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Nitrogen cycling processes in soil organic matter pools of grasslands as mediated by land use intensity and soil diversity

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Soil organic matter (SOM) provides crucial storage for carbon but also contains a majority of soil nitrogen. Land use intensity (LUI) may affect the particulate and mineral-associated SOM pools having repercussions on the carbon and nitrogen storage and cycling. Soil organic matter dynamics and composition plays a key role for the extent of these processes, yet its interactions remain poorly understood preventing targeted mitigation measures for carbon and nitrogen-related soil functions. Here we provide insights investigating how LUI and soil properties affect the storage of carbon and nitrogen in functional SOM pools in the topsoil (0-30 cm) of grassland soils across three different regions in Germany. Furthermore, we present a conceptual framework integrating biological, mineral, and organic nitrogen pools to disentangle nitrogen cycling processes and their interactions with organic matter dynamics.

Across the land use intensity gradient, we isolated particulate organic matter (POM), which is part of the >20 µm fraction, and mineral associated organic matter (MOM) in the <20 µm fraction. Random forest and mixed model analysis showed that LUI did not significantly affect SOM storage, but led to reduced C/N ratios in POM and MOM, driven by increased N fertilization intensity. Rather than land use intensity, soil properties, such as clay and iron oxide content, and soil type diversity exerted most influence on SOM.

To reconcile the influences of soil properties on soil nitrogen cycling, we provide a novel conceptual framework integrating organic matter stabilization mechanisms, microbial N uptake and release as necromass, as well important processes catalyzed by the soil microbiome including biological nitrogen fixation pathways. Our integrative nitrogen cycling framework stimulates different disciplines towards a new perception of the nitrogen cycle in unlocking multiple organic nitrogen pools as mediated by soil type and climatic conditions.

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