Soil Organic Matter

Fact Sheet FS1135

Cooperative Extension

Stephanie Murphy, Director, Soil Testing Laboratory
Daniel Giménez, Associate Professor, Environmental Sciences
Loren Muldowney, currently Nutrient Management Specialist, USDA-NRCS
Joseph R. Heckman, Specialist in Soil Fertility, Plant Biology and Pathology

Soil is the site of a huge recycling operation, whereby dead organisms and organic waste products are broken down to component parts – molecules, ions, or elements subsequently available as sources of nutrients and energy to the living soil organisms. The laborers in this operation are primarily mesofauna (insects, earthworms, and other visible soil-dwelling creatures) and microorganisms including fungi and bacteria that use the organic material as their food source - and that eventually become fodder for the next generation of recyclers. As decomposition proceeds, nutrients and other components are released to the soil, becoming available for uptake by plants. Despite being a fairly efficient process in "healthy" soil, complete decomposition of organic residue does not occur; instead, waste products of the decomposition process can recombine in infinite combinations to form new, more stable molecules. As the original organic matter is broken down, it is reduced in bulk (volume) and obtains a very dark or black color. Eventually, the material that remains is composed of relatively large, complex molecules that are resistant to further breakdown. This product of the soil's recycling operation is soil *humus.* [Commercial organic matter products advertised as "humus" are actually relatively fresh composted residues and should be expected to continue to break down (and release nutrients) through several growing seasons. Be aware that the continuing breakdown (decomposition) decreases the volume of the material.]

What is Organic Matter?

Organic matter refers to all compounds and structures that are derived from living organisms. It includes living organisms, although in soil the term is generally used to mean the breakdown products of organisms and their wastes. The non-living organic matter may be in various stages of decomposition, on a continuum from fresh residue to humus.

Is Soil Organic Matter Important?

Organic matter is essential to soil quality for chemical, physical, and biological reasons. Soil quality refers to the ability of the soil to "[do] what we want it to do"; that is, "the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation" (USDA-Natural Resources Conservation Service).

Organic matter in soil has many functions which interact in many ways to improve soil quality for production and environmental enhancement.

Biological benefits. Fresh organic matter/residue supplies food for such soil life as earthworms, ants, and rodents. These soil animals start the process of recycling of energy and nutrients. Further breakdown of organic matter benefits the soil ecosystem by providing energy and nutrients for microbial metabolism and releasing additional mineral elements for the nutrition of plants. That is, as organic matter decomposes, nutrients are released to become available for the growth of plants. The release of nutrients from decomposition of organic matter is relatively synchronized with the needs of the plants, since both are related to environmental conditions; temperature and moisture conditions that are favorable for rapid plant growth are often the same conditions that favor decomposition of organic matter.

RUTGERS
New Jersey Agricultural Experiment Station

Rutgers, The State University of New Jersey
57 US Highway 1, New Brunswick, NJ 08901-8525
Phone: 848.932.9295

Chemical benefits. Besides the direct effect of organic matter on soil fertility, there is an indirect effect. As organic matter decomposes, acids are released. This promotes chemical weathering of soil minerals, releasing various nutrients and making them available to plants. Some breakdown products of organic matter are particularly important in protecting the mineral phosphorus (P) for availability to plants in acid soil.

Even humus (organic matter in advanced stages of decomposition) still contributes to soil fertility by adsorbing nutrient ions, holding them in an available form to plants and microbes; this contributes greatly to the availability of potassium (K), calcium (Ca) and magnesium (Mg). Organic matter helps to buffer soils against rapid chemical changes due to the addition of lime and fertilizers.

Physical benefits. Physical properties of soils are also improved by organic matter because. Because it has a high affinity for water, organic matter increases a soil's available water-holding capacity. Thus sandy, droughty soils particularly benefit from additions of organic matter.

Humified organic matter promotes formation and stabilization of soil "structure", that is, aggregates of soil particles and the spaces between the aggregates, known as pores. Soil in good physical condition should be about half pore space. Stable organic matter physically enhances the soil by keeping it open and porous. This greatly improves infiltration, the term used to describe the entry of water into the soil surface. More infiltration means less runoff, less downstream flooding, and less soil erosion and water pollution.

Once rainwater infiltrates, several other benefits are also realized. If the water drains into the subsoil, it may remain stored there for weeks or months and be recoverable by plant roots during periods of no rainfall. Infiltrated water in excess of what is stored in the deeper soil slowly makes its way underground to groundwater, providing a long-term source of water (called "base flow") to stream and river ecosystems. Stream-dwelling life needs water all year round, not just following a rain event.

The kind of porous structure best for air and water relationships allows excess water to drain from the surface layers into the subsoil and air to enter the pores. Well-drained and well-aerated surface soils are optimal for both agricultural production and landscape management of all kinds. This is especially important for medium- to fine-textured or "heavy" soils (loam, silt loam, clay loams).

The life in the soil, promoted by the presence of organic matter, provides a positive feedback to further improve the soil. Plant roots grow and animals of various sizes burrow to create channels, thus contributing to the structure of soils. These channels are effective in transmitting excess water to subsoil and allowing air exchange (oxygen entry and carbon dioxide release, essential for most organisms).

Coarse organic matter on the soil surface, a mulch, reduces the impact of falling raindrops and permits clear water to seep gently into the soil. Surface runoff and erosion are thus reduced, and as a result there is more water available for plant growth. Mulch will also protect the soil from losses by wind erosion. During the summer, surface mulches maintain cooler soil temperatures by shading (blocking radiant solar energy), and they reduce air movement at the soil surface, resulting in less water evaporation from soil. Mulches also insulate soils in winter, minimizing the depth of freezing.

Planetary Health: Physical, Chemical, and Biological

Finally, there is the issue of carbon sequestration. Consider the present context where a high (and increasing) level of carbon dioxide is present in the atmosphere. This has occurred because reduced carbon formerly buried (sequestered away from further reaction) and stored in the earth's crust over millions of years (fossil fuels such as coal and petroleum) was brought to the surface and oxidized (burned) over a relatively short period of time. The result is a buildup of oxidized carbon in the atmosphere. Organic matter is largely composed of "reduced" carbon, the opposite of "oxidized" carbon.

Carbon becomes reduced by photosynthesis. Ancient photosynthesis was the source of the formerly sequestered carbon, and current photosynthesis could be managed to reduce the carbon dioxide in the atmosphere and store it in the soil as organic matter. This is possible because many soils all over the world have been depleted of their organic matter and so have the capacity to accept and retain more organic matter if managed accordingly. Soils of different textures and in different climatic zones have variable capacity to store organic matter. If each soil were managed such that its organic matter was maintained as "high" relative to its capacity, an enormous proportion of the excess carbon in the atmosphere could be stored in the soil, with great agronomic and environmental benefits in addition to carbon sequestration.

References

USDA-NRCS Soil Quality website, http://soils.usda.gov/sqi/concepts/concepts.html.

Acknowledgement

Modified & updated from an unofficial fact sheet (#4S) by Dr. Roy Flannery, former extension specialist/professor, Rutgers University.

Additional Resources

Rutgers Cooperative Extension Fact Sheet FS1136 Soil Organic Matter Level and Interpretation.

Rutgers Cooperative Extension Fact Sheet FS1137 Improving Soil Quality by Increasing Organic Matter Content.

For a comprehensive list of our publications visit www.njaes.rutgers.edu *March 2012*

Cooperating Agencies: Rutgers, The State University of New Jersey, U.S. Department of Agriculture, and County Boards of Chosen Freeholders. Rutgers Cooperative Extension, a unit of the Rutgers New Jersey Agricultural Experiment Station, is an equal opportunity program provider and employer.

RUTGERS
New Jersey Agricultural Experiment Station

Rutgers, The State University of New Jersey
57 US Highway 1, NJ 08901-8525
Phone: 848-932-9295