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# How mucilage and EPS shape the spatial configuration of the liquid phase in the rhizosphere and other soil hotspots

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Plant roots and bacteria are capable of altering their local soil environment by releasing a diverse, highly polymeric blend of substances (e.g. extracellular polymeric substances EPS and mucilage). Despite the importance of EPS and mucilage for plants and microorganisms is well accepted, the physical mechanisms by which EPS and mucilage interact with the soil matrix and determine the soil water dynamics remain unclear.

High-resolution X-ray CT revealed that upon drying in porous media mucilage and EPS form one-dimensional filaments and two-dimensional interconnected structures spanning across multiple pores. Unlike water, these mucilage and EPS structures connecting soil particles did not break up upon drying, which is explained by the high viscosity and low surface tension of EPS and mucilage. During drying the polymers are progressively stretched and their viscosity exponentially increases until a critical point when the polymers can no longer follow the receding air-liquid interface. At this critical point the polymers start to behave as a solid matrix that enhances the soil water retention and connectivity of the liquid phase. A model is introduced to predict the formation these one- and two-dimensional polymer structures in drying porous media. Viscosity of the soil solution, drying rate and specific soil surface are the key parameters determining the transition from one- to two-dimensional structures. The model also explains the apparent hysteresis in the relation between water content and water potential in soils embedded with root mucilage.

We propose that the release of viscous polymeric substances and the consequent creation of a network bridging the soil pore space represent a universal strategy of plants and bacteria to engineer their own soil micro-hydrological niches where stable conditions for life are preserved.