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► To cite this version:

Marion Le Gall, Olivier Evrard, François Thil, Anthony Foucher, Salvador-Blanes Sébastien, et al.. Application of strontium isotope measurements to trace sediment sources in an upstream agricultural catchment (Loire River basin, France). EGU General Assembly 2015, Apr 2015, Vienne, Austria. cea-02648005

HAL Id: cea-02648005

<https://cea.hal.science/cea-02648005>

Submitted on 29 May 2020

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Application of strontium isotope measurements to trace sediment sources in an upstream agricultural catchment (Loire River basin, France)

Marion Le Gall (1), Olivier Evrard (1), François Thil (1), Anthony Foucher (2), Sébastien Salvador-Blanes (2), Olivier Cerdan (3), and Sophie Ayrault (1)

(1) Laboratoire des Sciences du Climat et de l'Environnement, (LSCE), UMR 8212 (CEA/CNRS/UVSQ) – Bâtiment 12, Avenue de la Terrasse, F-91198, Gif-sur-Yvette, France, (2) Laboratoire GéoHydrosystèmes Continentaux (GéHCO), E.A 6293, Université F. Rabelais de Tours, Faculté des Sciences et Techniques, Parc de Grandmont, 37200 Tours, France, (3) Département Risques et Prévention, Bureau de Recherches Géologiques et Minières (BRGM), 3 avenue Claude Guillemin, 45060 Orléans, France

Soil erosion is recognized as one of the main processes of land degradation in agricultural areas. It accelerates the supply of sediment to the rivers and degrades water quality. To limit those impacts and optimize management programs in such areas, sources of sediment need to be identified and sediment transport to be controlled.

Here, we determined the sources of suspended sediment in the Louroux (24 km², French Loire River basin), a small catchment representative of lowland cultivated environments of Northwestern Europe. In this catchment, channels have been reshaped and 220 tile drain outlets have been installed over the last several decades. As a result, soil erosion and sediment fluxes have increased drastically.

The variation of ⁸⁷Sr/⁸⁶Sr ratios, driven by the weathering of rocks with different ages and chemical composition, may reflect the mixing of different sediment sources. Strontium isotopic ratios (⁸⁷Sr/⁸⁶Sr) were therefore determined in potential soil sources, suspended particulate matter (SPM) and a sediment core sampled in the Louroux Pond at the catchment outlet.

Soil, SPM and core samples displayed significantly different isotopic signatures. ⁸⁷Sr/⁸⁶Sr ratios in soil samples varied from 0.712763 to 0.724631 ± 0.000017 (2σ, n=20). Highest values were observed in silicic parts of the catchment whereas the lower values were identified in a calcareous area close to the Louroux Pond. ⁸⁷Sr/⁸⁶Sr ratios in SPM (0.713660 to 0.725749 ± 0.000017, 2σ, n=20) plotted between the soil and sediment core (0.712255 to 0.716415 ± 0.000017, 2σ, n=12), suggesting the presence of particles originating from at least two different lithological sources, i.e. silicic rocks and carbonate material. Variations in ⁸⁷Sr/⁸⁶Sr ratios in the outlet core sample were used to reconstruct the sedimentary dynamics in the catchment during the last decades.

These results will guide the future implementation of appropriate management practices aiming to reduce erosion in upstream catchments and the subsequent transport of sediment degrading the stream systems and the filling of reservoirs.

Keywords: soil erosion; ⁸⁷Sr/⁸⁶Sr isotopic ratio; end-members; mixing models