

Biochar Properties

Ion Adsorption

Adsorb: (verb) *Physical Chemistry* to gather on a surface in a condensed layer
(gas, liquid, or dissolved solid)
charcoal will adsorb gases

Adhesion of atoms, ions or molecules from a gas, liquid or dissolved solid to create a film on a surface of the adsorbent.

This differs from **Absorption**, where a fluid permeates or is dissolved by or into a solid, such as: *water is absorbed by a sponge*.

Adsorption is a surface process.

Absorption involves the whole volume of material.

Sorption applies to both processes.

Desorption is the reverse of **adsorption**, and is thus a surface phenomenon.

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Ion Adsorption

Adsorb (verb) *Physical Chemistry* to gather on a surface in a condensed layer:
Typically, **Adsorption** is an electric attraction between atoms and molecules quite different from **Absorption**

Ion is an atom with an electric charge

Cations are made when atoms give up one or more electrons and thus have a **positive (+)** charge

Anions form when atoms gain one or more electrons and thus have a **negative (-)** charge

Each element has different attraction for electrons

Hydrogen has a weak attraction for electrons

Oxygen has a strong attraction for electrons

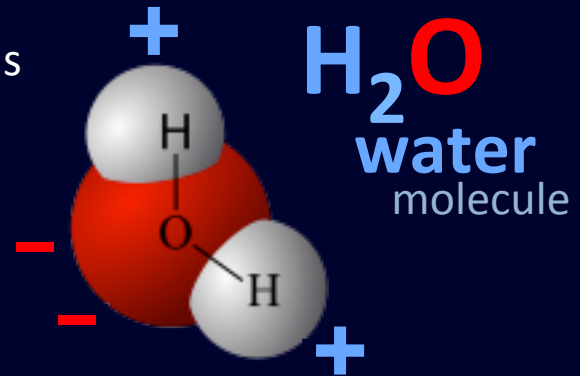
In a water molecule, **Hydrogen** yields its electron

Oxygen attracts two electrons

Thus, a water molecule has an electric polarity,

Hydrogens each have a slight **positive (+)** charge

Oxygen becomes a mild **negative (-)** charge



Cations (+)

Cation Exchange Capacity

Sodium, Potassium, Calcium, Magnesium
most Trace Elements

Anions (-)

Anion Exchange Capacity

Phosphorus, Sulfur, Chlorine
Nitrogen

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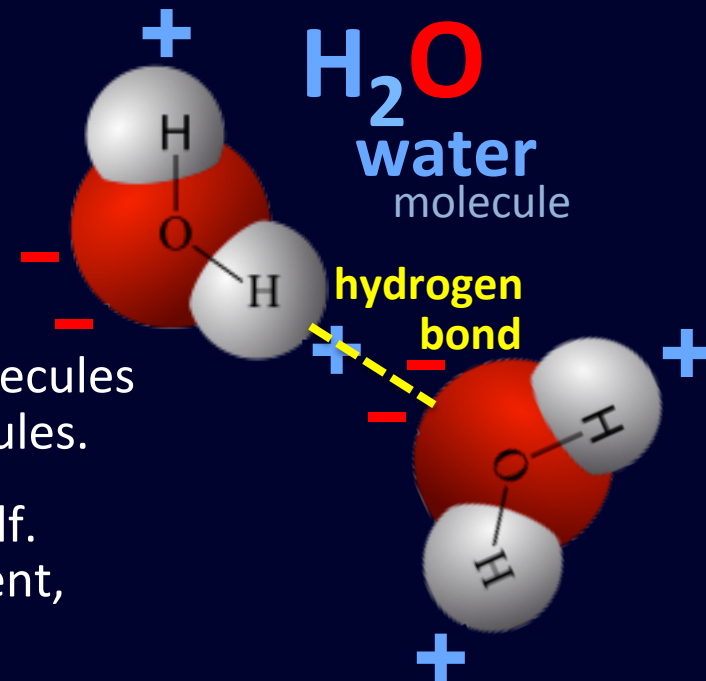
An **H₂O water** molecule is not an **Ion**,
because it has no net electric charge

+ protons = - electrons

But **water** molecules do have electric polarity,
and attract ions and polarized molecules
with opposite electric charge,
including other water molecules.

Useful example of attraction between polarized molecules
is the "**hydrogen bond**" between water molecules.

Hydrogen bonds make water "wet" and stick to itself.
This slight attraction makes water a great solvent,
and gives water structure as a "liquid crystal."



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Anion Exchange Capacity

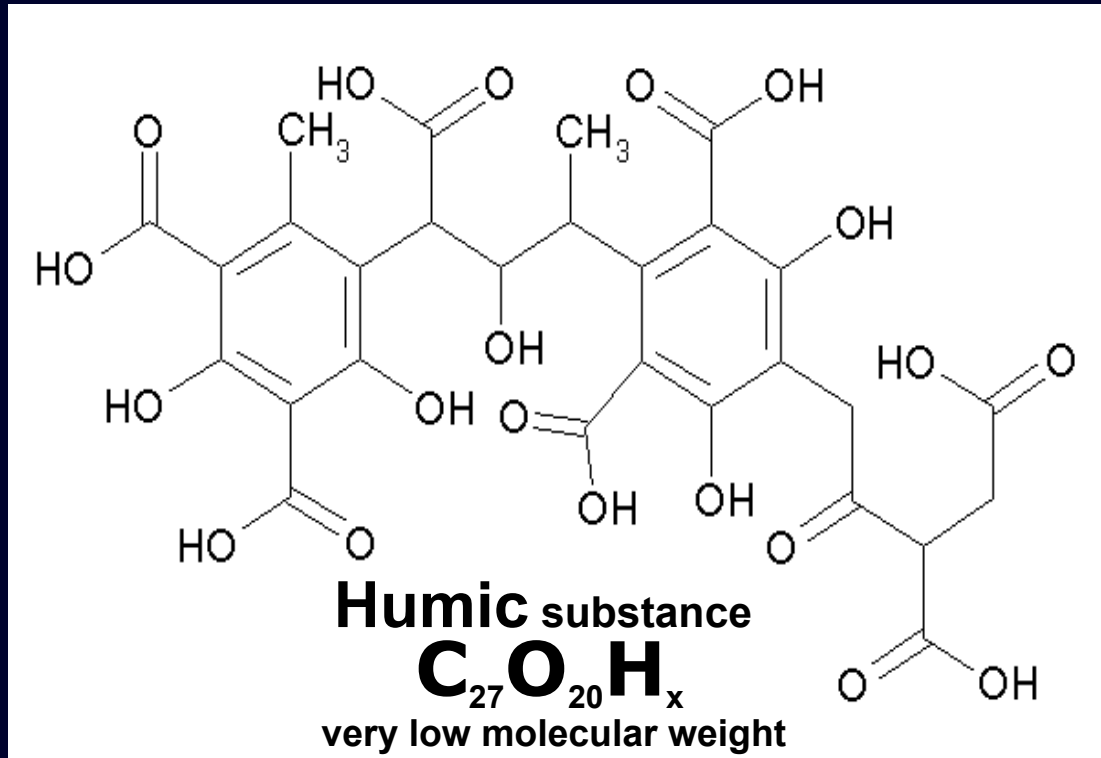
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Adsorb (verb) *Physical Chemistry* to gather on a surface in a condensed layer:
Typically, *Adsorption* is an electric attraction between atoms and molecules
This attraction quickly gets much more complex with biocarbon molecules

Humus and biochar molecules consist of tens, hundreds, even thousands of carbons.



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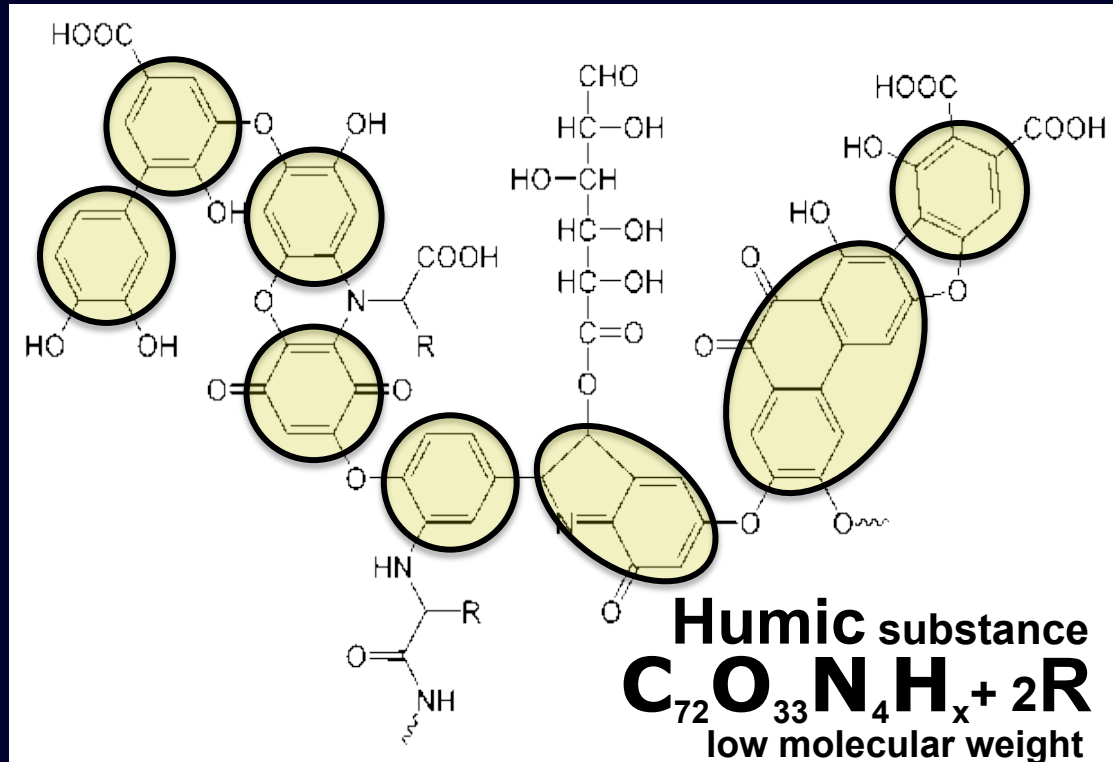
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These are very large molecules with multiple carbon rings,



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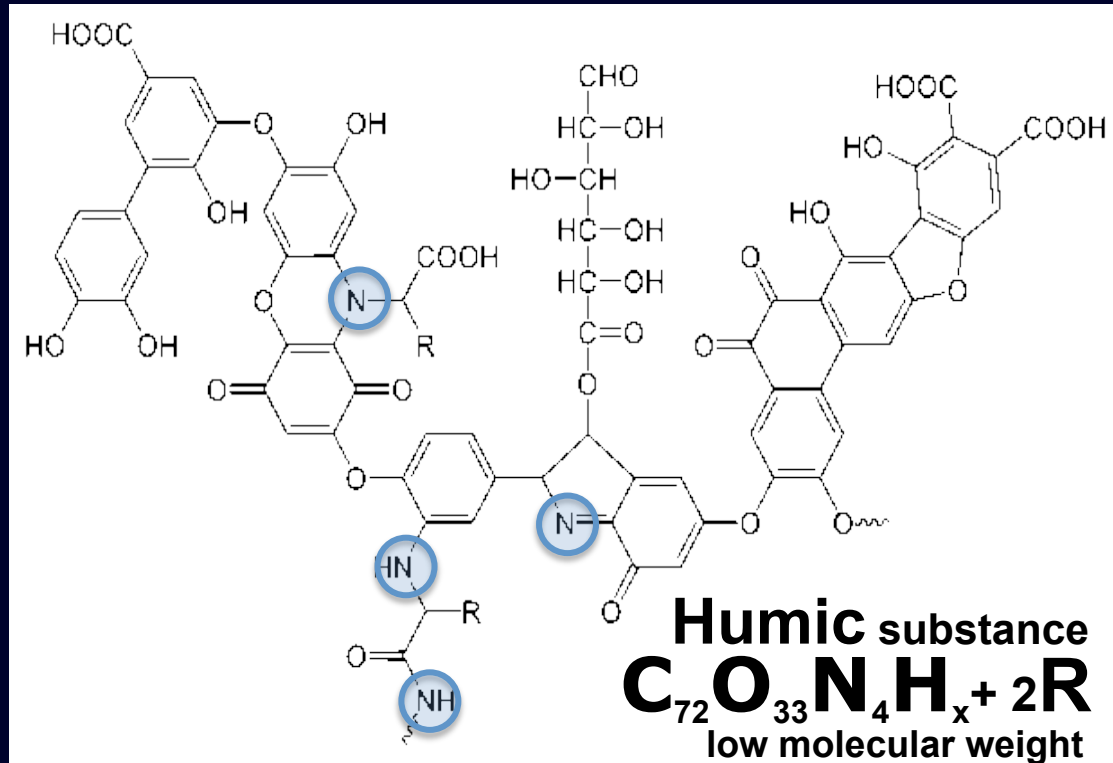
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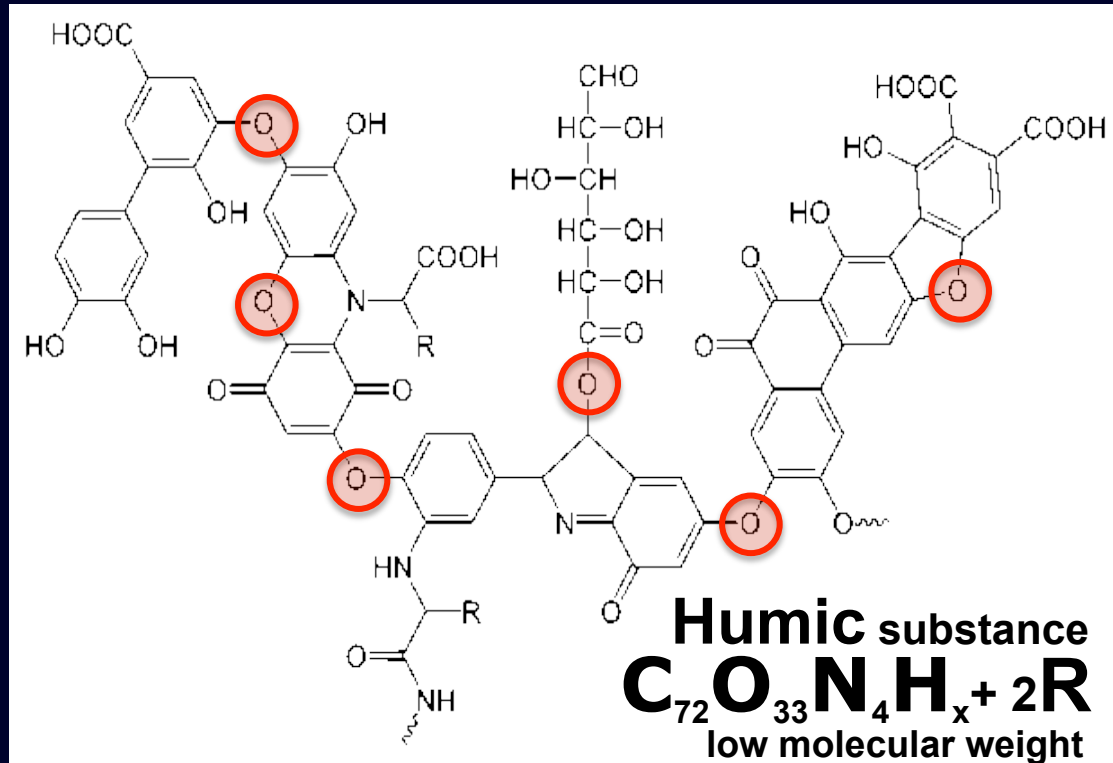
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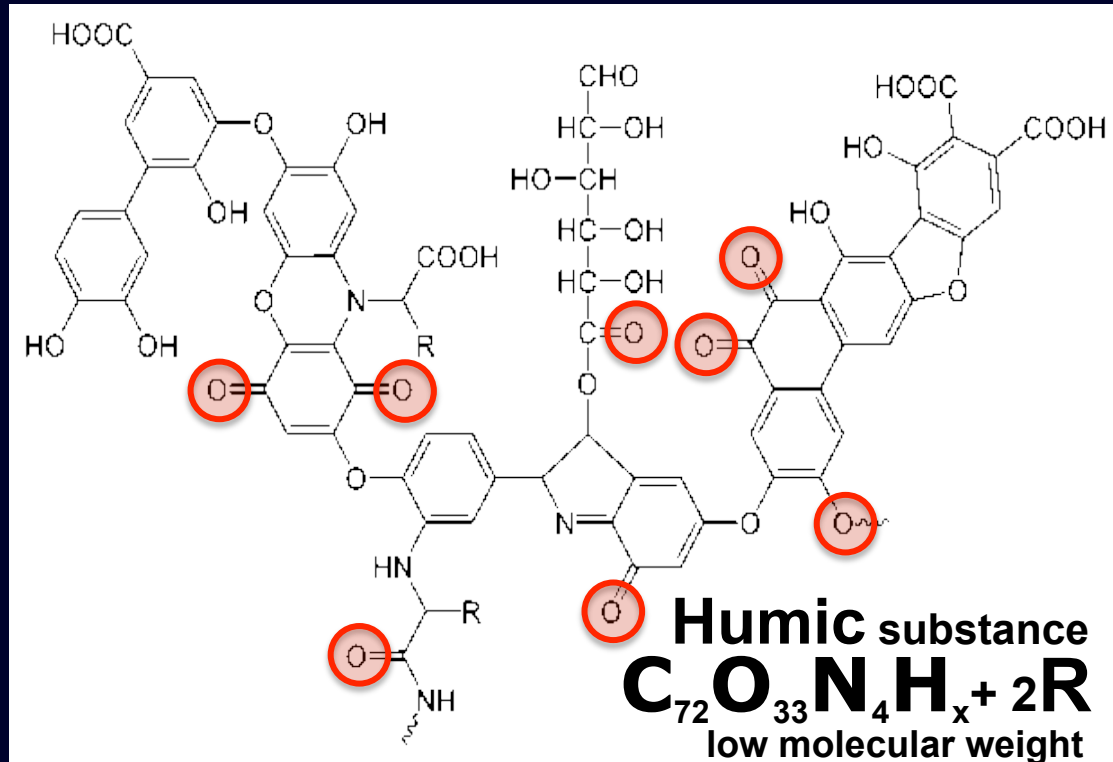
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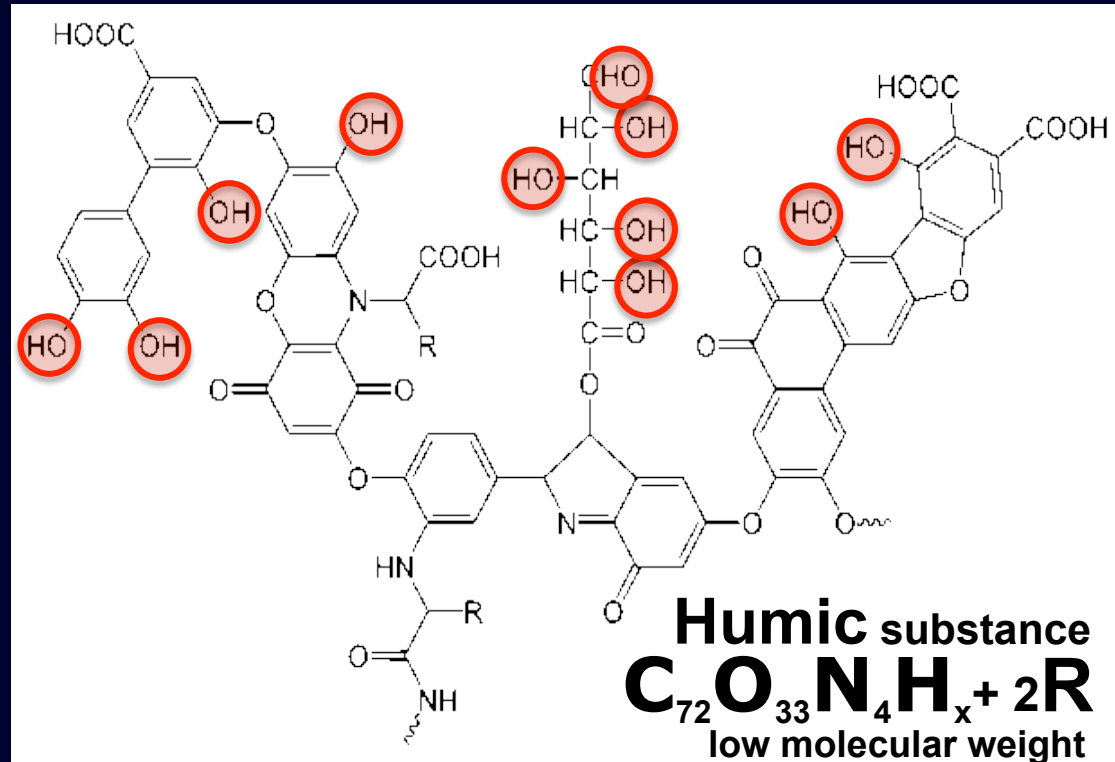
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These are very large molecules with multiple carbon rings, **Nitrogens** and **Oxygens**, and embedded mineral **ions**.

Each ring, **Nitrogen**, **Oxygen**, and mineral **ion** is an electric charge on the surface of the molecule.

Each charge site will attract and **adsorb ions** of opposite polarity.



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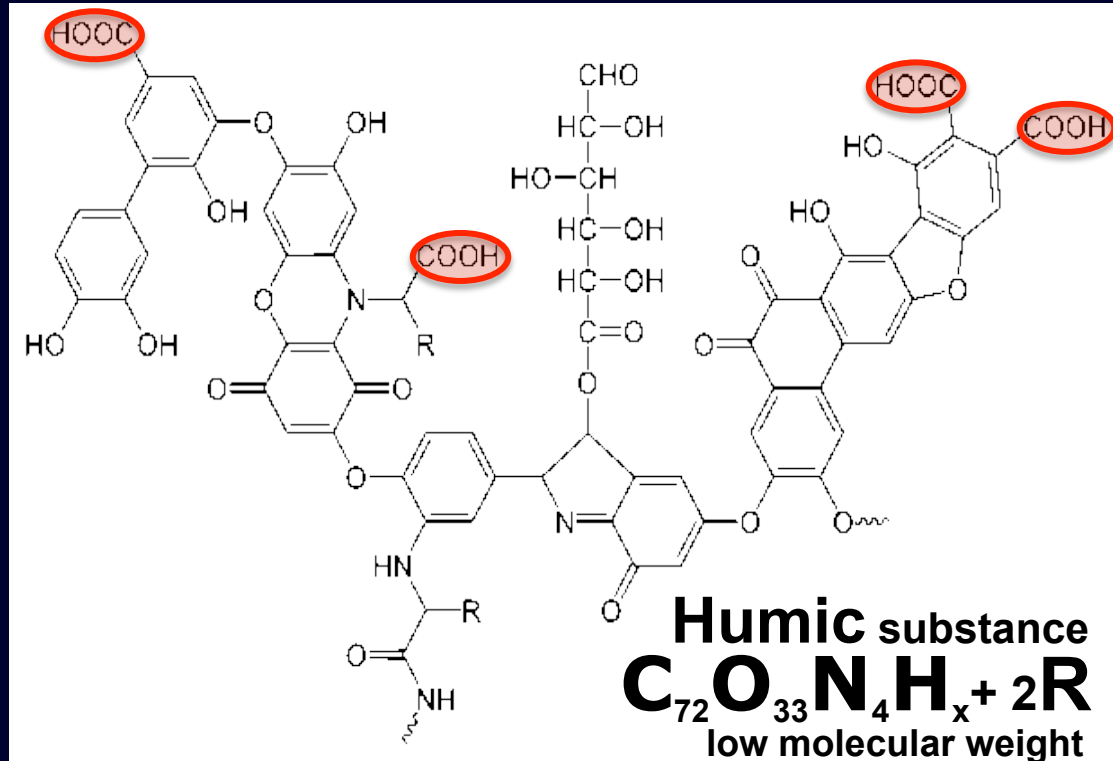
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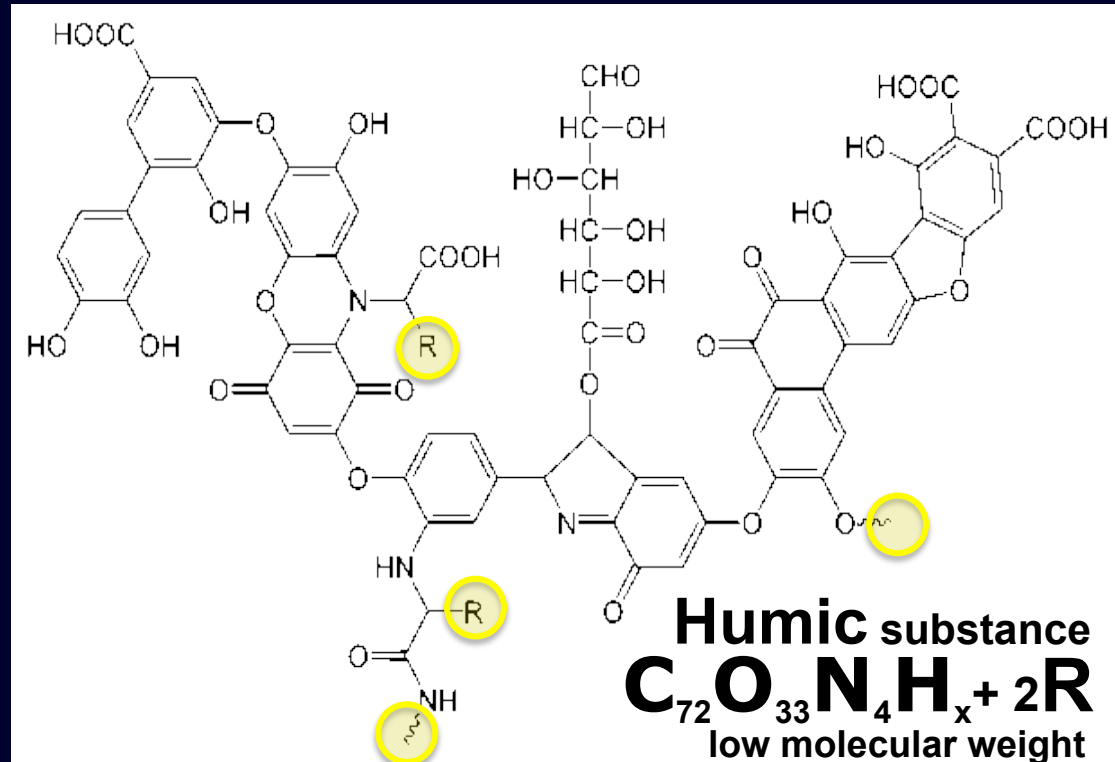
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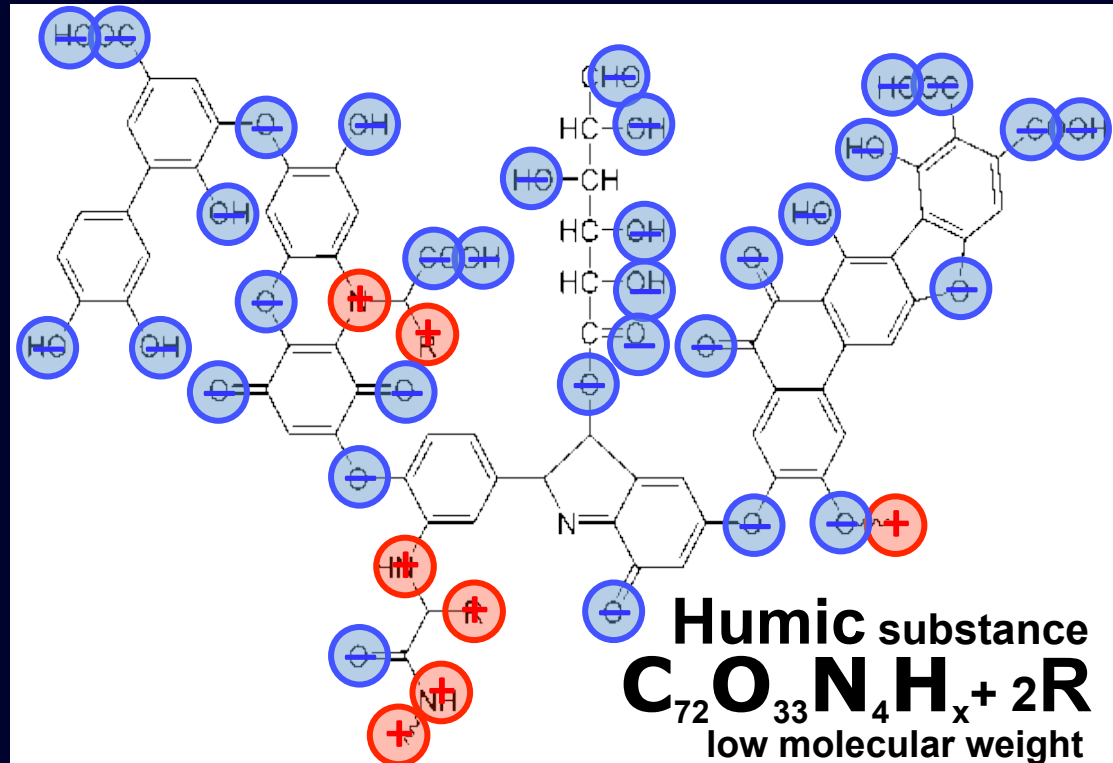
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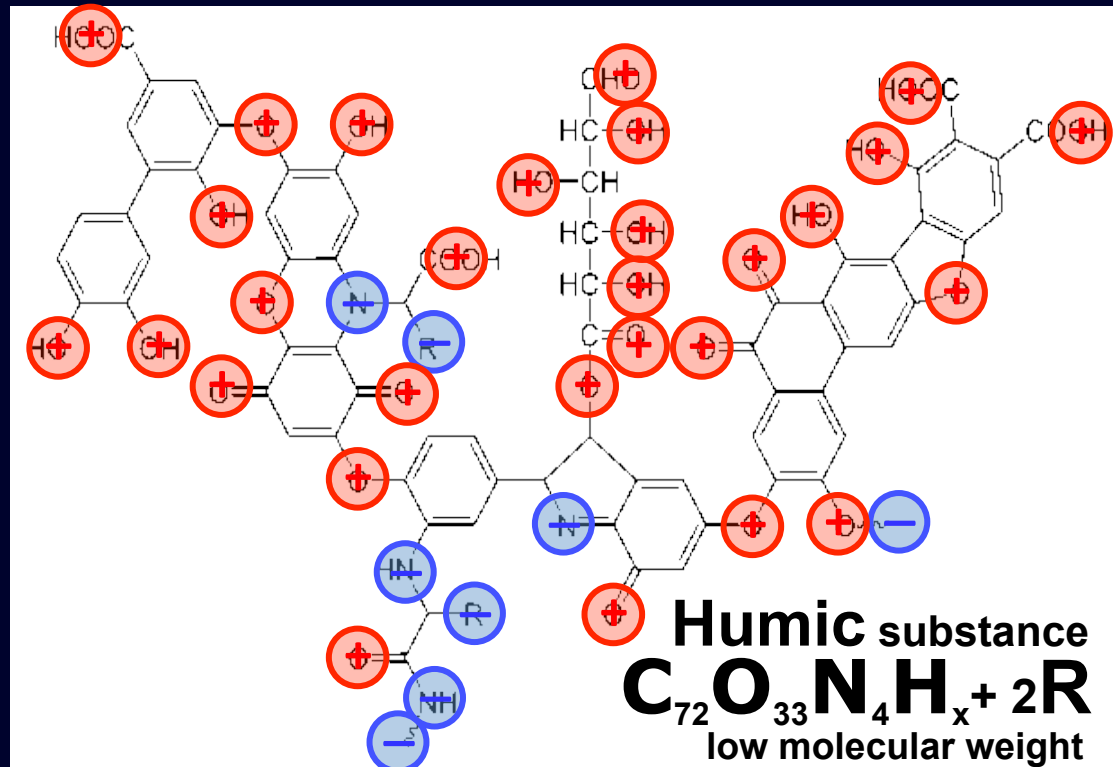
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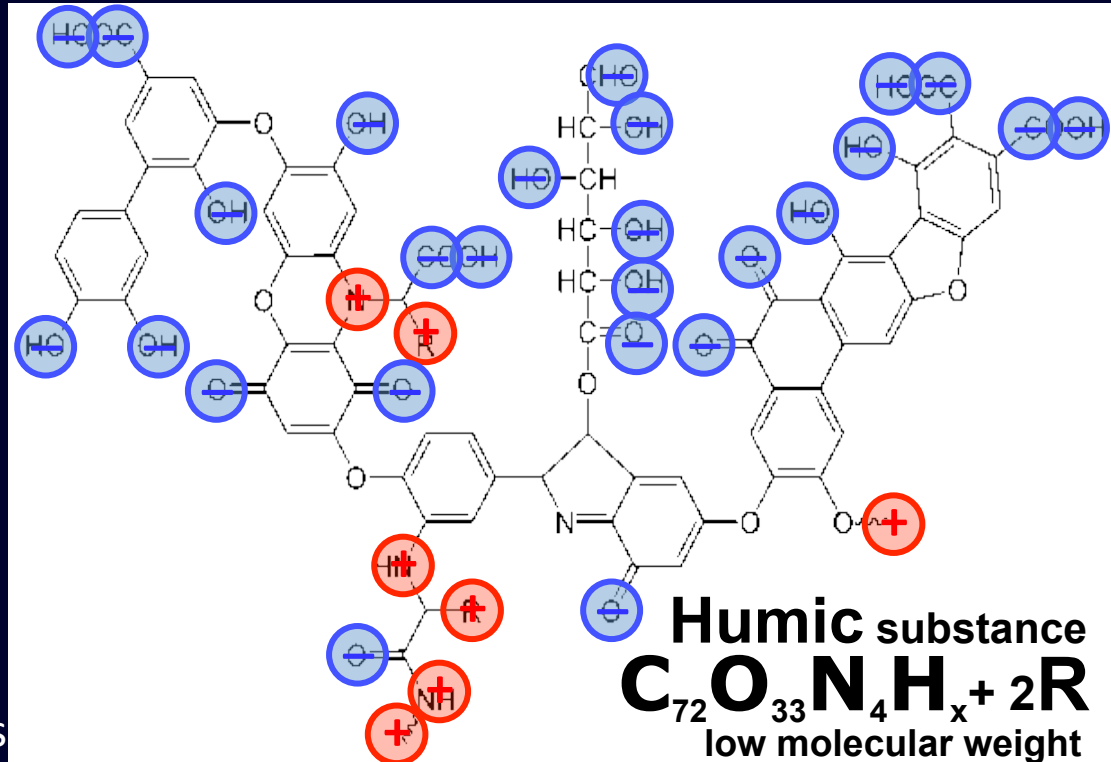
Biochar micropores provide a huge internal **ion adsorption** capacity, hundreds, even thousands times greater than other soil substances.

Thus, charcoal is an ideal media to filter and purify water.

Biochar's advantage is to **adsorb** both **Cations (+)** and **Anions (-)**, Including **Nitrogen** & **Phosphorus**.

Simple mineral **ions**
Complex organic **ions**

Ion exchange with microbes & roots



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Ions in the circulating solution are **adsorbed** by char particles

Cations & **Anions** are attracted to electric charges on char particles and gradually removed from the soil-water solution.

This electric attraction is like water's **hydrogen bond**

Adsorbed **ions** are loosely held, not bonded

Ions are slowly caught and held by char's electric charges

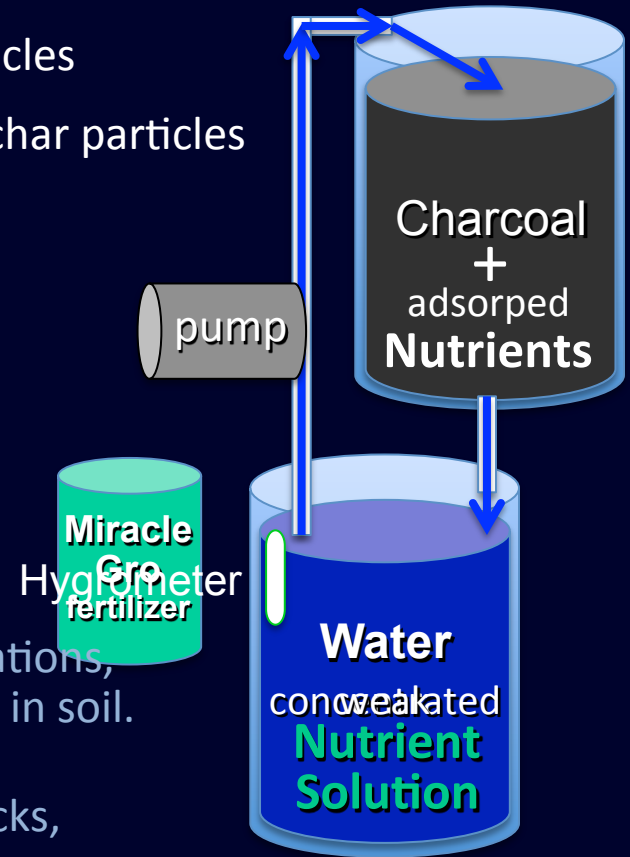
Slowly, the **ion** concentration in solution will drop

Charcoal **adsorption** removes and neutralize toxic chemicals

Adsorption also holds nutrient **ions** safely in soil

Pure water run thru soil all day barely affects **ion** concentrations, because **ions** are **adsorped** onto soil particles and held in soil.

Microbes can free elements chemically bound in soil and rocks, a process different from balancing exchangeable **ions**.



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