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Universal microbial reworking of dissolved organic matter along soil gradients

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Soils lose a large amount of carbon annually to freshwaters as dissolved organic matter (DOM), which, if degraded, can undermine climate change mitigation. The degradation state of DOM in aquatic ecosystems can reflect the distance from its source, with DOM increasingly dominated by similar compounds as degradation proceeds. However, the processes underlying the degradation of DOM and its generality across environments are poorly understood. Here we found DOM changed similarly along two soil-aquatic gradients irrespective of environmental conditions. We tracked DOM across soil depths and hillslope positions in forest headwater catchments using ultra-high-resolution mass spectrometry and related its composition to soil microbiomes and physical chemistry. Along both gradients, carbohydrate-like and unsaturated hydrocarbon-like compounds increased in mass, suggestive of microbial reworking of plant material. Most of the variation in the abundance of these compounds (>56%) was related to the expression of genes important for breaking down plant-derived carbohydrates. Our results highlight the value of high-resolution molecular data in understanding global carbon cycles, directly implicate microbial processing in shifting DOM towards universal compounds in soils, and suggest that this process is generalizable across ecosystems and spatiotemporal scales. This consistent degradation process could provide insights for estimating the state of DOM in different environments and inform the management of soil-to-stream carbon losses.