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1 Sorption, microbial incorporation, and decomposition of position-specific ^{14}C-labeled acetate in soil

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Low molecular organic acids (LMOA) are released into soil by root exudation or plant and microorganisms residue decomposition. They are subject to a variety of processes: microbial utilization and decomposition to CO_2, sorption by mineral particles and soil organic matter, or leaching. Among LMOA acetate is most abundant and occurs typically in concentrations from 0.5 to 1000 μM in soil solution.

All previous studies to transformation of LMOA in soil used uniformly ^{14}C or ^{13}C labeled substances. The amount of ^{14}C or ^{13}C served as parameter of substance concentration in solution, its sorption, and decomposition of the whole molecule. With these approaches it remained unclear which functional group (in the case of acetate CH_3- or COOH-) controlled the processes and whether it was the whole molecule or one of its metabolites. To overcome this shortcoming and to trace C from individual positions in the molecule we conducted experiment with 1-^{14}C-acetate and 2-^{14}C-acetate. By this position specific labeling we distinguished between C from the CH_3-group and C from the COOH-group of the molecule contributing to all processes. When results for these two ^{14}C positions differ from each other it is probable that the two functional

groups are subject to different fates in the respective process.

Acetate was added to 1 g of dried, sieved, and re-moistened loamy soil as 2.5 ml aqueous solution and gently shaken for periods between 10 s and 1 d. Concentrations in the soil solution varied from 0.1 to 1000 μmol l^{-1}. ^{14}C-activity in the supernatant was measured after centrifugation at 1500 g and represented not absorbed acetate. Sterilization by $CHCl_3$ or $HgCl_2$ + NaN_3 allowed separate determination of microbial decomposition and sorption to the soil matrix.

The equilibrium between sorption, incorporation, decomposition to CO_2 was reached after 28 min for ^{14}C from CH_3- and after 85 min for ^{14}C from COOH-. In the not sterilized samples ^{14}C from CH_3-group declined in soil solution faster than ^{14}C from COOH-group. Higher ^{14}C recovery in soil from CH_3- than from COOH- indicated that CH_3- was preferentially incorporated in microorganisms. The losses from the soil-solution system (= decomposition to CO_2) were equal for ^{14}C from both groups.

In $CHCl_3$ sterilized soil samples the sorption was influenced by substances released from microbial cells. However, in $HgCl_2$/NaN_3-sterilized samples sorption of ^{14}C from both groups did not differ significantly.

After combining the information from sterile and not sterile conditions, the following pool sizes could be determined for acetate at 100 μM: of the COOH-group 15.9$\pm$0.9% were sorbed to the soil matrix, 47.8$\pm$0.9% were decomposed to CO_2, and 22.8$\pm$0.7% remained in solution. For the CH_3 was found: sorption 15.6$\pm$0.5%, decomposition to CO_2 47.1$\pm$0.3%, solution 13.6$\pm$0.4%. Thus, about 24% of CH_3 was incorporated into microorganisms compared to only about 13% of COOH.

At concentrations higher than 100 μM and incorporation and decomposition decreased. For CH_3 at 1000 μM decomposition was 10.8$\pm$0.9%, for COOH 20.5$\pm$5.5%. Obviously, allotted time (200 min) was too short for complete decomposition.

With the presented approach we showed that the functional groups of acetate are subject to different processes in soil. The use of position-specific labeled substances is an appropriate tool to elucidate these differences.