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Erosion and sedimentation evaluation in a small agricultural Austrian watershed using Caesium-137, Lead-210 and traditional approaches

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Quantitative and qualitative studies on degradation of arable soils have been carried out all over the world and water erosion has been identified as one of the major type of soil degradation. To integrate interannual climatic variability traditional soil erosion monitoring techniques require at least 10 years of measurements. Soil erosion can also be assessed by isotopic techniques based on the use of fallout radionuclides (FRN) that can integrate the last 50 years of soil redistribution. Fallout of Caesium-137 ($t_{1/2}$=30.17 years), an artificial radionuclide coming from thermonuclear weapon tests, and Lead-210 ($t_{1/2}$=22.26 years), a natural geogenic radioisotope, have been validated and used to quantify medium-term soil erosion/sedimentation rates under varied agro-environmental conditions.

In a small agricultural watershed located in Austria (Mistelbach), soil erosion and sedimentation magnitude were evaluated respectively using a combined approach based on conventional runoff plots measurement and FRN approaches (^{137}Cs and ^{210}Pb).

Mistelbach is situated 60 km north of Vienna in the so-called Wine Quarter. This region is one of the warmest and also driest parts of Austria. The landscape is characterized by gentle to fairly steep slopes. Long-term average precipitation reached 643

mm $yr^{-1}$and air temperatures 9.6 ˚C yr^{-1}. Soil textures range from silt loam to loam and crop rotation consists mainly of corn-small grains.

The study design consists of three runoff plots (3m x 15m) including a conventional tilled plot, a conservation tillage plot and one plot under direct seeding. Runoff and soil loss were measured using an automated erosion wheel. Based on the data collected during 1994-2006, the average soil erosion was 29.4 t ha^{-1} yr^{-1} from the conventional tilled plot, 4.2 t ha^{-1} $yr^{-1}$from the conservation tillage plot and 2.7 t ha^{-1} yr^{-1} from the direct seeding treatment. Compared to conventional tillage, conservational tillage and direct seeding in combination with cover crops during the winter period reduced the soil loss by 86 and 91%, respectively.

In order to test the use of FRN tools a potential reference site was searched as uneroded area. Because of the restricted number of permanent pasture and after compilation of background information coupled with field reconnaissance, the choice was deferred to an undisturbed forest within the Mistelbach watershed. In this reference site a classical exponential depth distribution of ^{137}Cs activity was found with 90% of the ^{137}Cs in the first 15 cm and no ^{137}Cs below 20 cm. The initial ^{137}Cs fallout were evaluated at 1954$\pm$91 Bq m^{-2} (n=76) with a coefficient of variation of 20.4 %.

Two one meter soil profiles were collected in the sedimentation area and analysed using the ^{137}Cs method. The areal activities of ^{137}Cs was converted into soil movement (t ha^{-1} yr^{-1}) using the Mass Balance Model 2 (MBM 2) and linked with the net erosion rates provided by the 13 years plot erosion measurements.

A sedimentation rate of 13.2 t^{-1} ha^{-1} $yr^{-1}$to 65 t^{-1} ha^{-1} yr^{-1} corresponding to an average layer deposition of 0.9 mm $yr^{-1}$and 4.7 mm yr^{-1}during the 1954-2007 period was evaluated from the ^{137}Cs data. If^{137}Cs reported exploitable results however the ^{210}Pb method was not applicable in the study site due to a very low level of $^{210}Pb_{ex}$ and a high γ-spectrometry measurement error.

This contribution demonstrates the complementarities of erosion plots and radioisotopic methods to assess erosion and sedimentation processes under different conservation cropping practices.

To better understand and quantify sediment mobilization, transfer and storages fluxes, our future investigations will focus on the comparison of the magnitude and spatial distribution of soil erosion/deposition using FRN especially ^{137}Cs (laboratory and in-situ measurements) and conventional measurement. Also geostatistical tools will be used to evaluate the spatial structure of the initial ^{137}Cs fallout in the undisturbed forested site.

Keywords: soil erosion; runoff plots; fallout radionuclide (FRN); ^{137}Cs;^{210}Pb.