Identifying sources of soil erosion and sediment deposition by fallout ^{137}Cs in a mountain catchment (South-Pyrenees)

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Under conditions of climate change and because of its influence on earth surface processes it is necessary to investigate the relationships between climate, physiographic factors, vegetation cover and erosion-deposition processes. Upland environments that sustain productive agricultural lands in the Mediterranean region are especially sensitive to changes in the factors that affect the patterns of soil erosion (Navas et al., 2008, López-Vicente et al., 2008), transport and deposition of sediments and have an impact on sediment budgets.

The use of radiotracers is of interest for the spatial analysis of sediment redistribution and to gain information on sediment transfers in mountain agreoecosystems (Navas et al., 2005; Porto et al., 2006; Gaspar et al., 2011). The application of radiotracer techniques has contributed to improve estimates of soil redistribution in recent decades. An approach to an integrated study of source-to-sink sediment fluxes in an upland small catchment by combining fallout ^{137}Cs and GIS is presented in this work.

A small catchment located in the central part of the Southern Pyrenees was selected to conduct this study. Point data of ^{137}Cs inventories across the catchment were derived from a grid sampling scheme and bulk core samples were collected at the intersections of a 100 x 100 grid. Estimates of soil erosion and deposition at the sampling points were obtained after calibration of ^{137}Cs data by using profile activity and mass balance models (Soto and Navas, 2004, 2008). Geostatistical interpolation methods were applied for deriving the spatial distribution of erosion and deposition rates in the catchment. GIS tools were used to establish the sediment budget in the catchment.

The spatial distribution of the rates of soil erosion and deposition indicates that higher soil redistribution occurs in the lowlands whereas lower rates are measured on steeper slopes. The distribution of the vegetation cover and the land uses in the catchment explain these apparently contradictory results. Mediterranean dense and open forests occupy the highlands and dense and open shrublands are interspersed along high to moderate slopes. Under these vegetation covers the mean erosion rates range between 3 - 17 Mg ha yr^{-1} while mean rates of soil deposition are lower (3 to 6 Mg ha yr^{-1}).

The agricultural uses in the catchment mainly occupy the lowlands with average slope gradients less than 12 %. The tillage practices are responsible for the higher rates of soil redistribution in the relatively gentle areas of this mountain catchment. Mean estimates of both soil erosion and deposition in fields of cereal crops amount to as much as - 40 Mg ha yr^{-1} and 43 Mg ha yr^{-1} for deposition. In the severely eroded grazing areas, where soil loss is the highest in the catchment mean rates of soil erosion are as much as -54 Mg ha yr^{-1} but deposition rates are much lower (2.4 Mg ha yr^{-1}).

The spatial distribution of the erosion and deposition areas indicates that percentages of eroded surfaces exceeded that of depositional areas (Table 1). The sediment budget estimated for the catchment indicates that intra-storage of sediments in the catchment amounts to 46 % of the total soil redistribution and that a net soil loss of around 14 % occurs.

The results outline the interest in combining radiotracing and GIS techniques to obtain comprehensive information on the sources and sinks of sediments and the factors that affect their redistribution in agricultural upland landscapes.

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References

Gaspar, L., Navas, A., Walling, D.E., Machín, J. Gómez-Arozamena, J., Using ^{137}Cs and ^{210}Pb to assess soil redistribution on slopes at different temporal scales. Catena doi:10.1016/j.catena.2011.01.004.

López-Vicente, M., Navas, A., Machin J., 2008: Identifying erosive periods by using RUSLE factors in mountain fields of the Central Spanish Pyrenees. Hydrol. Earth Syst. Sc. 12(2): 523-535.

Navas, A., Machín, J., Soto, J., 2005: Assessing soil erosion in a Pyrenean mountain catchment using GIS and fallout ^{137}Cs. Agr. Ecosyst. Environ. 105: 493-506.

Navas, A., Machín, J., Beguería, S., López-Vicente, M., Gaspar, L., 2008: Soil properties and physiographic factors controlling the natural vegetation re-growth in a disturbed catchment of the Central Spanish Pyrenees. Agr. Syst. 72(3): 173-185.

Porto, P., Walling, D.E., Callegari, G., Catona, F., 2006: Using fallout lead-210 measurements to estimate soil erosion in three small catchments in southern Italy. Water Air Soil Poll. 6: 657–667.

Soto, J., Navas, A., 2008: A simple model of Cs-137 profile to estimate soil redistribution in cultivated stony soils. Radiat. Meas. 43: 1285-1293.

Soto, J., Navas, A., 2004: A model of ^{137}Cs activity profile for soil erosion studies in uncultivated soils of Mediterranean environments. J. Arid Environ. 59: 719-730.