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Linking spatial patterns of soil redistribution traced with 137Cs and soil nutrients in a Mediterranean mountain agroecosystem (NE Spain)

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Mediterranean mountain agroecosystems are prone to soil loss mainly due to the accelerated erosion as a consequence of human induced changes from agriculture and grazing practices over the last centuries and the climatic conditions (i.e. irregular and scarce precipitations and drought periods). Soil erosion leads to soil degradation inducing the loss of soil functions. The progressive decline of soil functions thereof soil quality is associated to a decrease of soil productivity and can threat the sustainability of cultivated soils. The use of fallout 137Cs as a soil movement tracer provides useful data to identify areas where loss and gain of 137Cs occurs and that of soil.
This study aims to address soil movement and soil nutrient dynamics closely related to the status of soil degradation. A rain-fed cereal field (1.6 ha) representative of Mediterranean mountain agricultural landscapes (42°25'41"N 1°13'8"W) was selected to examine the effects of soil redistribution processes on the spatial variability of soil organic carbon (SOC) and nitrogen (SON) and their relationships with soil properties and topographic characteristics. From the hydrological point of view, the field is isolated due to the effect of landscape features and man-made structures. Climate is continental Mediterranean with an average annual rainfall of 500 mm and soils are Calcisols. The reference inventories of 137Cs and soil nutrients were established from 21 soil samples collected in nearby undisturbed areas under typical Mediterranean vegetation cover. A total of 156 bulk soil samples (30-50 cm depth) and 156 topsoil samples (5 cm) were collected on a 10 m grid. 137Cs and soil nutrients loss and gain areas were identified by comparing the reference inventories with the values of inventories at the sampling points. A new approach to characterize and measure active (ACF) and stable (SCF) carbon fraction contents by using a dry combustion method based on the oxidation temperature of carbon fractions to analyze the SOC pool dynamics is presented in this study. A detailed field topographic survey and mapping of the spatial variability of soil properties and nutrient contents from soil analyses displayed similar spatial patterns of 137Cs and soil nutrients that also were directly and significantly correlated ($p \leq 0.01$). As much as 70% of the surface of the study field had lower values of 137Cs inventory indicating a predominance of soil loss linked to a generalized loss of soil nutrients. SOC gain was found in less than 1% of the study field and there was a large loss of SON compared to the undisturbed reference site. Higher and significant ($p \leq 0.01$) contents of soil nutrients were found in topsoil samples than in the bulk ones. Furthermore, there was an enrichment of the relative contribution of ACF to total SOC in sampling points where there was a 137Cs gain in both bulk and topsoil samples. Understanding patterns of soil nutrients can be useful for developing and implementing land management strategies to preserve soil quality in Mediterranean agricultural areas.