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Human health risk assessment in urban environments: introducing uncertainties of exposure variables through Monte Carlo 2D

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The quantitative characterization of exposure factors is a critical point in human health risk assessment since those factors strongly control the numerical result of such assessment. As opposed to a deterministic approach, which makes use of single values for each input variable, probabilistic risk assessments consider random variables in the intake equations and thus allow to assess the influence of the variability of exposure factors on the risk uncertainty. The aim of this study is to develop a method to characterize the uncertainty introduced by the variability of each exposure factor when they are derived from (reliable) bibliographic sources.

The exposure scenario to validate this methodology considers a 0 to 6 years old infant receptor exposed to pollutants through accidental soil ingestion and dermal contact in urban parks. The variables analyzed were soil ingestion rate (includes indoor dust, outdoor soil and outdoor dust on the soil surface from 7 studies), exposure frequency (from a local survey), body surface area (17 distributions from 5 authors), body weight (two regional studies with 34 and 8 distributions respectively, according to gender and age), and average life expectancy for carcinogenic risk (from a regional study).

Uncertainties in the documented mean values of each exposure factor were assessed through a bootstrap process. A 10.000-iteration simulation was performed considering sample size and theoretical distribution (usually normal and lognormal) as described in each bibliographic source. Mean values obtained in each simulation were used to obtain a normal distribution. Parameters of the mean distribution were employed in a 2D-Monte Carlo simulation. The concatenation of vectors resulting from 2D simulations from each study allows to obtain variables that consider the uncertainties arising from sample size and variability between studies. An R-script was developed to conduct the probabilistic risk assessment and to perform a sensitivity analysis.

The results for the considered scenario show that the variables with a greater contribution to risk variability were soil ingestion rate, for the accidental soil intake exposure pathway, and exposure frequency for dermal contact.