Soil organic carbon stability in European mountain meadows

Soil organic carbon (SOC) stocks play a significant role in global climate regulation. CO₂ fluxes between soils and atmosphere partly depend on soil organic matter (SOM) biogeochemical stability. Cold ecosystems are generally characterized by a high SOC stock, a large part of it being stabilized by environmental conditions (e.g. low pH and temperature). SOC stocks of cold ecosystems are also supposed to be highly vulnerable to climate change that is cancelling the stabilizing effect of low temperature on SOM.

The aim of this study was to investigate the biogeochemical characteristics of SOM in mountain meadows at the European scale. Our goal was also to determine how environmental factors, including climate, elevation and plant functional traits could drive SOM stability and chemistry. To do so, we used the soil sample set of the ODYSSEE project (1), collected in 65 sites located in the main European’s mountains range (Alps, Pyrenees, Carpathians, Balkans). Topsoils (0–10 cm) from two plant communities (when both were present) were sampled in acidic meadows: Nardetum strictae and Caricetum curvulae. To assess SOM chemistry and biogeochemical stability, we used several indices based on Rock-Eval® 6 thermal analysis.

The topsoil samples showed a high concentration of organic carbon (114 ± 54 gC/kg of soil), and a weakly decomposed SOM as indicated by a relatively high C:N ratio (15 ± 2.5), hydrogen content (Rock-Eval® hydrogen index = 358 ± 44 mgHC/gC) and a relatively low oxygen content (Rock-Eval® $O_{RE6}$ = 151 ± 10 mgO₂/gC). The decomposition state of SOM increased with mean air temperature in winter. The size of the thermally labile SOC pool was high for all samples (pyrolysable SOC = 27 to 44% of total SOC), and it strongly increased with elevation. The size of the labile SOC pool (pyrolysable SOC) was also negatively correlated to a plant functional trait: the mean height of the plant community.
The topsoils of European mountains meadows have a high SOC content characterized by a globally high lability that further increases with elevation. The high lability of SOM revealed by Rock-Eval® 6 thermal analysis indicates a generally high vulnerability of SOC to climate change throughout European mountain meadows ecosystems.

The grass adaptative strategy developed under a cold climate induces lower plant height and higher carbon allocation to the root system. Higher carbon input to soil and/or allelopathic mechanisms protecting SOM from decomposition could possibly explain that lower plant communities of European acidic alpine meadows are characterized by a more labile SOM.