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Lignin decomposition along an Alpine elevation gradient in relation to physicochemical and soil microbial parameters

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Abstract

Lignin is an aromatic plant compound that decomposes more slowly than other organic matter compounds; however, it was recently shown that lignin could decompose as fast as litter bulk carbon in minerals soils. In alpine Histosols, where organic matter dynamics is largely unaffected by mineral constituents, lignin may be an important part of soil organic matter (SOM). These soils are expected to experience alterations in temperature and/or physicochemical parameters as a result of global climate change. The effect of these changes on lignin dynamics remains to be examined and the importance of lignin as SOM compound in these soils evaluated. Here, we investigated the decomposition of individual lignin phenols of maize litter incubated for 2 years *in-situ* in Histosols on an Alpine elevation gradient (900, 1300, and 1900 m above sea level); to this end, we used the cupric oxide oxidation method and determined the phenols' ^{13}C signature. Maize lignin decomposed faster than bulk maize carbon in the first year (86 vs. 78% decomposed); however, after the second year, lignin and bulk C decomposition did not differ significantly. Lignin mass loss did not correlate with soil temperature after the first year, and even correlated negatively at the end of the second year. Lignin mass loss also correlated negatively with the remaining maize N at the end of the second year, and we interpreted this result as a possible negative influence of nitrogen on lignin degradation, although other factors (notably the depletion of easily degradable carbon sources) may also have played a role at this stage of decomposition. Microbial community composition did not correlate with lignin mass loss, but it did so with the lignin degradation indicators (Ac/Al)s and S/V after 2 years of decomposition. Progressing substrate decomposition toward the final stages thus appears to be linked with microbial community differentiation.

Keywords: ^{13}C, compound-specific isotope analysis, cupric oxide, Histosols, lignin, PLFA, soil microbial communities, soil organic matter

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Introduction

Litter decomposition is a key process in biogeochemical cycles, affecting for example nutrient availability and carbon sequestration. While the rate of litter degradation was found to be related to its lignin content (Berg & McClaugherty, 2008), lignin decomposition itself was found to be influenced by N availability, with excess N impeding decomposition (Berg & McClaugherty, 2008). Additionally, lignin decomposition was found to be favored by high mean annual temperature and low soil pH, which is probably related to an optimum activity of fungi at around pH 5 (Thevenot *et al.*, 2010; and references therein). As a consequence, lignin decomposition can be highly ecosystem-specific and changing environmental parameters, such as temperature or N deposition, may have an influence on lignin degradation. Moreover, litter decomposition is the result of several physical and biochemical mechanisms in which soil microbial communities play a major role. Lignin can be degraded by basidiomycete brown-rot and white-rot fungi, and some bacteria such as *Streptomyces* sp. or *Nocardia* sp., but only the white-rot fungi are able to mineralize lignin (Thevenot *et al.*, 2010; and references therein). In a previous study on an alpine elevation transect, we have shown that soil microbial communities (as assessed by the phospholipid fatty acid (PLFA) method) quickly adapted upon translocation to a new environment, and we found an increasing differentiation of the microbial community with progressing substrate decomposition (Djukic *et al.*, 2013).

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