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USE OF BIOACCESSIBILITY TESTING IN HUMAN HEALTH RISK ASSESSMENT OF CCA-CONTAMINATED SOILS

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Extended Abstract

In human health risk assessment (HRRA), soil ingestion can be a major exposure route to soil contaminants for children. Health criteria values obtained from toxicological and epidemiological studies can overestimate health risks when applied to risk assessment of metal contaminated soils. Such contaminated soils can be found in soils immediately adjacent to chromated copper arsenate (CCA)-treated wood structures and utility poles. In case of incidental soil ingestion by children, what percentage of the total metal concentration in the soil will be absorbed in their gastrointestinal tract? Oral bioavailability is defined as the fraction of a contaminant that remains in the organism and reaches the systemic circulation from the gastrointestinal tract. Previous studies have shown that oral bioavailability of soil metals depends on soil type and contaminant bonding. Because of default estimates' limitations, site-specific results of oral bioavailability may be required for an appropriate exposure assessment.

To decrease costs and avoid technical and ethical difficulties inherent to in vivo studies with animals, numerous in vitro methods have been developed in the past decade as simple, cheap, and reproducible tools to evaluate gastrointestinal bioavailability. In vitro methods measure the contaminant bioaccessibility, which is the soluble fraction of the contaminant dissolved in the gastrointestinal environment, which is potentially available for absorption.

The objective of this paper is to discuss the use of bioaccessibility tests in HHRA of metallic contaminants in soils. The discussion focuses on arsenic, chromium, and copper. A short review of current knowledge is presented and applicability and limitations of bioaccessibility tests are discussed. The regulatory position of environmental protection agencies in North America and European countries regarding the use of bioaccessibility tests in HRRA is also presented. The results from a case study conducted in the Montreal area (Canada), where bioaccessibility was assessed in soils immediately adjacent to chromated copper arsenate (CCA)-treated utility poles are also presented.

Because of the potentially high metal concentrations found in soils immediately adjacent to chromated copper arsenate (CCA)-treated wood structures and utility poles, CCA-contaminated soil ingestion may be a significant exposure route to Cr, Cu, and As for children. Therefore, a strong need exists to provide data on oral bioavailability of these elements in field-collected CCA-contaminated soils. The objectives of this study were (1) to assess the bioaccessibility (IVG method) of As, Cr and Cu in contaminated soils collected near in-service CCA-treated utility poles, (2) to determine the influence of selected soil

properties on their bioaccessibility, and (3) to estimate an average daily metal intake from incidental soil ingestion.

Total soil arsenic concentrations in soils (< 300 µm) varied from 37 ± 2 to 251 ± 12 mg/kg (mean: 169 ± 69 mg/kg), irrespective of soil organic matter content. Arsenic bioaccessibility ranged between 25.0 ± 2.7 and 66.3 ± 2.3 % (mean value: 40.7 ± 14.9 %), and was influenced by soil properties and arsenic fractionation. The in vitro arsenic bioavailability was in agreement with the in vivo arsenic bioavailability reported by Casteel et al. (2003) in soil collected adjacent to CCA-treated utility poles. Bioaccessible arsenic was positively correlated (n = 12) with total organic carbon content ($r^2 = 0.36$, $p < 0.05$) and with water-soluble arsenic ($r^2 = 0.51$, $p < 0.01$), and was negatively correlated with clay content ($r^2 = 0.43$, $p < 0.05$). Using conservative exposure parameters, the mean daily arsenic intake from incidental ingestion of contaminated soil near CCA-treated utility poles was 0.18 ± 0.09 µg As/kg/d (range: 0.05-0.32). The maximum potential intake would occur following exposure to CCA-impacted organic soils (mean daily intake of 0.27 µg As/kg/d) and sandy soils (mean daily intake of 0.22 µg As/kg/d).
These arsenic intakes were lower than the non carcinogenic oral minimal risk levels for chronic and acute intake of arsenic (0.3 and 5 µg/kg/d) and appeared negligible compared to the daily intake of inorganic arsenic from water and food ingestion for children.

Cr and Cu bioaccessibilities (IVG method) were determined on surface soil samples collected immediately adjacent to 12 CCA-treated utility poles after 18 months of service. Bioaccessible Cr and Cu were also determined in 3 certified reference materials. Total soil Cu concentrations in soils varied from 95.6 ± 4.5 to 3,580 ± 680 mg/kg, whereas total soil Cr concentrations were lower and ranged between 26.4 ± 2.1 to 394 ± 53 mg/kg. Copper gastrointestinal bioaccessibility ranged between 19.4 ± 3.6 % and 89.4 ± 4.9 % (mean value: 54.1 ± 23.4 %) whereas Cr bioaccessibility varied from below detection (< 0.3 %) to 32.9 ± 17.6 % (mean value: 8.5 ± 10.1 %). Bioaccessible Cr and Cu were both negatively correlated with silt content ($r^2 = 0.39$, $p < 0.05$, and $r^2 = 0.65$, $p < 0.005$, respectively). Copper bioaccessibility was also negatively correlated with total organic carbon content ($r^2 = 0.64$, $p < 0.01$).
Using conservative exposure parameters, the mean potential Cr intake from incidental ingestion of soil near CCA-treated utility poles was very low (0.03 ± 0.03 µg Cr/kg body weight/d). The estimated mean Cu intake was also low (2.5 ± 1.2 µg Cu /kg body weight/d) in spite of its higher bioaccessibility. These values are much lower than the dietary reference intakes and oral minimal risk levels for Cu and Cr.

Literature

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