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Carbohydrates as Biomarkers for Studying Soil Biota and Land Use Change

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We present results from three different studies, which show, firstly, that carbohydrate composition can be used as a very sensitive biomarker of changes in soil biota community. Secondly, we show that carbohydrate concentrations react very quickly to land use conversion, and can be used as sensitive biomarker to study short-term changes in soil organic carbon dynamics following land use change.

Carbohydrates are the main components of plant residues (up to 60%) but constitute only 2 - 20% of the organic matter in soils. Three hexoses (glucose, galactose and mannose) and two pentoses (xylose and arabinose) usually represent 90% of all monosaccharides in soils. The ratio of pentoses to hexoses indicates whether carbohydrates are mainly of plant- or of microbial-origin since plant biomass is rich in pentoses, whereas microbial biomass is predominated by hexoses.

The objective of the first study was to test if carbohydrate composition can be used track changes in naturally occurring succession of soil biota in marshes at the North Sea coast. For this purpose we studied the carbohydrate composition in a marine and a brackish mash sequence, which both followed a gradient in inundation frequency. Both sequences exposed a very similar distribution of total organic carbon (TOC) and nitrogen. It was found, firstly, that carbohydrates contributed significantly stronger to the SOM in the marine marshes (up to 4.6% of the TOC) than in the brackish marshes (on an average 1.9 ($\pm$ 0.2) % of the TOC) and showed highest concentration in the mid-salt marsh. This can be attributed to the high middle and fine root biomass of the marine soils as well as to the high polyol concentrations in halophytes. Secondly, we showed that the ratios of hexoses to pentoses in both sequences were significantly highest in the tophorizons of the first, most frequently inundated profile in each sequence, which indicates a high amount of microbial biomass. The microbial derived carbohydrates where twice as highly concentrated in the marine than in the brackish marsh, which shows that there is more microbial biomass in the marine than in the brackish ecosystem. From the results we conclude that carbohydrate composition in soils can be used as a very sensitive biomarker of different soil biota to better understand soil succession.

To evaluate carbohydrates as a biomarker to study changes in soil organic matter dynamics following land use change two chronosequence studies were conducted. The zero point of each chronosequence was represented by permanent pasture sites, while the following sites have been converted from pasture to cropland at different times in history. Both chronosequence studies showed that carbohydrate concentrations in the soils decreased very rapidly after land use change from pasture to cropland by 61 % and 64 %, respectively. A new equilibrium of the carbohydrate concentration was reached 14 ($\pm$ 6) years after the land use conversion. Concentrations of TOC and the fungal protein glomlin, in contrast, reached a new equilibrium 23 ($\pm$ 5) and 56 ($\pm$ 5) years after land use change. From these results it can be concluded that carbohydrates are a sensitive and fast responding biomarker to track short-term changes in carbon cycling in soils following land use change.