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Extracellular enzyme stoichiometry reflects the C-and P- microbial metabolic limitations along a grassland succession on the Loess Plateau in China.

Zhijing Xue[1], Chunhui Liu[1], and Wanek Wolfgang[2]
[1]Shaanxi Normal Univerisity, School of Geography and Tourism, Xi'an, China (xuezhijing1986@gmail.com)
[2]Unversity of Vienna, Center of Microbiology and Environmental Systems Science, Vienna, Austria
(xuezhijing1986@gmail.com)

Soil extracellular enzyme stoichiometry (EES) reflects the biogeochemical balance between microbial metabolic requirements and environmental nutrient availability. Previous studies have focused on the perspective of nutrient acquisition, while soil microbial metabolic limitations (SMML) were minor in the focus of those studies. Therefore, how grassland succession drives SMML has mainly been under explored. Here, we used EES models to identify the response of SMML during grassland restoration while also investigating potential implications of microbial nutritional limitations across the time series (herbaceous succession) and with space (transformation interface soil and underlying topsoil layer) in a grassland restoration series. The results showed that soil microorganisms were generally limited by C, both in the transformation interface soil (TIS) and the underlying topsoil layer (UTS). During herbaceous succession, microbial P-limitation was more substantial than that by N-limitation. Microbial C-limitation displayed a uni-modal direction, peaking in intermediate successional stages. However, microbial P-limitation presented the opposite trend. In the TIS layer, SMML gradually transferred from P- to N- and back to P-limitation at later successional stages. Biotic factors, together with soil basic index, and soil nutrients, explained 92.2% of the variation in microbial C-limitation and 84.4% of the variation in microbial P-limitation. Multi-interaction factors show the most significant relative influences of 65.11% (TIS) and 43% (UTS) of the SMML, respectively. Microbial C-limitation was induced by the imbalance between C supply and microbial C demand, while the changes in microbial P-limitation were due to changes in the competition for P between plants and microorganisms. Therefore, the impacts of long-term grassland succession on SMML resulted from the concerted changes in vegetation composition, soil properties, and the nutritional demands of the soil microorganisms.