6

Carbon

Carbon (C) occurs in soils in many forms. These include carbonate minerals (mostly calcite and dolomite), HCO_3^- (Pratt 1966), elemental C (e.g. charcoal; ≈60–98% C), OM from plant and animal residues, and as CO_2, which can be both free and dissolved in the soil solution. Organic C, includes carbohydrates, proteins, fats, waxes, residues of micro-organisms, and complex molecules termed humic substances (Ure and Berrow 1982).

The important contribution of SOC to the physical, chemical and biological properties of soils, including soil CEC, is well documented (Parfitt 1980; Stevenson 1986). It is also known that soil degradation problems caused by exploitative farming practices are often accompanied by declines in SOC (Chan *et al.* 2001). Soil properties and how these are modified by land use are influenced by the nature and degree of decomposition of the OM 'pool'. Complex OC, which involves associations between OC and soil clay particles, affects water retention and soil bulk density in predictable ways (Dexter *et al.* 2008).

More labile (reactive) and water-soluble forms of SOC influence soil acidity, nutrient availability, the toxicity and transport of metals (Thurman 1985), and the BOD of adjacent water bodies, following land runoff as the transport pathway (Rayment 2003). SOC features at lower taxonomic levels in Soil Taxonomy, such as in ustollic and fluventic sub-groups (Soil Survey Staff 1975).

Soils account for around two-thirds of the OC of terrestrial ecosystems in active exchange with the atmosphere. Much of this SOC has a residence time of around 1200 y (Post *et al.* 1982). Typically, soil C density increases in undisturbed ecosystems with decreasing temperature for any level of rainfall, albeit SOC density is usually enhanced in humid regions relative to arid areas exposed to the same level of soil weathering. In practice, OC levels are commonly highest in surface horizons, as this is where most biological activity occurs in fertile, well-drained soils (Dalal and Chan 2001). Insects such as ants and termites, birds and animals, which dig into and dwell in soil, also relocate OM at points of activity (e.g. Lobry de Bruyn and Conacher 1990).

The amounts of soil C vary from almost zero in silica sand to ≥60% in peaty soils that contain accumulations of partially decayed vegetative material and few soil mineral constituents. Peaty soils develop in places where poor drainage and/or sustained low temperatures inhibit the decomposition of plant residues by micro-organisms. In contrast, SOM quite quickly breaks down in warm to hot, moist, fertile, aerated soils of the subtropics and tropics.

Laboratory estimates of SOC contents are restricted to the quantity and condition of organic materials that accompany soil particles through a 2 mm sieve (Nelson and Sommers 1996), after the removal of obvious plant debris. Finer grinding is commonly recommended prior to analysis to improve soil homogeneity and to lessen the effects of using a small sample size. Aside from mineral-bound forms of C contained in carbonates and the like, most analytical methods on prepared samples focus on total and (less commonly) labile forms of OC. In