

Bioavailability and Sources of Lead in the Terrestrial Environment of Egypt

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Lead (Pb) is considered a major contemporary eco-toxicological threat with smelting operations and fossil fuel combustion regarded as the major sources in the environment. The majority of studies characterising Pb in soil have sought to determine: (i) its source, from ^{206}Pb , ^{207}Pb , ^{208}Pb isotope ratios, (ii) its distribution among operationally defined soil fractions and (iii) its lability as defined by chemical extraction or isotopic exchangeability. The objectives of the current work were: (i) to source-apportion the soil Pb burden in Egypt between petrol, geological and other origins over a wide range of soil characteristics and diverse locations; (ii) to quantify the isotopically exchangeable fraction of Pb (Pb_E) as a measure of Pb reactivity; and (iii) to develop multivariate relationships to predict soil Pb lability. Combined determinations of SEP fractionation, isotopic lability and natural isotopic abundances were used as a means of characterizing Pb in ~ 150 Egyptian soils (selected to cover a wide range of soil properties, locations and Pb exposure). Results showed a wide range of $\% \text{Pb}_E$ values ($\sim 5 - 40\%$ of the total soil Pb concentration, Pb_{total}). However, Pb_E showed no consistent correspondence to any single fraction of the SEP. Non-labile Pb ($\text{Pb}_{total} - \text{Pb}_E$) showed reasonable agreement with the SEP 'residual' fraction in relatively uncontaminated soils from both inland and shoreline soils. However, in other soils, notably those from contaminated peri-urban and urban locations, the *non*-residual fractions (bound to oxides and humus) included non-labile forms of Pb. Up to 90% of the observed variability in the $\% \text{Pb}_E$ in soils from the inland and shoreline areas (uncontaminated) could be explained by soil factors, including variation in soil pH, soil organic matter content, total Pb and P concentrations. However, in the case of the contaminated peri-urban and urban soils the figure was only 33% implying a significant contaminant 'source' effect on Pb lability. Isotopic ratios ($^{206}\text{Pb}/^{207}\text{Pb}$ and $^{208}\text{Pb}/^{207}\text{Pb}$) fell on a mixing line between end-members attributed to petrol and regional geogenic Pb sources and clearly showed a distinction between Pb from geogenic and anthropogenic sources (mainly petrol-derived Pb). In contaminated locations, there was clear evidence that petrol-derived Pb, in average, remained considerably more labile than Pb from the soil parent material. However, in all samples, both petrol-derived and geogenic Pb contributed to the labile fraction depending on soil conditions.