Thermodynamic principles of soil organic matter decomposition in a changing world

A.M. HERRMANN[1]*, S.M. GRICE[1,2], K. RITZ[2] AND J.A. HARRIS[2]

[1]Uppsala BioCentre, Swed. Univ. Agric. Sci., 75007 Uppsala, Sweden (*correspondence: Anke.Herrmann@slu.se)
[2]School of Applied Sciences, Cranfield University, U.K.

The role of soils in governing the terrestrial carbon balance is acknowledged as being important but remains poorly understood within the context of climate change. Soils exchange energy with their surroundings and are therefore open systems thermodynamically, but little is known how energy transformations of decomposition processes are affected by temperature. Soil organic matter and the soil biomass can be conceptualised as analogous to the 'fuel' and 'biological engine' of the earth, respectively, and are pivotal in driving the belowground carbon cycle.

Thermodynamic principles of soil organic matter decomposition were evaluated by means of isothermal microcalorimetry (TAM Air, TA Instruments, Sollentuna Sweden: (i) Mineral forest soils from the Flakaliden long-term nitrogen fertilisation experiment (Sweden) were amended with a range of different substrates representing structurally simple to complex, ecologically pertinent organic matter and heat signatures were determined at temperatures between 5 and 25°C. (ii) Thermodynamic and resource-use efficiencies of the biomass were determined in arable soils which received contrasting long-term management regimes with respect to organic matter and nitrogen since 1956.

The work showed that (i) structurally labile components have higher activation energy and temperature dependence than structurally more complex organic components. This is, however, in contrast to the thermodynamic argument which suggests the opposite that reactions metabolising structurally complex, aromatic components have higher temperature dependence than reactions metabolising structurally more labile components. (ii) Microbial communities exposed to long-term stress by heavy metal and low pH were less thermodynamic efficient and showed a decrease in resource-use efficiency in comparison with conventional input regimes. Differences in efficiencies were mirrored in both the phenotypic and functional profiles of the communities.

We will present our findings illustrating the capacity of isothermal microcalorimetry to evaluate temperature dependencies of soil organic matter decomposition, associated energy transformations and thermodynamic principles in soil ecosystems.

Compositional and structural dynamics of dissolved organic matter in Taihu lake, China

NORBERT HERTKORN*[1], FENFEN ZHANG[2], PHILIPPE SCHMITT-KOPPLIN[1], AGNES FEKETE[1], ANDRAS GASPAR[1], YING WU[2] AND JING ZHANG[2]

[1]Institute of Ecological Chemistry, Helmholtz Zentrum München, German Research Center for Environmental Health, Ingolstaedter Landstrasse 1, D-85764 Neuherberg, Germany (hertkorn@helmholtz-muenchen.de)
[2]State Key Laboratory of Estuarine and Coastal Research, East China Normal University, 3663 North Zhongshan Road, 200062 Shanghai, P.R. China

Lake Tai (Taihu) near Shanghai / China experiences with a surface area of 2250 square kilometers and a remarkable average depth of only 1.9 m pronounced seasonal variance in climate conditions, biodiversity and composition of dissolved organic carbon (DOC). High resolution organic structural spectroscopy (high field NMR and FTICR mass spectrometry) revealed a remarkable seasonal variation of DOC composition and structure throughout all structural regimes which nevertheless followed the seasonal cycles. Taihu DOC showed variable contents of abiotic molecules and biosignatures; however, the time-dependent individual molecular signature of Lake Taihu DOM was likely dominated by microbial metabolism rather than abiotic chemistry. Non-target high-resolution organic structural spectroscopy offers opportunities to considerably improve the significance of future functional biodiversity studies which might lead to a novel unified perception of biodiversity and biogeochemistry.