



TOTAL ORGANIC CARBON

Key points

- Total organic carbon is a measure of the carbon contained within soil organic matter.
- Continuous pasture builds organic carbon quicker than other rotations.
- Plant residue removal and constraints to crop growth reduce organic inputs.
- Erosion events remove topsoil which contains the bulk of a soil's organic matter. This can take years of good management to replace.
- Micro-organisms breakdown soil organic carbon as an energy source—this occurs faster when the soil is moist and warm.
- Cultivation can also enhance breakdown as soil aggregates are disrupted; making protected organic matter available to micro-organisms to decompose and because better soil aeration increases microbial activity.
- Gravel in soils will “dilute” the total carbon in your paddock when total organic carbon is calculated on a per hectare basis.

Background

The term organic is used to describe materials relating to or derived from living organisms. Management practices and plant inputs influence both the quantity and quality of soil organic matter, which directly impacts on soil productivity, soil resilience and soil sustainability. Soil organic matter plays a key role in nutrient cycling and can help improve soil structure.

Carbon makes up approximately 50% and nitrogen 0.5–10% (dependent on residue type) of the molecules in organic matter; some of which turns over rapidly (labile fraction) and is available to plants, whilst other more recalcitrant forms (passive, slow turnover fractions) contribute to the stable organic pools. Soil micro-organisms breakdown (i.e. decompose, mineralise) organic matter to obtain carbon, nitrogen and other nutrients for their own growth and activity. In doing so they release carbon dioxide (CO₂) into the atmosphere.

The role of organic carbon

Total organic carbon influences many soil characteristics including colour, nutrient holding capacity (cation and anion exchange capacity), nutrient turnover and stability, which in turn influence water relations, aeration and workability.

In soils with high clay content the contribution to cation exchange from the organic fraction is generally small compared to that from clay. In sandier soils the relative contribution of the organic fraction is higher because there is less clay, even though the amount of total organic

carbon present may be similar or less to that in clays.

By providing a food source for micro-organisms, organic carbon can help improve soil stability by micro-organisms binding soil particles together into aggregates or ‘peds’. Bacteria excretions, root exudates, fungal hyphae and plant roots can all contribute to better soil structure.

Moist, hot and well-aerated conditions favour rapid decay of organic additions. If the rate of organic matter addition is greater than the rate of decomposition, the organic fraction in a soil will increase (figure 1). Conversely, if the rate at which organic matter is added to soil is lower than the decomposition rate, the organic fraction will decline.

At a steady state level, the rate of addition is equal to the rate of decomposition. Large organic additions can temporarily increase the organic fraction in a soil, but unless additions are maintained, the soil will revert to its steady state equilibrium, which is usually low.

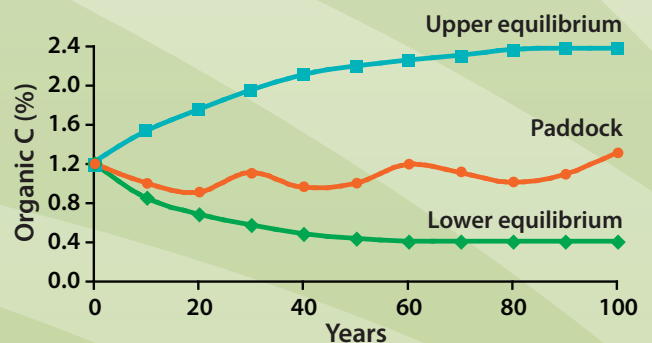


Figure 1: An example of organic carbon levels over time under different management systems.

Definitions

A fundamental understanding of the different components of soil organic matter is required to best use it to improve farming systems. Total organic carbon forms are derived from the decomposition of plants and animals. They are capable of decay or are the product of decay. They contain organic compounds whose molecules contain carbon, oxygen, nitrogen and hydrogen; therefore carbonates, bicarbonates and elementary carbon like graphite are not organic carbon.

Total carbon is the sum of three carbon forms; organic (described above), elemental (which is insignificant in most soils) and inorganic (usually carbonates and bicarbonates). The term total carbon is different to total organic carbon, which refers specifically to the organic carbon fraction.

The terms **total organic carbon**, **soil organic carbon** and **organic carbon** are the same.

Organic matter is commonly and incorrectly used to describe the same soil fraction as total organic carbon. Organic matter is different to total organic carbon in that it includes all the elements (hydrogen, oxygen, nitrogen, etc) that are components of organic compounds, not just carbon.

Organic matter is difficult for laboratories to measure directly, so they usually measure total organic carbon. This is probably why organic matter and organic carbon are often confused and used interchangeably. A conversion factor of 1.72 is commonly used to convert organic carbon to organic matter:

$$\text{Organic matter (\%)} = \text{Total organic carbon (\%)} \times 1.72$$

This conversion factor assumes organic matter contains 58% organic carbon. However this can vary with the type of organic matter, soil type and soil depth. Conversion factors can be as high as 2.50, especially for subsoils.

Total organic carbon can be further defined as fractions that vary in size and decomposability. The 'passive' fraction is chemically stable and can take more than 2500 years to turnover. Consequently, it is the largest pool and the least likely to be influenced by changes in management practice.

The 'slow' fraction, with a turnover rate of 20–40 years, consists primarily of organic compounds that are either

resistant to decomposition or physically protected. Soil manipulations that disrupt soil aggregates (e.g. tillage) can influence the turnover of this pool, by exposing previously protected organic material to microbial decomposition.

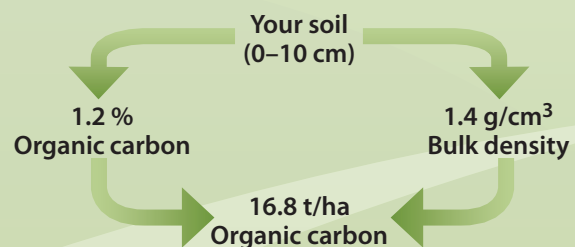
The 'active' or 'labile' fraction consists of smaller pools that can be readily utilised by micro-organisms. This fraction originates from new residues and living organisms (including micro-organisms) and turnover generally occurs within 2–3 years. The microbial component of this fraction represents only 1–5% of total soil organic matter. However, since this soil fraction is more sensitive to changes in management practices, significant differences can generally be measured earlier than in the larger, more stable pools. The capacity of a soil to supply nutrients is often defined by the proportion of total soil organic carbon that is labile.

Gravel in soil

In addition to converting total organic carbon (%) to a tonne per hectare basis, it is important to account for gravel content in the soil. Total organic carbon is measured only on those soil particles that are less than 2 mm, everything larger is classed as gravel. If there is a significant gravel fraction in your soil, this means that the organic carbon is concentrated into only the less than 2 mm component of the soil. So for any given organic carbon (%) when gravel is taken into account on a hectare basis the more gravel the lower the tonnes of organic carbon per hectare.

Organic carbon in your paddock

Soil organic carbon is usually reported as a percentage of your topsoil (0–10 cm). This value can be converted to a meaningful volume for a paddock. For example:



i.e. $10,000 \text{ m}^2$ in one hectare $\times 0.1 \text{ m}$ soil depth $\times 1.4 \text{ g/cm}^3$ bulk density $\times 1.2\% = 18.8 \text{ t/ha}$.

Authors: Wayne Pluske (Nutrient Management Systems), **Dan Murphy** (The University of Western Australia), **Jessica Sheppard** (Avon Catchment Council).

This soilquality.org.au fact-sheet has been funded by the Healthy Soils for Sustainable Farms programme, an initiative of the Australian Government's Natural Heritage Trust in partnership with the GRDC, and the WA NRM regions of Avon Catchment Council and South Coast NRM, through National Action Plan for Salinity and Water Quality and National Landcare Programme investments of the WA and Australian Governments.

The Chief Executive Officer of the Department of Agriculture and Food, The State of Western Australia and The University of Western Australia accept no liability whatsoever by reason of negligence or otherwise arising from the use or release of this information or any part of it.