Geophysical Research Abstracts
Vol. 14, EGU2012-8964, 2012
EGU General Assembly 2012

Lead isotopes in sediments of the Loire River (France): natural versus anthropogenic origin

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Sediments along the Loire River (central France) were investigated by means of lead isotopes determined on the labile sediment fraction, or acid-extractable matter (AEM). The combination of trace elements and lead isotopes allows deciphering the origin of the elements (i.e. natural or anthropogenic) and their history, both in the sediment and soil from two small watersheds (one draining basalt, the other one granite-gneiss gneiss in the upper part of the catchment), in present-day suspended matter in Loire River water, and in sediment from the Loire estuary.
Fe-Mn oxides act as the main carrier phase of the elements in the AEM extracted by cold HBr, Th and Pb concentrations were determined by ICP-MS and lead isotopes by ICP-MS-MC Neptune. Thorium displays mostly insoluble behaviour in hydrosystems, but the small amount of dissolved Th shows a strong tendency to be adsorbed onto oxyhydroxides. Therefore, Mn and Th (as well as other trace elements) correlate well in AEM, the correlations of Mn, and Pb with Th as a typical indicator of crustal weathering points to their derivation from the silicate basement of the upstream part of the catchment.
Crustal weathering, as confirmed by the Pb-isotope ratios for most sample points, is the main natural source of lead in the upstream part of the Loire River, as well as that transported in the middle part of the basin and up to the estuary.
Among anthropogenic sources, the use of Pb-isotopic compositions shows an influence of agricultural lead-derived inputs and a large input from lead as a gasoline additive, particularly in the estuary due to harbour activities and for one downstream tributary river that is strongly marked by this type of lead input.