

The **C:N ratio of soils** is influenced by many factors:

- The **C:N ratio is highest** when the organic matter added to the soil each year is **low in Nitrogen** (wide **C:N** ratio).
- The **C:N ratio of the A horizon** of a “forest-derived” soil averages 20:1. Because the **C:N ratio of grasses** is much narrower, the **C:N ratio of the A horizon** of a “grass-derived” soil averages 12:1.
- The low **C:N ratio of the B horizon** of most soils (8:1) is due to microbes having decomposed much of the vegetative material. A higher proportion of this humus is composed of dead microbial tissue.
http://www.pals.iastate.edu/agron154/Agron_154/Unit_22/terms.htm

100	C	High	Carbon	C
—	—			
1	N			
25	C	Medium	Nitrogen	N
—	—			
1	N			
7	C	Low		
—	—			
1	N			

C:N Ratio – What does it mean?

http://www.fibl.org/english/publications/training-manual/pdf/Tran_4-4.pdf

Applying organic matter with excess carbon to the soil can create problems. In order to “complete the nitrogen cycle and continue decomposition, the microbial cells will draw any available soil nitrogen in the

proper proportion to make use of available carbon. This is known as ‘robbing’ the soil of nitrogen, and delays availability of nitrogen as a fertilizer for growing plants until some later season when it is no longer being used in the life-cycles of soil bacteria.”

[Iowa State University]

Organic matter is affected by the presence of both carbon and nitrogen in the course of decomposition. The **C:N ratio** represents the relative proportion of these two elements. For example, compost having 25 times as much carbon as nitrogen is said to have a **C:N ratio of 25 to 1** (= **C:N ratio of 25**). Some of the carbon present may be so resistant to biological attack that its presence is not significant. It is actually the ratio of available carbon to available nitrogen that is the important relationship. This is because the very organisms that decompose organic matter use Nitrogen for building cell structure, but utilize Carbon as their source of energy. Thus, they need more Carbon than Nitrogen. If too much available Carbon is present, decomposition slows as the Nitrogen is used up and some organisms begin to die along the way. However, organisms may form new cell material using their stored Nitrogen, but in the process, more carbon is burned. Meanwhile the amount of Carbon is reduced while Nitrogen is recycled. The bottom line is that decomposition takes longer than normal when the initial **C:N** ratio oscillates significantly above 30.

For **C:N ratios** in feedstocks, see:

http://whatcom.wsu.edu/ag/compost/fundamentals/needs_carbon_nitrogen.htm

Conclusions:

Both the rate of decomposition and the amount of humus formed are related to the C:N ratio of the residue. When all other conditions are equal, the rate of decomposition increases as the C:N ratio narrows.

“Since organisms use about 30 parts Carbon for each part of Nitrogen, an initial C:N (available quantity) ratio of 30 promotes rapid composting and would provide some Nitrogen in an immediately available form in the finished compost. Researchers report optimum values from 20 to 31.” [Washington State University]

Here are four conditions that are constant for all residue decomposition:

1. A maximum of 35% of the Carbon in fresh organic material will be converted into soil humus **if** there is sufficient Nitrogen present.
2. A minimum of 65% of the Carbon in fresh organic material will be given off to the atmosphere as carbon dioxide (CO₂) due to microbial respiration.
3. The humus formed from the decomposition of fresh organic material will contain approximately 50% Carbon and 5% Nitrogen. In other words, the C:N ratio of the humus is **10:1**.
4. Most fresh plant material contains 40% carbon. The C:N ratio varies because of differences in Nitrogen content, **not** Carbon content.

Using these relationships, the quantity of humus formed from the addition of a known amount of plant residue can be calculated. [Kansas State University]

An interesting note: “It has been estimated that natural biological Nitrogen fixation supplies approximately 175,000,000 tons of Nitrogen per year to the world's agricultural needs.(1) Man-made chemical Nitrogen fixation, through the Haber-Bosch and similar processes, provides 50,000,000 metric tons per year and approximately 40,000,000 tons per year are produced by natural physico-chemical fixation, e.g. lightning, ultraviolet radiation, etc., which converts Nitrogen and Oxygen into oxides of Nitrogen.”

<http://digicoll.library.wisc.edu/cgi-bin/EcoNatRes/EcoNatRes-idx?type=div&did=ECONATRES.0003.0206.0061&isize=text>

For the next section, first take a look at: www.colloidaltraceminerals.net

Cations and Colloids: “Humus tends to bond strongly to **clay**. While bonded it resists decomposition. For this and other reasons, soils higher in clay tend to be higher in organic matter.” [Iowa State University]

We know that clay is comprised of colloidal material, and some say that **humus** itself is also [\[http://en.wikipedia.org/w/index.php?title=Humus&action=edit§ion=1\]](http://en.wikipedia.org/w/index.php?title=Humus&action=edit§ion=1) a **colloidal** substance, but others state that this characterization constitutes a basic misunderstanding about the application of terminology. “The term **colloids** is being mistakenly used to refer to Fulvic Acid complexes, which are readily absorbable and in the perfect electrolyte form to react with cells.” [\[http://www.msminerals.com/v200/include/FATMM.pdf\]](http://www.msminerals.com/v200/include/FATMM.pdf)

According to a New Zealand company that is a major advocate of foliar sprays, “Humus is a structureless colloidal material resulting from the decomposition (humification) of any type of dead organic matter (mostly plant residues and animal remains). It is a complex mixture including proteins, lignin (plant cell walls); fats, carbohydrates, and organic acids. These acids, humic acids and chelates, provide a storehouse of essential plant nutrients.” [\[http://foliarfert.com/pages/humus.htm\]](http://foliarfert.com/pages/humus.htm),

The connection between **clays** and **humus** and the formation of **colloidal substances** capable of increasing bioavailability of nutrients is spelled out by some other nice folks “downunder” from **New South Wales** [\[http://www.ricecerc.org/reader/soil-types-structure/ss393-cation-exchange.htm\]](http://www.ricecerc.org/reader/soil-types-structure/ss393-cation-exchange.htm)].

Cations are held by negatively charged particles of clay and humus called **colloids**. Colloids (in turn consist of thin, flat plates, and) for their size have a comparatively large surface area. For this reason they are capable of holding enormous quantities of **cations**. They act as a storehouse of nutrients for plant roots. As plant roots take up **cations**, other **cations** in the soil water replace them on the **colloid**. If there is a concentration of one particular **cation** in the soil water, those cations will force other cations off the **colloid** and take their place. **The stronger the colloid's negative charge, the greater its capacity to hold and exchange cations, hence the term cation exchange capacity (CEC).**

Sand on the other hand has no capacity to exchange cations because it has no electrical charge. This means sandy soils such as **podzolic topsoils** have very low **CEC**, but this can be improved by adding organic matter.

(**Podzolic soil** = member of a group of soils that are gray in color, have an ashy appearance, and extend immediately south of the tundra regions of the Northern Hemisphere. Although characteristically capped with an abundant surface accumulation of organic matter, these soils are often severely leached and highly acid.) [**Columbia Encyclopedia**]. Recalling that another form of sand, silica, is the basis for **Diatomite**, it is not surprising then why clays, particularly **Montmorillonite** with its affinity for organic matter, are far superior for growing orchids and all other vegetation.

H **Heavy Metals and Chelation:** The domain of the **New South Wales** governmental Agency further informs that:

Aluminium (Al^{+++}) and Sodium (Na^{++}) **cations** are not plant nutrients, so are not wanted by the plant. Aluminium is not present as a cation when soil pH (CaCl_2) is over 5 because it is precipitated out of the soil solution. It is only at pH (CaCl_2) levels below 5 that it may become available as a cation,... This is one reason why it is important to maintain pH levels at 5.0 or more.

Therefore, it would seem that Aluminum content of the soil generally, is not a concern provided that the soil's pH is approaching neutrality, or on the alkaline side.) However,

when exchangeable Sodium is present in quantities greater than about 5% of the **CEC**, it makes the **clay** particles unstable in rainwater. This shows up as dispersion or cloudiness in water. Dispersive soils have poor water entry and drainage and set hard on drying. If a soil has a low **CEC** and high Sodium levels, up to half the **cations** in the soil may be in the water around the soil particles, and not actually held by the particles. These cations are very susceptible to being leached or drained away in the soil water. [**Lines-Kelly, 1993**]

In consequence, one must be careful when choosing amongst certain clays for agricultural purposes, some of which may have a high Sodium content. There would seem to be a compelling argument when selecting **clays** to be used as remineralizers, to lean toward **Montmorillonite** with an enviable **CEC** (and extremely low Sodium, i.e., 1% <), instead of **Bentonite** (often between 5% - 10% Sodium).

Montmorillonite in particular has a vast array of nutritional uses, and yet is an Aluminum silicate. But, unlike ordinary clays, **Montmorillonite** also contains a profusion of nearly all other naturally-occurring elements, albeit in trace amounts, complexed with organic matter, or in other words, "chelated".

What is chelation, exactly?

Chelates are molecules consisting of organic material that has trapped certain highly reactive trace metal cations. The otherwise inorganic elements encapsulated in the new molecule are actually suspended between **amino acids**, or hooked onto **proteins**. This arrangement prevents the heavy metals and other chelated elements from entering into unwanted chemical reactions and forming insoluble compounds, which are unavailable. The result of the compound is essentially a new mineral. Chelated minerals have quite different qualities from the individual elements thus bound up. One quality is bio-availability of the individual ingredients, i.e., the ability of the resultant molecule to be absorbed by the small intestine and be uptaken by plant roots.

Bio-availability can be increased or decreased depending on the mineral-chelate complex formed. Natural chelating agents do not share the problems created by synthetic chelation and man-made chemicals. Although Mother Nature's chelation has been

around for millennia, it is still the benchmark or are state-of-the-art technology for delivering selected mineral and trace elements with maximum bio-availability, tolerability, and safety.

Chelated minerals applied as a foliar spray will address plant deficiencies more accurately and with greater speed than any other nutrient. If a yield-limiting deficit is suspected or established, an application of a naturally-balanced formula of chelated minerals in trace amounts will introduce catalysts and create synergies with the prevailing fertilizers to allow them to perform optimally and correct the problem. Just having elements present in the soil is not enough. They must be bio-available.

These elements are far more easily absorbed by plant roots and leaves in this chelated form because of changes in the electrical charge from the trace minerals as a result of their organic encapsulation. The chelation process removes the positive charge from the metals, allowing the neutral or slightly negatively charged, chelated molecule to slide through the pores on the leaf and root surface more rapidly.

These pores are negatively charged, so there is a problem with fixation of unchelated positively charged minerals at the pore entrance. <http://foliarfert.com/pages/chelates.htm>

There is no such restrictive barrier for the neutral, chelated mineral. Besides this type of presentation being more attractive to the cell wall it still permits the tissues to control dosage. The peculiar molecule structure allows tissues to selectively admit ions by breaking their bonds and freeing them for absorption without the risk of overdose which could be the case if unchelated ions were ingested in mass. Unwanted atoms are simply left on the molecule or the molecule is not admitted at all. Furthermore, the electrical charge problem is ameliorated as explained in the preceding paragraphs.

To George Crile (research scientist and author of *A Bipolar Theory of Living Processes*), is attributed the discovery that all living cells are like miniature batteries. Crile demonstrated that the nucleus of the cell is comparatively acidic while that the cytoplasm of the cell is more or less alkaline. The nucleus and the cytoplasm are separated by a semi-permeable membrane. The nucleus acts as the positive element and the cytoplasm acts as the negative element. This creates a true bipolar mechanism much like a battery.

Crile also tabulated evidence showing that the performance, integrity, and structure of living cells are dependent on the maintenance of normal electrical potential.

Fulvic acids chelate metal ions and are electrolytic in nature, lending themselves easily to dispersion in water mediums. By changing cation metallic minerals (with a positive charge) into anion nonmetallic minerals (with a negative charge), fulvic acids produce a hydrophilic colloidal/ionic mineral with superior electrical potential!

<http://minerallogic.com/cell.htm>

Lots of Aluminum in the soil. As we have already seen given the proper pH the concern about the high Aluminum content of clays is unfounded. (The following are edited excerpts from *Aluminum, Friend or Foe?* [Kenneth D. Westwood, 1997]. Undocumented information having been disseminated throughout the health food industry regarding “Aluminum Toxicity”, has unduly alarmed health-conscious individuals, particularly in the USA.

Fact: Aluminum is one of the most abundant elements on Earth, and is a major component in all soils, clays and non-clays alike, with one seventh of the Earth’s crust being made up of that element.

Fact: It is never found in its pure form (typically extracted for industrial purposes from the mineral bauxite), but is always combined with other elements--silicon being one of the most common.

Fact: Aluminum combines with Silicon and Oxygen, to make up the major constituent in Montmorillonite clay, and other members of the Smectite family of clays.

Fact: These “Healing Clays” have been known to diverse peoples for their medicinal properties (both externally and internally) on at least three continents for thousands of years.

Fact: Any clay compound found in health food stores contains very high levels (tens of thousands of parts per million) of Aluminum.

Fact: Aluminum enters the food chain at every level, be it plant or animal.

Fact: Any element when used in excess becomes toxic whether it is considered to be a macro nutrient, or one that is essential only in trace amounts, i.e., micro nutrient.

However, if natural compounds of “organic” Aluminum were toxic or hazardous to human health, life as we know it on planet Earth would cease. The fact that most natural compounds of Aluminum are inert and pass through the system without harm coupled with the fact that Aluminum compounds are so prevalent, points to the absurdity of the claim that all forms of Aluminum are toxic (poison).

Fact: Most food crops contain 20-200 parts per million of Aluminum; with beans testing 1640 ppm (**46.5 mcg** per ounce).

Dr. Melvin N. Westwood (Internationally recognized, Oregon State University scientist), observed that of the thousands of analysis of plant and fruit fibers which he has tested, not one sample has ever shown the absence of Aluminum. Since **all** seeds contain that element he has expressed grave doubt that samples run in an “Aluminum-free” culture could be grown.

Fact: All green-leafy vegetables used in salads and green-drinks contain “high” levels of Aluminum.

Fact: Onions are especially high in Aluminum, and the strawberry receptacle is loaded with natural compounds of “organic” Aluminum.

Fact: Reported in parts per million, mint leaves may contain 160 ppm. Plantain leaves typically contain 56ppm, and beets 28ppm while beet leaves have 72ppm. Various marine algae test at between 40-98 ppm of Aluminum

Fact: Even our good friends such as spinach contain 102 ppm of Aluminum.

If natural forms of Aluminum are toxic why do we classify most of the above as health foods?

The Alzheimer's Myth: With legumes being especially high in Aluminum (e.g., beans) ppm) all ethnic groups eating legumes as a staple part of their diet would manifest epidemic numbers suffering from Alzheimer's disease if natural forms of Aluminum contributed in any way to this disease. If Aluminum toxicity were possible from the garden there wouldn't be very much else on earth to eat.

Fact: Nutrients always work as a team.

Fact: When there is an abnormal concentration of one element, it results in an upset metabolic balance.

Human effort to produce super concentrates of any nutrient, at best may be disregarding both the synergistic and catalytic properties of various elements. At worst, by failing to complex certain elements together, and maintain some semblance of balance, our pharmaceutical formulators might be overriding the system's ability to deal with a particular element in high concentration, and be creating a deadly poison, albeit one whose effects are slow to appreciate.

Two examples:

Fact: 1) "Organic" Arsenic in trace amounts is essential, yet in higher concentrations is a poison.

Fact: 2) Selenium in trace amounts is absolutely essential, yet the same element in high concentrations is also a deadly poison. (Scientists like Dr. Westwood are quick to point out that we should not mistakenly assume that because certain elements are lethal in high concentrations, that they are also harmful in "trace" amounts.)

All trace elements found in organic beds of ancient origin must be assumed to be of importance.

Fact: These elements have been placed there by nature and not by man.

Supporting Conclusion: Because we find natural forms of Aluminum in all our food chains we cannot assume that "plant derived" Aluminum is non-essential. To refine out Aluminum, Arsenic and other trace elements from minerals extracted from naturally-occurring organic beds, or sediment, is to change from a "natural" to an "unnatural" state.

Fact: Since "organic" Aluminum is in all plant foods without exception, one of the surest methods of determining whether a product is natural is the presence (or absence) of Aluminum. If there is no Aluminum it cannot be natural.

Hypothesis: In all likelihood, Aluminum (as obtained by, and contained in plants) may yet prove to be one of our closest friends (especially in the complex with **fulvic acid**).

Reactive mineral surfaces in natural soil and aquatic environments are coated to a large extent with natural organic matter, such as humic substances. ...One important aspect is the question whether metal sorption is additive, or whether specific interactions between metal ions and fulvic acid at the mineral surface lead to non-additive behavior. Predicting the fate of metal contaminants therefore requires a quantitative understanding of the interactions between metal cations, humic substances, and mineral surfaces.

http://www.ito.ethz.ch:16080/SoilChem/bcresear/bcresear_ilona.html and <http://ilona.heidmann.info/Thesis.htm>

In conclusion, soil is a complex material with many components, each with subsets of their own. Apart from fairly homogeneous deposits such as sand dunes and obvious clay deposits, we have seen that soil is generally a combination of these mineral forms along with silt and organic matter, air spaces or trapped gasses, and moisture.

To determine a soil type some simple equations are available to make a generalization about a soil sample. As an illustration take for instance what is meant by **clay loam**. Typically loamy soil is about 35% clay and 32% sand on average, meaning that the residual of 33% is silt.

- 1) Multiply each of the relative percentages by the individual particle diameter.
- 2) Add the resultant numbers and you get a weighted average particle diameter.
- 3) In this case we get a result of .063125. This might actually be an overestimate, as fine particles (such as clay) can fill-in, in between large particles like sand.

Sand, typically	$(0.175) \times (.32) = .056000$
Clay	$(.0015) \times (.35) = .000525$
Silt	$(0.02) \times (.33) = .006600$
	.063125

Using the Soil Textural Triangle posted by Washington State University on its webpage: <http://cru.cahe.wsu.edu/CEPublications/pnw0475/fig1.pdf>. We can get the relative percentages we need for further calculations by first:

- 1) Searching out the name of the soil type for which we wish to quantify texture
- 2) Looking along the Y Axis (for the clay %) to the horizontal midpoint of the appropriate block
- 3) The looking along the X Axis (for the sand %) to the vertical midpoint of the appropriate block.
- 4) Adding these two percentages and subtracting the sum from 100 to give us the probable silt proportion according to popular definition.
- 5) Consulting <http://www.newton.dep.anl.gov/askasci/env99/env201.htm> for additional particle sizes and those cited in this article.

For **sandy loam** the same series of calculations gives a weighted average diameter of 0.12 mm (rounded off), as follows:

Sand, typically	$(0.175) \times (.65) = .113750$
Clay	$(.0015) \times (.27) = .000405$
Silt	$(0.02) \times (.08) = .001600$
	.115755

The Soil Textural Triangle is a useful resource and a fun one to know about.

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Australian Soil Identification Spreadsheet

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Texas A&M University System, *(Taken from: National Garden Bureau, Liz Ball, author)* This article appeared in the **July/August 2001 issue of Horticulture Update**, edited by **Dr. Douglas F. Welsh**, and produced by Extension Horticulture, Texas Agricultural Extension Service, College Station, Texas.

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Westwood, Kenneth D., *Aluminum, Friend of Foe?* ©1997 **Fulvica BioScience** (as republished in *Fulvic Acid-- the Miracle Molecule*)

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From the *Soil Sense leaflet 3/93, Agdex 530* (produced by **Rebecca Lines-Kelly**, formerly soils media officer), **Wollongbar Agricultural Institute**, for **CaLM** and **NSW Agriculture**, North Coast region, under the National Landcare Program, September 1993. <http://www.ricecrc.org/reader/soil-types-structure/ss393-cation-exchange.htm>

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Hydrolysis of para-substituted benzonitriles in water

Sedimentary humic acid and fulvic acid as surface active substances.

Determination of organically-associated trace metals in estuarine seawater by solvent extraction-atomic absorption spectrometry.