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Colloid-facilitated transport of hydrolytic enzymes in soils

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Colloids are known to facilitate transport of a broad variety of chemicals and microorganisms in soils. Extracellular hydrolytic enzymes, produced by many soil microorganisms and plant roots, have high affinity to clay and silt particles constituting soil mineral colloids (SMC). Therefore, those enzymes can be released jointly with colloids from soil matrix during high water flow events and transported convectively attached to the colloids carried by the water flow. At the same time hydrolytic enzymes are often considered as free-mobile proteins with a self-propelled diffusion mechanism. Current literature lacks any information on enzyme transport in soils, and it is not clear whether enzymes are transported and, if so, whether they are transported in free- or colloid-associated form. Studying enzyme transport in soils is challenging due to infeasibility of their enumeration in soil solutions and suspensions, differences in activity of free and colloid-associated enzymes, the influence of colloid size and composition, pH and ionic strength in the colloidal suspensions on the enzyme activity. This study presents the first experimental evidence of enzyme transport in soils facilitated by SMC in sandy, loamy and two sandy-loam soils. Its results suggest from 50 to 80% of transported hydrolytic enzymes are associated with transport of coarse SMC. The remaining 20 to 50% of enzymes are likely transported by organic colloids and fine SMC (Ø < 1 mm). The ionic strength played a dual role in the joined enzyme and colloidal transport: (1) by affecting dispersion and release of SMC colloids from soil; and (2) modifying optimum pH of enzymatic activity in released colloidal suspensions. Our results provided insights into factors governing plant-soil-microbial interactions through the transport and activity of hydrolytic enzymes. Support for this research was provided by the NSF LTER Program (DEB 1027253) at the Kellogg Biological Station, by USDA NC1187 project, by the Great Lakes Bioenergy Research Center, U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research under Award Number DE-SC0018409.