Biophysical processes shaping bacterial life in soils – an unexplored universe under our feet

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By some accounts exploring the microbial diversity found in soils represents an uncharted scientific frontier at a scope similar to that of space exploration. The immense diversity of soil microbial life is attributed to the complex and heterogeneous pore surfaces and spaces with highly dynamic aqueous and chemical microenvironments. In most unsaturated soils a flickering aqueous network defines nutrient diffusional pathways and shapes microbial dispersion patterns. We quantitatively explored effects of microscale hydration on biophysical interactions affecting microbial dispersion and controlling coexistence of competing bacterial species inhabiting unsaturated surfaces. The rapid fragmentation of the aqueous phase yields a surprisingly narrow range of hydration-enabled motility, and marks the onset of flux limiting and heterogeneous diffusion fields that promote coexistence. Conditions promoting coexistence occur under mild unsaturated conditions within matric potential values of a few kPa nearly independent of soil or rock type. The spontaneous spatial organization of interacting microbial populations and formation of consortia shaped by dynamic diffusion fields and trophic interactions offer a fascinating and robust level of self-organization that support high diversity found in soil. The resulting length scales for interactions offer new insights into biogechemical function of soil microbes and could guide bioremediation activities of the subsurface.