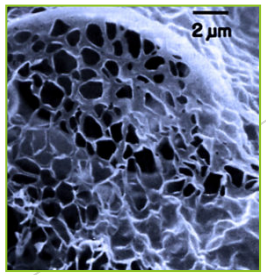
Compost and Humic Substances, and their Relationship to Cation Exchange Capacity and Stability

By: Ron Alexander

1/26/21

Principal, R. Alexander Associates, Inc.

Ron@alexassoc.net www.alexassoc.net 919-367-8350



R. Alexander Associates, Inc.
4 DECADES OF SERVICE
TO THE COMPOSTING AND ORGANICS RECYCLING INDUSTRY

Humic Substances

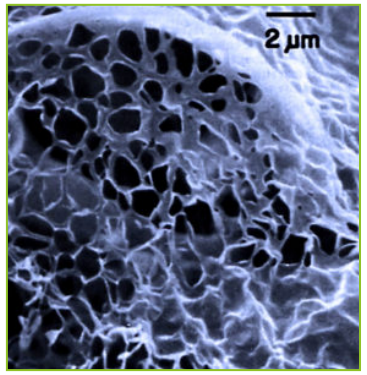
- Humus is the dark organic matter that forms in soil when dead plant and animal matter are thoroughly degraded, specifically through the action of anaerobic organisms
  - -It is difficult to define humus precisely, because it is a very complex substance that is not fully understood
  - -Although formed through the microbial degradation of organic matter, it is stabilized to a point that it resists further degradation
  - -All organic matter is not humus, but humus is an important fraction of organic matter (about 35-55 percent of the non-living part of organic matter)

- Humification can occur naturally in soil, or can occur artificially, during the production of compost
  - Organic matter is humified by a combination of saprotrophic fungi, bacteria, microbes and animals (e.g., earthworms)
  - It is commonly believed that humus is created through anaerobic fermentation, while compost is created through aerobic decomposition

R. Alexander Associates, Inc.
4 DECADES OF SERVICE
TO THE COMPOSTING AND ORGANICS RECYCLING INDUSTRY

Humus, and the humic and fulvic substances (found within humus), have the ability to provide a variety of benefits to the soil, such as:

- Improving water holding capacity
- Improving nutrient retention (through an increased cation exchange capacity)
- Providing nutrients to soil microbes
- Improving the aggregation of soil particles (enhancing air, water, etc. movement)



Bruce Bailey, Kurtz Bros., Inc.

Humic and fulvic substances can also enhance plant growth directly through physiological and nutritional effects. Some of these substances function as natural plant hormones and are capable of improving seed germination, root initiation, uptake of plant nutrients, and can serve as sources of nitrogen, phosphorus and sulfur (modified from Tan, 1994; Schnitzer, 1986)

Compost contains humic substances — very stable forms of organic matter. A strong positive correlation exists between compost stability and CEC, and the amount of humic substances

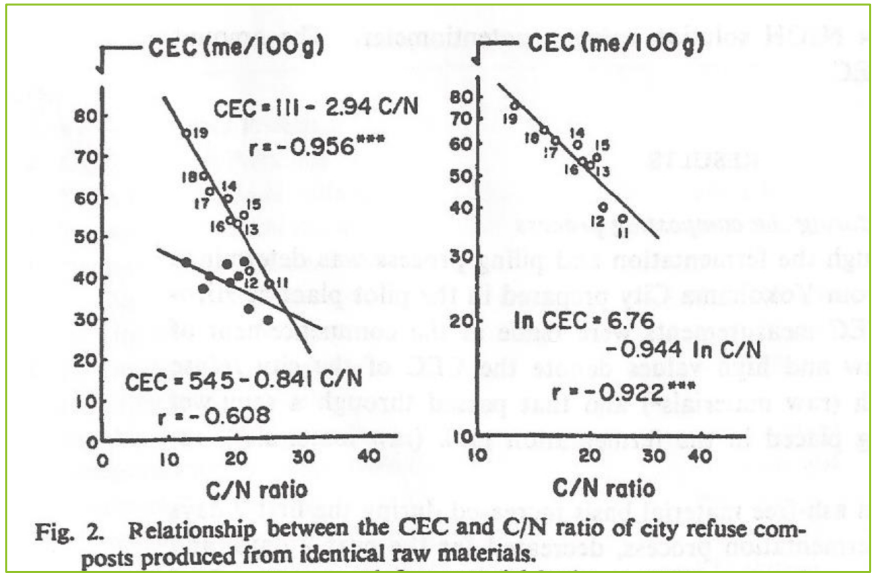


Fig. 2. Relationship between the CEC and C/N ratio of city refuse composts produced from identical raw materials.

-Regression analyses yielded a highly significant negative correlation between CEC and C:N ratio of compost
-The CEC increased as the C:N ratio decreased

A search of the literature provides correlating research data

- Harada (1980) noted that many studies have been completed illustrating the positive relationship between cation exchange capacity (CEC) and the degree of humification of soil humic substances.
- Kumada (1956) reported that the CEC of soil humic acid increased as humification progressed.
- Millar et al. (1936) found a positive correlation between the CEC of decomposing organic matter and its lignin content. Therefore, Harada concluded that the degree of maturity of (city refuse) compost can be assessed by measuring its CEC.
- The researchers also concluded that composts were considered to have been sufficiently matured for application, once the CEC was greater than approximately 60 meq/100g (of ash-free material).
- Al-Alwari et al. (2019) found during their green waste composting trials that the CEC value rose substantially (over time from 37.1 to 160.1 meq/100g) after 30 days of composting.
- Finally, Smidt et al. (2007), using spectroscopic analysis, found that humic acid content in compost increased during the composting process.

R. Alexander Associates, Inc.
4 DECADES OF SERVICE
TO THE COMPOSTING AND ORGANICS RECYCLING INDUSTRY

Test Results of Recycled Organic Matter Based Products

Table 1. Humic substances

Organization	Product Name	Humic Acid %[1]	Fulvic Acid %[1]	Sample Age	Sample Feedstock(s)
DC Water	Cured Bloom	0.55	2.41	6-8 weeks	Biosolids, THP[2] + AD[3] (not composted)
DC Water	Privately Produced Cured Bloom	0.55	2.69	Several months	Biosolids, THP[2] + AD[3] (not composted)
Engel & Gray	Harvest Blend Compost	5.22	1.96	150-180 days, windrow composting	Yard trimmings, agricultural by-products, biosolids, wood chips, coir, stall shavings
Raleigh	Organic Compost	2.31	2.4	Over 6 month old, windrow composting	Yard trimmings
We Care	We Care Organics - Rockland	6.54	3.46	40-50 days, (curing included) aerated in-vessel composting	Biosolids
We Care	We Care Organics - Freshkills	1.94	1.3	6 months (curing included) passive windrow composting	Yard trimmings

[1]Reported on dry weight basis; [2]Thermal hydrolysis process; [3]Anaerobic digestion
Compiled by R. Alexander Associates, Inc., 12/19-1/20

- Older and more properly composted products contain larger amounts of humic substances
- Biosolids-based products may innately contain larger amounts of humic substances

R. Alexander Associates, Inc.
4 DECADES OF SERVICE
TO THE COMPOSTING AND ORGANICS RECYCLING INDUSTRY

What Does This All Mean?

- Compost contains humic substances, which are very stable forms of organic matter, and are important components of healthy soils
- There appears to be a strong positive correlation between compost stability, and both CEC and the content of humic substances

  -This correlation suggests that extending composting and/or curing phases, or optimizing these processes, could create composts containing greater levels of humic substances. Obviously, additional research is required to verify these claims
- The takeaway is that as compost applications are identified which require, or can be improved by, composts possessing higher CECs (e.g., bioretention soils, contaminated soil reclamation, revegetation of sandy soils, etc.), composters could modify their processes to create a product that better suits the requirements of specific applications

  - It could also raise the interest and value of compost used in soil and water protection applications

References

•Al-Alawi, M., Szegi, T., El Fels, L., Simon, B., and Gulas, M.. *Green Waste composting under GORE® cover membrane at industrial scale: physic-chemical properties and spectroscopic assessment.* International Journal of Recycling of Organic Waste in Agriculture. October 2019.

•Bot, A., and J. Benites. The importance of soil organic matter: Key to drought-resistant soil and sustained food production. Food And Agriculture Organization Of The UN. 2005.

•Brady, N.C., Weil, R.R. (1999). *The Nature and Properties of Soils*. Upper Saddle River, NJ. Prentice Hall.

•Di Giovanni, C.; Disnar, J. R.; Bichet, V.; Campy, M. (1998). "Sur la présence de matières organiques mésocénozoïques dans des humus actuels (bassin de Chaillexon, Doubs, France)". Comptes Rendus de l'Académie des Sciences, Série IIA (in French). **326** (8): 553–559. *Bibcode*1998CRASE.326..553D *doi 10.1016/S1251-8050(98)80206-1*

•Harada, Y. and Inoko, A. *Relationship between cation-exchange capacity and degree of maturity of city refuse composts.* Soil Science and Plant Nutrition., 26(3), 333-362. 1980.

•Kumada, K., *Several properties of humic acids,* Soil Plant Food, 2, 44-48 (1956).

•Millar, H.C., Smith, F.B., and Brown, P.E., *The base exchange capacity of decomposing organic matter*, Journal of the American Society of Agronomy, 28, 753-766 (1936).

•Schnitzer, M. 1986. *The synthesis, chemical structure, reactions and functions of humic substances. In* R.G. Burns, G. dell'Agnola, S. Miele, S. Nardi, G. Savoini, M. Schnitzer, P. Sequi, D. Vaughan & S.A. Visser, eds. *Humic substances: effect on soil and plants.* Congress on Humic Substances. March 1986, Milan, Italy.

•Smidt, E., Eckhardt, K., Lechner, P., Schulten, H., and Leinweber, P., *Characterization of waste materials using FTIR spectroscopy; process monitoring and quality assessment.* Spectrosc Lett 38:247-270.

•Tan, K.H. 1994. *Environmental soil science.* New York, USA, Marcel Dekker Inc. 304 pp.

R. Alexander Associates, Inc.
4 DECADES OF SERVICE
TO THE COMPOSTING AND ORGANICS RECYCLING INDUSTRY