Controlled Microbial Composting and Humus Management: Luebke Compost
by Steve Diver
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Introduction

Controlled Microbial Compost (commonly known as "Luebke compost") is a premium-grade, well-humified compost that has been microbially inoculated, aerated, and monitored to ensure high standards of quality. The CMC method was developed through on-farm and laboratory research by Siegfried and Uta Luebke of Austria. "Humus management" is a soil management system the Luebkes use in conjunction with CMC compost. Both of these techniques are described below.

The Luebke Family

Siegfried and Uta Luebke are well known in Europe and rapidly gaining a wider audience in the United States. The Luebkes have managed an organic farm since the mid-1960s, specializing in a diverse mix of vegetables and dairy sheep. They sell organic produce, dairy products, and breads at a town shop in Peuerbach, Austria.

In addition, Siegfried Luebke is a soil microbiologist with an on-farm laboratory that includes an extensive collection of microbial cultures and microscopic equipment. One outcome of his research is a database of 3,600 microbe-driven enzyme reactions in soils and composts. The Luebke's on-site lab analysis of different methods of compost preparation, tillage, green manuring, and compost application has been instrumental in the development of the CMC Compost and Humus Management system.

Early on, the Luebkes realized the importance of soil microorganisms in the management of agricultural soils. They gained insights from several people, including Anne France, a biologist herself and wife of Raoul H. France, author of the classic biology text *Bios, die Gesetze der Welt (Bios: The Laws of the World)* (1).

The Luebkes also worked directly with colleagues of Dr. Ehrenfried Pfeiffer (1899-1961) at The Pfeiffer Foundation in Spring Valley, NY. Dr. Pfeiffer was a microbiologist and agronomist who studied under Rudolf Steiner, the founder of biodynamic agriculture. The Luebkes experimented with microbial inoculants developed by Dr. Pfeiffer, including B.D. Compost Starter® and B.D. Field Starter®, a green manure inoculant. The Luebkes also learned how to use the circular chromatogram technique developed by Dr. Pfeiffer to evaluate the humus condition of soils and composts.

A companion ATTRA publication, Biodynamic Farming and Compost Preparation, provides background reading on Dr. Pfeiffer's work with composting systems, chromatography, and humus management.

Chromatogram

Circular chromatography image of biodynamic compost
Source: Human Dimensions Institute Professional Paper #4

Humus management is really an old concept in organic agriculture. Many of the early books on organic farming talked about "humus farming." Essentially, humus management is a system of biological farming practices — crop rotations, cover cropping, green manuring, composting, grazing, and proper tillage — that provides food and shelter for soil organisms. The humus management system employed by the Luebkes relies on forage- and covercrop-based rotations, green manures, proper tillage operations, rock dusts, microbial inoculants, and CMC compost to build soil humus and meet fertility and pest control needs. Several "indicators" of success with humus management, as reported by the Luebkes, include the following:

- In a ten-year period, the organic matter content of a clay loam soil on their farm was changed from 2% to 15%
- Following downwind fallout from the Chernobyl nuclear reactor accident, root vegetables raised on their farm were uniquely free of radioactive contamination in comparison to other farms in the region
- The nitrate content of vegetables raised on their farm was significantly lower than conventionally-grown produce in Austria
- Soil and compost samples on their farm have well developed humus crumb and high numbers and diversity of microbes, as revealed by a specialized light microscope

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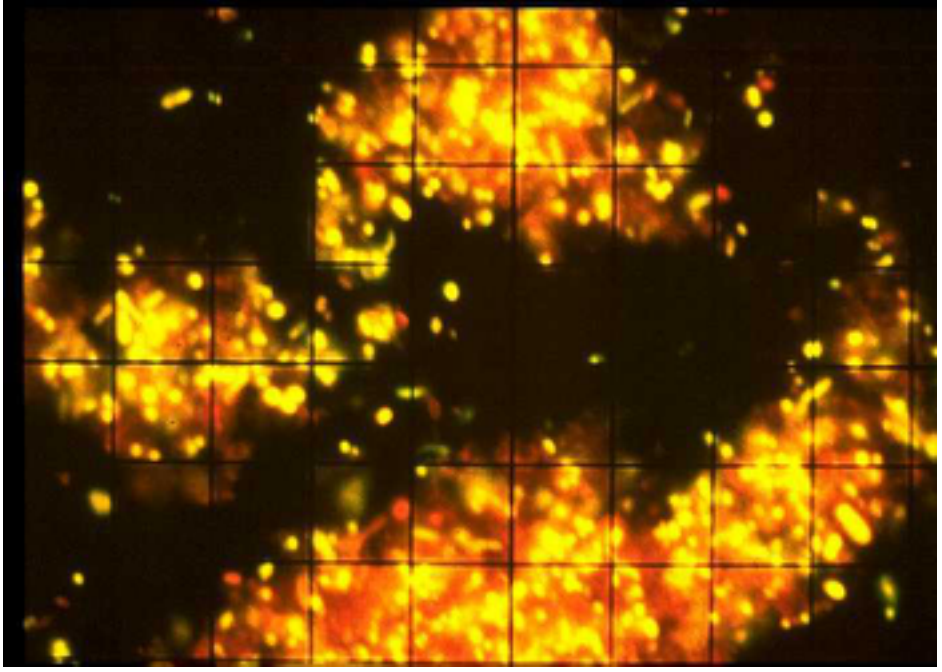
Well Managed Soils are Full of Life!



Soil microbes inhabiting the surface of clay-humus crumb,
glowing under UV light, stained with acridine orange,
as seen under a high-resolution Leitz microscope.

Source: Siegfried Luebke's CMC Group Laboratory; Peuerbach,Austria.

The CMC Compost Consulting group includes Siegfried and Uta Luebke, their daughter Angelika, as well as a compost consultant, Mr. Urs Hildebrandt. Two courses are offered: a 3-day Humus Management Seminar and a 4-day CMC Compost Seminar. The seminars include classroom instruction with color slides, hands-on lab activities, and hands-on compost preparation in the field. The Luebkes teach primarily in Central Europe, but they have also conducted seminars in Norway, Finland, India, and the United States.

The Luebkes' first speaking engagement in the U.S. was at the Acres, U.S.A. Conference in Kansas City, MO, in 1985. They've also spoken at several Eco-Farming Conferences at the Asilomar Center in Monterey, California. Annual seminars on Humus Management and CMC Compost were held in Pennsylvania and California from 1992 to 1997. Currently, they conduct one English-speaking international seminar each year in Peuerbach, Austria.

George Leidig (2) is the U.S. liaison for the CMC Compost Group. Leidig worked with the Luebkes for 3 years in Austria prior to forming Autrusa/Imants USA in Perkiomenville, Pennsylvania. Leidig hosted seminars for the Luebkes in the 1990s, and coordinates CMC product distribution in the U.S. This includes manufacture and distribution of the Sandberger Compost Turner® as well as distribution for the Imants Spade Plow® and Top Tex Compost Fleece®.

Humus Management: Humus Formation &
The Role of Soil Microbes

Basic to humus management is an appreciation for the vital role of microorganisms in soils and composts. Microbes are essential to breadkdown of raw organic matter, mineralization of organic matter and subsequent release of plant nutrients, disease suppression, enzyme reactions, and a host of other biochemical functions, including formation of soil humus and clay-humus crumb.

Selman Waksman's Graph on Crop Yields & Soil Bacteria

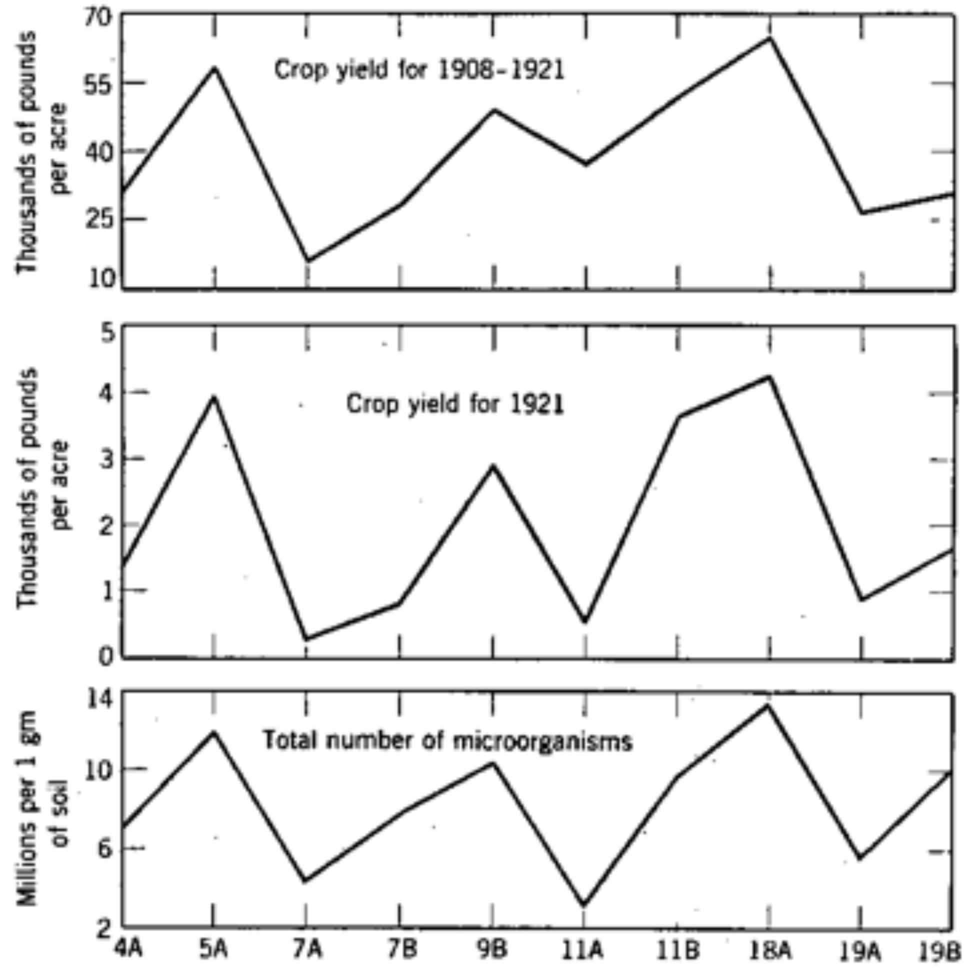


Fig. 24. Crop yields and bacterial numbers (from Waksman).

Graph used by the Luebkes in the humus management seminar, published by Dr. Selman Waksman, the famous microbiologist from Rutgers University. The graph illustrates a correlation between crop yields and occurrence of soil bacteria: Higher populations of soil microorganisms are correlated with higher yields of crops.

Source: Waksman, Selman. 1952. Soil Microbiology. John Wiley & Sons, New York

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Humus is the end result of organic matter decomposition and recomposition by microbes. When fresh, undecomposed organic matter (green manures, animal manures, crop residues) is added to soil or placed in a compost pile, a rapid multiplication of soil microorganisms takes place. Certain microbes (bacteria, fungi, and actinomycetes) break this raw organic matter down into smaller particles (gums, waxes, lignins) resistant to further decay and simple organic compounds (sugars, amino acids) that are water soluble. Following the **breakdown phase**, a second group of microbes bind these materials together, especially lignins and microbial biomass, into more stable humic substances (fulvic acid, humic acid, humins) in the **buildup phase**.

The physical, chemical, and biological transfomation of raw organic matter into a complex humic substance is known as humification. Friable humus (also known as effective humus or nutritive humus), which supplies slow-release nutrients over a period of weeks or months, is a short-chain humic compound. Stable humus (also known as permanent humus), which has a half-life of years and may be viewed as the soil humus bank, is a long-chain humic compound.

When conditions are optimal, microbes attach these long-chain humic compounds to the clay fraction, resulting in clay-humus crumb. These clay-humus crumbs are full of "nooks and crannies" which provide shelter for soil microorganisms. The enormous surface area and negative charge associated with clay-humus provides exchange sites for cations, and building soil humus is one of the few ways farmers can actually increase the cation exchange capacity (CEC) of soils. Clay-humus crumbs are highly desirable in building soil tilth and maintaining good soil structure and water holding capacity.

The goal of humus management is to arrive at an active, high-quality humus that is insoluble in water and therefore resists leaching of nutrients. Instead, nutrients are released through mineralization, a process driven by secretion of weak acids from plant roots and microbial action. In a healthy soil system, the Luebkes propose an interactive feedback loop exists whereby plants secrete root exudates that tell soil microbes what they need. In response, soil microbes regulate mineralization and feeding of crop plants.

Dr. Pfeiffer promoted microbial inoculation of green manures and composts to help regulate the humification process. Uta Luebke explained that in nature, different microbes perform specialized tasks. She used the analogy of building a house: carpenters, masoners, plumbers, and electricians all work together to build a house. Uta explained that microbe A cannot do the work of microbe B due to different genetic makeup. Further, Uta explained that when specialists are missing, it takes longer to do the same amount of work. For example, when crop residues from the last growing season are still largely intact it is an indication of a poor, inactive soil. In a good, microbially active soil, crop residues may be decomposed in a few weeks.

Based on these ideas and drawing on his experience with the Pfeiffer inoculants, Siegfried Luebke developed a microbial inoculant that doubles as both a green manure and compost inoculant. The end result is CMC Compost Starter®, a mixture culture of 55 different types of microbes.

Clay-Humus Crumb

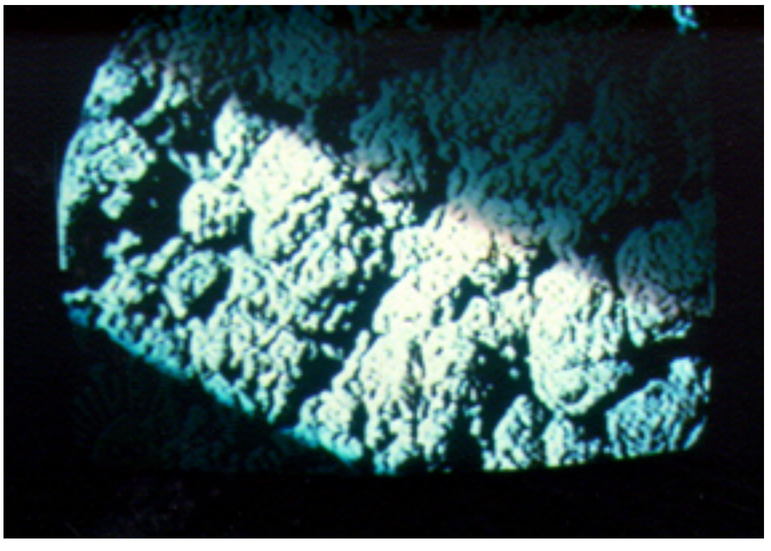

Image of clay-humus crumb formation in well managed soil, as seen under a microscope. This beautiful structure is built by microbes, which tie humus particles to clay particles in the formation of clay-humus crumb. Clay-humus is an architectural masterpiece of Nature.

Source: Siegfried Luebke's CMC Group Laboratory; Peuerbach,Austria.

Humus Management: Crop Rotations and Green Manuring

Early on, drawing on the experience of The Pfeiffer Foundation, the Luebkes learned that microbial inoculation of green manures has substantial benefits. They observed enhanced humus crumb formation in comparison to fields managed with non-inoculated green manures. They also found that inoculated green manures break down faster and therefore enable the farmer to plant sooner. Normally, a 3-4 week delay between green manuring and planting is recommended. Yet, after working down a green manure with a spading machine, the Luebkes often plant a vegetable crop the same day or just a few days after green manuring.

In the spring season of April & May, every day is valuable for plant growth. Green manures are rapidly accumulating plant biomass and producing extra nitrogen. It is important, then, when planting into freshly incorporated green manures, that the soil be capable of digesting organic matter. The key is a microbially active soil, enhanced through inoculation of green manures and regular amendments of compost. "Farming is quite different when you work with an active soil," said Uta Luebke.

The Luebkes became convinced that green manure inoculation was making a difference when they were able to roto-till in mid-summer and the tiller sank down into a loose, friable soil. Normally a tiller would just bounce around on hard ground at that time of year.

On the topic of establishing green manures and cover crops, Uta said that soil needs a vegetative cover at all times. They reseed a cover crop as soon as they take off a cash crop. Exposed soils are prone to loss of organic matter through oxidation and erosion. The maintenance and buildup of soil humus should be foremost on every farmers mind, according to Uta.

The basic sequence for green-manuring, practiced by the Luebkes, is as follows: flail chop or rotary mow the green manure and let it lie on the field until the moisture is right for tilling into the soil, then inoculate it just before turning under. The inoculant is applied at 1 unit/ha (1 hectare=2.47 acres) via boom spray nozzles (1.2 mm, cone-shaped mist nozzles) positioned on the front of the tractor. An inoculant spray tank is mounted on the side of the tractor, and applied at a cost of about $50/ha (about $20/acre). A spade plow is attached to the back of the tractor.

The tillage implement is a vital component of the humus management system. Tools that create a hard pan should not be used. The spade plow is preferred by the Luebkes because it performs primary and secondary tillage in one pass, working the soil into a friable condition and providing good aeration.

Following incorporation of fresh organic matter, the microbe population builds up rapidly. Young green material decomposes in as little as 5 days. Rain following incorporation is desirable to move organic matter into deeper layers of soil. Uta said soil humus can be improved as deep as 2-3 ft, or more.

The Luebkes grow a variety of cover crops. Faba bean is popular cover crop in

Austria. Rye and rye-vetch mixtures are also common. Legumes are important because they are nitrogen fixers. One of their main rotations is an alfalfa-grass mixture that stays in the ground for 4 years. The grass-legume mix is cut to provide feed for their dairy sheep and green chop for their compost. On the last rotation, it is chopped down with a flail mower, inoculated, and turned under as a green manure.

The Luebkes explained that harvest and removal of plant top-growth does not deplete soil organic matter (OM) when OM is 5% or above; below 5% OM, however, removal of green chop exceeds a sustainable level.

The Luebkes stress the following points in relation to green manuring:

- Green manures are important because they provide food to microbes, thus enabling the microbes to perform many important functions in the soil.

- Be sure there is enough moisture for microbes to do their work; otherwise, OM will not be attacked properly. Conversely, if soil is too moist when it's time to green-manure, the crop should be chopped and allowed to wilt sufficiently prior to incorporation.

- Oxygen is the other important requirement of soil microbes that should not be overlooked. Incorporation of green manures should not extend to depths where soil oxygen is inadequate. Partial incorporation of green manures is necessary, and full incorporation preferred, to assure optimum microbial breakdown. Microbes are inhibited or killed by ultra-violet (UV) light when exposed on the soil surface.

- Always cut and chop the green manure prior to incorporation. Top removal causes root sloughing (a microbial food source), and chopping increases the surface area of the crop residue (which enables the microbes to digest it faster)

- Inoculation of each green manure crop is advised. The Luebkes use CMC Compost Starter to inoculate green manures. [Note: CMC Compost Starter is not yet available in the U.S.; see alternative suppliers in the compost section below.]

- Controlling the breakdown process will help reduce the chance of putrefaction. For example, if heavy rains compact green manures after plowdown, go back and work the soil again (after the soil dries sufficiently to avoid compaction) to assure proper breakdown.

- Especially heavy residues tend to go anaerobic and putrefy. Avoid too much crop biomass at plowdown by incorporating earlier in the season, as necessary.

Close-up display of shovels on an Imants spader, a rotating-type spading machine.	Imants spading machine in the field; working down crop residues in one pass.

Humus Management: Compost Application

The Luebkes recommend the addition of 10-12 tons of compost per acre annually for the first 2-3 years, then tapering off to about 5 tons. For heavier-feeding vegetables, 8 tons/acre is recommended. Maintenance rates may be as low as 3 tons/acre with high-quality compost.

The Luebkes apply 6-8 tons compost per acre for greenhouse tomatoes, which is about the same rate they use on field-cultured tomatoes. They use a 1:1 compost/peat moss potting mix for transplants, adding 1/3 sand for soil blocks.

Humus Management: Compost-Enhanced Weed Control

A decrease in weed pressure is considered a sign of soil improvement. This is a common observation of organic farmers all across Europe, according to the Luebkes. One producer who prepared CMC compost and applied it to carrots reported that only a single weeding was necessary. Previously, 4-5 weedings were required.

In a field trial designed to observe the weed suppressive effects of humified composts, the Luebkes applied immature and mature composts to vegetable plots. The composts were obtained from seven different compost windrows at 2, 3, 4, 5, 6, 7, and 8 weeks into the composting process. Weeds were noticeably greater in plots treated with immature composts (e.g., weeks 2, 3, 4) and largely absent in plots treated with composts of greater maturity (e.g., weeks 5, 6, 7, 8). The hypothesis for compost-enhanced weed control is that soils treated with humified composts mimic soil conditions in mature ecosystems. Conversely, soils treated with immature composts respond to water soluble leachates (e.g., nitrates and raw humic substances) that signal weeds of “disturbed” sites to sprout and provide vegetative ground cover. Nature abhors a vacumn. Weeds respond to ecosystem signalers to help protect the soil.

Humus Management: Soil Evaluation and Testing

Evaluating the humus condition and biological activity of soils and composts is an important part of the CMC program. The Luebkes use the following tests: (1) percent organic matter; (2) colorimetric humus; (3) circular chromatography; and

(4) potential pH.

Percent Organic Matter

Standard organic matter tests, like the Walkly-Black method, are based on extraction with concentrated sulfuric acid. Typical organic matter rates for temperate-region soils (North America & Europe) range between 0.5% to 2.0% in a sandy loam and 2.0% to 5.0% in a clay loam. The Luebkes say that 2% soil OM is the minimum amount needed to support normal biological functioning, a range that echoes "The Humus Law" developed by Dr. Ehrenfried Pfeiffer.

Suggested goals for organic matter levels in well managed agricultural soils:

Field crops	3-5%
Vegetables, orchards, pastures	5-8%
Gardens	10-14%

The Humus Test

The colorimetric humus test was developed in the United States in the early 1900s, but it fell out of widespread use. It had been used by East German agricultural scientists for several decades, and became more widely known following the fall of The Berlin Wall. The Luebkes teach it in their seminars, and several commercial soil labs in the U.S. have started offering it as a regular lab test.

The humus test indicates the degree to which organic matter has become humified. Humified organic matter is desirable because it is relatively stable, so nutrients and simple organic compounds associated with decomposing organic matter are less likely to leach away.

Briefly, the humus test is a colorimetric comparison test. Soil or compost samples are processed with a weak alkali solution (sodium hydroxide) and treated with EDTA chelating agent. The filtered solution, or extract, that results from this procedure will have a distinctive color. The extract is compared to a standardized set of colored vials on a scale of 0 to 100. These range from light yellow to dark yellow; light orange to dark orange; and light red to dark red. The darker the color, the greater the presence of humus. The number that results is a relative number rather than a percentage, and is commonly known as "humus value."

In evaluating soil health, the Luebkes found that the ratio of humus value:percent organic matter should be at least 2:1 to 3:1. For finished compost, humus values should be between 50 and 80. Using CMC compost and humus management techniques, the Luebkes were able to raise the organic matter of a clay loam soil from 2% OM to 15% OM, with a humus value of 45 to 50.

Circular Chromatography, The Chroma Test

The chroma test is a common term for circular chromatography. It is done by wicking an alkali extract from soil or compost samples onto circular filter paper previously treated with silver nitrate. As the solution slowly wicks across the filter paper, separation of humic fractions occurs through capillarity. The silver nitrate serves as a photoactive reagent to fix the fractions and make them visible.

In the chroma test, humic substances, depending on their molecular weight, settle out at different points along the filter paper as they move by capillarity. Patterns and colors that emerge on the filter paper provide a visual, qualitative assay. It is commonly known as a picture-forming test. Sukhu P. Mathur (3) explained that circular chromatography is "based on the fact that humus is formed during composting and that as the [composting] process progresses the relatively low molecular-weight humic substances produced initially are polymerized into less soluble, macromolecular, mature humus." Will Brinton provides an authoritative description of the chemistry behind the chroma test in *Sustainable Food Systems* (4).

Chromatograms are interpreted by analyzing the distance, shape, and color of the central, transitional, and peripheral zones. Various colors are noted: white, pink, brown, violet, and black, as are shapes such as smooth, jagged or irregular.

Interpretation of the chromatogram can identify features such as biological activity, humus formation, humus condition, enzyme activity, mineralization, partial decomposition, poor aeration, crude organic matter versus humified organic matter, fertile status and yield potential, and excessive cultivation.

The chroma test was developed by Dr. Ehrenfried Pfeiffer as an on-farm assay that farmers can perform themselves. However, attention to detail is required and it is time consuming. It is not widely used because it requires training and experience to interpret the chromas.

Dr. Pfeiffer made extensive use of the chroma test in his research at The Pfeiffer Foundation in Spring Valley, New York. He published a 44-page book, *Chromatography Applied to Quality Testing*, containing color plates and descriptive entries for different soils, composts, and grain samples. It is available for $8 from the Biodynamic Farming and Gardening Association, Inc. (5).

One of the most helpful and practical guides to chroma interpretation is based on the Luebke seminar on humus management, which includes chroma preparation and interpretation. *Der Chroma-Boden-Test* (6) is a German-language book. The chapter titled *Der Chroma-Test Eine Praktishce Anleitung* contains a series of chroma images with detailed interpretive analysis. A color poster that accompanies the book contain color plates of the original chromas.

Translated excerpts from *Der Chroma-Boden-Test*:

The chromatogram provides a clear answer to the simple question: "What is the biological condition of my soil?"

Plate 12:

Good soil formation with nearly ideal humus relationships; high microbial activity, with continuous break-down and build-up (transformation) of organic materials. With such soil, the farmer can expect more than average yields. There will be no nutrient problems, even without the addition of mineral fertilizers. Soils of this type are also high in water-retention, having a high buffer-capacity against acid rain; they are easy to cultivate, and are resistant to erosion and leaching.

Potential pH Test

The potential pH test is a simple method for determining the exchange capacity of a soil or compost sample. Indirectly, it is a measure of biological activity and degree of humification. This test is described by Struchtemeyer in *Basic Properties of Forest Soils* (7).

In brief, two samples are prepared. The first sample is diluted with distilled water. A pH reading of this sample will provide the actual pH. The second sample is diluted with potassium chloride (.1 Molar KCl solution). A pH reading of this latter sample provides the potential pH.

The degree to which potassium ions displace hydrogen ions on the soil or compost colloids in solution will be reflected in the difference between the actual and potential pH readings. This is an indication of the ion buffering capacity, or the cation exchange capacity, of the sample. When the pH readings are further apart, they are an indication of poor exchange capacity. The aim is to achieve as little difference as possible; less than 0.5 pH units for soils and 0.3 pH units for compost is ideal.

During the humification process, microbes are actively building long-chain polymers of polysaccharides and other molecules. Well-developed humus has numerous exchange sites and therefore holds hydrogen ions more tightly. The actual pH and potential pH readings will be close together and indicate a high degree of microbial activity, humus structure, and surface area. Conversely, pH readings with divergent numbers are an indicator of poor humus development.

The Complete Luebke Soil Health Picture

To gain a complete picture of soil and compost quality, it is important to use all the tests described above. Soil tests should be done by the same lab (either on-farm or through a commercial lab) so that readings are accurate and meaningful in comparison to each other.

In the U.S., Autrusa/Imants USA used to sell a chroma test kit that contained all the supplies and instructions needed to prepare chromatograms. This equipment was donated to the Josephine Porter Institute for Applied Biodynamics (8). Pike Agri-Lab (9) sells instruments and supplies to perform the complete Luebke compost test, used to determine: pH, oxidation-reduction, electrical conductivity, carbon dioxide, temperature, nitrates, nitrites, ammonium nitrogen, and sulfides.

CMC Compost Preparation

CMC compost is a high-quality humified compost with the following characteristics:

- Aerobically produced
- Abundant and diverse microflora
- Nutrients in stable form
- A high ratio of humus to total organic matter
- No sulfide, nitrite, or other harmful plant compounds

- Low ammonium levels
- Nitrogen fixed into stable humus and microbial biomass

For preparation of CMC compost, the following compost site guidelines are suggested:

1. Slope. The compost site should have a 3-5% slope in the direction of the windrow. There should be no side slope or center slope. Water that collects under the compost pile will result in putrefaction.

2. Compost pad. A good, stable pad is very important when you are moving heavy equipment around in wet weather. It should be constructed so that precipitation moves away from the compost windrows. The USDA Animal Manure & By-Products Laboratory published an article that describes how soils can be lime-stabilized at a cost that is considerably cheaper than concrete or asphalt (10).

3. Storage space. Ample space is needed to stockpile yardwaste, manure, and other feedstock, and for operation of equipment.

4. Access to water. The source may be a fire hydrant, creek, pond, or well, but it is important that no chlorine is present because chlorine kills microbes. Water is added when the compost windrows are turned to maintain moisture at optimum levels.

5. Protection from drying winds. Windbreaks are an effective method for modifying the environment.

6. Electrical power source. A power source can be helpful for operation of on-site testing equipment, electrical-powered grinders and tools, or an equipment shed.

CMC compost is built in layers and laid out in windrows for mechanical turning. The base layer should be a dry, high-carbon material like municipal yardwaste (leaves and shredded tree trimmings) or dried hay or straw. A moist, high-nitrogen material (animal manure, green chop) is laid down next, and so on, in repeating layers. Added last to the windrow, are:

- Diabase or basalt rock dust (10-20 lbs/cu yd) — stimulates microorganisms and provides micronutrients
- Finished compost (10% by volume) — regulates moisture and odor and provides microbial inoculum
- Clay loam (10% by volume) — retains nitrogen and promotes formation of clay-humus crumb
- CMC Compost Starter — a microbial inoculant

The use of rock dusts as a mineral amendment to compost piles is more common in European organic farming. Rock dusts are valued for their fineness of grind, resulting in a huge surface, and for their contribution of a broad range of trace elements. Many of these micronutrients function as biocatalysts for enzymatic reactions. Keep in mind that Siegfried Luebke developed a database of 3,600 microbial driven enzymatic reactions. Enzymes are critical in the breakdown of raw organic matter during the composting process. In turn, organic acids formed as a byproduct of microbial activity help to solubilize and mineralize elements in the parent rock dust material, thus making these mineral elements more bioavailable. When organic matter, clay, and rock dusts are mixed together in the compost windrow, the complex biotransformation and repolymerization processes that occur during composting provide an opportunity for organo-mineral chelated complexes to form.

The following helpful instructions on the use of rock dusts in composts were published in the Spring 1993 issue of *Remineralize the Earth*, in an article by George Leidig titled "Rock Dust and Microbial Action in Soil: The Symbiotic Relationship Between Composting and Mineral Additives" (11):

- Finely ground rock dust should be added at a rate of 10-20 lbs per cubic yard of raw material
- The particle size should be less than 20 microns in diameter, or pass through a #300-mesh screen or finer. The fineness of the material is important, since you want to assure that the minerals are readily available to the microbes during the composting process
- Magnesium levels should be under 5%, since high magnesium levels rob nitrogen from the compost and soil
- Calcium levels between 5-10% are preferred—calcium is a macro-nutrient essential for microbial life and plant growth
- The rock dust analysis should display a well-balanced array of micro-nutrients, which, as in the soil, stimulates microbial action. This is even more important in composting, since the microbes are totally limited to the materials present in the pile for their nutrition
- Granite dust is not recommended for compost because of its quartz content. The larger size and slickness of the quartz particles resist breakdown and inhibit the attachment of organic particles necessary for proper humus crumb formation
- Rock dusts of volcanic origin are preferred, such as diabase or basalt, because of their high silica value. Silica is an often forgotten element necessary for proper cell structure in plants and animals. Recent studies have shown silica play a vital role in calcium and phosphorus assimilation

In addition, other items essential to CMC compost include:

- Use of Sandberger Compost Turner®
- Use of Top Tex Compost Fleece®
- Proper and timely aeration, or turning with a compost turner
- Monitoring temperature and oyxgen levels on a daily basis
- Testing finished compost for percent organic matter, humus value, potential pH, nitrates, nitrites, sulfides, and ammonium

Top Tex compost fleece is a geotextile fabric material that sheds rainfall but helps retain moisture inside the pile; it also blocks UV light harmful to microbes working the outer layers of the pile. In Europe, where composting is regulated to control nutrient leaching and runoff, compost fleece is very common and in some locations it is required by law.

Pending import approval of live organisms, CMC Compost Starter® — which is prepared in a laboratory in Austria—is not yet available for sale in the United States. Three sources of compost inoculants most often cited by farmers modifying

CMC compost to U.S. conditions are Josephine Porter Institute for Applied Biodynamics (8), Midwest Bio-Systems (12), and Petrik Laboratories (13).

Compost Turners and Compost Aeration

One of the unique characteristics of CMC compost is the careful and frequent turning, or aeration, of the compost windrow. CMC compost takes 6-8 weeks to prepare. In a 6-week period, the windrow is turned 17 to 22 times. A typical schedule might go something like:

Week 1: 7 times per week
Week 2: 6 times per week
Week 3: 5 times per week
Week 4: 4 times per week
Week 5-6: 2 times per week

Turning is best accomplished with equipment designed for the purpose. The Sandberger Compost Turner® was designed and tested for use with CMC compost preparation and moves very slowly (900 ft/hr). The drum itself revolves slowly and the tines are designed to roll the material towards the center of the pile and thoroughly mix everything together. The end result is a well-aerated, fluffy pile.

Several Sandberger models are available, including self-propelled and tractor-pulled types. Tractors used in combination with the Sandberger turner should have a hydro-static drive or a "creeper gear." Farmers who don't own a slow-moving tractor can purchase a diesel-powered "pusher axle" on wheels, which has its own gears to push both the tractor and attached Sandberger turner at a slow pace.

Sandberger models available in the U.S. range in size (7-ft to 10-ft) and price ($7,000 to $55,000). The pusher axle costs around $5,000.

Here it may be helpful to note that two additional compost turners have evolved in the United States, based on the Luebke experience and compost turner design. These include the Aeromaster compost turner from Midwest Bio-Systems in Illinois and the HCL compost turner from HCL Machine Works (14) in California.

Tractor-pulled Sandberger Turner

Self-propelled Sandberger turner

Implementing CMC Compost on the Farm

Published information on CMC compost is limited; most of the technology transfer occurs through compost workshops. This document summarizes the key points of humus management and CMC compost compost preparation. For those interested in trying CMC compost, here are a few suggestions:

1. Acquire some finished CMC compost and use it on test plots or as a potting mix ingredient. Observe the results and judge performance in comparison to current practices.

2. Visit a CMC composter and observe compost equipment and windrow management procedures. Learn how to use testing instruments to monitor temperature and carbon dioxide, and see what compost fleece looks like.

3. Attend the international CMC seminar hosted by the Luebkes in Austria, or attend a similar compost seminar here in the United States.

4. Implement parts of CMC compost technology as finances and time allow. For example, use existing compost equipment, but integrate other CMC concepts and methods such as clay soil, compost fleece, frequent aeration, and monitoring for compost quality. "Modified Luebke compost" has become a common approach in the USA. Practitioners have found, for example, that amending the windrow with 5% clay and 5% compost can be helpful, yet less expensive. Keep in mind that the microbial inoculant helps overall compost quality, but it is secondary to good preparation and windrow management.

Contrasting Viewpoints on Intensive Compost Management

While the CMC system emphasizes high quality compost, it also entails the purchase of a specialized compost turner, compost fleece, monitoring instruments, and windrow amendments like clay and rock dust. Essentially, it is an intensive compost windrow management system geared to producing a premium-grade, humified compost.

However, Will Brinton (15) of Woods End Research Laboratory takes exception to intensive compost management in “Sustainability of Modern Composting: Intensification Versus Costs and Quality,” (16) an article that appeared in the July-August 1997 issue of *Biodynamics*. This article reviews two research trials — in Canada and Pennsylvania — that compared compost biology and economics on the basis of compost pile management. The trials examined composts made by the following treatements: No-turn, Manure-Spreader, Front-End Loader, and Compost Turners. Despite the advanced equipment technology and management procedures inherent to the treatments, no appreciable differences were found for oxygen levels, the Dewar self-heating test for maturity, and microbiological parameters. Nitrogen and organic matter losses were greater with increased turning frequency. The costs associated with compost windrow intensity ranged from $3.05/wet ton to $41.23/wet ton of compost. In summary, Brinton argues that low-tech composting methods are just as effective in stablizing nutrients and managing humus. He concluded, "Our view of sustainability is analogous to a reduced tillage approach to maximizing soil quality. By carefully managing composting to achieve proper mixes and limited turning, the idea of a quality product at low economic burden can be achieved."

Likewise, Steven Wisbaum (17) of Champlain Valley Compost Co. in Vermont feels that too much emphasis is placed on intensive compost windrow management and the additional input expenses associated with clay, microbial inoculants, turning frequency, monitoring, and so forth. His article, "A Comparison Of High And Low-Input Composting", (18) summarizes his viewpoints. It may be helpful to note that Wisbaum uses both a compost turner and compost fleece, yet he simply turns much less frequently.

Parallel CMC Composting Systems

Edwin Blosser of Midwest Bio-Systems (MBS) in Tampico, Illinois, promotes the Advanced Compost Systems (ACS) method and manufacturers the Aeromaster® line of compost equipment and associated compost inoculant. Blosser trained with the Luebkes in and as well as the U.S., and the ACS method parallels many of the same composting guidelines developed by the Luebkes; i.e., compost turner design, emphasis on aerobic conditions and frequent turning, windrow monitoring, and striving for a high-quality, well-humified compost. Midwest Bio-Systems sponsors a two-day compost seminar a couple of times each year. Through its association with the Agri-Energy Resources Laboratory in nearby Princeton, Illinois, Midwest Bio-Systems offers a complete compost testing service. This includes feedstock analysis to determine the appropriate compost windrow recipe, as well as finished compost analysis to determine final product quality.

Interpretive Summary

Organic farming is based on a healthy soil regularly fed with organic amendments to provide food and shelter for soil organisms. The Luebkes evaluate the humus condition through several innovative soil tests, and manage soils through the use of well-planned crop rotations, green manures, rock dusts, proper tillage, microbial inoculants, and CMC compost.

CMC compost requires specialized training and purchase of additional equipment and supplies. While many people will not be able to adopt this technology in its entirety, at least initially, some farmers are choosing to adopt the general concepts and methods outlined by the Luebkes, going as far as their current equipment and resources allow.

On the other hand, the green manuring techniques described herein are readily adaptable and will greatly speed up formation of the humus crumb. Whereas some farmers may be hesitant to spend $20 per acre inoculating a green manure, the cost of the inoculant may be viewed as a fertilizer input, since no additional N-P-K fertilizers are applied in the Luebke system.

Since a transition to a green manure- and compost-managed farm may take several years before sustained yields can be expected solely through adequate humus and microbial activity, organic farmers are advised to amend their soils with limestone and rock minerals in the transition phase, as necessary.

Based on my observation, Luebke compost appears to be better-suited to farms that either generate a lot of organic wastes (i.e., dairy farms) or to horticultural operations that rely on humus management (organic fruit and vegetable farms and greenhouse operations). A lot of time and money is dedicated to preparation of premium-grade compost. CMC compost is especially well suited to premium-grade potting mixes.

In some parts of the country, for example in the Mid-Atlantic and Northeastern states, dairy farmers face phosphorus loading regulations. By making a good-quality compost, they can bag the product and sell it to urban green industry (landscapers, turfgrass keepers, greenhouses) for a profit, thereby reduce phosphorus loading on the farm at the same time.

Compost teas, which are prepared from high quality composts and brewed with a microbial food source such as molasses, are rapidly gaining popularity as a natural disease control practice. CMC compost, since it can provide a consistently high-quality compost, is well suited to compost teas for commercial horticulture farms and greenhouses.

References:

1) *Raoul France' and the Doctrine of Life*. 2000. By Rene' Romain Roth. 1st Books Library,
Bloomington, IN. 320 p.

It may be helpful to know that Dr. Raoul France's work is printed in German and therefore inaccessible to English-speaking North Americans. However, an English-language biography was published in 2000 and it provides a fascinating account of Raoul France's lifetime achievements in microbiology, accompanied by an extensive bibliography. France' is considered the father of soil ecology, and coined the terms and underlying concepts for "edaphon," "biocenotics", "biotechnik," "bionics," and "psychobiology." See: *Raoul France' and the Doctrine of Life* is a fascinating biography. It provides insight to Raoul France's studies in microbiology, microscopy, soil ecology, and onwards to the unifying philosophical systems he developed resulting in *Bios: The Laws of the World*, and so forth, dating from 1892 to 1943. Raoul, who was director of the Munich Biological Institute, published dozens of papers and books, for example: "Forays into a Drop of Water" "Edaphon - A New Biological Community" "Studies on Edaphic Organisms" "Edaphon - Studies in the Ecology of Soil-inhabiting Microorganisms"

In 1950, Annie France-Harrar published *The Last Chance for a Future Without Want* through the Bavarian Agricultural Publishing House. The book "created a sensation among soil scientists and agronomists because it sounded an alarm for the future food supply of humanity by drawing attention to the danger of humus destruction and soil erosion."

This resulted in an invitation from the Mexican government to help remediate soils in Mexico. Annie subsequently worked in a microbial laboratory in Mexico from 1955 to 1961. They developed a new type of fertilizer called "Edaphon-humus" bricks which "contained a selection of soil-inhabiting microorganisms in pure culture and which were used to inoculate agricultural soil with humus-producing microbionts."

"Besides, she also created "Petrofil" bricks which contained lithobionts; i.e., microorganisms that
inhabited rock surfaces and caused rocks to disintegrate into soil."

On the web, when you look for Annie France-Harrar, many of the websites pertain to wurmhumus, regenwurm, regenwurmfarm, humusproduktion, and so forth.

Altogether, Annie published 36 books and Raoul published 84 books; they published one book together; plus hundreds of articles and journal papers.

2) George Leidig
Autrusa/Imants USA
941 Perkiomenville Rd.
Perkiomenville, PA 18074
610-754-1110
610-754-1112 FAX
george@autrusa.com
http://www.imantsusa.com/

3) Mathur, S.P. 1993. Determination of compost biomaturity. I. Literature Review. Biological
Agriculture and Horticulture. Vol. 10. p. 65-85. See:
http://www.bahjournal.btinternet.co.uk/classic.htm

4) Brinton, William F., Jr. 1983. A qualitative method for assessing humus condition. p. 382-393.
In: Dietrich Knorr (ed.) Sustainable Food Systems. AVI Publishing, Inc., Westport, CT.

5) Biodynamic Farming and Gardening Association, Inc.
25844 Butler Road
Junction City, OR 97448
888-516-7797
541-998-0105
541-998-0106 Fax

biodynamic@aol.com
http://www.biodynamics.com/

6) Helmut Voitl/Elisabeth Geggenberger. 1986. Der Chroma-Boden-Test. Die Bodenqualität bestimmen, bewerten und verbessern. Ein unentbehrlicher Ratgeber für Landwirte, Berufs -und Hobbygärtner. Verlag Orac, Wien, Germany. 181 p.

7) Struchtemeyer, Roland A. 1980. Basic Properties of Forest Soils. Penobscot Times, Old Town, ME. 106 p.

8) Josephone Porter Institute for Applied Biodynamics
Box 133
Woolwine, VA 24185
276-930-2463
276-930-2475 FAX
Contact: Hugh Courtney
info@jpibiodynamics.org
http://www.jpibiodynamics.org
B.D. Compost Starter® and B.D. Green Manure Starter®

9) Pike Agri-Lab Supplies
RR 2, Box 710
Strong, ME 04983
207- 684-5131
207-684-5133 FAX
Contact: Bob Pike, Cheryl Clough
info@pikeagri.com
http://www.pikeagri.com/

10) The leaflet from on lime-stabilized soil for use as a compost pad, from the USDA Animal Manure & By-Products Laboratory, is on the Web in two locations as HTML and PDF.

Making Lime-Stabilized Soil for Use as a Compost Pad
Lawrence J. Sikora and Harry Francis, USDA-ARS, Beltsville, MD and Consultant, Arlington, VA
http://www.anri.barc.usda.gov/ambl/Sikora_pages/Lime_Stab.htm

Making Lime-Stabilized Soil for Use as a Compost Pad
Lawrence J. Sikora and Harry Francis, USDA-ARS, Beltsville, MD and Consultant, Arlington, VA
http://www.p2pays.org/ref/11/1015817.pdf

11) Leidig, George. 1993. Rock dust and microbial action in soil: The symbiotic relationship between composting and mineral additives. Remineralize the Earth. Spring. p. 12-14.

12) Midwest Bio-Systems

28933 35 E. Street
Tampico, IL 61283
800-689-0714
815-438-7200
815-438-7028 FAX
Contact: Edwin Blosser
MBS@emypeople.net
http://www.midwestbiosystems.com/

13) Petrik Laboratories
109 Harter Ave
Woodland, CA 95695
530-666-1157
530-661-0489 FAX
mike@petriklabs.com
http://www.petrik.com/

14) HCL Machine Works
15142 Merrill Ave.
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209-392-6103 Phone
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hcl@dospalos.org
http://hclmachineworks.com/index.asp

15) Woods End Research Laboratory
Rt. 2, Box 1850
Mt. Vernon, ME 04352
207-293-2456
Contact: Dr. William Brinton
info@woodsend.org
http://%20www.woodsend.org/

16) Brinton, William F. 1997. Sustainability of modern composting: intensification versus costs & quality. Biodynamics. July-August. p. 13-18. See:
http://www.woodsend.org/pdf-files/sustain.pdf

17) Champlain Valley Compost Co.
245 Ten Stones Circle
Charlotte, VT 05445
802-425-5556
802-425-5557 FAX
Contact: Steven Wisbaum
steven@cvcompost.com
http://www.cvcompost.com/

18) A Comparison Of High And Low-Input Composting
by Steven Wisbaum
http://www.cvcompost.com/high_low_input.htm

Reading:

"Compost is King on Herbert Ranch" is a 5-page article from the now-defunct *Farmer to Farmer* magazine, Issue No. 8

Leidig, George. 1993. Austrian compost technology comes to the U.S. Northland Berry News. June. p. 10, 17.

Leidig, George. 1993. Rock dust and microbial action in soil: The symbiotic relationship between composting and mineral additives. Remineralize the Earth. Spring. p. 12-14.

Mulder, Jane. 1991. Windows into worlds unseen. Organic Food Matters. Fall/Winter. p. 24-27.

Useful Resources:

Overview of Crops and Green Manures
ATTRA - National Sustainable Agriculture Information Service
http://www.attra.org/attra-pub/covercrop.html

Farm-Scale Composting Resource List
ATTRA - National Sustainable Agriculture Information Service
http://www.attra.org/attra-pub/biodynamic.html

Alternative Soil Testing Laboratories
ATTRA - National Sustainable Agriculture Information Service
http://www.attra.org/attra-pub/soil-lab.html

The Carbon Catcher Program: Using the Earth to Take Carbon from the Sky. 1993. By Gerry Wass. The Water Foundation, Brainerd, MN. 31 p.

> This booklet summarizes the role of humus in ecological farming, outlines the basic principles of ecological agriculture, lists publications and resources, and contains a directory of alternative agricultural consultants and soil fertility labs. Available for $4.95 through:
>
> The Water Foundation
> 9121 CR 23
> Brainerd, MN 56401
> 218-764-2321
> bogfrog@bogfrog.com
> http://www.bogfrog.com
>
> Now on the Web as a PDF download:
>
> **The Carbon Catcher Program: Using the Earth to Take Carbon from the Sky**
> http://www.sustainablefarmingcentralmn.com/WaterFoundation.pdf

The Secrets of Fertile Soils: Humus as the Guardian of the Fundamentals of Natural

Life. 1997. By Erhard Hennig. OLV Organischer Landbau Verlag Kurt Walter Lau, Xanten, Germany. 202 pages.

This is a popular book from Europe on the importance of humus and soil life in sustainaning agricultural health. Erhard Hennig (1906-1998) was a contemporary of Dr. Hans Muller and Dr. Hans Peter Rusch, the pioneers of organic-biological agriculture in Switzerland and Germany, and spent 50 years as a research assistant with Dr. Gustav Rhode in Berlin. An English-language version is available through:

NHBS Mailorder Bookstore
2-3 Wills Road, Totnes, Devon. TQ9 5XN. UK
Tel: +44(0)1803 865913
Fax: +44(0)1803 865280
sales@nhbs.co.uk
http://www.nhbs.com/we-sell-books-worldwide/z93rz.html

Key References on Soil Humus and Microorganisms:

Balfour, Lady Eve. 1949. The Living Soil. Faber and Faber, LTD., London, England. 270 p.

Gershuny, Grace, and Joe Smillie. 1995. The Soul of Soil: A Guide to Ecological Soil Management. agAccess, Davis, CA. 158 p.

Howard, Sir Albert. 1943. An Agricultural Testament. Oxford University Press, New York and London. 253 p.

Jackson, William R. 1993. Humic, Fulvic, and Microbial Balance: Organic Soil Conditioning. Jackson Research Center, Evergreen, CO. 958 p.

Kononova, M.M. 1966. Soil Organic Matter. 2nd English Edition. Pergamon Press, New York, NY. 544 p.

Krasilnikov, N.A. 1961. Soil Microorganisms and Higher Plants. National Technical Information Service, Springfield, VA. 474 p. Publication No. TT-60-21126.

Stevenson, F.J. 1994. Humus Chemistry: Genesis, Composition, Reactions. 2nd Edition. Wiley & Sons, New York, NY. 496 p.

Waksman, Selman A. 1936. Humus: Origin, Chemical Composition, and Importance in Nature. The Williams & Wilkins Co., Baltimore, MD. 494 p.

Web Resources:

Understanding the Soil Process
Petrik Labs
http://www.petrik.com/PUBLIC/library/ups.html

The classic Petrik Lab article on soils, humus, organic transformation (humification, catabolism, anabolism), edaphon, etc.

The Soil Life - Humus - Soil Fertility Connection
Agri-Energy Resources
http://www.agrienergy.net/ffertconn.htm

The classic Agri-Energy Labs article by Dave Larson, with the Vitality Theory of Soil Fertility by Siegfried Luebke, background information on life in the soil, effective and stable humus by H. Koepf, etc.

Cooking up a recipe for fertility: Boost soil health by turning formerly discarded organic matter into compost
The Grower magazine | April 2002
http://www.growermagazine.com/home/04-02compost.html

Farm magazine article on Herbert Ranch in Hollister, California. It discusses their production and use of Luebke compost, and how they raised soil organic matter on the farm from 0.9 percent to over 3.5 percent in 3.5.

Rock Dust and Microbial Activity in the Soil: The Symbiotic Relationship Between Composting and Mineral Additives
by George Leidig
Reprint, In: Warm Earth, January 2002 | Number 40
http://homepage.powerup.com.au/~warmearth/articles/rockdust.htm

Controlled Microbial Composting: On-Farm Composting at Foster Ranch Creates a Quality Product
From the Ground Up, Compost News for Landscape and Agricultural Professionals
Sponsored by the City of San Jose, February 2002 | pages 1-2
http://www.urbancompost.org/pdfs/newsletter_0202.pdf

Soil Microorganisms and Higher Plants
N.A. Krasil'nikov, Academy of Sciences of the USSR, Moscow 1958
http://www.soilandhealth.org/01aglibrary/010112Krasil/010112krasil.toc.html

Loss of Soil Organic Matter and Its Restoration
William A. Albrecht
Soils and Men, Yearbook of Agriculture 1938, pp. 347-360.
http://www.soilandhealth.org/01aglibrary/010120albrecht.usdayrbk/lsom.html

Sustainable Soil Management: Web Links to Make Your Worms Happy!
Steve Diver, ATTRA
http://web.archive.org/web/20021004064632/http://ncatark.uark.edu/~steved/soil-links.html

A collection of web resources on soil biology, mycorrhizae, rhisosphere ecology, the role of microorganisms in organic farming, soil microbiology, soil fauna, soil foodweb, soil quality, soil health, NRCS educational materials, earthworms, cover crops, alternative soil testing laboratories.

Compara.nl
http://www.compara.nl/compara_uk.htm

A European website featuring CMC compost and related topics like disease suppression, compost teas, humus, etc.

Note: The concepts and practices associated with Luebke compost are mainly taught through seminars. The author attended compost and humus management seminars taught by the Luebke family and George Leidig in the mid-1990s, and compost seminars taught by Edwin Blosser in the late 1990s. This aim of this document is to provide a summary of this European compost technology, thereby making it available to a wider audience in North America. The author advocates multiple approaches to composting and handling of soil organic amendments and recommends that farmers match their equipment and composting methods on a case-by-case basis.

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Updated June 2004

Also see the ATTRA web page:

ATTRA — National Sustainable Agriculture Information Service
http://www.attra.ncat.org/
