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Potential return on investment that microbial communities can obtain from the consumption of organic matter determines overall soil microbial activity

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Microbial communities are a critical component of the soil carbon (C) cycle as they are responsible for the decomposition of both organic inputs from plants and of soil organic C. However, there is still no consensus about how to explicitly represent their role in terrestrial C cycling. The objective of the study was to determine how the properties of organic matter affect the metabolic response of the resident microbial communities in soils, using a bioenergetics approach. This was achieved by cross-amending six soils with excess water-soluble organic matter (WSOM) extracted from the same six soils and measuring heat dissipated due to the increase in microbial metabolic activity. The conditions of the experiment were chosen in order to replicate conditions in activity hotspots. The metabolic activity was then related to the potential return on investment (ROI) that the microbial communities could derive from the WSOM. The objective of the study was to determine how different energetic profiles in available organic avec the metabolic response of different microbial communities.

The ROI was calculated as the ratio between the total net energy available (ΔE) in the WSOM and the weighted average standard state Gibbs energies of oxidation half reactions of organic C (ΔG°Cox) of the molecules present in the WSOM. The ΔE was measured as the heat of combustion of the WSOM, which was measured using bomb calorimetry. ΔG°Cox was estimated from the average nominal oxidation state of C (NOSC), which itself was determined from the elemental composition of each molecular species in the organic matter amendments analyzed by Fourier transform ion cyclotron resonance mass spectrometry. The soil bacterial community structure was determined by 16S rRNA gene sequencing and using the weighted UniFrac distance of rarefied amplicon sequence variants data.

We found that the potential ROI that microbial communities could obtain from the consumption of the added organic matter was positively related to the overall metabolic response of microbial decomposers. However, the observed temporal differences in metabolism across soils indicate that bacterial communities do not exploit energetic return-on-investment in the same ways.

Overall, our results suggest that microbial communities preferentially use organic matter with a high energetic return on investment.