

Factors governing the preservation of insoluble soil organic matter

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Understanding the long-term flux of CO₂ to and from the atmosphere is of critical importance as it directly affects global climate. One important controlling factor is the preservation and mineralization of organic matter. Soil Organic Matter (SOM) represents one of the major pools of organic carbon. The total reservoir of organic carbon in the soil is estimated two to three times that in the biomass and two to three times the amount of C in the atmosphere clearly indicating its significance in the global carbon cycle (Reeburgh, 1997). The size of the SOM reservoir in a given soil depends on a number of factors including plant production and the mineralization of the plant residues entering the soil (Coûteaux *et al.*, 1995). This latter aspect is believed to be controlled by three main factors: climate, the nature and abundance of decomposing organisms and the chemical composition of the plant material (Coûteaux *et al.*, 1995).

Apart from carbon, organic nitrogen in soils also provides insight into the turnover and formation pathways of organic matter in soils. To date, different forms of organic nitrogen have been recognized in soils including, proteins, amino acids, hexoamines and nucleic acids. However, it has long been known that substantial amounts, sometimes up to 50%, of the organic nitrogen occurring in the organic matter of soils are present as so-called 'unidentified' or

'unknown' forms. These latter forms are of significance to the global carbon cycle as they affect nitrogen mobilisation which in turn has been considered to cause changes in the extent of organic matter decomposition, which influences carbon dioxide emission to the atmosphere (Coûteaux *et al.*, 1995).

Rothamsted Experimental Station

In this paper we have studied the solvent insoluble fractions of SOM using a large number of soils from Rothamsted Experimental Station. This is the oldest and one of the best documented experimental agricultural sites in the world. In addition to samples with differing soil pH, several were chosen for their different types of vegetation cover (i.e. woodland, grassland). In parallel with the underlying soils, vegetation samples were examined in an effort to follow the fate of the major plant components in soil. The solvent-insoluble material was studied using elemental analyses, bulk stable isotopes, amino acid analyses and flash pyrolysis-gas chromatography-mass spectrometry to investigate the molecular composition of soil organic matter. In addition, some samples were treated with base and, subsequently, acid to determine the mode of occurrence of the organic carbon and nitrogen in the soils.

TABLE 1. Stable carbon isotope and bulk elemental data from three soil horizons at Geescroft Wilderness

Sample	$\delta^{13}\text{C}$ (‰)	C _{org.} (%)	N _{total} (%)	C/N
Leaf litter	-27.9	46.08	1.88	28.7
Humic layer ¹	-27.8/-28.0	19.29/9.59	1.47/0.91	15.3/12.3
Mineral soil ¹	-26.4/-26.6	1.77/1.78	0.44/0.38	4.7/5.5

¹ Values for the replicate soil samples are reported separately.

Soil organic matter composition

Although often considered to be an important contributor, recognizable vegetation-derived macromolecular organic carbon was only present in humic rich acidic soil horizons (cf. Fig. 1a,b). The soil organic matter in such acid soils/horizons clearly revealed the presence of ligno-cellulose (cf. dicotyledon angiosperm lignin or grass lignin depending on the site) which constitutes the bulk of organic matter in vegetation. In addition, products of amino sugars, most probably origination from chitin present in mesofauna, were also observed. Markers for proteins/polypeptides were detected but only in relatively small amounts. The similarity in bulk carbon composition of the vegetation and the SOM in humic rich soils/horizons was also obvious from the stable carbon isotope data (Table 1).

In stark contrast, the organic matter in mineral horizons and soils with alkaline pH revealed products known to originate from amino acid moieties. In addition, these samples yielded numerous nitrogen-containing products, not directly related to biomacromolecules, which we believe represent the so-called 'unknown' soil organic nitrogen. Evidence of ligno-cellulose was virtually absent. The stable carbon isotope data of these mineral soil samples showed that the organic carbon was less depleted in ^{13}C in comparison with overlying humic rich horizons (Table 1). This is in concordance with carbon derived from proteins or polypeptides.

These data clearly show that ligno-cellulose is not recalcitrant in all soils and that other macromolecular complex may be more stable. In particular, amino acid-derived moieties appear to form the more recalcitrant back bone of soil organic matter in mineral horizons and soils under alkaline conditions. Whether this resistant organic matter is composed of (modified) polypeptides, either vegetation of microbial derived, or represents newly formed moieties such as melanoidins is at present unknown. However, it does show that dependant on the environmental

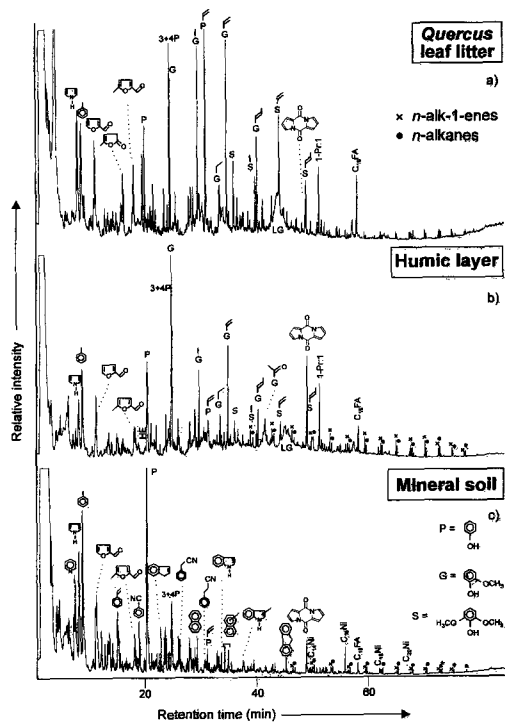


FIG. 1. Pyrograms of insoluble soil organic matter from Geescroft Wilderness.

conditions (e.g. pH, etc.) the bulk of the organic carbon input, mainly from vegetation, can be very easily transformed and hence further contribute to the CO_2 flux.

References

- Coûteaux, M.-M., Bottner, P. and Berg, B. (1995) *TREE*, **10**, 63–6.
 Reeburgh, W.S. (1997) *Bull. Eco. Soc. Amer.*, **78**, 260–7.