Microbial hotspots and hot moments in soil

Kuzyakov, Yakov

Department of Soil Science of Temperate Ecosystems and Department of Agricultural Soil Science, University of Goettingen, Germany

Soils are the most heterogeneous parts of the biosphere, with an extremely high differentiation of properties and processes within nano- to macroscales. The spatial and temporal heterogeneity of input of labile organics by plants creates microbial hotspots over short periods of time – the hot moments. We define microbial hotspots as small soil volumes with much faster process rates compared to the average soil conditions. Such hotspots are found in the rhizosphere, detritusphere, biopores (including drilosphere) and on aggregate surfaces. Hot moments are short-term events or sequences of events inducing accelerated process rates as compared to the average rates. Thus, hotspots and hot moments are defined by dynamic characteristics, i.e. by process rates.

Localization and size of hotspots, their spatial distribution, transport of labile C to and from hotspots, lifetime and process intensities will be presented with a special focus on process rates and microbial activities. The fraction of active microorganisms in hotspots is 2-20 times higher than in the bulk soil, and their specific activities (i.e. respiration, microbial growth, mineralization potential, enzyme activities, RNA/DNA ratio) may be much higher. The duration of hot moments in the rhizosphere (hours to few days) is limited and is controlled by the length of the input of labile organics. In the detritusphere, however, the duration of hot moments is regulated by decomposition rates of litter (weeks to months). The faster turnover and lower C use efficiency in hotspots counterbalances the high C inputs, leading to the absence of strong increases in C stocks. Consequently, the intensification of fluxes is much stronger than the increase of pools. Maintenance of stoichiometric ratios by accelerated microbial growth in hotspots requires additional nutrients (e.g. N and P) from soil organic matter, i.e. priming effects. Consequently, priming effects are localized in microbial hotspots and are consequences of hot moments.