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Depth-dependent, small-scale characteristics of earthworm burrow walls of L. terrestris influence water infiltration and transport processes

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Earthworms are one of the main producers of large biopores (> 2 mm i.d.) in soil, hence affecting the infiltration and flow of water, transport of particles and nutrients as well as soil aeration. During rain events that lead to ponding conditions, earthworm burrows may serve as short circuits between the top- and subsoil, thereby bypassing the soil matrix. Yet, burrow wall characteristics and their continuity with increasing soil depth may have a severe impact on the amount and time scales of water flow and matter transport.
In this study, we investigated the wettability and properties of earthworm burrow walls of Lumbricus terrestris in three depths (15, 30 and 50 cm) compared to the bulk soil. The wettability was inferred from water drop penetration time (WDPT) tests. Fourier transform infrared (FTIR) spectroscopy of burrow wall samples were analyzed for the presence of hydrophobic moieties of organic matter (OM). Scanning electron microscopy (SEM) was used to visually explore the burrow wall structure and accumulation with organic matter and microorganisms. Elemental distribution on the burrow walls was investigated with energy dispersive X-ray (EDX) spectroscopy.
Earthworm burrow walls were more hydrophobic in all depths compared to the soil matrix. Long-chained aliphatic hydrocarbons, indicated by strong CH2 and CH3 vibrations in FTIR spectra, are suspected to cause water repellency. Such substances are accumulated along burrow walls during decomposition of organic matter and plant residues as well as deposition of cutaneous earthworm mucus. Larger plant residues, microorganisms and fungal hyphae as well as earthworm and microbial extracellular polymeric substances were identified along burrow walls by SEM. Clay minerals along the burrow walls were aligned. Thus, the burrow wall structure was found to be smoother compared to the soil matrix. The recurrent up- and downward burrowing and migration of earthworms and their feeding behavior and application of radial pressure on the walls results in the burrow wall characteristics (displacement of OM and minerals, aggregation and formation of organo-mineral associations and compaction) and consequently in a lower porosity and bulk density in the innermost burrow wall. Hence, lateral water transfer through the burrow wall might be impeded. However, differences in water repellency and chemical composition between the burrow walls and the soil matrix were decreasing with increasing depth. This in turn implies, that upon ponding conditions, the infiltrating water is translocated faster through the topsoil, yet may spread easier in the subsoil. This will also comprise the dissolved, colloidal and particulate organic matter and microorganisms. Thus, biopores may have a severe effect not only on the environmental conditions and biogeochemical cycles in the subsoil, but also on the habitat and established communities.