Focus on Soil Carbon Sequestration

DEPARTMENT OF ECOLOGY
State of Washington

Waste 2 Resources **June 2013**

Carbon dioxide (CO_2) in the atmosphere has increased about 40%, from about 280 parts per million (ppm) by volume prior to 1850, to 396.8 ppm in 2013 [1]. This is mainly a result of burning fossil fuels, changes in land use, and cultivation of the land for food production. Most scientists believe the increased atmospheric CO_2 levels are causing global climate change, with rising global atmospheric and ocean temperatures, and increased frequency of extreme weather events.

Climate change poses a significant threat to Washington State's environment and economy. If we do not prepare for it, it could cost the state $10 billion a year by 2020 from increased health care costs, storm damage, coastal destruction, rising energy costs, increased wildfires, drought, and other impacts [2].

Atmospheric CO_2 levels are projected to continue increasing if we do not take actions. One strategy to mitigate the risks of climate change is to remove some of the CO_2 from the atmosphere by storing it in the soil. This is called sequestering.

Atmospheric CO_2 emissions (%) from human activities since 1850 [4]

Primary Causes:

- Burning fossil fuels - 65.5%
- Land clearing for agriculture - 19.3%
- Land conversion to cropland - 9.7%
- Deforestation - 5.5%

Total - 100%

This focus sheet addresses the questions:

(1) What is soil carbon sequestration?
(2) How is carbon sequestered in soils?
(3) What are the benefits of soil carbon sequestration?
(4) How can soil carbon sequestration be increased?

What is soil carbon sequestration?

Soil is a large reservoir of carbon, with about 60% organic carbon in the form of soil organic matter (SOM), and the remaining inorganic carbon in the form of inorganic compounds (e.g., limestone, or CaCO3).

It is estimated that SOM stores about twice as much carbon as the atmosphere, and about three times more than forests and other vegetation [3]. ***Soil carbon sequestration*** is the removal of CO_2 from the atmosphere through plant photosynthesis, and storage as long-lived, stable forms of soil organic matter that is not rapidly decomposed.

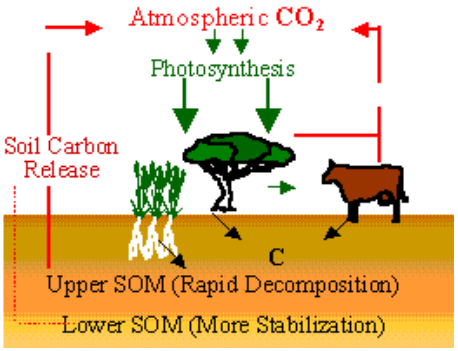
Changes in soil organic carbon levels can have significant affects on atmospheric CO_2 levels. Each 1% increase in average soil organic carbon content could reduce atmospheric CO_2 by up to 2% [4].

---

[1] Trends in atmosphere carbon dioxide: http://www.esrl.noaa.gov/gmd/ccgg/trends/
[2] Washington state's strategies for responding and adapting to changing climate conditions: http://www.ecy.wa.gov/news/2012/102.html.
[3] Soil carbon sequestration impacts on global climate change and food security. *Science*, Lal, R. Vol. 340, 2004, page, 1623-1627.
[4] Soil carbon and organic farming. November, 2009. Soil Association (England).

How is carbon sequestered into soils?

SOM originally comes from atmospheric CO_2 that is captured by plants through the process of photosynthesis (see figure from Tschakert 2000, http://ag.arizona.edu/oals/ALN/aln49/tschakert1.html). When plants die and decompose, some CO_2 is sequestered in the soil, while some is released back to the atmosphere. The primary way to store (sequester) carbon in the soil is to add organic soil amendments such as compost or animal manures.



SOM is a complex of carbon (C) compounds, and includes everything in or on the soil that is of biological origin. It includes plant and animal remains in various states of decomposition, cells and tissues of soil organisms, and substances from plant roots and soil microbes.

Organic carbon in the form of humus, the dark, spongy organic matter in soils, is highly resistant to soil microbial decomposition. It can be stored in the soil for hundreds to thousands of years, while other SOM (e.g., partially decomposed plant residues) can be quickly released as CO_2 back into the atmosphere.

What benefits will soil carbon sequestration have?

In addition to reducing current atmospheric CO_2 levels, increasing soil carbon sequestration can provide other benefits for soil quality, the environment, and agricultural production:

- Increased agricultural productivity.
- Improved soil structure.
- Increased soil fertility.
- Increased water holding capacity.
- Increased infiltration capacity.
- Increased water use efficiency, due to reduced moisture loss from runoff, evaporation, deep drainage below the root zone.
- Improved soil health resulting in higher nutrient cycling and availability.
- Reduced fertilizer (N, P) needs over the longer term.

How can soil carbon sequestration be increased?

The following management practices can increase soil carbon sequestration and help mitigate climate change:

- Add organic soil amendments such as compost, animal manure, biosolids, and organic mulch.

- Add biochar to the soil. Biochar is a microbially resistant carbon substance which is produced by heating organic wastes such as crop residues or wood chips in the absence of oxygen by a process called pyrolysis.
- Leave crop residues on the soil without open burning.
- Apply agronomic rates of nitrogen fertilizers to increase soil fertility and crop production.
- Adopt no-till or minimum till to avoid mechanical disturbance of the soil.
- Adopt crop rotations with cover crops in the rotation cycle.
- Switch from single crop farming to more diverse practices such as pasture, crop and pasture rotation, inter-cropping (growing two or more crops close to each other), pasture cropping (sowing crops such as cereals into pastures), and agroforestry (combining trees or shrubs with crops or pasture).
- Shorten or eliminate summer fallow periods.
- Practice organic, biological, or biodynamic farming or gardening methods (management practices that restore, maintain, and enhance ecological balance).
- Enhance biological nitrogen fixation through the use of legume crops such as alfalfa.
- Grow bioenergy crops which are grown specifically for their fuel value to make biofuel (e.g., switchgrass) on marginal lands.

Learn more about climate change and soil carbon sequestration:

- Washington State Department of Ecology: http://www.ecy.wa.gov/climatechange/.
- EPA Resources on Climate Change: http://www.epa.gov/climatechange/basics/.
- WSU Resources on Climate change: http://www.puyallup.wsu.edu/soilmgmt/ClimateChange.htm.
- Soil Carbon Sequestration in Agriculture (Montana State University Extension Services): MT200404AG.pdf.

More information:

Organic Materials Management program:
http://www.ecy.wa.gov/programs/swfa/nav/organic.html

Contact:

Canming Xiao 509-575-2842 or canming.xiao@ecy.wa.gov

Special accommodations:

If you need this document in a format for the visually impaired, call the Waste 2 Resources Program at (360) 407-6900. Persons with hearing loss, call 711 for Washington Relay Service. Persons with a speech disability, call 877-833-6341.