Lead isotope signatures in different particle sizes and chemical fractions from Athens urban soil: possible linkage with house dust

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Abstract

We investigated Pb distribution and isotope compositions in various particle sizes (< 2000 μm, < 200 μm, < 100 μm, < 70 μm, < 32 μm) and chemical fractions (total digestion, 0.05 M EDTA and 0.11 M acetic acid (HAc)) from contaminated urban soils from Athens, Greece. A gradual increase in total Pb concentrations with decreasing particle size fraction was observed. Lead concentrations extracted by EDTA and corresponding percentual extractabilities were also higher in the < 32 μm fraction (medians 137 mg kg^{-1} and 44%, respectively). $^{206}Pb/^{207}Pb$ isotope ratios of soil samples (range 1.140-1.180, average 1.159 ± 0.016) measured by inductively coupled plasma mass spectrometer (ICP-MS; ICapQ, Thermo Scientific, Germany) were evenly distributed among the various particle size fractions. Differences in the $^{206}Pb/^{207}Pb$ isotope ratios among the digests and extracts were not seen; nonetheless, the steep decrease in the $^{206}Pb/^{207}Pb$ ratios with respect to the low HAc-extracted Pb concentrations suggests that this chemical extraction captures the most labile anthropogenic Pb fraction in the soil. The isotope composition of environmental materials (tunnel dust, recycled battery sludge) and local bedrock samples were used to characterize anthropogenic and natural Pb in the soil. The existing levels of Pb contamination in Athens soil is a combined effect of regional highly radiogenic natural (rock-derived) Pb ($^{206}Pb/^{207}Pb$ = 1.200) and the re-suspension of Pb-bearing particulates deposited from past vehicular exhaust emissions of leaded gasoline with distinctly low Pb isotope composition ($^{206}Pb/^{207}Pb$ = 1.059). The $^{206}Pb/^{207}Pb$ isotope ratios of vacuum house dusts (range 1.138-1.167, average 1.159 ± 0.020) from Athens residents is mostly comparable to that of urban soil suggesting that exterior soil particles are transferred into homes. As a result, anthropogenic Pb in house dust from Athens urban environment principally originated from soil particles containing Pb from automobile emissions (former use of leaded petrol).