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Quantifying variation in 7Be depth distribution under simulated rainfall for an increased understanding of fallout radionuclide use in erosion assessments

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Models for the use of 7Be as a sediment tracer are all based on the observed depth distribution of 7Be and the derived relaxation mass depth (h0). Spatial variations in h0 however are not quantified, although this could have major implications for model application.
In this study, 18 undisturbed soil cores (9.5 cm diameter, 7 cm depth) were collected at 2 reference locations, located 200 m from each other, near the field of interest (Nukerke, East Flanders, Belgium). Both locations were bare at time of sampling. Laboratory rainfall simulations with Be enriched water (0.5 mg/l) were performed on 16 of the undisturbed soil cores. After 3 rainfall simulations (30 minutes, average intensity 43 mm/h), the soil cores were cut in depth increments of 1.5 mm for Be analysis with ICP-OES after aqua regia digestion. The observed variation in depth distribution, and thus h0, was used for a model sensitivity analysis on a collected 7Be data set at an erosion plot nearby (Nukerke). Further, section cores for 7Be analysis were collected at both sites using 2 sectioning strategies, namely sectioning of undisturbed soil cores by a fine soil increment collector (FSIC) in the lab and in-field sectioning by scraping thin soil layers. Depth distributions of 7Be are measured by a high purity germanium gamma detector and strategies of sampling compared.
Comparison of both sectioning strategies revealed that scraping soil layers resulted in higher 7Be activities at all depths, most likely due to contamination from the upper layers during the scraping process. With the use of a FSIC, precise fine soil increments could be collected more accurately.
The variation in Be depth distribution after the rainfall simulations was studied within and between the reference sites. The depth distribution proved to be very similar among the different sampling sites within the first location (X), whereas more variation was measured within the second location (Y). When comparing both locations a general trend could be observed, with Be being more concentrated near the surface at X having an average surface Be concentration of 8.9 μg/g compared to 4.1 μg/g at location Y. In addition, elevated Be concentrations were observed till an average mass depth of 6.5 kg/m^2 at X while this was up to 16.7 kg/m^2 at location Y. The h0 followed this trend with higher values at the Y location, showing a deeper penetration of Be in the soil. After the rainfall simulations, infiltration and bulk density measurements respectively showed lower infiltration and a higher compaction at location X, indicating the importance of soil structure on the depth distribution of short term fallout radionuclides. X-ray tomography is performed to map the pore distribution in the cores.
These results indicate the importance of selecting proper reference sites. As soil structure can strongly influence 7Be depth distribution, it can strongly influence total modeled sediment redistribution. Hence selected reference sites should have similar soil structure and a similar recent history of tillage. Finally, the use of a FSIC is strongly recommended for 7Be studies.