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Dynamics and turnover of lignins in soils: a review

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Lignins are amongst the most studied bio-macromolecules in natural environments, for their properties as biomarkers and their suggested influence on soil organic carbon dynamics. A large number of methods exists to characterize lignins, but the alkaline CuO oxidation is the most used for determining lignin fate in soils. The CuO oxidation products of lignins yield quantitative information (sum of V, S and C monomers) as well as qualitative information on the degradation of lignins (S/V, C/V, (Ad/Al)V,S…). The CuO-lignin products provide information on lignins but also on the environment and particularly on the present and past vegetation.

Data from several studies were compiled in order to evaluate the relations between lignins in soils and various environmental parameters. The results of the multiple correspondence analysis (MCA) performed suggest that the lignin content in soils is directly related to the C and N contents, confirming its contribution to the pool of organic carbon. The lignin distribution appears also related to the climate and to the soil texture, which suggests the impact of these parameters on the lignin degradation and retention in soils, as observed for organic carbon (Burke et al., 1989). The total lignin content generally decreases with the soil depth and with the decreasing size of the granulometric fractions. Hence, the more lignins are degraded, the more they are associated with the finest fractions. In addition, it appears that lignin contents are linked to land-use. Thus, in accordance with the land cover, management type and amount of annual input, the forest soils are described by high contents of VSC, C and N, in contrast with the arable land.

Lignins were often considered to greatly participate to the stock of slowly degradable and stable carbon in soils. However, several studies suggest that lignin turnover can be more rapid than that of the bulk soil organic carbon (SOC), suggesting that they are not stabilized in soil. On the other hand, other studies suggest contradictory results, suggesting the retention of a large part of the initial lignin input and its preservation in the organo-mineral fraction (Hofmann et al., 2009; Dümig et al., 2009). This contradiction could be due to the existence of two pools of lignins in soils: one pool of fresh lignin residues with a fast turnover and one of protected lignins with a slow turnover (Lobe et al., 2002; Rasse et al., 2006). However, the mechanisms of protection are not yet clear, and could be related to chemical variation in the structure of the lignins leading a decrease of their degradability (chemical protection) and/or to interactions between a fraction of the lignins with the mineral phase of the soil (physical protection).

In conclusion, this review suggests that lignins greatly influence the bulk SOC dynamics, but their fate in soils needs to be elucidated. To this end, the future researches could focus on the relations between the lignin distribution and the environmental parameters, and on the kinetic pools of lignins in soils.

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