Constraining sediment dynamics in rivers using fallout radionuclides: How to move forward from the lessons learnt in catchments of Mexico, Laos and France

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ABSTRACT

Land use change (e.g. deforestation, overgrazing, cropping intensification) and the associated acceleration of soil erosion have led to an increase in sediment supply to rivers across the world during the last decades. This degradation leads to important on-site (e.g., decrease in soil fertility) and off-site (e.g., reservoir siltation and water pollution) impacts. In order to better understand the dynamics of sediment in catchments and rivers and to implement efficient mitigation measures, it is necessary to better constrain the pathways of sediment in time and space. Fallout radionuclides characterized by different half-lives and origins (Be-7, Cs-137, and unsupported Pb-210) have proved to provide very useful indications to constrain the transfer times of sediment at various scales (plot, hillslope, small catchment, large basins) and in a range of different environments and climates across the world. However, several limitations were raised regarding the assumptions underpinning the methods used to derive sediment residence time or transport distances. Furthermore, doubts regarding the validity of using those tracers in large rivers and catchments were also put forward in recently published papers.

In this study, we provide additional data indicating that the hypotheses underlying the method are meaningful. We also compiled radionuclide data (Be-7, Cs-137, and unsupported Pb-210) measured in both rainfall and suspended sediment during recent studies that were conducted between 2009−2013 in catchments of different sizes (3−60,000 km²) and located in different environments (Central Mexico, Northern Laos, France). The results obtained in the different catchments are compared and reinterpreted, with the specific objective of dealing with the limitation that fresh Be-7 fallout may not label river bank or subsurface material.

The results show that providing additional and independent information on the sources delivering sediment to the rivers helps constraining their transit times with the method based on Be-7 and unsupported Pb-210 measurements. Implications of the use of this technique in larger rivers and catchments are discussed. Their contribution to quantify the persistence time of particle-borne contaminants in those riverine systems is specifically addressed.