Active Carbon

Introduction

Soil organic matter (SOM) offers many benefits to the biological, chemical, and physical aspects of soil including, but not limited to improved soil structure, water holding capacity, and nutrient availability. Soil organic carbon (SOC) is a component of SOM. SOM is a non-mineral soil fraction that contains SOC as well as other organic biochemicals like proteins, fiber, nitrogen, sulfur and many other biochemicals found in many organic biological materials. SOM does not include inorganic carbon such as carbonates. This fact sheet explains active carbon as a component of SOC and its importance for maintaining soil health.

Components of Soil Organic Carbon

Soil organic carbon can be split into two main categories: active and passive organic carbon. Active carbon (Figure 1) refers to the relatively young (0 to 5 years) and readily decomposable component of SOC. Typically this fraction consists of a mixture of plant roots, actively decaying animal and plant material, and recently deceased soil organisms. Active carbon makes up a small percentage of SOC, typically between 10 and 20%.

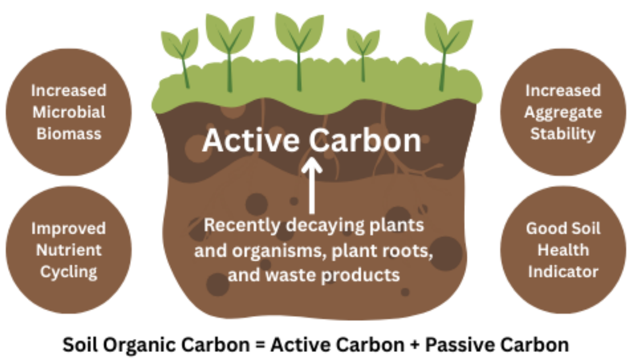

Figure 1: Active carbon formation in soil and its benefits.

A typical C:N ratio of active SOC is between 20:1 and 30:1. Passive carbon is the relatively older carbon component, having undergone significant modification from weathering and microorganisms. Passive organic matter provides soil with its brown color and typically makes up between 80 and 90% of SOC. A typical carbon to nitrogen (C:N) ratio of passive SOM is between 10:1 and 12:1.

Why is Active Carbon Important?

Despite making up a small percentage of SOC, having adequate active carbon levels is necessary for maintaining healthy soil. Active carbon is important for heterotrophic microorganisms, providing them with the nutrients and energy needed to grow and support a large and active microbial biomass. High soil microbial biomass supports aggregate stability, good cation exchange capacity, and helps to regulate water holding capacity. Adequate active carbon levels further support nutrient cycling, as microorganisms release nutrients in their plant usable forms through the mineralization (breakdown) of SOM. If the soil is lacking in active carbon, nutrient cycling will decrease and as a result, soil fertility and crop productivity can decrease.

Active carbon also supports soil structure and creates more resilient crop fields that support production also in years of weather extremes. Carbon in the soil helps bind soil particles together, forming stable soil aggregates that allow for good aeration and help resist erosion. A strong soil structure promotes root growth and will contribute to increases in crop productivity over time.

In addition, active carbon serves as a meaningful and sensitive soil health indicator because it adjusts quickly to shifts in soil management practices. In some cases, active carbon levels showed differences after just one year of changes in soil management while other measurements like SOM will take years to reflect changes in soil management. To record changes due to management, it is important to check active carbon levels both before and after implementing a new management strategy.

Testing for Active Carbon

The potassium permanganate oxidative method is commonly used to determine active carbon levels in soil which is why active carbon is also referred to as permanganate oxidizable carbon or 'POxC'. In the presence of organic matter, potassium permanganate oxidizes carbon which reduces the manganese found within the permanganate ion, causing a color change (Figure 2).

Testing a soil for active carbon involves combining soil with a potassium permanganate ($KMnO_4$) and calcium chloride ($CaCl_2$) solution and shaking the mixture for 10 minutes. When the solution reacts with the soil, a purple color is produced. A change from darker purple to lighter purple is proportional to active carbon levels in the soil. A lighter purple color indicates greater active carbon levels as more carbon is oxidized by the potassium permanganate (Figure 2). Active carbon can be reported in mg active carbon per kg or in ppm of whole soil (numerically the same). Common active carbon levels for agricultural soil range from 300 to 1,000 ppm.

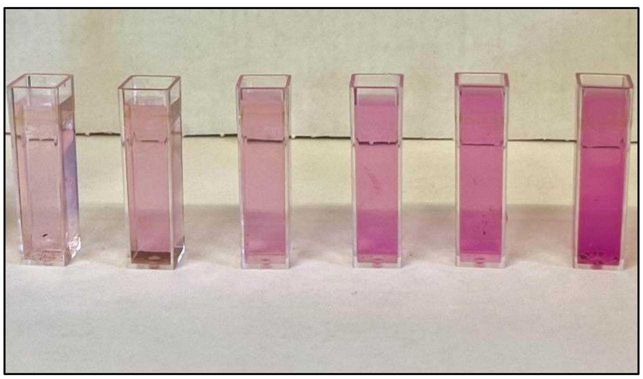

Figure 2: Results from the potassium permanganate oxidative method. From left to right, the samples decrease in active carbon levels.

How to Maintain Good Active Carbon Levels

Planting cover crops, crop residues, reducing or eliminating tillage, and adding organic amendments such as manure, help build active carbon levels.

Cover crops use carbon from the atmosphere and convert that carbon into SOM, directly increasing the carbon content of the soil. They also provide continuous soil coverage, reducing risk of erosion and SOC loss.

Crop residue can contribute to greater active carbon levels over time when incorporated into the soil using reduced tillage practices rather than more aggressive tillage practices. Using reduced tillage will conserve more carbon.

Manure and compost are largely composed of organic matter, so their addition to soils can contribute to an increase in active carbon levels through decomposition. In addition, manure and compost provide habitat for beneficial soil microorganisms which will further increase active carbon levels.

In Summary

The active carbon fraction of SOC is important for maintaining healthy soil. Active carbon supports a high and active microbial biomass contributing to increased water holding capacity, aggregate stability, and cation exchange capacity. Active carbon is an important indicator of soil health as it can respond to changes in soil management as fast as within one year of implementation of a new management practice. The potassium permanganate oxidative method can be used to measure active carbon levels in the soil and determine the impact of management change on soil carbon.

Additional Resources

- Grubinger, V. (n.d.). Soil organic matter: The living, the dead, and the very dead. University of Vermont Extension https://www.uvm.edu/vtvegandberry/factsheets/soilorganicmatter.html.
- Magdoff, F, and H. van Es (2021). Building soils for better crops. Ecological management for health soils (4th edition). Sustainable Agriculture Research and Education (SARE). Handbook Series Book 10. https://www.sare.org/wp-content/uploads/Building-Soils-for-Better-Crops.pdf.
- Weil, R. R., and Brady, N. C. (2017). The nature and properties of soils (15th edition). Pearson.

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Sarah Jane Flanagan, Gurpreet Kaur, Kitty O'Neil, and Quirine M. Ketterings

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