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Integrating lead isotope and oral bioaccessibility data for source apportionment of trace elements in kindergarten dust

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Due to the hand-to-mouth activities frequently observed among the youngest children, they are likely to ingest higher amounts of indoor dust than adults. Since pre-schoolers are prone to exposure to potentially toxic elements through the ingestion route, characterising exposure within kindergarten microenvironments is paramount for children who spend considerable time in school. Ergo, an interdisciplinary study encompassing five kindergartens in the Estarreja municipality, was carried out. Indoor dust, playground dust, and garden soil samples were collected from the kindergartens. Near total concentrations of 51 elements were determined by ICP-MS, and the oral bioaccessibility of chromium (Cr), cobalt (Co), nickel (Ni), cadmium (Cd), arsenic (As) and lead (Pb) was estimated using the Unified BARGE Method. Isotopic measurements of lead were performed by ICP-MS in the bulk dust samples and solid residues resulting from the UBM extractions. The Kruskal-Wallis omnibus test showed no significant differences in the total and bioaccessible concentrations of Co and As in soil, outdoor and indoor dust samples. Pairwise comparisons performed using the Dunn-Bonferroni post hoc method showed different distribution patterns for some PTEs. Three elements (Cd, Ni and Pb) show significant differences ($p < 0.05$) between total concentrations in soil and indoor dust samples. The bioaccessible fraction of the Pb and Ni is significantly higher ($p < 0.05$) in indoor dust samples than in garden soil. The isotope ratios 206Pb/207Pb and 208Pb/206Pb of garden soil are significantly different ($p < 0.05$) from those measured in the dust. Differences between the isotopic composition of bulk samples and UBM residues are not statistically significant. We propose a methodology for source apportionment and provenance analysis using the bulk dust sample and the residues of the UBM extractions.