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Molecular characterization of organic matter in converted forests in Western Europe; disentangling the effects of edaphic factors and input differences on SOM composition

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By storing carbon in the soil, forests can play an important role in climate mitigation. We studied how the SOM composition was affected by conversion of deciduous stands to mono-culture spruce plantations in the Mullerthal in Luxembourg and the Gaume in south-east Belgium. Both regions have a known and similar vegetation history on different lithologies, ranging from carcareous marls to decalcified sands. Lignin and cutin/suberin biomarkers were identified by using thermally assisted hydrolysis and methylation (THM) with unlabelled tetra methyl ammonium hydroxide (TMAH). Lignin was used to distinguish deciduous and coniferous litter sources, whereas cutin and suberin indicated the respective input of above- and belowground litter input. A twinplot setup was used to be able to independently evaluate the effect of edaphic factors versus input differences on SOM composition. pH values and SOC stocks reflected the lithological gradients in both study areas. The difference was more subtle in the Gaume where the gradient is much narrower.

The existence of pedogenic thresholds explains why significant differences in lignin yield and SOC stocks between plots with different lithology were also found along the subtle gradient in the Gaume. Secondly, we observed differences in molecular composition and also in decomposition state of lignin that were caused solely by input differences between adjacent deciduous and coniferous forest plots. Furthermore, we found a legacy effect, a signal of former deciduous forest in the deeper soil layers (15-20 cm) under the current spruce plantations, in the loamy substrate plots of the Gaume, which was not observed in the Mullerthal, despite the similar vegetation history of both regions. This can be explained by differences in environmental conditions between both areas. Higher pH values resulting in a higher biological activity could explain the absence of a legacy effect in the Mullerthal plots.

Therefore, an important conclusion of this work is that the presence of a legacy effect depends on local soil conditions and soil process domains. Lignin decomposition was found to be higher under more acid conditions, as present in spruce soils compared with the soils under deciduous trees. Moreover, the observance that in the Mullerthal the amount of lignin relative to TOC decreased with increasing depth from the surface, indicates preferential decomposition of lignin with depth. This is in line with the new paradigm that the (soil) environment rather than molecular composition is in many situations a dominant factor in determining the lignin turnover rate. Lastly, in both study areas within most twin plots SOC stocks were similar for both forest types, while SOC stocks were higher on a marl or limestone substrate than on a sandy substrate. We therefore argue that edapthic factors are of vital importance when considering forests to effectively mitigate climate change and that litter quality,and therefore the molecular composition of the organic matter, cannot be ignored when discussing organic matter persistence and carbon sequestration.