

Calcareous & Alkaline Soils

Paul Stukenholtz

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What is a Soil?

Solid

Mineral (sand, silt, clay)

Organic Material

Liquid

Water

Stuff dissolved in water

Gas

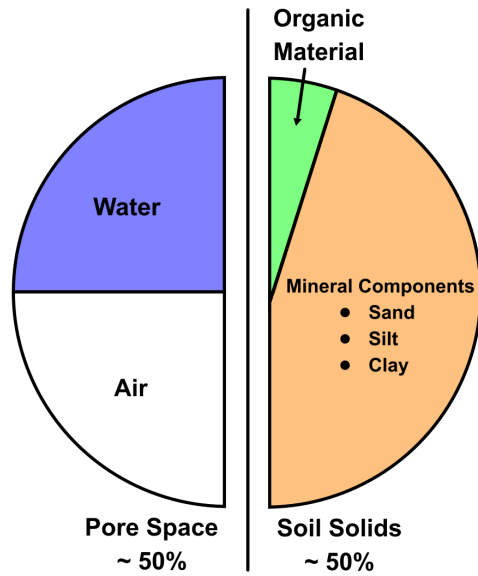
Air (Oxygen and CO₂)

Creatures, Microbes

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Components of Soil



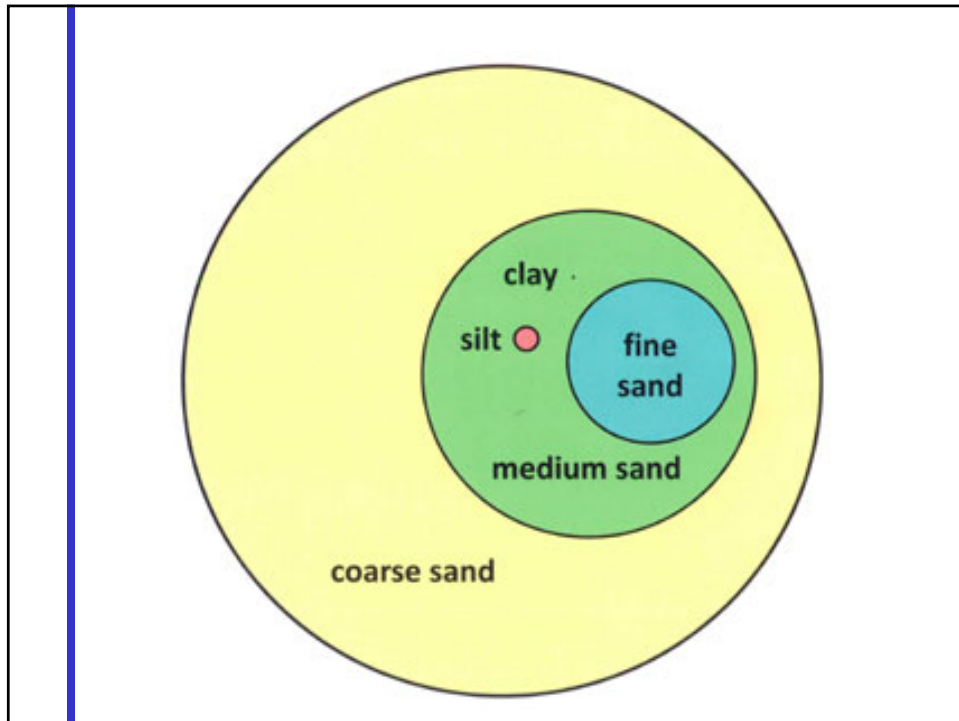
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Soil Particle Sizes

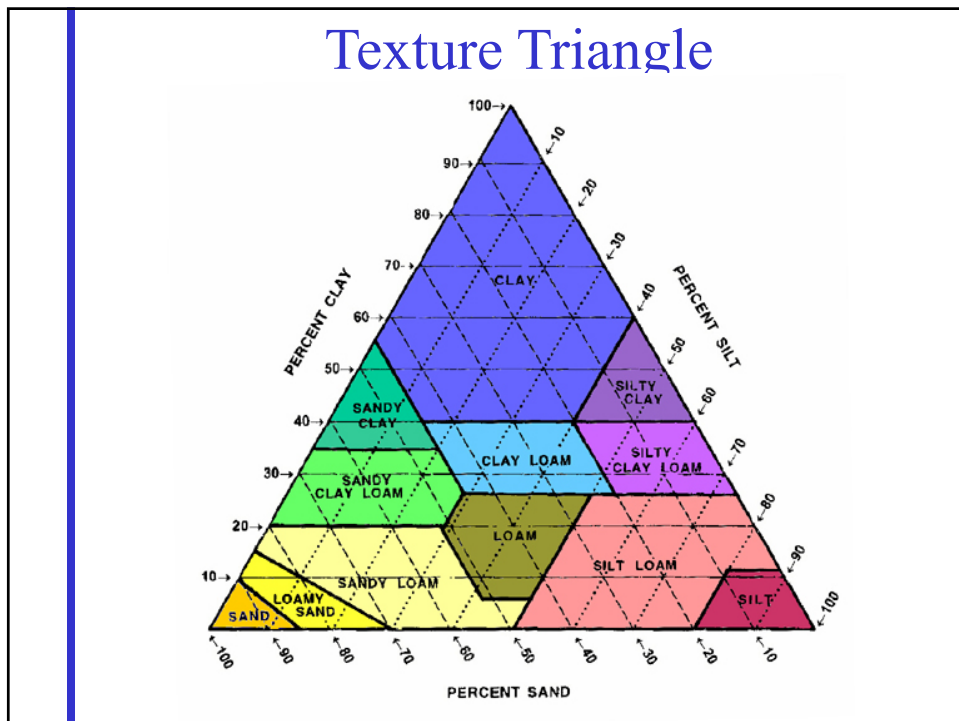
- Rock > 2.0 mm
- Sand 2.00 - 0.05 mm
- Silt 0.05 - 0.002 mm
- Clay <0.002 mm

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Ion

- An atom or group of atoms that has acquired an electrical charge by gaining or losing an electron.
- Cation - Positive charge
- Anion - Negative charge

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Cation

K^{+}

Potassium

Anion

NO_3^{-}

Nitrate

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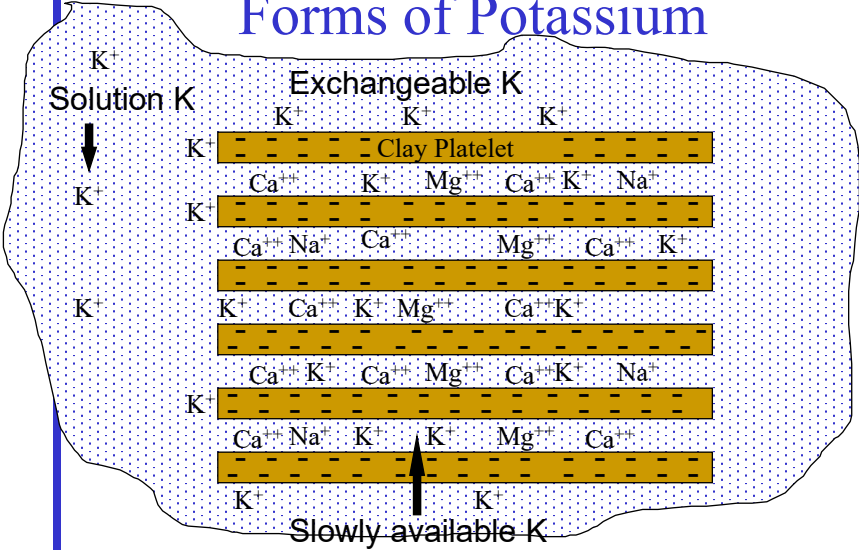


Cation

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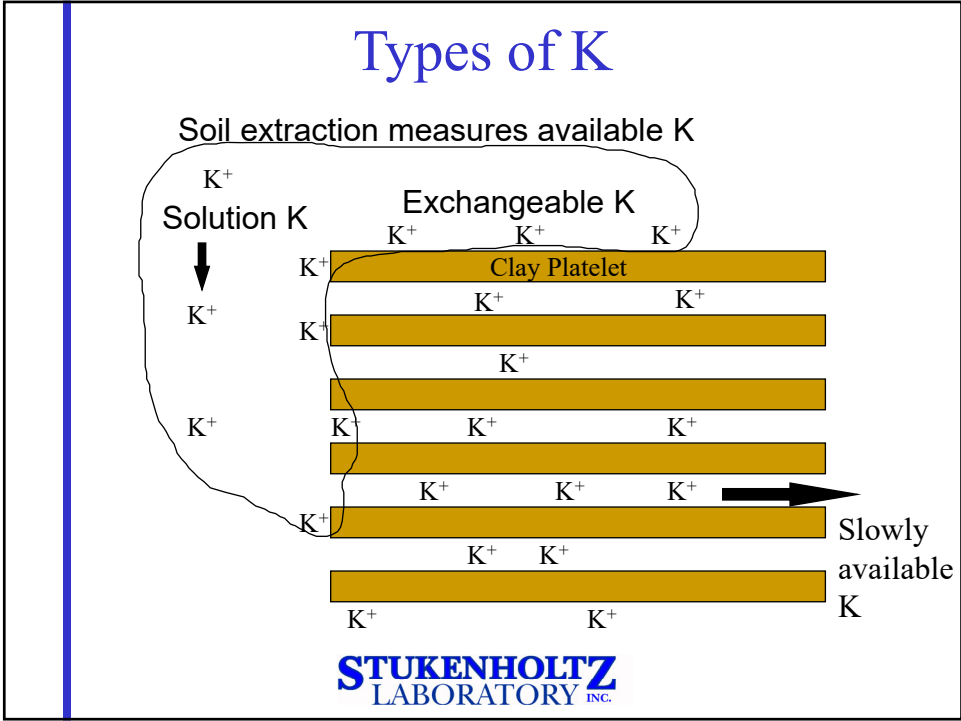
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Forms of Potassium

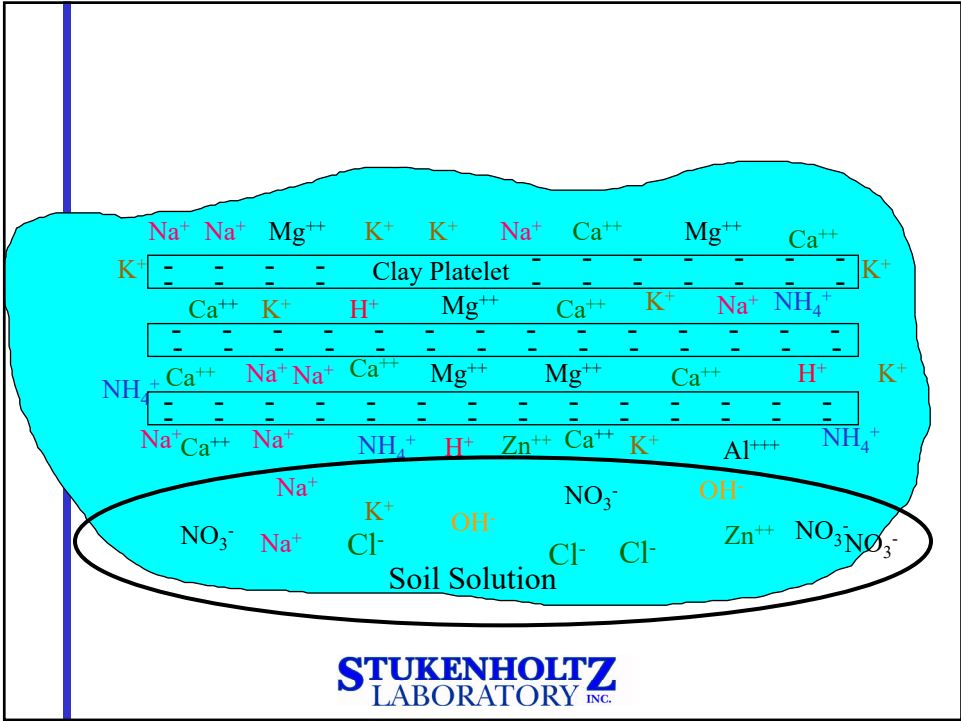


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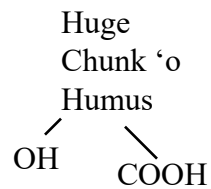
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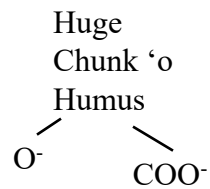
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Organic Matter & CEC

Acid Soil



Basic Soil



A very acid soil has less or no CEC from
soil Organic Matter

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Calcareous

- Contains Calcium
- Contains **Calcium Carbonate** CaCO_3
- $\text{pH} > 7.0$
- pH typically 7.5 - 8.3

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Calcareous Wyoming Soil

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208-734-3050 Fax: 208-734-3919 www.stukenholtz.comSTUKENHOLTZ, PAUL
2924 ADDISON AVE. EAST
TWIN FALLS, ID 833030353

Tel: 208-734-3050 Fax: 208-734-3919

Report No: 148470

Date Received: 11/14/2023

Date Reported: 11/15/2023

<u>SOIL TEST DATA</u>	<u>Sample 1</u>	<u>Sample 2</u>	<u>Sample 1</u>	<u>Sample</u>
pH	8.0	H	Grower	U OF WY
Salts, mmhos/cm	1.1	L	Sample Identity	PARK BROME SD
Chlorides, ppm	13	L	Crop	BROME SEED
Sodium, meq/100g	0.20	VL	Yield Goal	GOOD
CEC, meq/100g	13.6	M	Acres	36
Excess Lime, %	6.9	H	Prev Crop T/Acre	MALT BLY 1
Organic Matter, %	1.71	M	Manure T/Acre	
Organic N, lb/Acre	70	M	Prev Applied Nut	

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**Max Water Infiltration Rate
Bare Soil in/hr**

<u>Soil</u>	<u>0% XS Lime</u>	<u>20% XS Lime</u>
Sand	0.75	0.40
Sandy Loam	0.40	0.30
Loam	0.35	0.18
Silt Loam	0.30	0.15
Clay Loam	0.25	0.12
Clay	0.15	0.10

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Total vs. Available P_2O_5 at pH of 8.1 5% Excess Lime

<u>Total in Soil</u>	<u>Soil Solution</u>	<u>Labile</u>
0.05-0.25%	0.02-0.05 ppm	10-30 ppm
2000-8000 lbs/Ac·ft	0.1-0.2 lbs/Ac·ft	40-80 lbs/Ac·ft

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pH and Phosphorus

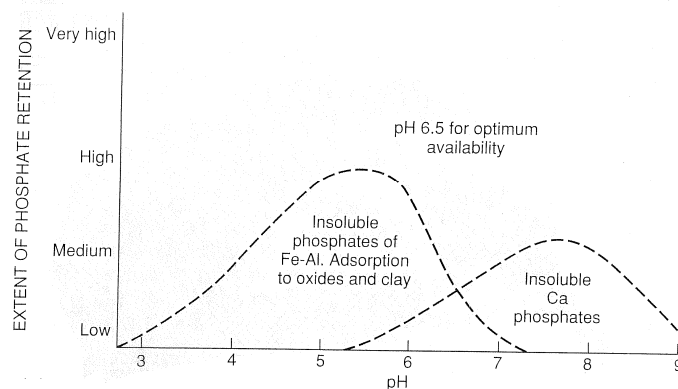


FIGURE 6.11 Soil pH effect on P adsorption and precipitation. Adapted from Stevenson, *Cycles of Soil*, p. 250, John Wiley & Sons, 1986.

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Saline / Sodic Soils

Wait
What happened to Alkaline?

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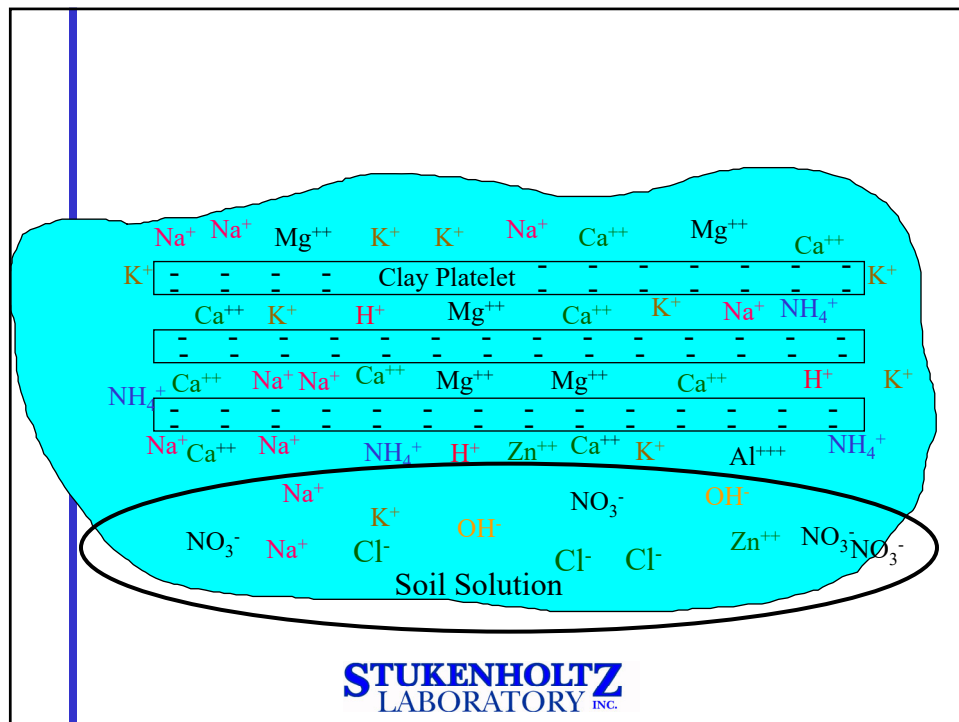
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What is Saline?

- A **saline** soil is one that contains sufficient **soluble salts** to interfere with the growth of most crop plants.
- $> \sim 4.0$ mmhos/cm
- A saline soil does not have to be high in sodium, but it often is.
- A saline soil often has high nitrates, sulfates, boron, and chlorides.

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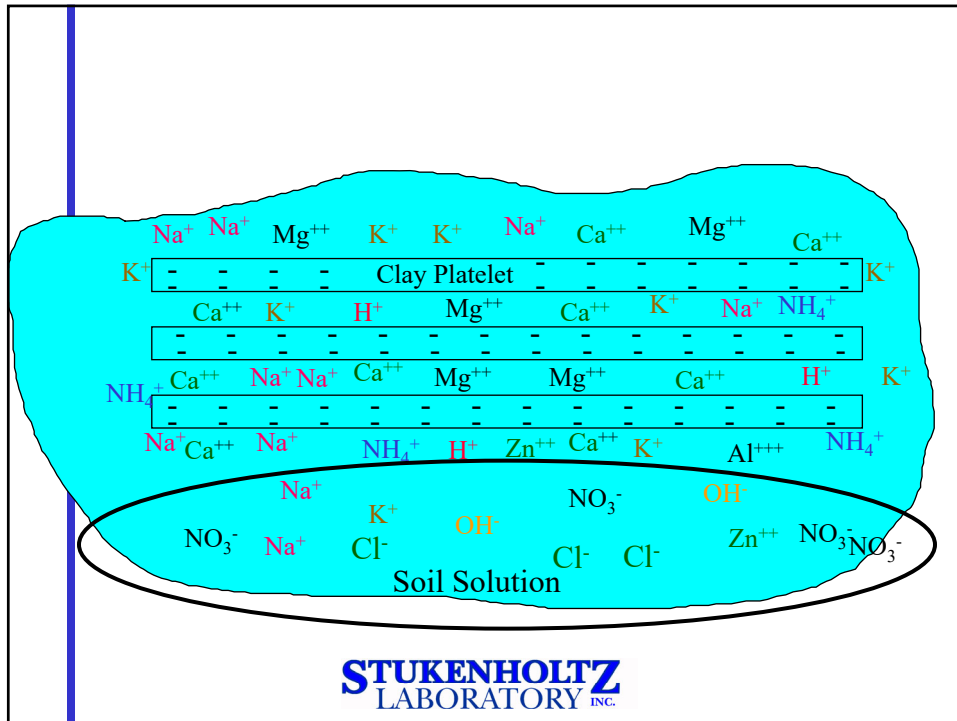
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What is an Sodic Soil?

- An **Sodic** soil is one that contains enough **exchangeable sodium** to interfere with the growth of most crop plants.
- Also called an **Alkali** soil or **Natric** soil.
 - May have a toxic level of sodium
 - Sodium may interfere with water **infiltration**
 - Most soils start to become alkali when **3-6%** of the **CEC** is filled by **sodium**.
 - At **13% sodium** they are considered fully **Alkali**

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Confusing Terms

- Alkaline - a soil with a $\text{pH} > 7.0$, also called a basic soil. Most alkali soils are alkaline, but they do not have to be.
- Calcareous - a soil with excess or free lime (CaCO_3).
- Limey Soil- Calcareous soil
- Caliche - A soil with a zone near the surface cemented by Ca or Mg Carbonates. "Limey ridge". Does not imply salt or sodium.
- Salt Ridges or Salt spots - White areas in the field. Often not salty at all.

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Saline-Sodic Wyoming Soil

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2924 ADDISON AVE. EAST

Report No: 148472

TWIN FALLS, ID 833030353

Date Received: 11/14/2023

Date Reported: 11/15/2023

<u>SOIL TEST DATA</u>	<u>Sample 1</u>	<u>Sample 2</u>		<u>Sample 1</u>
pH	9.0	VH	Grower	U OF WY
Salts, mmhos/cm	32.0	VH	Sample Identity	PARK ALKALI
Chlorides, ppm	560	VH	Crop	FOXTAIL
Sodium, meq/100g	6.80	VH	Yield Goal	GOOD
CEC, meq/100g	35.5	VH	Acres	1.5
Excess Lime, %	6.6	H	Prev Crop T/Acre	FALLOW
<u>Base Saturation, %</u>				
Potassium (Ideal 3 - 6)	2.4	L		
Calcium (Ideal 65 - 80)	62.0	L		
Magnesium (Ideal 15 - 25)	16.3	M		
Sodium (Ideal < 3)	19.2	H		

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What is a “Salt”

- Salt: the precipitate of a strong acid and a strong base.
 - Dry: a cation (+) and an anion (-) with ionic bond
 - In solution: a free cation and anion
- Table Salt: NaCl Na⁺ Cl⁻
- “Lite” Salt: KCl K⁺ Cl⁻
- Gypsum: CaSO₄ Ca²⁺ SO₄²⁻
- MAP: NH₄H₂PO₄ NH₄⁺ H₂PO₄⁻

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Cation

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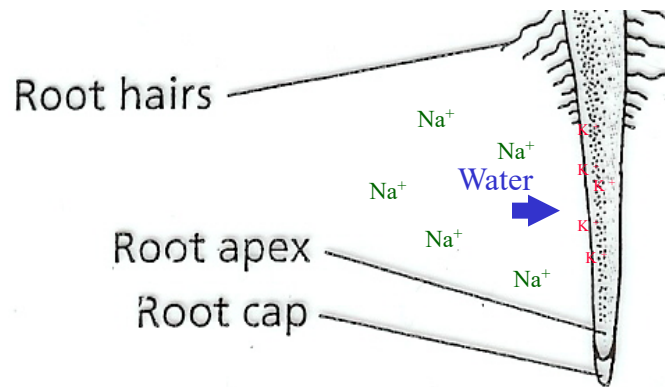
Soil Salinity

- Measured by looking at the **electrical conductivity** (EC) of a soil saturated paste.
- The units of measure are **mmhos/cm** or dS/m. They are equivalent. The unit “mho” is a geek joke. It is the inverse of an ohm; the unit of resistance.
- Siemens per meter is true SI unit
 $4.0 \text{ mmhos/cm} = 4.0 \text{ dS/m} = 0.4 \text{ S/m}$

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Water Absorption



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Reduction in Yield (Soil EC_e)

Crop	10% Yield Loss	50% Yield Loss
Dry Beans	1.5	3.6
Potatoes	2.2	5.9
Corn	2.5	7.2
Alfalfa	2.9	8.8
Wheat	6.0	15.0
Sugarbeets	7.0	15.0
Barley	10.0	18.0

Does not apply at germination time!!!

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Where does the Salt come from?

Fertilizer for 1 season of alfalfa:

	lbs/Acre	Salt Index	NaNO ₃ Equivalent
11-52-0	300	27	81
<u>0-0-60</u>	<u>200</u>	<u>116</u>	<u>232</u>
Total	500		313

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Where does the Salt come from?

Fertilizer for 1 season of potatoes:

	lbs/Acre	Salt Index	NaNO ₃ Equivalent
(NH ₄) ₂ SO ₄	500	69	345
11-52-0	500	27	135
0-0-60	500	116	580
<u>Urea</u>	<u>200</u>	<u>75</u>	<u>150</u>
Total	1,700		1210

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Where does the Salt come from?

Irrigation Water:

- Typical snowmelt irrigation water:
500 umho/cm
 $\times 0.64 = 320 \text{ ppm salt}$
 $= 864 \text{ lbs soluble salt / Acre-foot water}$
- The average crop uses 2 Acre-ft water / year
 $= 1,728 \text{ lbs soluble salt / Acre-year}$

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Where does the Salt come from?

Irrigation Water:

- Typical tail-water:
1,500 umho/cm $\times 0.64 = 960 \text{ ppm salt}$
 $= 2,600 \text{ lbs soluble salt / Acre-foot water}$
- The average crop uses 2 Acre-ft water / year
 $= 5,200 \text{ lbs soluble salt / Acre-year}$

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To Fix Saline Soils

- Establish good drainage.
 - Tile drains
 - Drainage ditches
 - Rip up clay layers & plow pans
- Deep irrigate with good water, to leach away excess soluble salts.
- Soil amendments may be very useful.
 - Soil conditioners, Surfactants
 - Wetting agents
 - PAM

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To Fix Saline Soils

- Rip up clay layers



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To Fix Saline Soils

- Rip up clay layers



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To Fix Saline Soils

- Drainage Ditches



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To Fix Saline Soils

- Drainage Ditches



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To Fix Saline Soils

- Drainage Ditches



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To Fix Saline Soils

- Tile Drains



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Deep Irrigation

- Thumbrule - 6" of irrigation (over field capacity) into 1 acre-foot of soil will leach away 50% of soluble salts or water soluble fertilizer.
- 1" over irrigation leaches 10%
- Only water that passes through the soil counts!
- More water needed if water is salty

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Leaching Fraction / Leaching Requirement

- The percentage of water that must be leached below the root zone to avoid soluble salt build- up.

EC of Water umhos/cm	Leaching Requirement
1,000	10-20%
2,000	20-35%
3,000	25-50%

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Problems of Sodium

- Directly toxic to crop plants
 - ESP of 20 = 50% average yield loss
- Contribution to Soluble Salts
- Makes pH very high, >8.5
- Deflocculates (disperses) the soil and severely reduces water infiltration rates.

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Saline-Sodic Wyoming Soil

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Base Saturation, %

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Clay With Low (Na / Ca+Mg) Ratio
(Low Na base saturation)

Clay Platelet

Ca⁺⁺ Ca⁺⁺ Mg⁺⁺ Ca⁺⁺ Na⁺

Ca⁺⁺ Na⁺ Ca⁺⁺ Mg⁺⁺ Mg⁺⁺ Ca⁺⁺

Clay With High (Na / Ca+Mg) Ratio

Clay Platelet

Na⁺ Na⁺ Na⁺ Ca⁺⁺ Na⁺

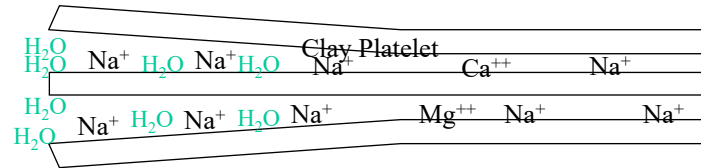
Na⁺ Ca⁺⁺ Na⁺ Mg⁺⁺ Na⁺ Na⁺ Na⁺

Water

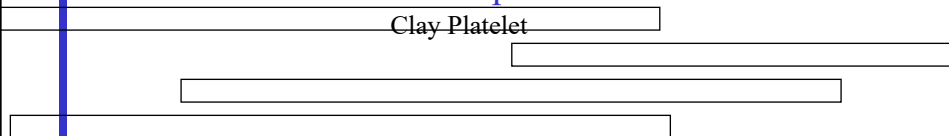
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Water pressure splits apart the clay



Dispersed clay forms “shingles” that water cannot penetrate



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When does a dispersed soil restrict water infiltration?

- Dispersal affects **clay** only.
 - The more clay in the soil, the worse the problem
- Dispersed clays “plug up” small soil pores sooner and easier than large pores.
 - The lower the % of sand, the worse the problem.
- Different clays disperse at different rates.
 - Illite 5% Na saturation
 - Montmorillonite 40% Na saturation

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When does a dispersed soil restrict water infiltration?

- Generally
 - <3% Base Saturation Na - No Problem
 - 3-15% Base Saturation Na - Possible Problem
 - >15% Base Saturation Na - Big Problem
- A field is Sodic if the sodium in the field is interfering with water penetration.

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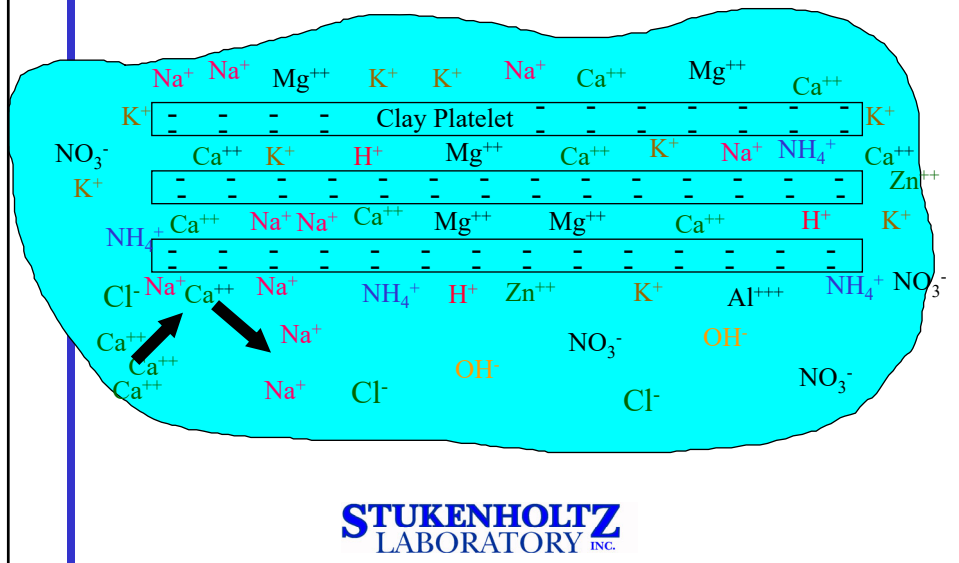
To Reclaim Sodic Soils

- Decide if the ground is worth reclaiming.
- Add source of Calcium
 - Elemental S If soil has excess lime > 0.5%
 - Gypsum If pH is high and lime is low
 - Lime If pH is Low
- Incorporate and irrigate.
- Raise sodium resistant crop, if necessary.

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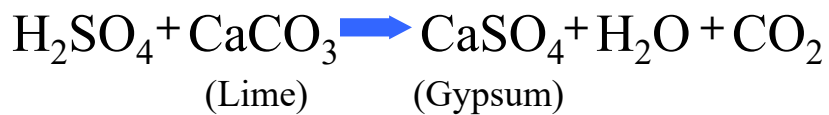
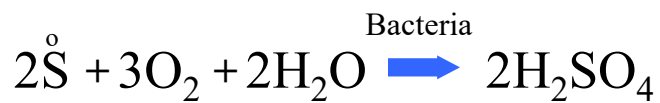
Added Ca^{++} replaces Na^+
(and K^+ & Mg^{++})



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Elemental Sulfur & Lime



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