239 + 240Pu from “contaminant” to soil erosion tracer: Where do we stand?

ID 4220956
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Year 2017
Title 239 + 240Pu from “contaminant” to soil erosion tracer: Where do we stand?
Journal Earth Science Reviews
Volume 172
Pages / **Article-Number** 107-123
Keywords Plutonium; Soil degradation; FRN; Fallout radionuclides; Cs; Review
As soil erosion is the major threat to one of the most essential resources of humankind, methods to quantify soil redistribution are crucial for agro-environmental assessment as well as for optimisation of soil conservation practices. The use of fallout radionuclides (FRN) as soil redistribution tracers is, next to modelling, currently the most promising approach for assessing soil erosion. This review aims to evaluate the suitability of Plutonium (Pu) in general and the 239+240Pu isotopes in particular as soil redistribution tracers. It provides information on its origin, distribution and behaviour in soils and in the environment. Analytical methods, their recent advances as well as limitations, are discussed. To establish the current state of knowledge and to deepen our understanding, particular attention is given to the main existing achievements and findings based on using 239+240Pu as soil erosion tracer in agroecosystems. We further discuss similarities and differences to other more mature FRN techniques such as the 137Cs based approach which has been until now the most widely used method. We conclude that 239+240Pu has the potential to become the next generation of soil redistribution tracer compared to the more mature FRN techniques mostly due to (i) its long half-life guaranteeing its long-term availability in the environment, (ii) its analytical advantage in terms of measurement precision and measurement time and (iii) its greater homogeneity at reference sites due to its main origin from past atmospheric nuclear weapon tests. In identifying some key future research opportunities and needs, we hope to refine the efficiency of this promising agro-environmental tracer for effective soil redistribution studies under future climate and land use change.
Publisher Elsevier
ISSN/ISBN 0012-8252
edoc-URL http://edoc.unibas.ch/59125/
Full Text on edoc Available;
Digital Object Identifier DOI 10.1016/j.earscirev.2017.07.009