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Limitations & challenges for understanding of δ13C variation in soil

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Natural variation of δ13C (δ13C natural abundance) in soil is frequently used for understanding of various processes, mainly: i) the equilibrium between the formation, stabilization and decomposition of soil organic matter (SOM) pools, ii) effects of environmental conditions on SOM, and iii) trends in the δ13C as a result of long-term effects. However, various factors affect simultaneously δ13C value of SOM pools and of CO_2 and consequently limit application of the δ13C natural abundance approach. Frequently these factors affect δ13C in opposite directions, and may compensate each other. Additionally, unexplained spatial and/or temporal variation of δ13C within different scales makes the interpretation of data extremely difficult. Therefore, I aimed this overview on i) evaluation of the ranges of spatial and temporal variation of δ13C values in soil, ii) distinguishing between 13C fractionation and preferential substrate utilization, and iii) separation of variations from trends.

Literature data and own results allowed to conclude that the spatial variation of δ13C of SOM within one agricultural field usually is more than 2‰Ṫhe CO_2 in soil and CO_2 flux from soil have spatial variation similar to that of SOM (∼2‰, but temporal variation δ13C in CO_2 is at least two times higher. This is connected with admixture of atmospheric CO_2 depending on soil and air moisture and on contribution of CO_2 from various soil depths. Within one meter soil depth the δ13C has an increasing trend of about 3‰ with variation up to ±2‰Ṡuess effect (1955) strongly depleted the δ13C of all SOM pools (especially in the upper soil horizons) up to –1.5‰ and this trend will be stronger and faster in the future.

It is very difficult to separate two processes affecting δ13C of SOM pools: 13C fractionation and preferential substrate utilization. The δ13C fractionation means favored involvement in processes of the chemically identical substances but with light isotopes (here 12C). The preferential substrate utilization is caused by preferable utilization of chemically different substrates within a substrate mixture (e.g. plant residues components) having different δ13C values. To clarify this, typical δ13C differences between SOM, microbial biomass, dissolved organic C and CO_2 were analyzed. Changes of δ13C values of CO_2 during incubation studies were caused by sequential utilization of substrates with different δ13C values. Finally, an overview of various processes leading to the directed changes (trends) and to unexplained variations were compared.