Application of isotopes in rhizosphere studies: Overview of approaches and results

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Rhizosphere is one of the most important and sensitive hotspots in terrestrial ecosystems. The cycles of most biogenic elements are implying rhizosphere as one major component where the nutrients will be microbially and chemically mobilized from insoluble and unavailable forms to forms available for plants and microorganisms. Therefore, the intensity of elements' turnover in the rhizosphere defines the turnover of biogenic elements in terrestrial ecosystems.

The unique property of the rhizosphere is a very high availability of organic carbon (C) and energy for microorganisms compared to the root free soil. This is connected with active and passive release of high amounts of easily available organic substances by roots. The difficulties to study element cycles in the rhizosphere are connected with very fast transformations (mainly decomposition and mobilization) and the necessity to distinguish between substances released by roots and microorganisms into the soil. To overcome these problems various tracer methods are used. The tracer methods used for rhizosphere research in the Dep. of Agroecosystem Research are mainly based on labeling with ^{14}C, ^{13}C or ^{15}N, as well as on application of ^{13}C or ^{15}N natural abundance. These labeling approaches allow: 1) identification of hotspots, 2) distinguishing of C and N originated from roots and from soil in microorganisms, pools of soil organic matter (SOM), dissolved organic matter (DOM), fluxes of tracer gases from soil, and 3) investigation of short-term dynamics of C and N.

In addition to determine fluxes and turnover of bulk organic carbon in soil, lipid biomarker analyses and the combination of biomarker and compound-specific isotope analyses became a new tool to get a deeper insight into processes occurring on a molecular level. Using this combination with biomarker analyses allows for a differentiation of microbial and plant-derived sources in soil, whereas plant material carries a specific lipidic pattern into soil, which itself facilitates turnover and flux determinations on a molecular level. Natural and pulse-labelling ^{13}C and ^{14}C techniques of plant materials in combination with compound-specific isotopic analyses of individual lipids have been shown to offer high potential for flux and turnover determination of individual organic substances in soils and plants.

Within the planned collaboration in the CN cluster "C and N in Terrestrial Ecosystems of Baikal Area", it is intended to study the contribution of root-derived C and N fluxes into soil and SOM pools (with Glaser), to losses of C and N by DOM leaching (with Guggenberger, connection to hydrosphere) and trace gases emission into the atmosphere (with Kiese, connection to atmosphere). These fluxes will be evaluated for representative areas around Lake Baikal characterized by contrasting land use (e.g. false time series of clear cutting areas, agriculture / forest / grassland) and dependent of the depth of active layer in permafrost regions. The studies will include manipulations on plot level with $^{13}C/^{15}N$ labeling experiments and obtained results will be extrapolated for water catchments of small rivers. The consequences of changing climate and land use around Lake Baikal on C input by vegetation and N turnover in terrestrial ecosystems will be driven.