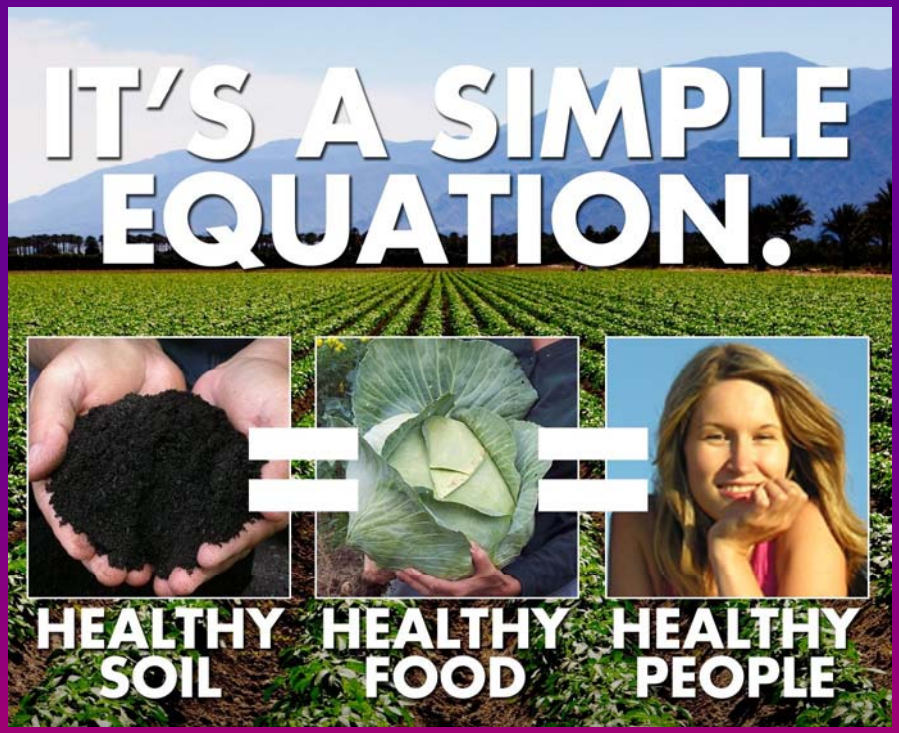
Understanding How Cation Nutrients

&

Soil Structure are Related

By Michael Martin Meléndrez



Only healthy soil can grow a nutrient dense food.

You are what you eat!

Soil

Must be able to hold onto water, hold onto nutrients, keep some of the nutrients in a nutrient solution with water, allow water and air to penetrate, and allow roots to expand into it.

This is called Soil Structure.

Top Soil

is a soil rich in carbon in the molecular form of Humic Substances

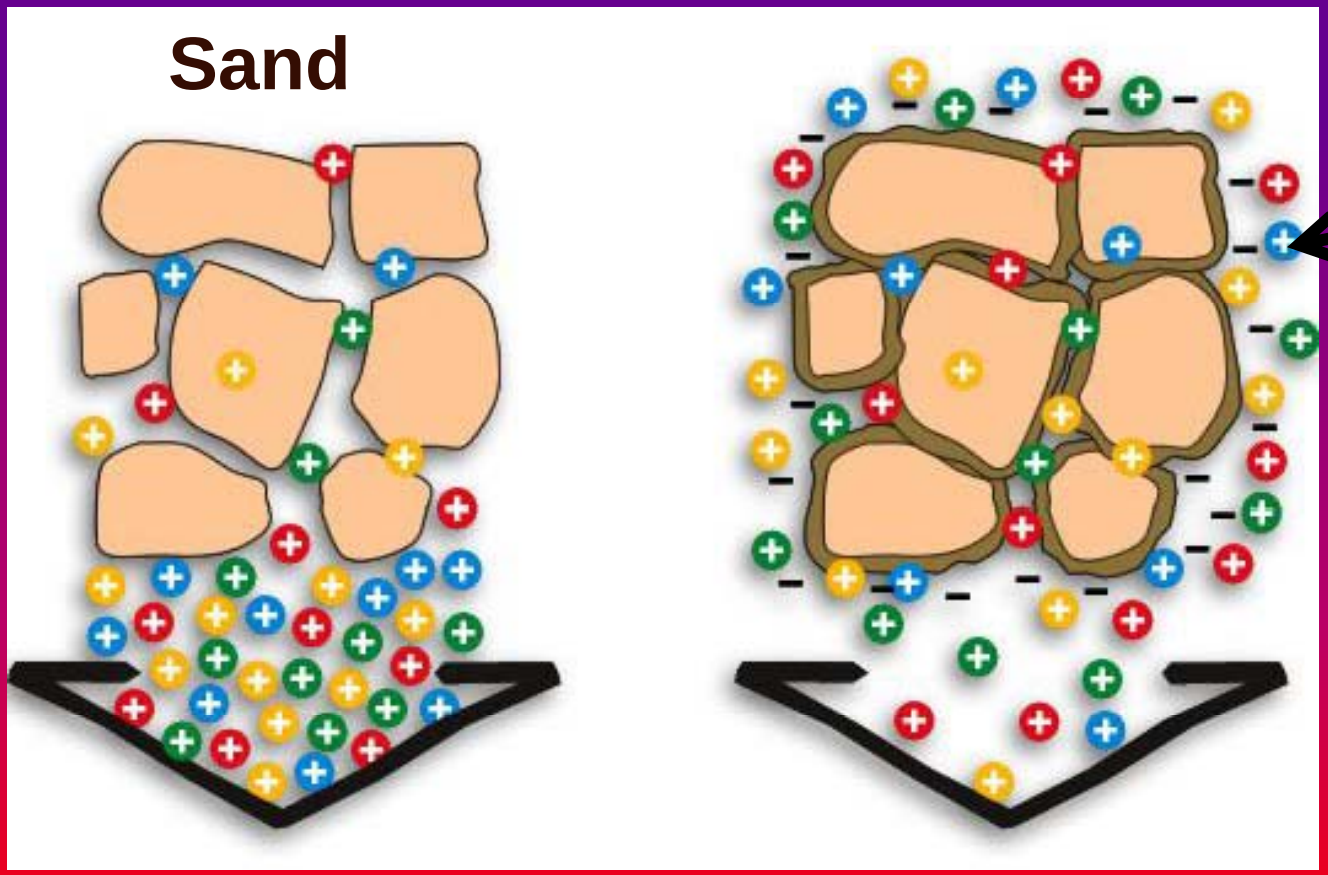
‘Soil Food Web”

Supramolecular Humic Substances are also known as Humus.

They:

1. Solubilize minerals in soil making them available. This helps prevent nutrient tie-up caused by alkaline soils.
2. Helps retain water and hold mineral nutrients in a soil nutrient solution for plant use.
3. Chelate nutrients by having a huge Cation Exchange Capacity.
4. Helps to Flocculate the soil structure into aggregates forming good soil structure!!!!!!!!!!
5. There are also hundreds if not thousands of other benefits that Humus provides a soil.

How Humic Substances relate to soil fertility by providing a Cation Exchange Capacity (CEC) that a Sand, Sandy Loam or Loamy Sand may be weak in.



Plant Nutrients

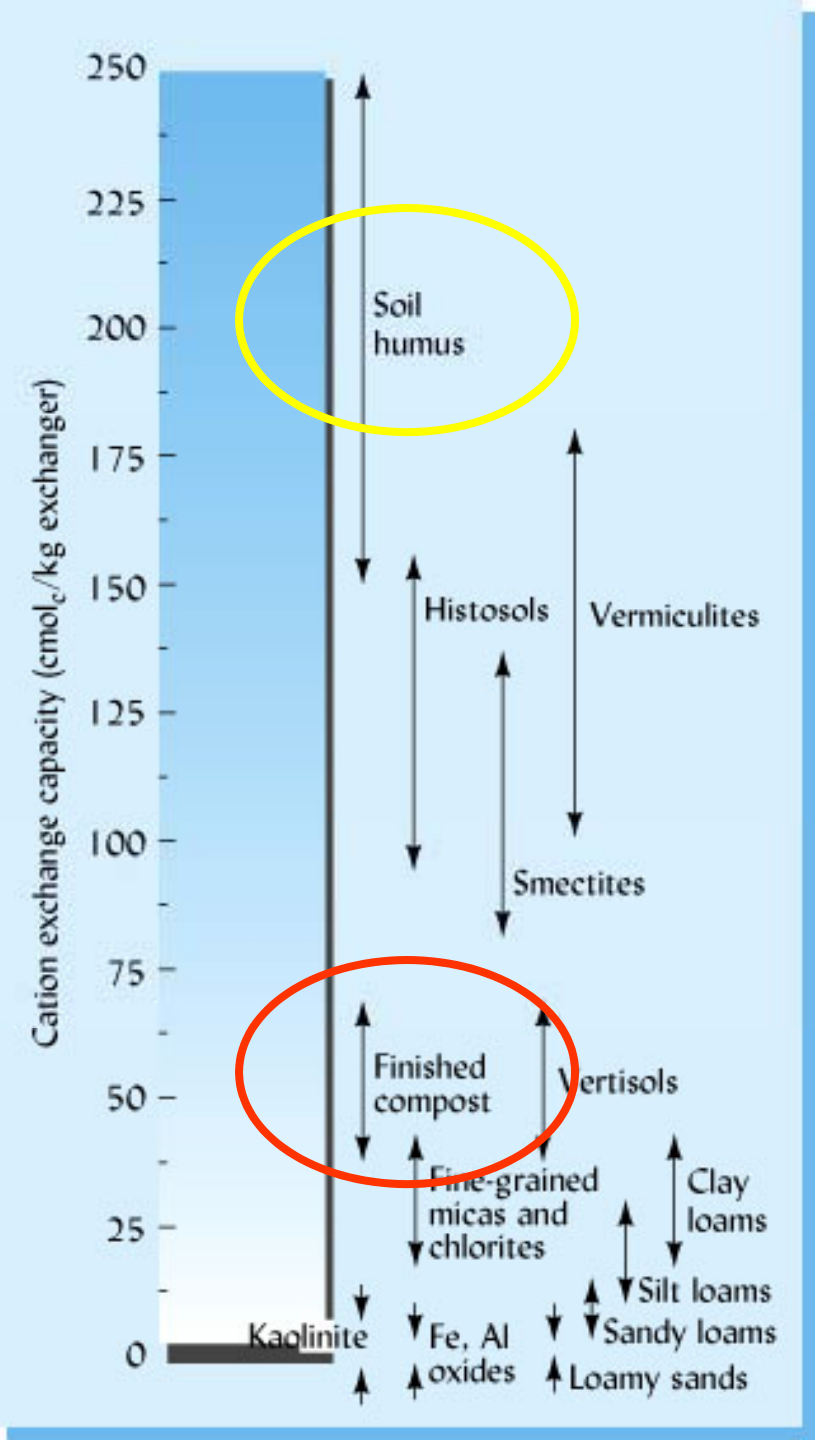
Notice that Cations have a positive charge. Humus has a negative charge which attracts positive charged cations. This is called the CEC. The CEC value of Humus prevents the leaching of the nutrient Cations.

Nutrient	Symbol	Cation	Anion
Nitrogen	N	NH_4^+	NO_3^-
Phosphorus	P		$H_2PO_4^-$
Potassium	K	K^+	
Calcium	Ca	Ca^{++}	
Magnesium	Mg	Mg^{++}	
Sulfur	S		$SO_4^=$
Iron	Fe	Fe^{++}	
Manganese	Mn	Mn^{++}	
Boron	B		$H_2BO_3^-$
Copper	Cu	Cu^{++}	
Zinc	Zn	Zn^{++}	
Chlorine	Cl		Cl^-
Molybdenum	Mo		$Mo0_4^-$
Cobalt	Co	Co^{++}	

CEC Values

Ranges in the Cation Exchange Capacities of various soils and materials, at a pH of 7.

Note that Humus has a much higher CEC value than Compost. It's important to understand that Humus and Compost are not the same thing!



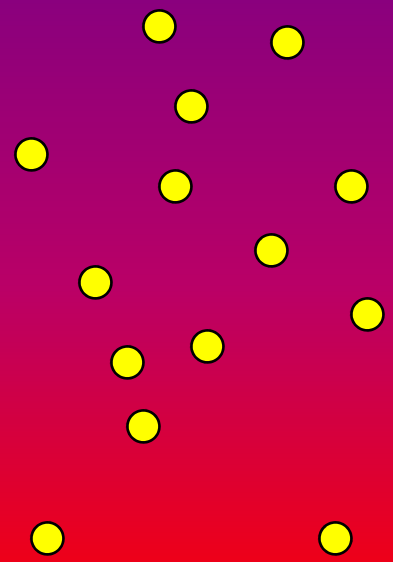
Dispersed Soil

Dispersed Soil is when salts in the soil cause the clay particles to collapse.

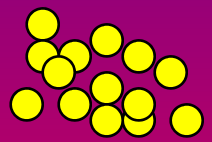
1. They crack when dry
2. Seal when wet, which suffocate and rot roots
3. Inhibit water from percolating
4. Are hard to dig in, or plow
5. Hard when dry, sticky when wet

Dispersed clays

Soil clay particles can be unattached to one another (*dispersed*) or clumped together (*flocculated*) in aggregates. Soil aggregates are cemented clusters of sand, silt, and clay particles.

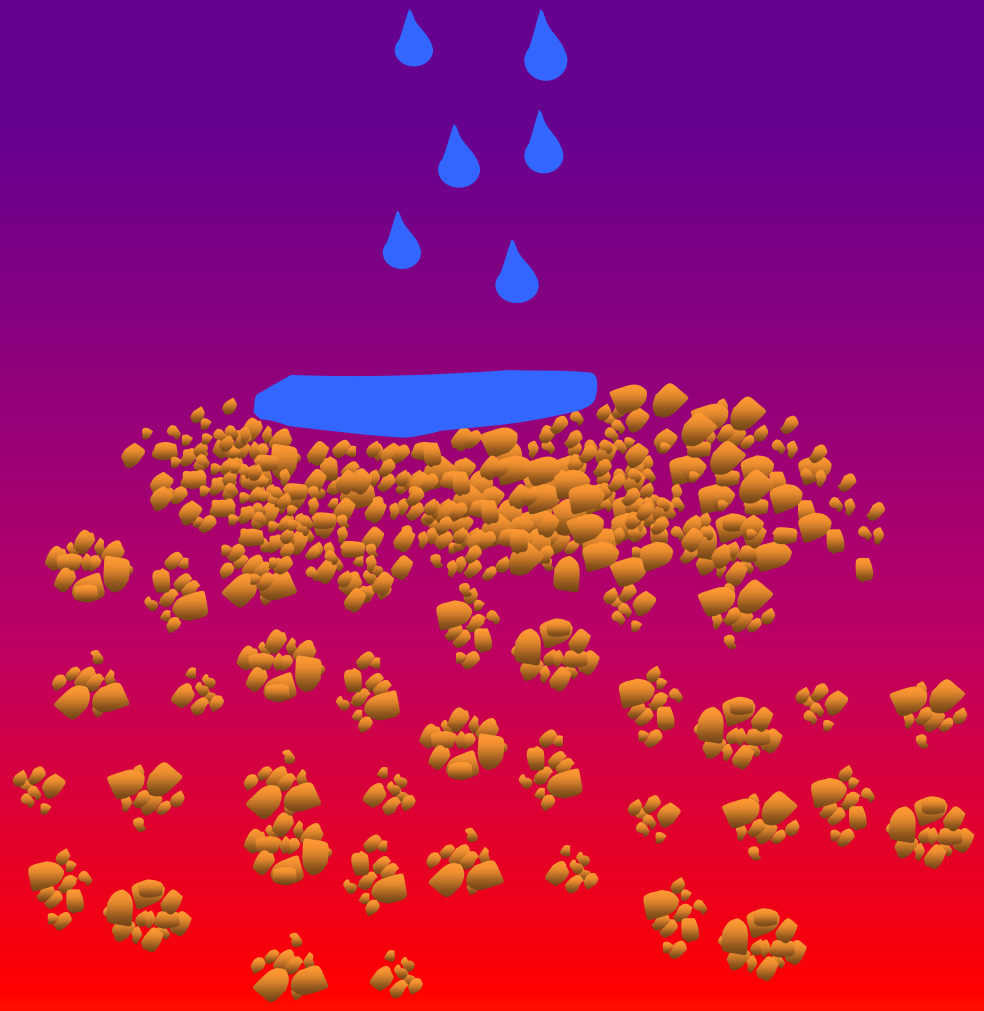


Dispersed Particles
This is bad!

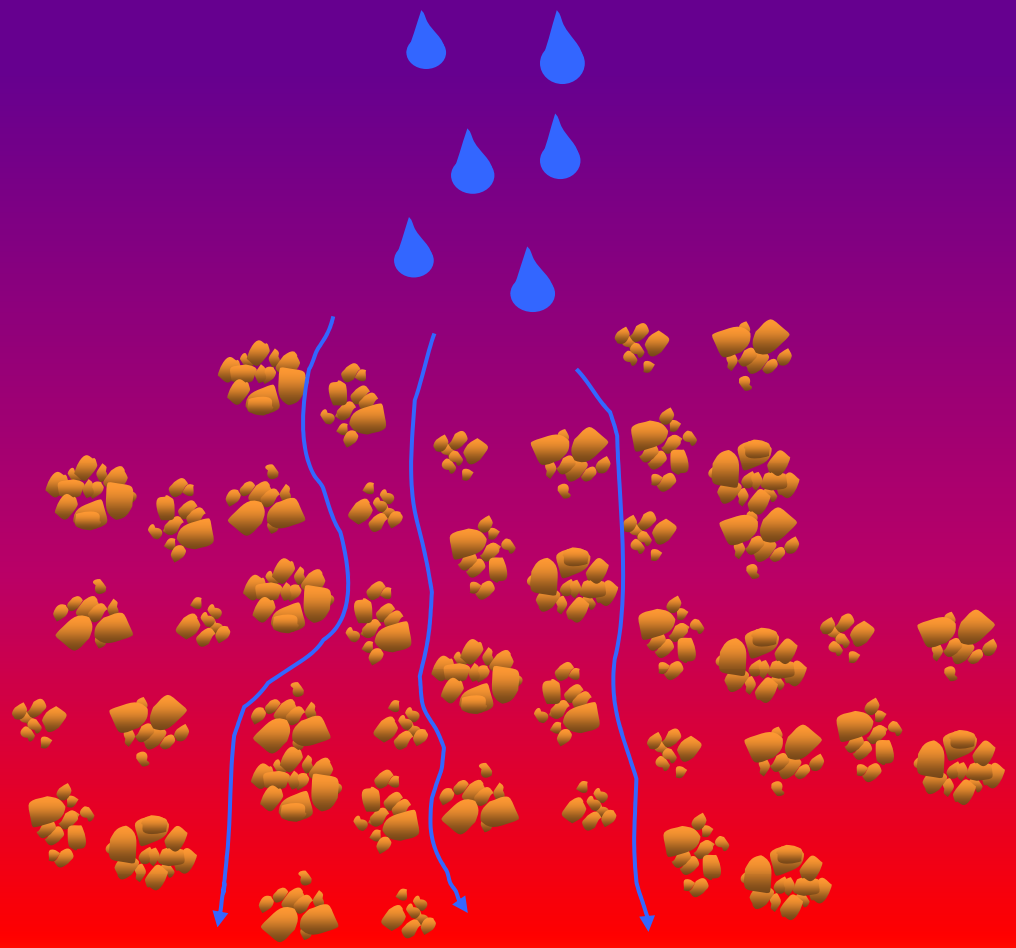


Flocculated Particles
This is good!

In all but the sandiest soils, dispersed clays plug soil pores and impede water infiltration and soil drainage.



Flocculation is important because water and oxygen moves mostly in large pores between aggregates. Also, plant roots grow mainly between aggregates.



How do we fix a dispersed soil?

Add Flocculating Cations

We can divide cations into two categories

1. **Poor flocculators**
   - **Sodium**
2. **Good flocculators**
   - **Calcium**
   - **Magnesium**

Ion		Relative Flocculating Power
Sodium	Na^+	1.0
Potassium	K^+	1.7
Magnesium	Mg^{2+}	27.0
Calcium	Ca^{2+}	43.0

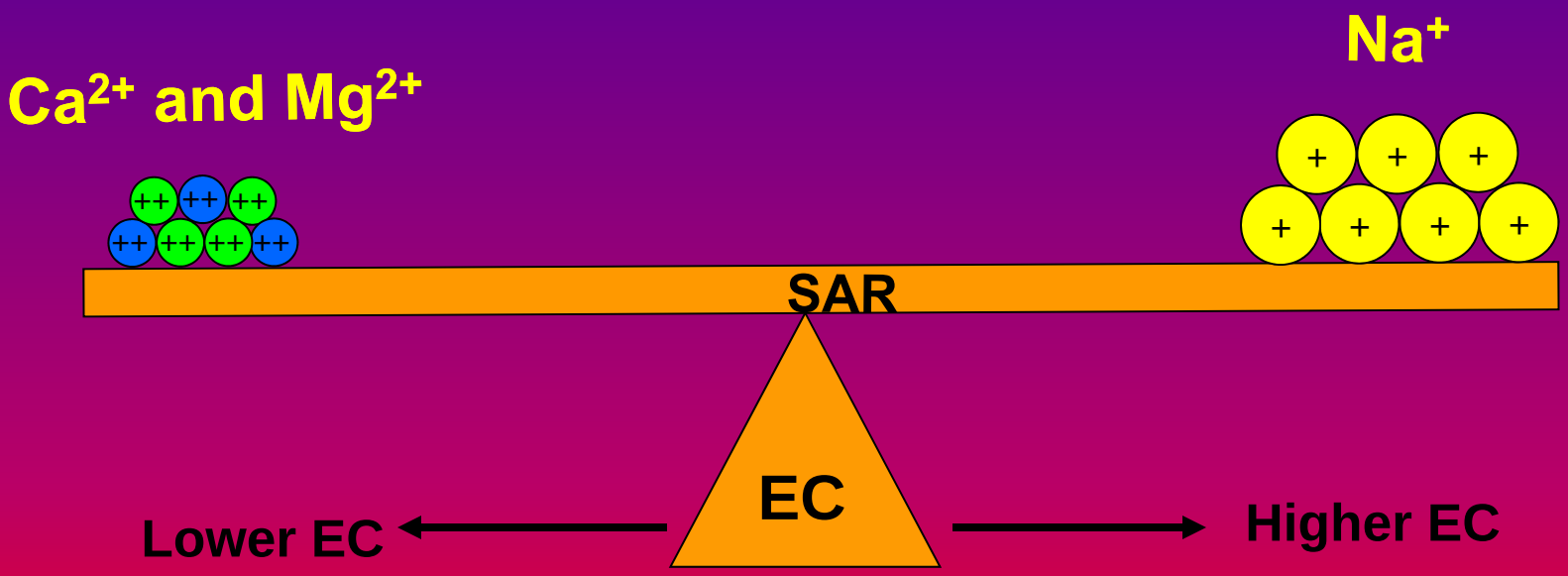
Sumner and Naidu, 1998

Flocculating Cations

Calcium is a powerful flocculating cation 43 times stronger than Sodium.

Which is why Gypsum can help reduce salt in a dispersed clay.

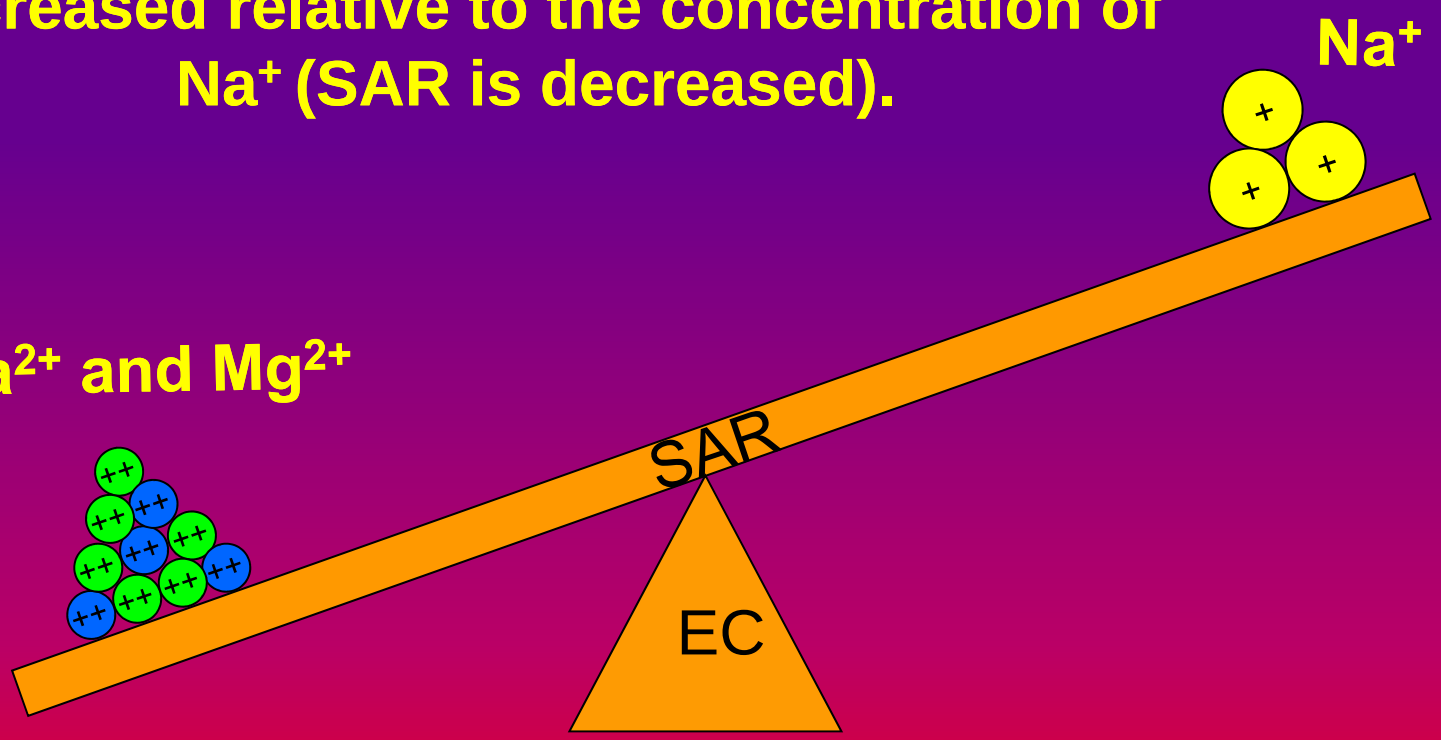
Aggregate stability (dispersion and flocculation) depends on the balance (SAR) between (Ca^{2+} and Mg^{2+}) and Na^{+} as well as the amount of soluble salts (EC) in the soil.



Tip the scale this way and you will *flocculate* the soil

Dispersed soil

Soil particles will flocculate if concentrations of (Ca^{2+} + Mg^{2+}) are increased relative to the concentration of Na^{+} (SAR is decreased).

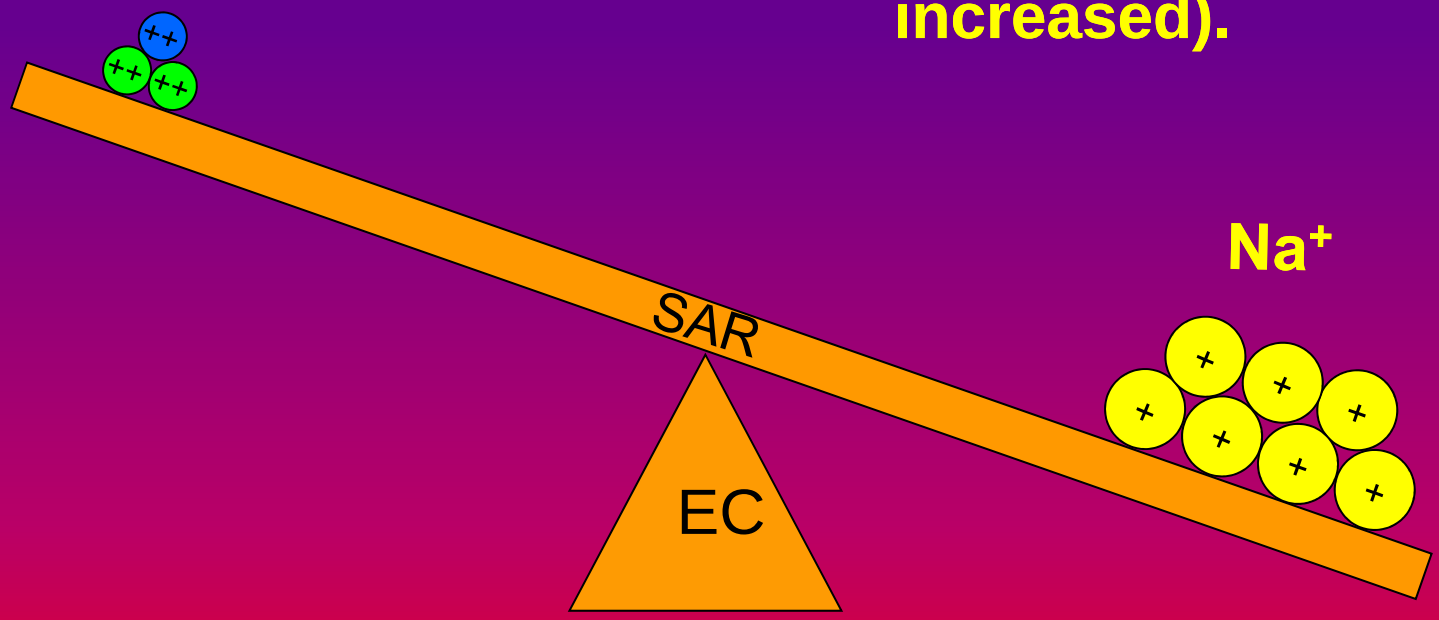


Flocculated soil

Dispersed soil

Soil particles will disperse if concentrations of (Ca^{2+} + Mg^{2+}) are decreased relative to the concentration of Na^{+} (SAR is increased).

Ca^{2+} and Mg^{2+}



Na^{+}

Flocculated soil

Dispersed soil

Dispersed Clay Particles

Before rehabilitating the arboretum soils, the clay was collapsed, hard, and sealed to percolation of water.

“Few things are harder to put up with than the annoyance of a good example”

Mark Twain

Flocculated Clay Particles

Arboretum soils today, showing the clay now aggregated and not sealed. It's Humic Acids chelating the flocculating cations that do this!