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Humic Acid Structure and Properties

Humic acid helps break up clay and compacted soils, assists in transferring micronutrients from the soil to the plant, enhances water retention, increases seed germination rates and percentages, and stimulates development of microflora populations in soils.

Humic Acid

Humic acid is one of the most important components of Bio-Liquid Complex® (BLC). Because of its molecular structure, it provides numerous benefits to crop production. It helps break up clay and compacted soils, assists in transferring micronutrients from the soil to the plant, enhances water retention, increases seed germination rates, penetration, and stimulates development of microflora populations in soils.

Humic acid is not a fertilizer, but instead a compliment to fertilizer. Fertilizer is a nutrient source for both plants and microflora. Humic acid essentially helps move micronutrients from soil to plant. Its benefits have been proven both experimentally and in the field.

How Humic Acid is Created

Humic acid is primarily found in manure, peat, lignite coal, and leonardite. Leonardite is a highly oxidized form of organic matter. The humic acid used in Bio-Liquid Complex is derived from a type of leonardite that differs from its theoretical formula: part of its chemical structure has been oxidized away. These broken bonds create places on the molecules where micronutrient ions can be absorbed. The oxidized sites give the entire molecule a negative charge enabling it to absorb micronutrients as shown below.

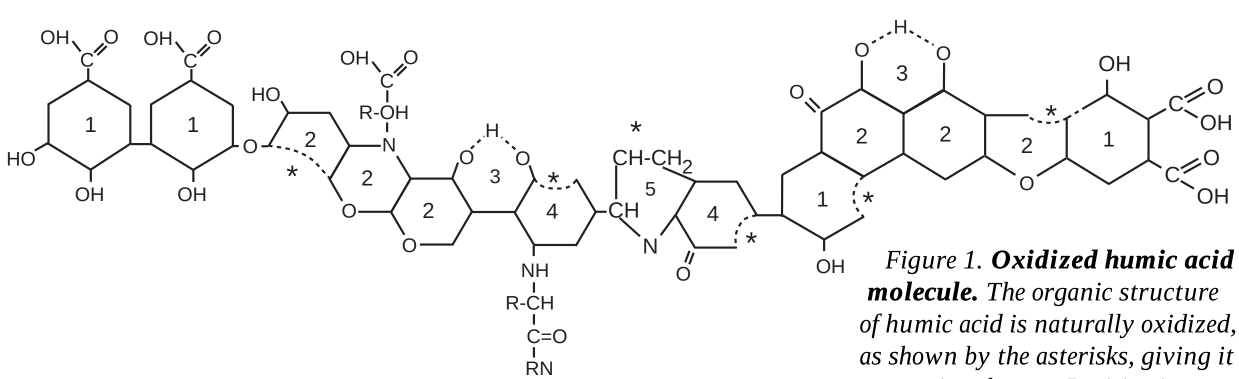


Figure 1. ***Oxidized humic acid molecule.*** *The organic structure of humic acid is naturally oxidized, as shown by the asterisks, giving it a negative charge. Positive ions, attracted to broken bonds at the site of the oxidation, create sites for micronutrients and microflora to attach.*

Humic Acid Absorbs Ions

Humic acid absorbs ions like aluminum relatively easily. We take advantage of this natural tendency by treating leonardite with potassium hydroxide. The oxidized sites on the molecule are saturated with potassium, which is readily exchanged for all major micronutrient ions in the soil. Treating humic acid with potassium hydroxide also raises its pH to 11, pushes the acids to their maximum solubility, and stabilizes hydrocolloids in suspension, as shown in Figure 2.

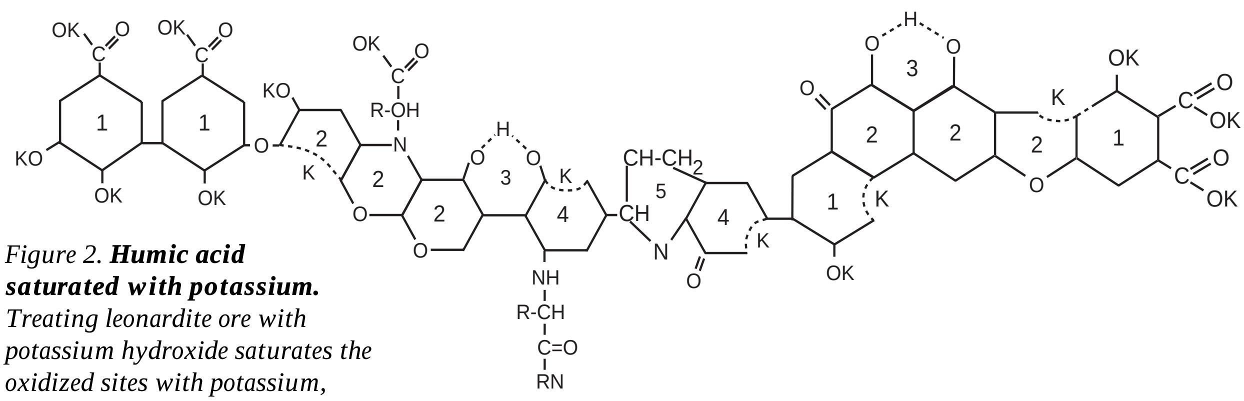


Figure 2. ***Humic acid saturated with potassium.*** *Treating leonardite ore with potassium hydroxide saturates the oxidized sites with potassium, which can be readily exchanged for all major micronutrients found in soil.*

We also treat leonardite ore with hydrogen peroxide. This liberates humic acid molecules from contaminants such as clay, shale, gypsum, silica, and fossilized organic matter found in the ore. These make up about 15% of the ore. Of course, not all of the remaining humic acid is active. Some is irreversibly combined with crystallized minerals and some is polymerized into insoluble molecules.

Only about half the leonardite ore can be successfully converted to humic acid. The rest must be settled out of the solution before it can be used, which takes from four to six months. The solution is then filtered, added to Bio-Liquid Complex, and prepared for distribution.

Why Humic Acid from Leonardite

The maximum saturation we have been able to achieve with highly active humic acid is 15%. Humic acid salts begin to precipitate if we increase the solids content above this figure. Any humic acid product that claims to contain more than 15% humic acid solids actually contains a smaller percentage of active acids plus inactive and often times insoluble particles. The inactive and insoluble portions add nothing to the solution but instead plug irrigation and spray distribution equipment.

Humic acid extracted from manure or peat is usually not as effective in absorbing micronutrients as humic acid originating in leonardite. Similarly, lignite-based humic acid performs poorly as a growth stimulator unless it is partially oxidized. This usually adds considerably to the product's cost. Leonardite has been oxidized by nature, resulting in a highly active humic acid at reasonable cost. Humic acid extracted from leonardite is an excellent balance of effectiveness and low cost.

How Humic Acid Works

Humic acid improves plant growth in several ways.

Clay Disaggregation

Clay particles normally lay together flat as shown in Figure 3 below.

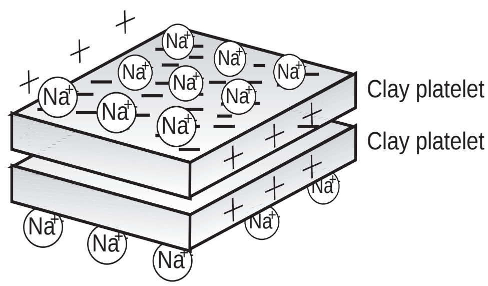


Figure 3. ***Clay platelet structure.*** *Clay particles normally lay together flat, but are repelled by the negative charges across their face. Salt (Na^+) is present in minor amounts.*

Soils with high clay content can become so dense and compact that they may resist plant rooting. This may happen for one of two reasons:

First, the salt in the soil has neutralized the negative electrical charges which normally cause clay particles to repel each other as shown in Figure 4.

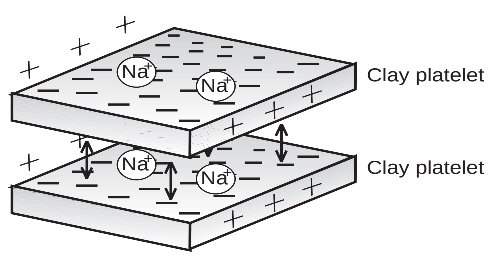


Figure 4. ***Salt overload causes clay platelets to attract each other.*** *When an excessive amount of salt is present, it neutralizes the negative electrical charges that normally cause clay particles to repel each other. The platelets move closer together.*

Second, the percentage of clay in the soil is so high that the positive charge on the edge of a clay particle combines with the negative charge on the flat surface of another, forming a tight three-dimensional structure as shown in Figure 5 at right.

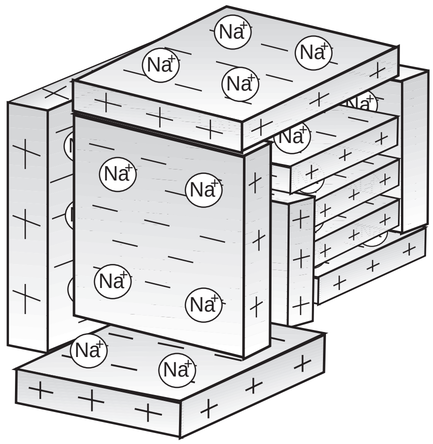


Figure 5. ***Clay compaction.*** *When the percentage of clay in the soil is very high, and especially when an excessive amount of salt is present, the positive charge on the edge of a clay particle combines with the negative charge on the flat surface of another, forming a tight three–dimensional structure.*

Water Penetration Enabled

Humic acid causes the clay particles to stand on end, allowing water penetration. It does this two ways.

First, it segregates salts and removes them from the surface of the clay particle. The net negative charge resulting causes the clay particles to repel each other, loosening the soil structure.

Second, a carbon group on the humic acid molecule (carboxyl group) bonds with the edge of the positively charged particles. This breaks the attractive force between the positive charge at the edge of a particle and the negative charge or the flat surface of another (Figure 6).

This action, called protective colloidal action, loosens soil, letting roots penetrate more easily. Humic acid's effect on clay soil is more evident as time passes. In heavy clay soils, six months or more may be needed before you will see a noticeable improvement in the soil's density. The sooner you add Bio-Liquid Complex, the greater its impact on your soil and future crop production.

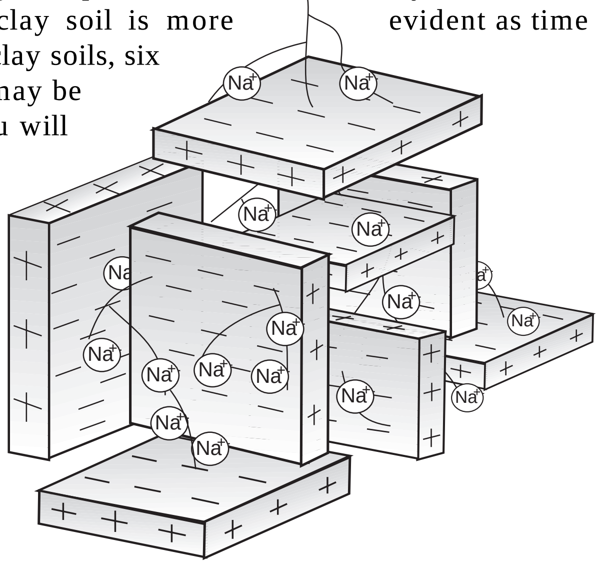


Figure 6. ***Humic acid encourages water penetration.*** *As humic acid penetrates compacted clay platelets, it segregates salts (positive ions) and removes them from the clay particle surface. This restores a negative charge to the face of the clay platelets, causing them to repel each other.*

Micronutrient Transference

Humic acid can acquire positive ions under one condition and release them when conditions change. It picks up ions depending on the availability of a different ion to replace the one released. Positive ions are called cations and the pickup and release property is called *cation exchange capacity*. Humic acid holds cations so they can be absorbed by a plant's root, improving micronutrient exchange and transference to the plant's circulation system (Figure 7).

The transference mechanism is not completely understood, but soil scientists theorize that as the plant absorbs water, the humic acids (carrying the absorbed micronutrients) move into close proximity to the root system.

Since the root system is negatively charged, when the humic acid moves close to the root, the root's negative charge exceeds the acid's negative charge. The micronutrients are released from the humic acid molecule and enter the root membrane. Some researchers, especially in Europe, believe that the shorter–chain humic acid and the attached micronutrients are actually absorbed and metabolized by the plant. Humic acid is extremely important as a medium for transporting nutrients from the soil to the plant.

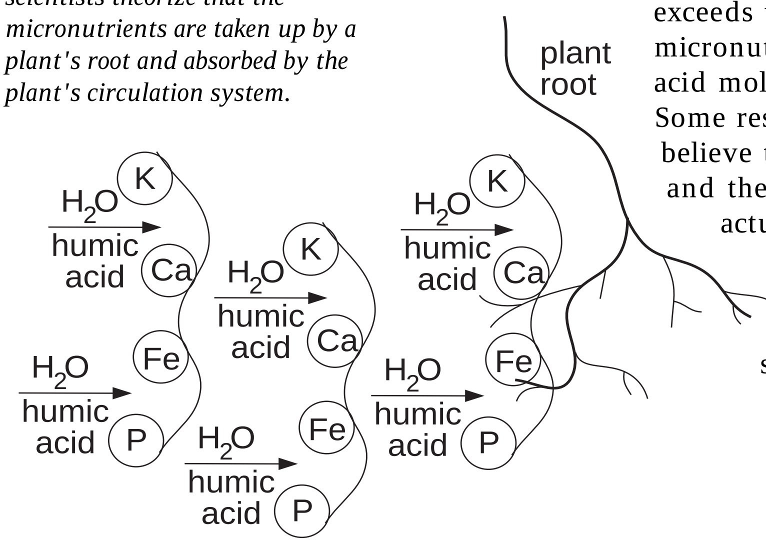


Figure 7. ***Micronutrient exchange is improved.*** *Humic acid picks up positive ions. Since the root's negative charge is greater than humic acid's negative charge, scientists theorize that the micronutrients are taken up by a plant's root and absorbed by the plant's circulation system.*

Water Sequestration

Humic acid slows water evaporation from soils. This is especially important in soils where clay is not present or in a low concentration, in arid areas, and in sandy soils without the capability to hold water.

In the presence of water, cations absorbed by humic acid partially ionize and move a short distance away from the humic acid oxidation sites. This restores part of the bonded ion’s positive attractive force. Water sequestration by humic acid is illustrated in Figure 8.

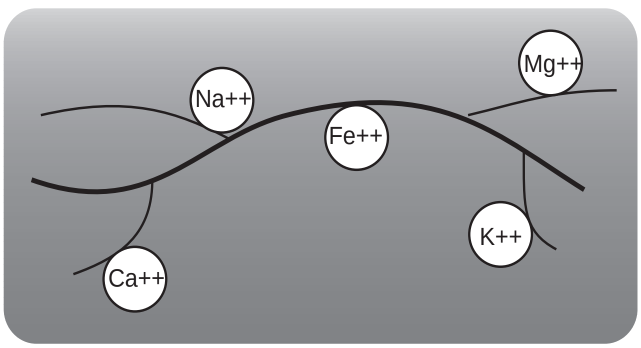


Figure 8. ***Positive ions are more easily absorbed by a plant's root.*** *Humic acid holds cations in a way they can be more easily absorbed by a plant's root, improving micronutrient transference to the plant's circulation system.*

Since water is a dipolar molecule and electrically neutral, the end of the molecule containing the oxygen atom loosely bonds to the ion. The hydrogen or negative end of the water molecule is partially neutralized, and as a result, increases the

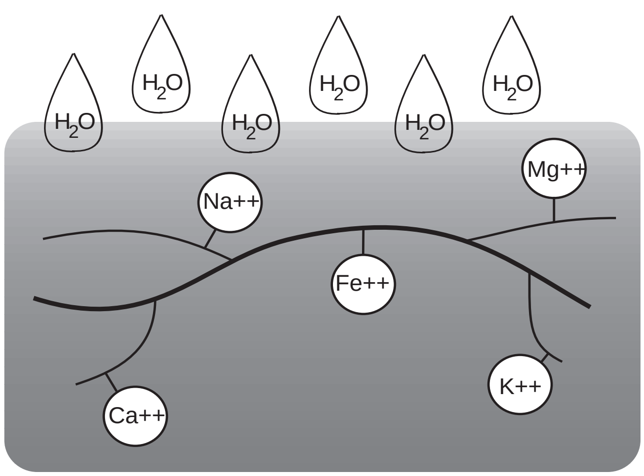
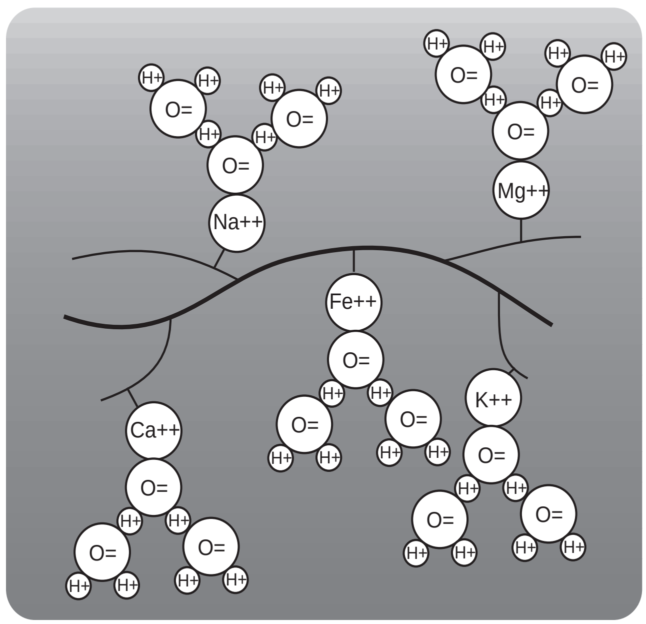


Figure 9. ***Ionized nutrients bond to water.*** *Cations in the presence of water are partially ionized and move a short distance away from the humic acid sites on the root. The movement restores the ion's positive attractive force, allowing the oxygen end of water molecules to loosely bond to the cation.*

hydrogen end's positive attracting force. The oxygen (or negative) end of another water molecule bonds with the hydrogen end and this continues until the attractive force of the water molecule is dissipated.

This effect reduces the evaporation rate by about 30% as shown below (Figure 10). Humic acid can significantly reduce water evaporation and increase its use by plants in non-clay, arid, and sandy soils.

Figure 10. ***Evaporation is minimized.*** *The oxygen end of another water molecule bonds with the hydrogen end of another, until the evaporation rate is reduced by 30%.*



Microorganism Stimulation

Humic acid becomes a source of phosphate and carbon, stimulating microflora populations. It also provide sites for microflora to colonize. The bacteria secrete enzymes which act as catalysts, liberating calcium and phosphorous from insoluble calcium phosphate, and iron and phosphorous from insoluble iron phosphate. As the calcium, phosphorous, and iron elements are liberated, they are absorbed by the humic acid present, making the elements less available to the bacteria.

The bacteria are further stimulated to secrete additional enzymes, liberating more calcium, iron, and phosphorous, until both the humic acid and bacterial populations are satisfied. In the same way, trace nutrients are also converted into forms more easily used by the plant.

Seed Germination

Humic acid's effect on seed germination is similar to its effect on rooted plants. Humic acid, carrying both micronutrients and water, is drawn into the seed through the pore, stimulating growth of the radical.

The mechanism for transference appears to be similar to that of indole butyric acid, but the exact method is unknown. Not only do seeds germinate faster when humic acid is present, but a higher percentage of seeds germinate. In a controlled cottonseed field in San Joaquin County, California, a farmer growing Brohm grass seed had averaged 800 lb / acre / yr over 20 years. He had never produced over 1000 lbs / acre in any year. With two folier applications of Bio-Liquid Complex (containing hemic acid) at 30 and 20 gal / acre, yields increased to 2200 lb / acre / yr over the entire planting.

Increased seed germination rates cut seed costs and improve plot usage. Enhanced stimulation of seed germination using Bio-Liquid Complex can compensate for cool or rainy conditions and give growers a wider margin of safety.

Fertilizer Use

Whenever possible, use Bio-Liquid Complex with fertilizer. Humic acids' (and thus, Bio-Liquid Complex's) ability to absorb fertilizer components and increases their release to plants is well documented. If you make judicious use of humic acid and fertilizer, you will improve the performance of marginally fertile soils, of soils with low native organic matter, and of crops grown in arid regions.

For More Information

Contact Bio Ag Technologies International at (916) 371-6941 x321 (PST).