Geophysical Research Abstracts, Vol. 8, 01245, 2006
SRef-ID: 1607-7962/gra/EGU06-A-01245

Test of ^{134}Cs as soil erosion tracer under rainfall simulation

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Soil erosion processes may be estimated from ^{137}Cs spatial redistribution data. Relationships between radioisotope distribution and soil losses have been validated and used in many locations around the world. However, estimations of soil movement from residual ^{137}Cs may overestimate net loss and underestimate net deposition if the selectivity of erosion is not taken into consideration. In order to investigate this aspect, experimental erosion tests were conducted under controlled conditions in a greenhouse with ^{134}Cs-labelled soil and using rainfall simulator.

Twenty 0.35 m^2 boxes were filled with a loamy soil and placed on a 5 % slope. The soil of the boxes was labelled by a surface application of ^{134}Cs. This isotope was selected because it shows the same physical and chemical behaviour in soils as ^{137}Cs. Once applied, the radiocaesium was incorporated in the first 5 cm of soil. Ten boxes received 7100 Bq (20285 Bq m^{-2}) of ^{134}Cs and the other ten, twice this amount. At the downslope and of each experimental plot, a S-shaped stainless steel ramp was placed in such a way to force deposition of some part of the suspended load leaving the plots. Eroded sediments leaving the plots, those deposited on the ramp and those leaving the ramp could thus be sampled, analysed and compared to the source material they originated from. A GRS-II type rainfall simulator was used to generate runoff and erosion from the plots. Three successive 80 mm hr^{-1} were applied with a delay of 24 hours between each event. The first rain was for 30 minutes, the two other lasted 20 minutes. Radiocaesium measurements on soil and sediment samples were performed using a high purity coaxial germanium detector with a relative efficiency of 26 % and resolution of FWHM of 1.8 keV at 1.3 MeV. Counting times ranged between 7 000

and 50 000 seconds, to produce an error smaller than 10 % at the 0.05 significance level. All the values were adjusted to a common date of 30 January 2002. Some 200 samples were thus counted, 180 sediment samples and 20 soil samples.

For the twenty experimental plots, individual runoff coefficients ranged between 75 and 83 % and soil losses varied from 0.94 to 1.24 Mg ha^{-1}. The ^{134}Cs concentration of the plot soils, in the first 5 cm, varied from 90 to 345 Bq kg^{-1}.

For each simulated rainfall, the results indicate that the quantities of ^{134}Cs exported represent approximately 1 % of the initial inputs. Moreover, for the same soil loss, the loss of ^{134}Cs was directly proportional to the initial soil activity. Losses from plots having received 14200 Bq of radiocaesium produced sediments that showed a ^{134}Cs concentration 2 to 2.8 times that of the plots receiving 7100 Bq.

On the sediments eroded from the plots, the concentration was between 590 and 7550 Bq kg^{-1}. This translate into an average enrichment ratio (concentration on sediments divided by that on plot soils) of 16. The sediments that deposited on the flat section of the ramp showed a higher content in large particles, when compared to sediments eroded from the plots. This translated into lower radioceasium concentrations and lower enrichment ratios. At the opposite, the sediments leaving the downslope portion of the ramp were strongly enriched in fine particles. This was reflected by ^{134}Cs concentration that were, on the average, 23 times higher than on plot soils.

These results indicate that ^{134}Cs can be used for erosion studies. They also show that enrichment ratios of eroded sediments can be quite high and that this enrichment effect must be considered when comparing eroded material to the soil it originates from.

Key Words: Soil erosion, radioisotope, cesium-134 (^{134}Cs), simulated rainfall, selectivity.