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Application of Human Biomonitoring and Physiologically-Based Pharmacokinetic Modelling to Quantify Exposure to Selected Toxic Elements in Soil

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Abstract : Current exposure models used in contaminated land risk assessment are highly conservative. Use of these models may lead to over-estimation of actual exposures, possibly resulting in negative financial implications due to un-necessary remediation. Thus, we are carrying out a study seeking to improve our understanding of human exposure to selected toxic elements in soil: arsenic (As), cadmium (Cd), chromium (Cr), nickel (Ni), and lead (Pb) resulting from allotment land-use. The study employs biomonitoring and physiologically-based pharmacokinetic (PBPK) modelling to quantify human exposure to these elements. We recruited 37 allotment users (adults > 18 years old) in Scotland, UK, to participate in the study. Concentrations of the elements (and their bioaccessibility) were measured in allotment samples (soil and allotment produce). Amount of produce consumed by the participants and participants' biological samples (urine and blood) were collected for up to 12 consecutive months. Ethical approval was granted by the University of Reading Research Ethics Committee. PBPK models (coded in MATLAB) were used to estimate the distribution and accumulation of the elements in key body compartments, thus indicating the internal body burden. Simulating low element intake (based on estimated 'doses' from produce consumption records), predictive models suggested that detection of these elements in urine and blood was possible within a given period of time following exposure. This information was used in planning biomonitoring, and is currently being used in the interpretation of test results from biological samples. Evaluation of the models is being carried out using biomonitoring data, by comparing model predicted concentrations and measured biomarker concentrations. The PBPK models will be used to generate bioavailability values, which could be incorporated in contaminated land exposure models. Thus, the findings from this study will promote a more sustainable approach to contaminated land management.

Keywords : biomonitoring, exposure, PBPK modelling, toxic elements
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