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A case study of soil erosion and sedimentation magnitudes in Morocco using 137-Cs & 210-Pbex

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Despite the severity of land degradation in Morocco, only limited data are available on the actual magnitude of soil erosion rates. Most of the previous research used conventional measurements. Since the mid 1990's only a few studies reported the use of the 137-Cs approach and, excess lead-210 (210-Pbex) as soil tracer in Morocco.

The site under investigation is a one hectare agricultural field dominated by cereals under conventional tillage (plough depth $\sim$ 16 cm) and semiarid climate located in Marchouch 68 km south east from Rabat (Morocco). In this field, 50 soil core samples were collected along 5 parallel transects. The initial 137-Cs and 210-Pb fallout were assessed through 12 core samples collected in an undisturbed pasture located 3 km from the field studied. After -spectrometry analysis, the areal activities of 137-Cs and 210-Pbex were converted into soil redistribution rates using the convertion model Mass Balance Model II (MBM II). Soil redistribution rates obtained from both isotopes were analyzed using geostatistic approach and a classical interpolation concept (Inverse Distance Weighting (IDW)). Maps of soil redistribution were established and a sediment budget for the whole field was calculated.

For the reference site, the vertical distribution associated with both radionuclides was similar and concentrated in the top 10 cm with a clear exponential decrease with depth. The reference inventories values were estimated at 3305 Bq m-2 (n = 12; CV of 30%) and 1445 Bq m-2 (n = 12; CV of 18%) for 210-Pbex and 137-Cs, respectively.

For the cultivated site, experimental variograms of soil redistribution rate calculated from the data provided by the 137-Cs and 210-Pbex results were fitted. Following the optimization of variographic parameters and the cross-validation analysis, the geostatistical study of the data set reported a very weak autocorrelation. So, a simple spatialisation of the data set using IDW2 was used to spatialise the soil redistribution magnitude based on 137Cs and 210Pbex results. Contours maps and soil redistribution budgets were established using the IDW2.
Similar results of soil redistribution were obtained using 137-Cs and 210-Pbex. From 137-Cs measurements, the erosion rates (over $\sim$ 50 yrs) in the study field ranged from 4 to 30 t ha-1 yr-1. The mean erosion rates and the net erosion reached 13.1 t ha-1 yr-1 and 11.7 t ha-1 yr-1, respectively. From 210-Pbex data, the erosion rates (over $\sim$ 100 yrs) ranged from 8 to 27 t ha-1 yr-1. The mean erosion rates and the net erosion reached 11 t ha-1 yr-1 and 10 t ha-1 yr-1, respectively.
The high sediment delivery ratio (SDR), corresponding to the ratio of the net erosion to the gross erosion rate obtained with 137-Cs (94%) and 210-Pbex (95%) approaches indicated that most of the sediment mobilized was moved out of the field. This is a logical result based on the fact that the soil cultivation is done in the main slope direction that can reach 17%. This high SDR also reflects the fact that using 137-Cs and 210-Pbex technique the eroded area represents 93 to 96% of the field surface and the deposition area was only 7 to 4%.

Keywords: Morocco, fallout radionuclides, 137-Cs, 210-Pbex, soil erosion mapping.