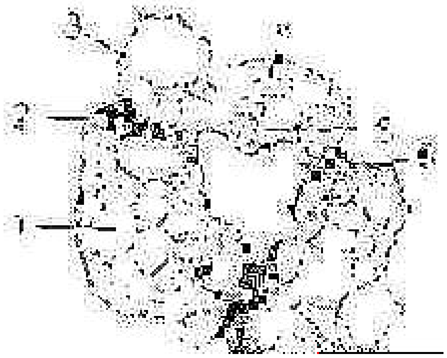
Jrnl. Woods End Institute 1998



Living Soil, Living Carbon

William F. Brinton, Jr.

> We don’t really have a science of nature anymore. We have a science of parts.
> In fact, the expression “Natural Science” is no longer applicable....
> WOLFGANG SCHAD

Any attempt to describe soil and compost from a scientific point of view involves an effort to convince an increasingly skeptical audience that we scientists have something *meaningful* to impart about it. In a world awash with data and information, this dilemma is always valid. Soil and compost organic matter has suffered the fate of having been relegated to “carbon” and shelved. In actuality, it is much more interesting and alive than we imagine.

There was a period in the 70’s when the so called cation exchange (CEC) theory in soils caught hold and for about 10 years *everything* about soils could be explained by it. Now in the context of soil quality and what we are learning about soil ecology, it is falling back into its rightful place. What is emerging is the concept of the *living* soil as an entity deserving attention. Carbon has re-entered the scene disguised as microbes, soil-enzymes and aggregate stability. Attempting to get a handle on it, using the customary mode of modern abstract thinking, however, presents a more difficult challenge.

In trying to present a theme of living compost and living carbon in view of soils, we struggle with the legacy of reductionism in soil science. There has been backlash to the excessive pursuit of deadening views in the form of “quasi-scientific” groups in agriculture and technology. You can travel all over and increasingly find persons presenting “new” facts, many of them just made-up. The idea is, if someone’s explanation is not meaningful, or doesn’t suit, try making another one up— people are likely to accept it. Countering this but from within the ranks of the establishment itself are the “reductionist-holists with “integrative” abstractions using “systems” and “networks”— an unfortunate result of listening to neurologists and computer engineers too much. The wholeness thinking approach behind the Goethean-science foundation of bio- dynamics has nothing to do with this techno-reactionary circus that more and more characterizes the modern age.

Within a mechanistic world view, soil and compost is a maze of interesting but unrelated features. Outside of bio-dynamics, we don’t yet have a “Gaia compost” theory which postulates that the entire soil or compost system is self-determining, self-informing. Where scientists admit an eco-system, it turns out to be a set of integrated mechanisms, and the microbes live in closets next to them, occasionally interacting.

Cation exchange theory in soils is an excellent example of a kind of false holism that was introduced from radical groups into agricultural circles. Our laboratory was the first in the northeast to start testing CEC and growers especially organic ones came rushing to our doors, and now all labs use the method. CEC was a new approach and in some ways superior to the earlier nutrient-barrel approach of looking at “sufficiency nutrients”. It caught on quickly and seemed to work well because it didn’t really shake anyone's existing views: it was just a new mechanical-electronic model into which we could stick soil minerals. It is pure mathematics and represents a complete abstraction of the soil system which in the end is neither entirely mathematical nor electronic. At the end of this wonderful growth era of the last 20 years, we still have a concept of the soil and compost in which life is almost completely cloaked. Part of this has to do with the way we moderns increasingly use instruments and data as crutches to shape our ideas (Bortoft, 1996; Capra, 1996; Brinton, 1997).

Schad (1970) succinctly addresses the problem 30 years ago in his famous, now out-of-print work on *gestalt biology*:

> The science of facts today is really the science of instrumentation. Heisenberg's uncertainty principle governs the theories themselves since they are now secondary to, and completely dependent upon, the complicated machinery used to extract the facts we are trying to see...[1]

When our laboratory examines a compost or soil, we present a range of data pertaining to the physical, mineral and biology components, which in their threefold aspect make of the matrix of the *whole* substance, including its potential productivity. Yet, the data doesn't really pull the picture together. To many persons less familiar with methods and numbers, it may well look like unrelated information. In later papers the author will describe studies which reveal how soil fertility data may be viewed as a totality. The way in which the numbers from a soil test themselves are interpreted is *influenced by the nature of the whole farm itself*-- a circularity. The dynamics of *part* and *whole* means that they are inseparable. Compost carbon -soil carbon, really belong together as a synthesis. This paper looks at organic matter and carbon dioxide activity in soil and composts and contrasts analytical and holistic approaches to data interpretation.

In trying to answer to the charge of reductionism in soil management, it may be worthwhile to point to the value of sustainable agriculture concepts. Now, practitioners and scientists are using a new motif of longevity and responsibility for the future to redefine how the details of farming down to the soil level are seen. The author found out recently that a prominent sustainability scientist didn't support composting because he questioned its *sustainability*. Seen as an isolated extra activity on a farm, the objection is valid. But viewed in the context of the movement of organic matter on a farm and especially the movement within a bio-regional community, it is eminently sustainable, and contributes to whole quality. That we farm and how logistically we do it may not change with sustainability views, but a new, organizing concept is apparent through which we will come to see the soil and the farm and composts differently, and no longer just as valuable parts, but as components of a whole.

Testing Organic Matter in Composts and Soil

Organic matter is usually reported by laboratories in terms "total carbon" when dealing with compost or "digestible carbon" in a soil, with different testing techniques used in either case. The expression "organic matter" is a generalization and the expression "carbon" is an abstraction— both word usages should be an embarrassment to realistic scientists. To test compost the organic content is burned out of the sample in a furnace and the weight loss is recorded to derive this

1. free translation rendered by the author

value. Or, the sample is heated and all the CO_2 coming out of it is captured in a detector and weighed. The tests are a challenge to perform and are not meaningless if you are a lab technician.

Compost is rich in carbon and when we apply it to soil, the organic matter is diluted. Theoretically, if you tested the soil right after that, you should be able to find it all. In reality, this is practically not possible. Imagine that with a soil test the lower limit of detection in the lab is about 0.1-0.2% - sometimes worse- which turns out to be 2,000- 4,000 pounds of organic matter /acre! With all the instrumentation we have in a laboratory, one to two tons of organic matter get lost in the test very easily. Worse than this, even considering the way soil vs. compost is tested, there is a way that organic matter becomes occluded or hidden by mineral particles in the soil, making it impossible to “recover” it all when testing, so that soil labs use “correction” factors, also called fudge factors, to “quantitate” the organic matter content.

These points reveal a contrast as follows: with laboratory equipment we can measure organic matter in compost much more accurately than is meaningful, and in soils much less so than is really important. This limitation of lab testing is more striking when viewed against the reality of the soil or compost itself— in soil, a ton of organic matter per acre *is* meaningful: it represents the residues of an entire crop plowed under, which feeds macro and micro-organisms and provides important structural factors. As we shall see later, the measurement of soil life, as opposed to testing the gross amount of organic matter, gives a much more meaningful set of numbers.

There is another important contrast in looking at compost and soil organic matter numbers. With soils, we often think of certain absolute levels of organic matter which are ideal, but there are no such absolute levels that make any real sense in compost. In soil it is important and meaningful to know- do we have 2, 3 or 4% organic matter? In the compost lab, where we can routinely test organic content to the same level of precision, we can’t honestly t explain the meaning of the difference between 30, 40 or 50% organic matter content! Of course, some meaning is found when we view the tested organic content in relation to the age of a compost material, or to its intended use. It is can also be meaningful to look at the initial organic level and contrast it with the same determined at a later point, but people rarely do this. The point is*: context* of the data defines much of its meaning, and you have to be willing to go the distant route if you want it.

Carbon-Dioxide Rate - Benchmark of the Living?

As we have described, there are aspects of soil and compost organic matter content that are not easily grasped with quantitative lab tests. However, there is a test that is analytically accurate *and* meaningful for both soils and compost and this is carbon dioxide (CO_2) activity. CO_2 is respired by all living micro and macro-organisms, and the sensitive measure of this compound is indicative of important conditions prevailing in the sample. These factors point to the quality and quantity of soil life and the maturity of the compost product, but do not lend themselves easily to quick interpretation.

The chemist Julius has addressed carbon dioxide phenomenologically by speaking of the “aggressiveness” of CO_2. From this point of view, the “calming down” of its rate leads to an "openness to living influences" (Julius, 1998). While the raising of CO_2 levels in growing environments has been found to lead to increased growth rate, high levels are very inimical to growth (ASA, 1997). In compost and soil environments, overly high levels of CO_2 are associated with anaerobic conditions and high microbial fermentation rates. This translates into a lack of oxygen and sets the stage for poor plant root development, among other things. It has even been shown that CO_2 can pass right across cell membranes as a gas and dissolve in the internal cellular juices and disrupt the system. Yet without CO_2 there would be no plant growth at all.

This laboratory has examined thousands of composts and soils for CO_2-rate in relation to other attributes. In a previous article (Biodynamics #) we showed how CO2 rate decline rapidly in the making of horn-manure preparation 500. With soils and composts, carbon dioxide rate tests contribute to understanding total soil-life without resorting to precise determination of what organisms are involved. In compost we can surmise the stability and maturity with the test, where the total organic matter test tells us almost nothing.

The research of CO_2 conducted in our laboratory has culminated in development of an entirely new gel-chemistry that registers CO_2 levels colorimetrically and is the basis of the Solvita® soil and compost testing method. With this new method gardeners, growers and composters can conduct their own examination of carbon dioxide activity and gain a sense of the dynamics of soil life and compost activity. As a colorless, odorless gas, CO_2 is difficult to gain a sense of, and we need to be more aware of it!

One of the significant aspects of looking at CO_2 rates is that we get a big picture of what it means to break-down raw organic waste via composting. The graph (see figure 1) shows how CO_2 rate in compost declines at first rapidly then more slowly over time. In some examples seen, it takes more than a year for a compost's carbon dioxide rate to come close to a natural soil background and this clearly has implications for its use.

If we take the relative CO_2 rate and contrast it with the total amount coming out of a sample, we can produce a two-fold table as seen below. Here by contrasting the *Relative* amount of carbon respired (which indicates stability of organic matter) and the *Total* amount, which indicates the volume per compost, and thus shows the potential for self-heating and weight/volume reduction, a whole new picture emerges which is useful for interpretation. Both tests must be carefully interpreted in order to understand compost dynamics. Basically, the more advanced the humification and stability, the less relative carbon dioxide is respired, but the total amount is dependent on the total amount of organic matter in the compost. If organic matter in compost is high enough, even a low-relative rate can still translate into heating as well as oxygen deprivation. As a matter of fact, if the pile is large enough, the same effect results. Thus the numbers when placed into this relationship become more dynamic and tell us more about the substance in question. We have produced a similar chart for soil carbon dioxide activity (see Biodynamics, Fall 1997).

<table>
<tr><th colspan="7">Relative Compost Respiration Rate
% of Total-C per day
(mg CO2-C / g / C / day)</th></tr>
<tr><td rowspan="4">Total Respiration Rate
, % of Total Wgt Lost as CO2-C / day</td><td></td><td>V. LOW
< 0.2 %

(0 - 2 mg)</td><td>LOW
0.2 — 0.8

(2 - 8 mg)</td><td>MED
0.8 — 1.5

(8 - 15 mg)</td><td>MED-HIGH
1.5 — 2.5

(5 - 25 mg)</td><td>HIGH
> 2.5 %

(> 25 mg)</td></tr>
<tr><td>LOW
< 0.2%</td><td colspan="2">VERY STABILE AND HIGHLY HUMIFIED COM-POST</td><td colspan="3"></td></tr>
<tr><td>MED
0.2-1.0</td><td rowspan="2"></td><td colspan="2">MODERATEY ACTIVE COMPOST -
still composting</td><td colspan="2"></td></tr>
<tr><td>HIGH
> 1%</td><td colspan="2"></td><td colspan="2">HIGHLY UNSTABLE AND POORLY DECOM-POSED
probably phytotoxic</td></tr>
</table>

The Solvita™ compost test measures carbon dioxide respiration in a specific volume of compost and gives a semi-quantitative color response. As mentioned the test was developed as a field procedure to enable producers and users of compost to make on-the-spot stability and maturity determinations.

The Solvita scale shows carbon-dioxide rate colors from 0 ÞÞ— 8 and is associated with the following interpretations:

SOLVITA COLOR TEST RESULT	APPROXIMATE STAGE OF THE COMPOSTING PROCESS	MAJOR CLASS
8 (purple)	Low CO2-rate, highly matured compost, well aged, possibly over-aged, like soil; ready for most uses	“FINISHED” COMPOST
7	Well matured compost, cured, ready for most uses med-low CO2-rate	
6	Aeration needs are reduced; compost ready for curing; significantly reduced management requirement	“ACTIVE” COMPOST
5	Past active phase of decomposition; curing can be started; reduced need for intensive management	
4	Compost in medium or moderately active stage	
3	Active compost; young materials, still needs intensive oversight and management	
2	Very active CO2-rate, moderately fresh compost; needs supplemental aeration and/or turning	“RAW” COMPOST
1 (yellow)	Very high CO2-rate! Fresh, raw compost; typical of new mixes; extremely high rate of decomposition; probably plant-toxic and odorous!	

CONCLUSION

In all these laboratory methods and field activities, we come to recognize carbon as active carbon: signpost of the living. The lab tests however do not deny the reality, nor falsify it, provided the interpretive scientist is attentive to the context. Static lab tests do little justice to the phenomena by themselves. We are not dealing in reality with the carbon of chemists (C) but the carbon of associated life that is never alone but is constantly moving, seeking balance and transforming itself and the environment around it whether soil, plant or atmosphere. We can easily accept the fact that plants are the dynamic entities in the world that give carbon form. Yet it is just as plausible to consider that soil and compost, by nature of their life, are also giving carbon a form. It is a dynamic battle ground where formless, reactive CO_2 is held in meaningful humus and microbe form, for the benefit of plant productivity.

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