The solid phase distribution and bioaccessibility of potentially harmful elements in natural ironstone soils in the UK

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Chemical reactions and physical and biological processes influence the mobility of potentially harmful elements (PHEs) present within soils. In the UK, soil PHE such as arsenic (As), chromium (Cr) and nickel (Ni) occur at elevated concentrations in soils derived from ironstone parent materials. Exposure to soil PHE via oral ingestion, inhalation or dermal uptake poses a potential risk to human health. However, PHE mobility in soils is governed by its solid phase distribution within the soil matrix and therefore the presence of PHE may not indicate a risk to human health.

This study examines the geochemical forms of As, Cr Ni, found in ironstone derived topsoils from north Oxfordshire in the UK, where total concentrations were in the range 14.0 – 417 mg kg^{-1} As, 51.0 – 447 mg kg^{-1} Cr and 17.0 – 218 mg kg^{-1} Ni. Solid phase distribution information was determined by the application of a non-specific sequential extraction methodology combined with self modelling mixture resolution of the concentrations of elements in the extract solutions, determined by ICP-AES. Seven distinct physico-chemical components, including iron (Fe), manganese (Mn) and aluminium (Al) oxides, calcium (Ca) carbonates, organic and fertilizer sources were identified in the Oxfordshire soils, all of which were identified as being hosts to one or more of the PHE of interest. Estimates of PHE intake via the oral ingestion route were determined using an *in vitro* physiologically based gastro-intestinal simulation bioacessibility test. Bioaccessible PHE concentrations ranged from 1.60 – 12.8 mg kg^{-1} As, 0.55 – 2.02 mg kg-1 Cr and 1.18 – 4.52 mg kg^{-1} Ni. The combination of bioaccessibility data with mobility/solid phase distribution information provided by the sequentional extraction methodology indicates that: Fe oxides are the predominant host of immobile As and Cr; mobile As is associated with carbonates and organic phases; relatively mobile Cr with Mn/Al oxides; mobile/relatively mobile Ni is predominant in Al/Mn oxide components and carbonate soil components. The coupling of sequential extraction and bioaccessibility techniques provides a robust approach to understanding the relationship between PHE mobility and the potential human health risks from soil exposure via ingestion.

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