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Measurements of the effectiveness of conservation agriculture at the field scale using radioisotopic techniques and runoff plots

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Growing evidence of the cost of soil erosion on agricultural land and off site impact of associated processes has emphasized the needs for quantitative assessment of erosion rates to develop and assess erosion control technology and to allocate conservation resources and development of conservation regulation, policies and programmes.
Our main study goal was to assess the magnitude of deposition rates using Fallout Radionuclides 'FRNs' (137-Cs and 210-Pb) and the mid-term (13 years) erosion rates using conventional runoff plot measurements in a small agricultural watershed under conventional and conservation tillage practices.

The tillage treatments were conventional tillage system (CT), mechanical plough to 30 cm depth (the most common tillage system within the watershed); conservation tillage (CS) with cover crops during winter; and direct seeding (DS) no tillage with cover crops during winter.
The experimental design - located in Mistelbach watershed 60 km north of Vienna/Austria - consists of one 3-metre-wide and 15-metre-long runoff plot (silt loam - slope of 14%) for each tillage system (CT, CS and DS) with the plots placed in the upper part of an agricultural field.

76 soil samples were collected to evaluate the initial fallout of 137-Cs and 210-Pb in a small forested area close to the experimental field, along a systematic multi-grid design,. In the sedimentation area of the watershed and down slope the agricultural field, 2 additional soil profiles were collected to 1 m depth. All soil samples were air dried, sieved to 2mm and analysed for their 137-Cs and 210-Pb contents using gamma detector.

The main results and conclusion can be summarised as following:

i) The initial 137-Cs fallout as measured in the 76 forested soil samples ranged from 1123 to 3354 Bq/m2 for an average of 1954 Bq/m2 with a coefficient of variation of 20.4 %.

ii) Long-term erosion measurements (1994-2006) from runoff plots located in the upper part of the agricultural field just up-slope from a deposition area reached 29.4 t/ha/year from the conventional tilled plot (CT), 4.2 t/ha/year from the conservation tillage plot (CS) and 2.7 t/ha/year from the direct seeding treatment (DS).
Soil losses were reduced significantly by a factor of 10 using no tillage, direct seeding treatment.
- From CS and DS 80% of the erosive events yielded a soil loss less than 1 t/ha/year. From CT plots only 72% of the events led to this low erosion amount, whereas about 4% of all events exceeded a soil loss of 50 t/ha/year. Under DS no soil loss > 50 t/ha was measured during the whole investigation period; under CS only 1.5% exceeded this threshold.

iii) Using 137-Cs data that integrate the 1954–2007 period, the sedimentation rates down slope of the field containing the runoff plots were estimated to be:
- a) 26.1 t/ha/year using the 137-Cs depth distribution profile
- b) 20.3 t/ha/year using the Mass Balance Model 2 (MBM2)
The erosion rates under conventional tillage are in agreement with the sedimentation rates estimated down slope of the field by the 137-Cs depth distribution profile and Mass Balance Model 2.

iv) In the lowest part of the watershed sedimentation rates of up to 50.5 t/ha/year were estimated through the 137-Cs depth distribution profile. These rates were greater than the average erosion rates measured by the erosion plots because this area is more representative of sedimentation processes that occur in the study area due to its topographical position and the basin geomorphology.

v) While 137-Cs produced exploitable results, the 210-Pb method was not applicable due to very low concentrations of 210-Pbex associated to a high uncertainty in the measurements.

vi) To control soil erosion and associated land degradation, there is a need to assess the impact of major land use and the effectiveness of specific soil conservation technologies. 137-Cs and runoff plots can be associated to assess the environmental impact and the magnitude of soil redistribution of soil conservation.

Keywords: Conservation agriculture; soil erosion; runoff plots; fallout radionuclides (FRN).