

# Creating World Class Soils

by John Todd, PhD, Ocean Ark Institute  
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Soil is formed by extraordinarily complex geo-chemical, biological, ecological, and diverse processes (*Brady, N.C. The Nature and Properties of Soils 10<sup>th</sup> edn Macmillan, 1990*). New discoveries in the last decade now make possible “creating” rich, fertile soils in very short time—in years, not decades, or centuries. Rapid soil formation requires several concurrent strategies, which together, produce excellent soils, that, in turn, support intensive agriculture, animal husbandry and agro-forestry. These strategies include remineralization, composting with newly discovered nutrient binding, compost teas, and “terra prêta,” or “dark earth.”

## Mineralization

Typical soils used in agriculture are leached of minerals, including trace minerals. Their absence limits soil productivity and fertility.

### Sea Minerals: stage 1

*The fastest and first step to put in soil a complete, balanced supply of elemental nutrients for soil microbes, plants and animals is an application of sea minerals. Spreading or spraying a light to moderate load of unrefined sea minerals delivers a fully digested, fully soluble, balanced blend of all 90 elements. The balance in seawater is very nearly like blood plasma and amniotic fluid. Like IV-solution in surgery and intensive care, a dose of sea minerals jumpstarts biological life cycles and food webs in soil.*

### Rock Powders: stage 2

Soils can be remineralized with volcanic and/or glacial rock powders ground to a small size to pass through 200 mesh screen. Benefits of remineralization are widespread, potent and highly suited to temperate and tropical environments. To review worldwide research and practices, see:

[www.remineralize.org](http://www.remineralize.org)

Here are some of the benefits:

- Provides slow release of nutrients and trace minerals.
- Increases the nutrient uptake by plants.
- Increases yields, in many cases, dramatically.
- Rebalances soil pH.
- Increases the growth of microorganisms and earthworms.
- Helps build humus.
- Prevents soil erosion.
- Increases the storage capacity of the soil.
- Increases resistance to insects, disease and drought.
- Produces more nutritious crops
- Decreases the need for fertilizers, pesticides and herbicides.
- Effective in tropical regions with heavy rainfalls.
- Increases timber volume
- Sequester more carbon to contribute to climate stabilization

Remineralization dramatically reduces input costs and increases yield for many crops, including bananas in Australia and rice in Malaysia. Remineralization is proven effective to control citrus blight in Florida. Currently, the world's largest carrot farmer, Grimmway Farms in northern California, is gradually remineralizing its total acreage of Cal-organic produce, applying 1000 tons/year at a rate of 250 lbs/acre.

[www.calorganicfarms.com](http://www.calorganicfarms.com)

Prof. Peter van Straaten of University of Guelph in Ontario has described remarkable effects of combining rock minerals with green manures from fertilizer plant *Tithonia diversifolia* to restore productivity to exhausted land in Zimbabwe and Kenya. He reported 900,000 people were brought out of poverty in Western Kenya alone using such methods. (First International Conference on Rocks for Crops, Brasilia & Patos de Minas, Nov. 7-14, 2004.)

Forest studies using remineralization show growth of four

times the timber volume in 24 years, and one application lasts 60 years. This is very promising for carbon sequestration to stabilize climate. (Von u. Sauter and K. Foerst:)

[www.remineralize.org/bavarian.php](http://www.remineralize.org/bavarian.php)

In western Australia, Men of the Trees plants millions of trees in arid landscapes, and gets up to five times more seedling growth and shortened potting time (from five months to six weeks) with soil remineralization and microbial inoculant:

[www.remineralize.org/trees.php](http://www.remineralize.org/trees.php)

Application rates vary greatly, depending on rock type, fineness, and situation—garden, commercial farm, or forest. Particularly for forests, rock powders are applied on their own, at 3-10 tons/acre. In badly degraded soils, up to 20 tons/acre may be recommended for long-term application with coarser material to gradually break down in soil.

Remineralization is part of integrated soil development strategy. In this case, low application rates are the norm. Some practitioners apply much lower rates, but more frequently for farmers accustomed to applying yearly fertilizers. We recommend applying rock minerals in agriculture from 250 lbs.-3 tons/acre. We also recommend rock minerals blended into compost as it's made; it then can be applied at lower rates.

The best source for rock minerals is local quarries. A diversity of hard silicate rocks, including volcanic origin, is better to build soils. Rock powder is a normal byproduct of aggregate quarries and rock crushing. We also recommend rock phosphates, as their ocean origins indicate trace mineral diversity and balance.

## Compost

Composting is the heart of good agriculture—recycling organic materials and wastes through the genius of microbial design, organization and synthesis to produce rich materials that create humus, a complex mix that is integral to good soils.

Compost is made in static piles, in special design structures, and most commonly, in windrows. Static piles take a long time to compost—up to three years—and oxygen-rich internal conditions are hard to maintain. In-vessel technology is complex and failure prone, and not recommended except in special circumstances.

Windrows are turned to aerate the piles. To avoid suffocation, compaction and scouring, windrows are kept to about 12 feet wide and no higher than 6 feet. With modern windrow equipment, rows are turned up 10 to 15 times in a six-to-eight week period. Temperature and moisture control are critical.

Temperatures in a pile should climb to a 150 degree F peak to eliminate weeds, and destroy phytotoxins and pathogens. Some composters use water repellent covers over windrows to regulate moisture, which should hover around 50-60%. Windrow turners use water injection systems should moisture levels fall too low.

Carbon-Nitrogen ratio in compost must be correct for optimal temperatures develop. Too much green matter and nitrogen can overheat, and too much carbon can create too-cool temperatures.

Experienced compost makers with an eye to rapid soil building build windrows from a mix of materials. They use materials like woodchips as base, on this is piled manure and bedding, above that green matter, then clay, gypsum, rock powders, including rock phosphates, for broad spectrum minerals. Natural clays added to compost were very important to some early compost pioneers, including Ehrenfried Pfeiffer, microbiologist and biodynamic agriculturalist in the 40's and 50's. Recent research at Rodale Institute in Emmaus, PA confirms this:

[www.rodaleinstitute.org](http://www.rodaleinstitute.org)

It is important the right microbial communities exist in the pile at the outset. To accomplish this, material from an existing healthy compost pile is added to the windrow. It's also possible to jump-start the process with compost tea “brewed” to activate the microorganisms. More on compost tea below.

Compost is applied at varying rates, but if ingredients are high

quality, low levels of 1-3 tons per acre per year will suffice. Most experts we know have soils, compost and compost tea tested for microorganisms by Dr. Elaine Ingram & assoc. at Soil-Food Web. [www.soilfoodweb.com](http://www.soilfoodweb.com)

Composting is both art and science. It has the advantage of being practiced on a wide range of scales, from backyard to acres of windrows. To learn about compost, vermicompost (using earthworms in composting) and compost tea, we recommend **Compost, Vermicompost and Compost Tea** by Grace Gershuny, a new NOFA (Northeast Organic Farmers Assoc.) booklet for \$7.95. They have other relevant booklets:

[www.nofa.org](http://www.nofa.org) [www.globalrepair.ca](http://www.globalrepair.ca)  
[www.midwestbiosystems.com](http://www.midwestbiosystems.com)

## Compost Teas

Compost teas and vermicompost teas as an agricultural practice is a new phenomenon, and large-scale application of these substances was only possible in the last few years. New technologies enable application of high quality and low cost teas on lands and crops. Making compost teas is quite simple. Compost, often in cheesecloth bags, is suspended in water that is aerated with an air stone. Ratios vary, but a rule of thumb is one pound of compost per gallon of water.

There are two processes, extraction and brewing.

Extraction quickly and efficiently raises the number of beneficial fungi and bacteria in the liquid. The organisms tend to be in an inactive state. Timing of this process varies from six to twelve hours depending on equipment and temperature. Extraction is generally used in soil applications where microbial populations are activated when they come in contact with carbon-containing materials in the soil.

Brewing is an additional process. Molasses, fish emulsion, seaweed extract, [sea minerals](#), and sometimes, rock powders are added to the liquid. This causes micro-organism populations to take off and become active feeders almost immediately. This makes brewed compost tea a potent foliar feed, also effective in disease and pest control. The activated micro-organisms feed on pests and pathogens on plant leaves and stems.

In recent years, technologies emerged to produce large volumes of compost tea—up to 10,000 gallons in six hours. One best known is Hydrocylone, developed by Sabino Cortez for large scale applications. This technology produces compost tea for 10–15 cents per gallon. Compost tea units cost \$10,000 each, and their potential to assist soils development and crop management is proven. They have the advantage of producing as little as 100 gallons, or up to 10,000 gallons at a time, depending on compost volume needs at the time. Recently, a smaller system for small farms and gardeners came on the market.

[www.erathearth.com](http://www.erathearth.com)

Applications of compost tea and vermicompost tea on land are almost endless. It gives land stewards a powerful new tool to accompany compost and re-mineralization strategies. For new developments in compost tea technologies:

**Acres USA: The Voice of Eco-Agriculture**  
[www.acresusa.com](http://www.acresusa.com)

## “Terra Preta” or Amazonian Dark Earths

In recent years, fascinating scientific studies in the Amazon discovered ancient soils that are extremely fertile and stable—in part of the world where soils are notoriously prone to leach and degrade in high temperatures and rainfall. These “terra preta” (or “black earth”) soils were created by the native peoples well before European arrival. “Terra preta” soils in some parts of the Amazon pre-date Christ. They are described as islands of fertility in a sea of nutrient-poor soils. These soils supported a large population in the Amazon—they cover an area larger than France. They are of human origin; the people who knew how to make them died out after contact with whites.

Discovery of these soils and their significance is chronicled in *Amazonian Dark Earths: Origins, Properties, Management*—a recent technical book edited by Johannes Lehman & colleagues (Kluwer Academic Publishers 2003), and in the excellent, popular *Terra Preta* by Charles C. Mann (Knopf 2005).

International teams of scientists are decoding what these soils were made of, their microbial ecology and ability to survive and—in some places, grow—in the last 500 years since the people who tended the land succumbed to disease, or were sold into slavery in the early years of European contact.

These dark soils have exceptionally high levels of organic matter and nutrients, and a humic structure that persists through time. The high organic matter and nutrients supports a unique microbial biota with an amazing ability to persist over time. We know high fertility levels were created by significant additions of wood ash, charcoal, and domestic residues from intensive human occupation. We know charcoal retains carbon in soil for thousands of years. It is still a mystery how the combination of factors produced these soils that continue to persist in places, and grow, up to the present.

Also, a lot of clay potsherds are found in these soils. Clay may play an important, as yet unappreciated, role in “terra preta” formation. To complicate the tale, crumbled ant and termite nests are a significant component in some “terra preta” soils.

It's clear on reviewing the literature, knowledge of “terra preta” formation is partly understood by some Amazonia inhabitants, and contemporary scientists are closing in on many aspects of its formation. The Kayapo people in Central Amazonia use fires very creatively, and continue to make dark soils with techniques that may have wider global applications. Scientists in Brazil are experimenting with methods to create modern dark earths. Early trials with rice and sorghum with charcoal combined with fertilizer had yields up to 880% above crops with fertilizers alone, although they didn't try to establish the ancient microbial balance.

We are proposing this research is news for the rest of the world. We can recognize some, but not all the inputs that went into terra preta formation, and duplicate them in other tropical regions with sufficient biomass, moisture and rain. We may be able to make them in temperate regions as well.

Last year, we taught watershed management in Costa Rica, and needed ponds to grow fish, but local soils didn't hold water. Based on our terra preta reading, we developed a soil recipe with clay, charcoal, woodash, horse manure, organic matter (banana leaves), and carbon sources like coconut coir and molasses. This mix was extremely biology active, and after inoculation, seemed to roil with microbial activity. The mix worked as pond liner, and held water as we hoped, but also was a potent source of ecological activity. We made a few small ponds; what most struck us was the mix turned dark, and seemed fertile to plant life.

Winter 2007 in Costa Rica, in dry, windy weather, our El Centro Verde associates began a commercial farm on fairly worn-out land. Their experiment combined terra preta formation with compost. Trenches were dug a meter and a half deep. Tree limbs and branches put in trenches were set on fire. Once combustion is initiated, green organic matter and soil is added on top of burning limbs to slow combustion and lower oxygen levels. This creates charcoal. As the pile cools, green matter, particularly banana stocks, and clay soil, is added to inoculate the compost.

In the future, trenches will be dug on contour slopes of hills, planted on the downside with vetiver grass to control runoff, capture moisture, and be powerful “sinks” for nutrients. Nutrients leaching down the hill and off the farm will be prevented.

It's possible these four approaches to soil building—re-mineralization, compost, compost tea, and a modern version of dark earth—when combined, can transform the soils of Appalachia, all of the Americas, and the rest of the world.

