

Source delineation of bioaccumulated Lead (Pb) in plants through isotope fingerprinting: Soil vs dry Deposition

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Epiphytes derive their nutrients from both air and the substrate on which they grow. Hence it remains a moot question as to what are the source(s) of non-essential toxic elements such as Pb in epiphytes. Concentration and Pb isotopic studies on fern species from the Indian megacity of Calcutta reveals that $[Pb]_{\text{root}}$ ($12.74 \pm 6.7 \text{ mg.kg}^{-1}$) is ~ 4.4 times higher than $[Pb]_{\text{clean leaves}}$ ($5.37 \pm 5.0 \text{ mg.kg}^{-1}$) of the ferns. However, the Pb isotopic composition of the roots ($^{206}\text{Pb}/^{207}\text{Pb} = 1.1365 \pm 0.01$) and leaves ($^{206}\text{Pb}/^{207}\text{Pb} = 1.136 \pm 0.006$) was distinctly different from the bulk soil ($^{206}\text{Pb}/^{207}\text{Pb} = 1.1650 \pm 0.02$). The $^{206}\text{Pb}/^{207}\text{Pb}$ compositions of the roots were analytically indistinguishable from the passively deposited dust (PD) (1.1321 ± 0.004) and PM_{10} fraction of aerosols (1.1389 ± 0.01). This indicates biological uptake of Pb by the roots is sourced from atmospheric dust.

As the bulk soil Pb is isotopically distinct from the root and plant tissues (leaf) we performed sequential extraction of the bulk soil. The leaching steps included extraction of the (i) exchangeable fraction (SE) by 1M Sodium Acetate at pH 7.8; (ii) carbonate fraction (SC) by 1M Sodium Acetate adjusted to pH 5 with Acetic acid; (iii) reducible/Fe-Mn fraction (SR) in 0.04 M Hydroxylamine hydrochloride dissolved in 25 % (v/v) acetic acid; and (iv) dissolution of silicate fraction (SS) in concentrated Nitric and Hydrofluoric acid mixture (3:1).

The Pb concentration and isotopic compositions as measured by single collector QQQ-ICP-MS revealed that the root and leaf compositions are analytically indistinguishable from SE ($^{206}\text{Pb}/^{207}\text{Pb} = 1.1397 \pm 0.01$; $[Pb] = 1.94 \pm 3.7 \text{ mg.kg}^{-1}$), SC ($^{206}\text{Pb}/^{207}\text{Pb} = 1.1339 \pm 0.01$; $[Pb] = 0.19 \pm 0.2 \text{ mg.kg}^{-1}$) and SR ($^{206}\text{Pb}/^{207}\text{Pb} = 1.1343 \pm 0.005$; $[Pb] = 1.02 \pm 0.76 \text{ mg.kg}^{-1}$). Whereas the SS fraction ($[Pb] = 4.72 \pm 3.7 \text{ mg.kg}^{-1}$) have distinctly different $^{206}\text{Pb}/^{207}\text{Pb}$ composition (1.1588 ± 0.01). Furthermore, the Pb in the SE, SC and SR fractions were isotopically identical to the PD and PM_{10} fraction aerosols. Thus, it is difficult to discern the source(s) [air or non-silicate fraction of soil] of Pb in ferns solely based on Pb isotopic composition and needs further investigation.

