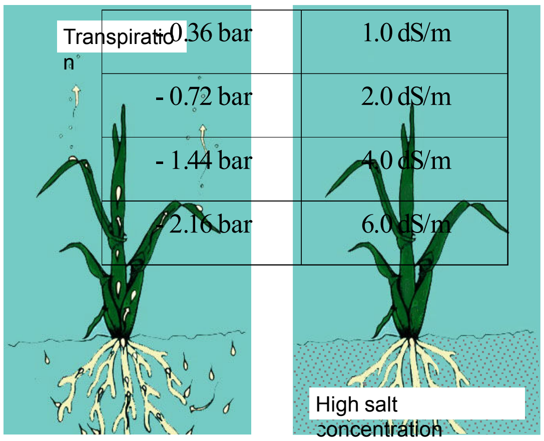
•sodic soils are more difficult.

•Each type of soil has unique properties that require special management.

Salinity Measurement



- Measured as the electrical conductivity of water (EC_w)
- Expressed as decisiemens per meter (dS/m); formerly as mmhos/cm.



Sodicity

A measure of the sodium $[Na^{+}]$ concentration in relation to the calcium $[Ca^{+2}]$ and magnesium $[Mg^{+2}]$ concentrations of water

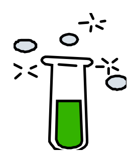
Sodicity Measurement

- Measured as the sodium absorption ratio of water (SAR_w)
- Expressed as the ratio:

$$Na^{+}/\left([Ca^{+2} + Mg^{+2}]/2\right)^{1/2}$$

- Where the concentration of each ion is expressed in milliequivalents per liter (meq/L)

Problem



With a water-quality report providing sodium, calcium, and magnesium concentrations as 76, 146, and 39 mg/L, how do we express these in meq/L?

Atomic Weights

Element	Atomic Weight (g/mole)
Calcium, Ca	40
Carbon, C	12
Chlorine, Cl	35.5
Copper, Cu	63.5
Hydrogen, H	1
Iron, Fe	55.9
Magnesium, Mg	24.3
Manganese, Mn	55
Nitrogen, N	14
Oxygen, O	16
Phosphorus, P	31
Potassium, K	39
Sodium, Na	23
Sulfur, S	32
Zinc, Zn	65.4

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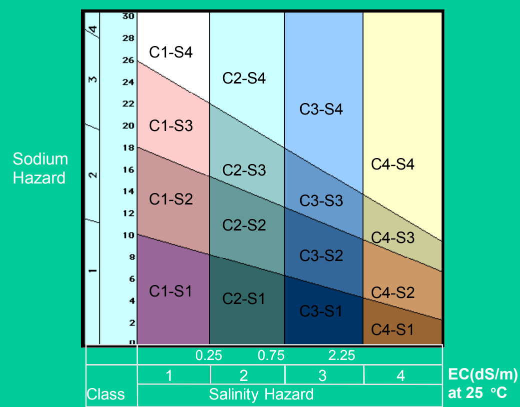
Ion	Molecular Wt. (mg/mmole)	Valence (#)	Equivalent Wt. (mg/meq)
Sodium (Na^{+})	23	1	23
Calcium (Ca^{2+})	40	2	20
Magnesium (Mg^{2+})	24	2	12

Sodium: 76 mg/L / 23 mg/meq = 3.3 meq/L

Calcium: 146 mg/L / 20 mg/meq = 7.3 meq/L

Magnesium: 39 mg/L / 12 mg/meq = 3.2 meq/L

$SAR_W = 3.3/ ([7.3 +3.2]/2)^{1/2} =$
$3.3/(5.25)^{1/2} = 3.3/2.29 = 1.44$



Carbonates and Bicarbonates.

Irrigation water with a pH value (above 8.4) may indicate that the water contains high levels of carbonates and bicarbonates (Table 1). Carbonates and bicarbonates tend to “tie up” calcium and magnesium during soil drying. This makes the sodium present potentially more damaging. High carbonates and bicarbonates in water essentially increases the sodium hazard of the water greater than indicated by the SAR

Resdiual Sodium Carbonate (RSC).

Situation. RSC tells you how much calcium and magnesium is in your water compared to carbonates and bicarbonates.

This value may appear in some water quality reports. Although not used often,

RSC gives similar information to SAR

Residual Sodium Carbonate

$RSC = [CO_3^{-2}] + [HCO_3^{-}] - [Ca^{+2}] + [Mg^{+2}]$

Where [ ] = ion concentrations in milliequivalents per liter (meq/L)

RSC Hazard

RSC	HAZARD
< 0	none
0-1.25	low
1.25-2.50	medium
>2.50	high

Amendments Required to Neutralize Residual Carbonates

RSC * 234 lbs gypsum/acre-foot

RSC * 133 lbs sulfuric acid/acre-foot

Soil Types

SOIL TYPE	ECe	pH	ESP	SAR
Saline	>4 dS/m	< 8.5	<15%	< 12
Sodic	< 4 dS/m	>8.5	>15%	>12
Saline-Sodic	>4 dS/m	>8.5	>15%	>12

Soil Salinity Hazard

ECe*	HAZARD
< 1.5	low
1.6-3.9	moderate
4.0-5.0	high
>5.0	very high

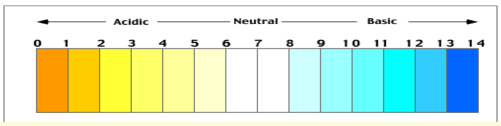
Soil Sodium Hazard

ESP	SAR	HAZARD
< 3	< 2.1	low
3-9%	2.1-7.0	moderate
9-15%	7.1-12.0	high
>15%	>12	very high

pH. Most crops will grow satisfactorily on soils with a pH ranging from 6.2 to 8.3. Crops susceptible to iron and zinc deficiencies may be affected at pH levels above 7.5.

Soils with a pH of 8.3 or higher usually have a high sodium content. Applications of sulfuric acid usually lower the pH for only a short period due to the high buffering capacity of the soils.

pH	*Classification*
> 8.5	strongly alkaline
7.9–8.5	moderately alkaline
7.3–7.9	slightly alkaline
6.7–7.3	neutral
6.2–6.7	slightly acid
5.6–6.2	moderately acid
3.0–5.6	strongly acid



Soil fertility is directly influenced by pH through the solubility of many nutrients. At a pH lower than 5.5, many nutrients become very soluble and are readily leached from the soil profile. At high pH, nutrients become insoluble and plants cannot readily extract them. Maximum soil fertility occurs in the range 6.0 to 7.2.

LOWERING SOIL PH

If soil pH is above 8.0, some action may be needed to reduce pH. After determining soil pH

consider the following measures to lower the pH of highly alkaline soils:

!Amend the soil with organic matter. On average, soils with higher organic matter contents have lower pH.

!Add elemental sulfur (90 or 99% sulfur material) annually at a rate of 6 to 10 pounds per 1000 square feet of area. Elemental sulfur slowly oxidizes in soil to form sulfuric acid. Test the soil occasionally and stop adding sulfur when pH has reached desirable levels.

!Use acidifying fertilizers such as ammonium sulfate and other products with label designations indicating an acidic reaction in the soil. With repeated use these materials may reduce soil pH.

!Plant on raised beds in a sandy medium amended with peat moss or another source of acidic organic matter. An alternative is to plant in boxes or ½ barrels heavily amended with acidic forms of organic matter.

Exchangeable Sodium Ratio (ESR) is determined from exchangeable Sodium (Nax) and cation exchange capacity (CEC) (me/100g) by the following relationship:

ESR = Nax/(CEC-Nax)

ESR = Kg x SAR
Where, Kg is Gapon coefficient.
(0.0041 to 0.0875)

Classification of Saline Waters

Water class	Electrical conductivity dS/m	Salt concentration mg/l	Type of water
Non-saline	<0.7	<500	Drinking and irrigation water
Slightly saline	0.7 - 2	500-1500	Irrigation water
Moderately saline	2 - 10	1500-7000	Primary drainage water and groundwater
Highly saline	10-25	7000-15 000	Secondary drainage water and groundwater
Very highly saline	25 - 45	1 5 000-35 000	Very saline groundwater
Brine	>45	>45 000	Seawater

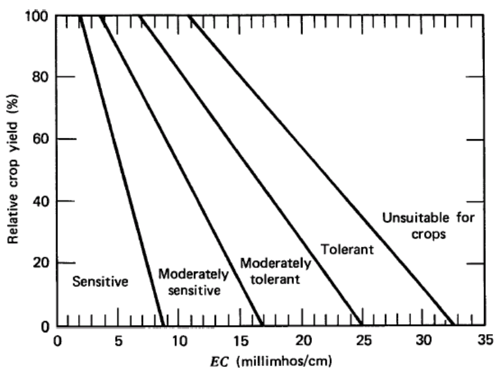


Fig. 1 Relative crop yield related to salinity (Ayers and Westcot 1987)
(to obtain TDS values in mg/L, multiply the EC value by 700)

Representative yields (in %) by crop and irrigation water salinity in survey of Hissar area of Haryana, India (after Boumans *et al.* 1988)

Crop	Tubewell salinity, EC in dS/m		
	2-4	4-6	6-8
Cotton	100	70	55
Millet	100	79	52
Wheat	100	89	60
Mustard	100	86	67
Average	100	81	59

Tools

- salinity hazard mapping;
- land use capability mapping; and
- groundwater vulnerability mapping.

Strategies

- water supply sources and availability (particularly water quality)
- road maintenance/repair.