Soil Organic Matter

Very briefly, what is meant by the carbon cycle (or any other nutrient cycle) is simply the cycling between organic and inorganic forms.

Soils and the Greenhouse Effect

Increasing concentration of certain gases in the atmosphere may cause a net gain in solar radiation, leading to increased average temperatures, alteration in weather patterns and rise in sea level. Although the burning of fossil fuels is the leading contribution in increasing concentration of CO_2 in the atmosphere, deforestation, drainage and tillage has caused and still is causing an increase the rate of soil organic matter decomposition and resultant atmospheric input of CO_2. In addition to CO_2, other greenhouse gases are released from soil. These include CO_2, CH_4 and N_2O produced by soil microorganisms.

The origin of soil organic matter is plant material. The rate of decomposition of plant residues depends on their composition and soil environmental conditions.

Composition of Plant Residues and Effect on Decomposition Rate

Dry Matter Composition

Carbohydrates

Cellulose	45 %
Hemicelluloses	20 %
Sugars and starches	5 %
Lignins	20 %
Proteins	8 %
Fats and waxes	2 %

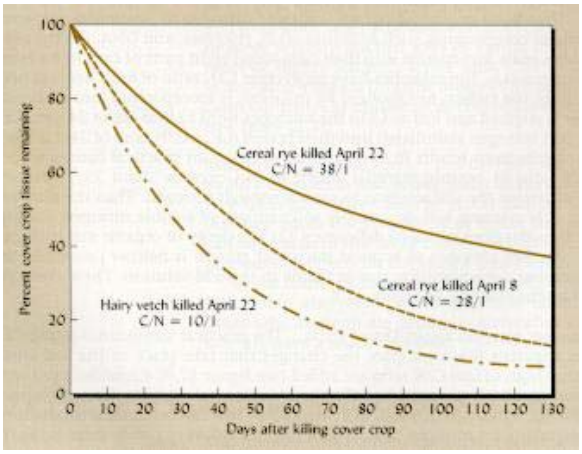
Decomposition of Residues

Rate of decomposition

sugars, starches, proteins >
hemicelluloses >
cellulose >
fats, waxes >
lignins

Decomposition proceeds with the liberation of CO_2 + H_2O; release of N, P and S in inorganic forms (*mineralization*) or synthesis into organic combinations (*immobilization*); and the formation of new compounds that are resistant to decomposition.

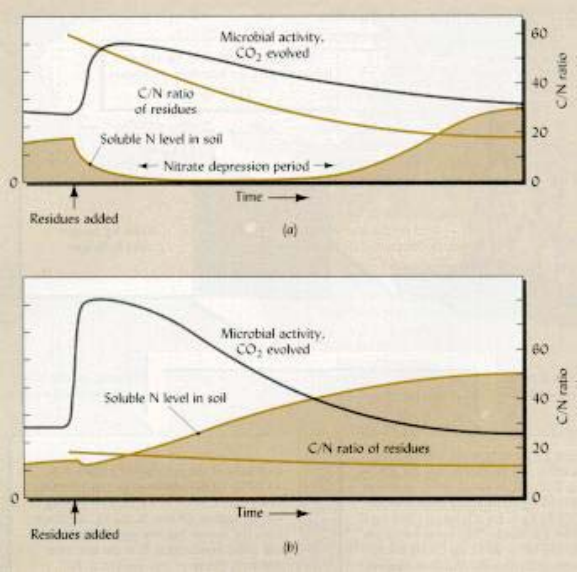
Another aspect of residue composition that affects the rate of decomposition is the C / N ratio. Since the organisms that decompose residues need N (and other essential elements) as well as C, if there is little N in the residue, decomposition is slow.



Effect of C / N ratio on rate of decomposition of residues.

Also, if there is little N in the residue, microorganisms will utilized inorganic N in the soil to satisfy their N requirement, thereby competing with plants for N and reducing the amount of soil N available for plant growth.

The C / N ratio in soil is relatively constant and = 12. In plant residues, it is highly variable and increases with maturity. The C / N is lower in microorganisms and = 8. Since microbes incorporate only about 1/3 of the C metabolized into biomass, the substrate material must have C / N = 24 to satisfy the N requirement of microbes. If the C / N ration of residue > 24, available soil N is consumed by microbes and plant-available N decreases.



Effect of the C / N of incorporated residue on available N in the soil.

Soil Environmental Conditions Affecting Residue Decomposition

Aeration

Decomposition under aerobic conditions is faster than under anaerobic conditions. The end products of anaerobic decomposition are incompletely oxidized.

Temperature

Activity is greatest at intermediate temperatures.

Humus

Soil organic matter is a broad term that includes biomass, partially decomposed residue and highly decomposed and transformed colloidal residue. The latter is called humus. It develops due to (microbial) synthesis as well as decomposition reactions. Humus includes:

Humic substances
Complex polymers that are resistant to decomposition (60 - 80 %)

Identifiable biomolecules
Less resistant to decomposition (20 - 30 %)

Humus substances include fulvic acids, humic acids and humin. These can be extracted from soil and differentiated based on their solubilities in acid or base.

Substance	*MW*	*Decomposition*
Fulvic acid	lowest	labile
Humic acid	higher	more resistant
Humin	highest	most resistant

One reason humic substances are only slowly decomposed is that these are adsorbed by soil mineral colloids.

Colloidal properties of humus include:

Surface area / unit mass > silicate clays
High CEC (pH-dependent)
High water holding capacity

Influences of Organic Matter on Plant Growth

Many beneficial influences on plant growth are indirect. These include:

Greater water holding capacity
Supply of nutrients
Better soil aeration
Stimulation of beneficial microbial activities
Reduced metal toxicities

Direct influences include:

Uptake of growth-promoting compounds such as vitamins and auxins
Allelopathic effects

Influences of Organic Matter on Soil Chemical and Physical Properties

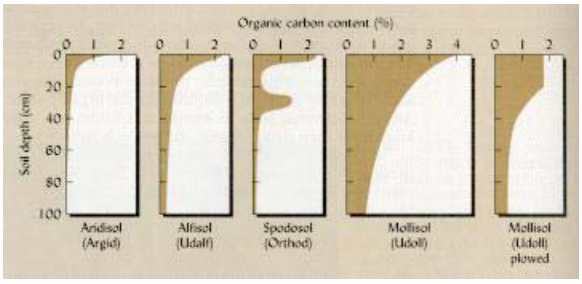
CEC is increased
Dark color
Increased aggregate formation and stability
Water content at any matric potential is increased

Influences of Soil Organic Matter on Water Quality

Greater infiltration results in reduced storm flow, soil erosion and surface transport of contaminants.
Greater sorption reduces contaminant mobility in soil.
Higher soil fertility reduces fertilizer inputs.

Amount of Organic Matter is Soils

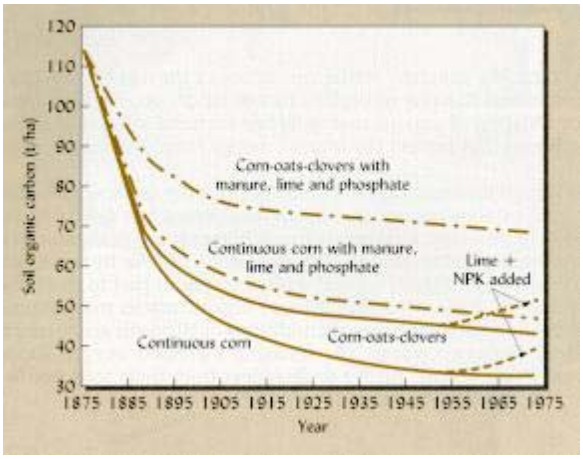
Organic soils 20 - 30 %
Mineral soils < 20 %



Typical distribution of organic C with depth for different soil orders.

Factors Affecting the Amount of Organic Matter in Soil

Climate (temperature and rainfall; greatest accumulation where cool and wet)
Natural vegetation (grasslands > forests)
Texture and drainage (clay > sand; poorly drained > well drained)
Cropping and tillage (virgin land > cropped land; no-till > conventional-till)
Crop rotations and additions of nutrients



Long-term effect of tillage, crop rotations and fertilizer application on soil organic matter.

Decomposition Rates of Different Pools of Organic Matter

Fresh residues decompose faster than soil organic matter. The rate of degradation of different fractions of soil organic matter varies from a half-life of only a few months for non-humic substances to centuries for the most resistant humic substances.

Organic Matter Management Guidelines

Supplying organic matter is good but limitations and a ceiling exist. Plant growth should be encouraged for residues and N is required for organic matter accumulation. Conservation tillage reduces the rate of organic matter decomposition and residues at the soil surface reduce erosion.

Histosols

Peat is partially decomposed plant residue. Muck consists of highly decomposed residues.

General properties of Histsols include:

Low bulk density 0.2 - 0.4 g cm^{-3}
High water holding capacity 2 - 3 x mass

Histosols are important:

Role in C cycle 20 % of soil organic matter is in Histosols
Agricultural use but are subject to oxidation and wind erosion
Potting media fibrous peat is best

Histosol.

Histosols subside when drained and allowed to decompose.

Composts and Composting

Creating humus-like materials outside of the soil. This is an aerobic process in which nutrients are conserved and concentrated. The high internal temperatures generated kills weed seed and pathogens. The compost product can be used for mulch, potting mix or slow-release fertilizer.