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Dynamics of soil organic matter and mineral nitrogen in soil: investigation into a complex relationship

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Soil organic matter (SOM) comprises complex macromolecular structures which play a major role in soil as they produce inorganic nitrogen (NH4+, NO2-, NO3-) by mineralization, and can also contribute to mineral nitrogen stabilization. Furthermore, SOM is related to dissolve organic matter (DOM), via decomposition and humification processes. The DOM fraction only represents a small proportion of soil Corg, but it is the most reactive to the environmental factors. However, in spite of its importance, the relation SOM-DOM is still partly unknown. As SOM is tightly related to the mineral nitrogen in soil, the aim of the present study is to investigate the relation between SOM chemical structure (C & N) and inorganic (NH4+, NO3-) and organic (COD, NOD) species present in soil solution. This should allow improving the knowledge about the relationship between the dynamics of SOM and of mineral nitrogen. Processes associated in SOM turn-over are mediated by microbial organisms, depending mainly on water and oxygen environmental conditions which determine the degree of anoxia and the possibility of migration for molecule and organisms in soil. As a result, to test the influence of water content on the dynamic of organic matter, soil samples were collected along a transect with a hydromorphic gradient and at different depth in a grassland site in Quimper, France (ORE AgrHys). Samples were also collected during high flow and low flow period. SOM and DOM were chemically characterized at a molecular level using spectroscopic (13C solid state NMR) and pyrolytic methods. Isotopic biogeochemistry was used to identify the origin of carbon and nitrogen species present in the environment and to follow the processes affecting their concentration. The global isotopic values of δ15N and δ13C of bulk soil, SOM and DOM and inorganic nitrogen (NH4+, NO3-) were measured. The soil δ15N varies between 3.6 ‰ and 7.8 ‰ and for all soil profiles we observed an increase of δ15N values with depth and the decrease of % N. On the same time the δ15N values of nitrate increase with the depth. We observed no significative tendency with the water content. The processes susceptible to generate an increase of δ15N in soil are gaseous loss denitrification and volatilization. Indeed, this processes undergoing a significant isotopic fractionation leading to 15N enrichment of the residual substrates. The deepest zones are subject to a higher number of volatilization/nitrification-denitrification cycles which are enriched in 15N the substrates (NH4+, NO3-). In parallel, SOM and DOM compositions exhibit differences. NMR spectra of SOM show a predominance of C aliphatic whereas DOM is dominated by carbohydrate signal. Pyrograms of SOM show an important contribution of lignin derived pyrolysis products and alkane/alkene doublets, in agreement with NMR. Pyrolysis in presence of TMAH, which allows the detection of polar compounds, reveals numerous fatty acids (C16-C30) along with characteristic lignin derived acids. DOM pyrograms are almost similar except a relative lower contribution of lignin derived pyrolysis products. No significatve modification of SOM and DOM structure is observed either with depth or with the moisture content.

Keywords : soil organic matter, dissolved organic matter, carbon, nitrogen, spectroscopic methods, natural stable isotopic composition