Bioavailability and Sources of Lead in the Terrestrial Environment of Egypt

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Introduction

Soils retain Pb originating from a range of sources. The *bioavailability* of soil Pb may depend on characteristics of both soil *and* the original source. Lead is present as a mix of four isotopes (^{204,206,207,208}Pb) which can help indicate the source of the soil Pb (Fig. 1).

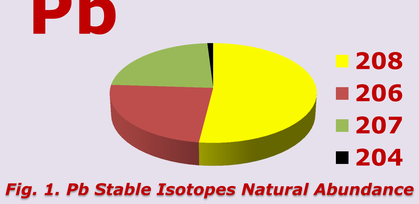

Fig. 1. Pb Stable Isotopes Natural Abundance

This work aimed to: (i) identify Pb sources using characteristic Pb isotope ratios (ii) quantify the reactive fraction of Pb by isotopic dilution with the minor isotope ^{204}Pb and (iii) develop a model to predict the isotopically exchangeable pool based on soil properties.

Methods

I- Lead concentrations, and Pb isotopic abundances (IA), in acid digestions (HNO_3, $HClO_4$, HF) of 150 widely distributed Egyptian soils were measured by ICP-MS (Fig. 2).

II- Isotopic exchangeability of soil Pb ($\%Pb_E$) was measured by spiking soil suspensions with enriched ^{204}Pb (99.4% IA) and determining the IA values of ^{204}Pb and ^{208}Pb in the suspension solution phase (Eq. 1).

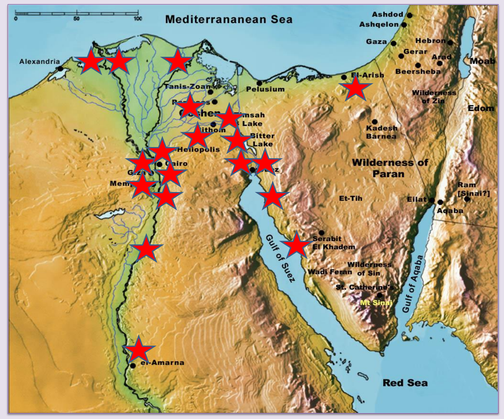

Fig. 2. Sampling Locations

The value of labile Pb (Pb_E) (mg kg^{-1}) was calculated from Eq. 1.

$$Pb_E = \left(\frac{M_{soil}}{W}\right)\left(\frac{C_{spk}V_{spk}}{M_{spk}}\right)\left(\frac{^{204}IA_{spk} - {}^{208}IA_{spk}Rss}{^{208}IA_{soil}R_{ss} - {}^{204}IA_{soil}}\right) \quad \text{Eq.1.}$$

M is the average atomic mass of Pb, W is the mass of soil (kg), C_{spk} is the conc. of Pb in the spike (mg L^{-1}), V_{spk} is the volume of spike (L), and Rss is the equilibrium ratio (^{204}Pb:^{208}Pb).

Multiple regression models were used to predict the labile pool of Pb ($\%Pb_E$) from soil variables (Eq.2).

$$\%Pb_E = a + b(pH) + c(Pb_T) + d(P_T) + e(\%SOM) \quad \text{Eq.2.}$$

(Pb_T) and (P_T) are total lead and phosphorus conc., respectively; a, b, c, and d are constants

Results

I- The Pb isotopic compositions of all soil samples fell close to a binary 'mixing line' between the two end-members (Background geogenic Pb and Petrol Pb) suggesting that these are the dominant sources of Pb (Fig.3). However, substantial scattering around the mixing line may indicate the presence of additional sources of Pb.

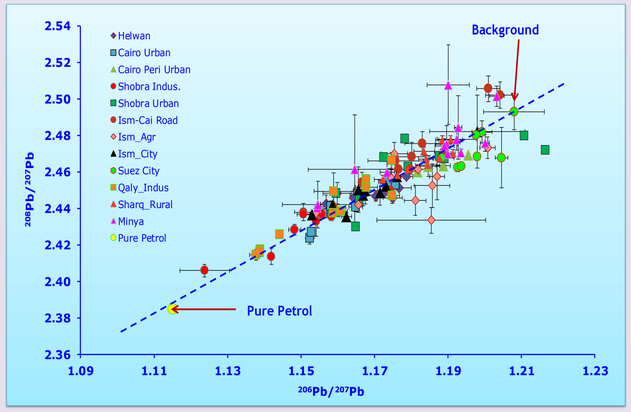

Fig. 3. Isotopic ratios of ^{206}Pb/^{207}Pb and ^{208}Pb/^{207}Pb in all soils with Petrol-Pb and background geogenic Pb end members indicated.

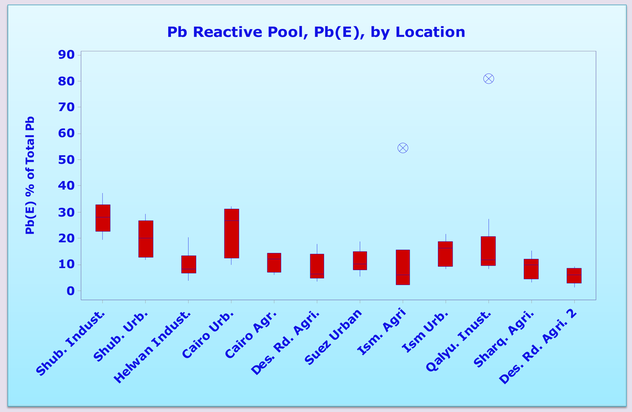

Fig. 4. Values of labile Pb ($\%Pb_E$) at all sampling locations

III- Fig.5 shows that the predicted values of Pb lability ($\%Pb_E$) from soil properties were in reasonable agreement with measured values (R^2 = 0.8; RSD 10%). Generally, 85 and 92 % of the variability in the $\%Pb_E$ could be predicted from total Pb content and pH, respectively. However, in phosphate rich soils, the total-P content was the major factor accounting for the variance.

II- A wide range of $\%Pb_E$ values(~ 5 – 40 %) were found in Egyptian soils (Fig.4). Lead lability was greatest around urban and industrial locations, perhaps indicating that the anthropogenic Pb remained more labile compared to geogenic Pb. However this pattern is also consistent with a greater soil Pb concentrations showing greater average 'reactivity' due to weaker adsorption.

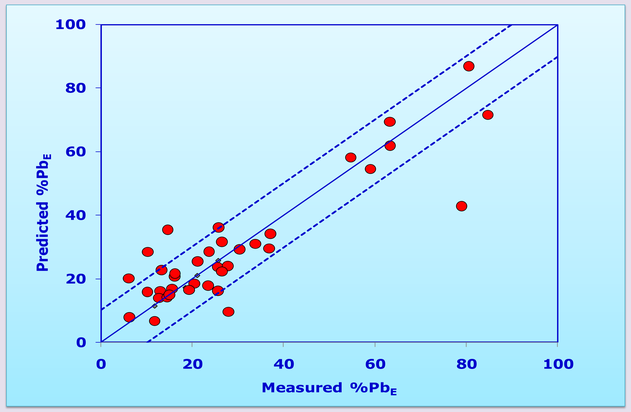

Fig. 5. Predicting $\%Pb_E$ from pH, % SOM and total P and Pb concentrations. Solid and broken lines represent the 1:1 relation and ± RSD, respectively.