LANDSCAPE SOUTH AUSTRALIA NORTHERN AND YORKE

Soil carbon

Soil organic carbon (SOC) is the measurable part of carbon in soil organic matter (OM) and includes all living and dead organic material less than 2mm in size.

What is soil organic carbon?

Soil OC is approximately 58% of OM by weight, with the remaining 42% mostly consisting of hydrogen, oxygen, with lesser amounts of nutrients such as nitrogen, sulphur, phosphorus, potassium, calcium and magnesium.

SOC is critical for soil health and function including stabilising soil structure, improving water infiltration and storage, capture and release of nutrients, sustaining and diversifying soil biota and offsetting greenhouse gas emissions.

How does organic carbon get into the soil?

Plant photosynthesis converts atmospheric carbon dioxide (CO2) into plant sugars which build shoots and roots. Plant roots exude carbon in sugars to attract beneficial microbes creating a valuable food supply to soil biota. Living and dead material of plant, animal (including excreta) and microbial origin can be eaten by other soil organisms, is excreted or dies and decomposes to become SOC.

Under usual conditions in agricultural South Australia, most surface plant and animal materials are decomposed by soil biota, with most (70-90%) of the carbon content returned to the atmosphere as CO2. Hence, the SOC measured is mostly derived from and depends on plant roots and microbes.

Some of the remaining OC stays in the soil in a stable form, protected from decomposition within soil aggregates or attached to clay particles or iron, aluminium or calcium complexes. Any SOC not protected in this way is susceptible to decomposition and release of CO2 gas to the atmosphere.

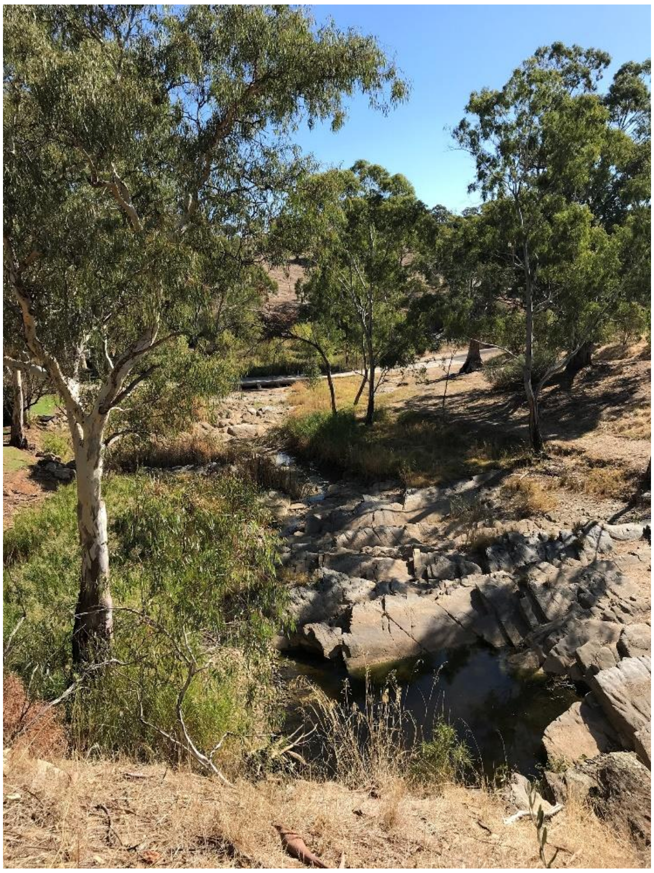
Forms of soil organic carbon

Soil OM is not a uniform material. It is a mix of organic compounds that change with different stages of decomposition in complex interactions with soil biota (all living soil organisms, including microbes and soil animals), as well as with water, nutrient and climate cycles.

There are three pools or fractions of biologically, physically and chemically significant SOC: particulate, humus and resistant.

Particulate OC (POC) includes relatively undecomposed plant, animal and fungal material and is 0.05 and 2 mm in size. POC resides in the soil for days to years and is the main food source for soil biota and important for nutrient availability for plants. POC is essential for a healthy, functioning soil with nutrient, water and microbial diversity benefits.

Humus or mineral associated OC (HOC or MAOC) primarily comprises complex humus compounds formed through microbial decomposition, including dead microbes. MAOC particles are less than 0.05 mm in diameter and largely protected from further microbial decomposition by their attachment to clay particles or inclusion within soil aggregates and can persist in the soil for many decades. MAOC contributes to the storage and release of nutrients (cation exchange capacity) and structural stability of



the soil. To store more OC in the soil, it is more desirable to increase levels of MAOC than POC due to the longer residence time in the soil and less vulnerability to increasing temperature.

Resistant OC (ROC) is dominated by charcoal and reflects the long fire history of the landscape. ROC is 0.05 to 2mm in size and is relatively inert material that can persist in the soil for centuries. ROC can provide varying degrees of nutrient exchange capacity and water holding capacity to the soil.

How much soil organic carbon can soil store?

The potential for storing more carbon depends on a soil's storage capacity and its initial OC content. Storage capacity is determined by soil type (amount of clay and mineralogy), climate (rainfall and temperature), land use and management practices. The initial OC content is determined by land condition, land use and management practices used.

Soil OC content results from carbon inputs and outputs. Each soil has a SOC content where inputs and outputs are in equilibrium. Carbon continually enters and leaves the soil, cycling in response to environmental changes and plant, microbial and soil animal activity, moving to reach a new equilibrium whenever changes in these factors occur. There are few limits to how much OC can be cycled through the soil (carbon flow), but each soil has a finite capacity to store OC.

Attachment of OC to clay particles and within aggregates protects OM from further decomposition, increasing the long-term SOC storage (MAOC). Sandy soils have lower potential to store OC than loamy soils as they have less clay.

A soil's potential to store OC based on its clay content is rarely achieved because climate and management practices also influence supply of OC to the soil. In dryland systems, rainfall has the greatest influence on plant production and input of OC to soil. Soils in areas of high rainfall tend to have greater OC storage than their counterparts in lower rainfall regions simply due to the amount of above and below ground biomass that can be grown. In irrigated systems, strategic waterings can increase biomass growth and hence OC inputs into the soil.

Management influences the type and amount of organic material produced – crop selection, provision of nutrients and soil amendments, residue management, tillage practices and pest management strongly influence SOC content. Losses of SOC can occur from topsoil erosion and removal of plant and animal products.

Ultimately, the opportunity to increase soil OC depends on the:

- ability to grow or supply sufficient biomass (mostly in the form of plant roots), and maintain these inputs
- ability of the soil to stabilise OC (within clay particles and soil aggregates)
- capacity of the soil to store more OC
- capacity to convert OC to more stable fractions and sufficient nutrients for this

Opportunity to store additional organic carbon in SA's agricultural soils

Soil organic carbon (SOC) concentration benchmarks and baselines for the South Australian agricultural zone were determined from soil test data for the period 1990-2007 (Schapel et al 2021). For each agricultural district, benchmarks for soil OC were determined for the surface soil layer based on the Walkley-Black analytical method.

To determine if there are opportunities to increase OC in a soil:

- Compare a paddock's soil OC concentration to the agricultural district benchmarks determined for soil texture and land use. If the paddock's soil OC value is below the 40th percentile there is a likely to be a significant opportunity to increase OC storage, a moderate opportunity if between the 40th and 60th percentile, and probably low opportunity if above the 60th percentile.
- Identify soil constraints limiting productivity and OM accumulation and consider if there are practical and economic means of overcoming these.
- Identify and consider management practices that can build and/or minimise loss of soil OC.

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References

Schapel A, Herrmann T, Sweeney S and Liddicoat C (2021). Soil Carbon in South Australia: Volume 4 - Benchmarks and Data analysis for the Agricultural Zone 1990-2007. Soil and Land Hub, Adelaide. Soil Carbon in SA Vol 4 - SA Ag Benchmark Analysis 1990-2007 June 2021 Final.pdf (environment.sa.gov.au)