Modelling Pb blood concentrations in pre-school children living in a residential setting using MERLIN-Expo

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Assessing multimedia/multipathway exposures to inorganic arsenic at individual level using MERLIN-Expo

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1. Introduction

The Merlin-Expo tool [1] was used to simulate a previously conducted exposure assessment on historical inorganic As (iAs) exposure to adults living in the vicinity of a former industrial site with zinc smelting activities in the North-Eastern part of Belgium, in order to verify the model with respect to real world biomonitoring data. The Merlin-Expo tool is an exposure assessment software tool that has been developed over the course of two successive EU funded projects, 2FUN (FP6) and 4FUN (FP7). The software tool allows to model lifetime exposure assessments at the individual or population level, integrating exposure through multiple pathways.

For the current paper model simulations were performed at individual level and are compared with biomonitoring data from Belgian monitoring campaign [2,3] in order to verify the model performance of MERLIN-Expo when simulating complex scenarios that account for subject mobility, i.e., residence time at different locations (both indoors and outdoors) with varying exposure levels in the vicinity of the hot spots, and individual food consumption patterns. Adopting an assessment approach at individual-level improves on more commonly performed generic exposure assessments at population level, by including intake of iAs from local and purchased food products, and taking into account the mobility of participants, , which results in a more comprehensive assessment of individual recent intake of inorganic arsenic. The current paper extends data previously published by Van Holderbeke et al. [3].

2. Materials and methods

Details on the case study area, the MERLIN-Expo model as well as the conceptual model are provided in Van Holderbeke et al. [3]. The input and verification data sets used for this study have been derived from a large-scale environmental and biomonitoring campaign (hereafter referred to as "monitoring campaign") that was conducted previously in the considered case study area [2,3] .

3. Results and discussion

Modelling was performed using individual exposure data (10 adults in each study areas), i.e., individual urinary tAs (i.e., iAs, MMA and DMA) levels matched to the corresponding environmental measurement data, the corresponding age and sex as well as the time-activity and consumption patterns derived from the questionnaires.

The model predictions for individual adults under-predict the biomonitoring data by 7% on average, but with more important under-predictions for subjects at the upper end of exposure [3].

Because the biomonitoring campaign collected also details on time-activity and food consumption for each subject individually next to environmental monitoring data, the contribution of different exposure pathways to each of them can be further dissected. This is illustrated in Figure 1 showing the contribution of dust ingestion in different areas to the overal iAs exposure for 2 different subjects living in the same reference area but traveling between areas in distinct ways. Similar differences in exposure patterns between individuals related to life patterns will be discussed in further detail for other exposure pathways and/or other study areas during the presentation.

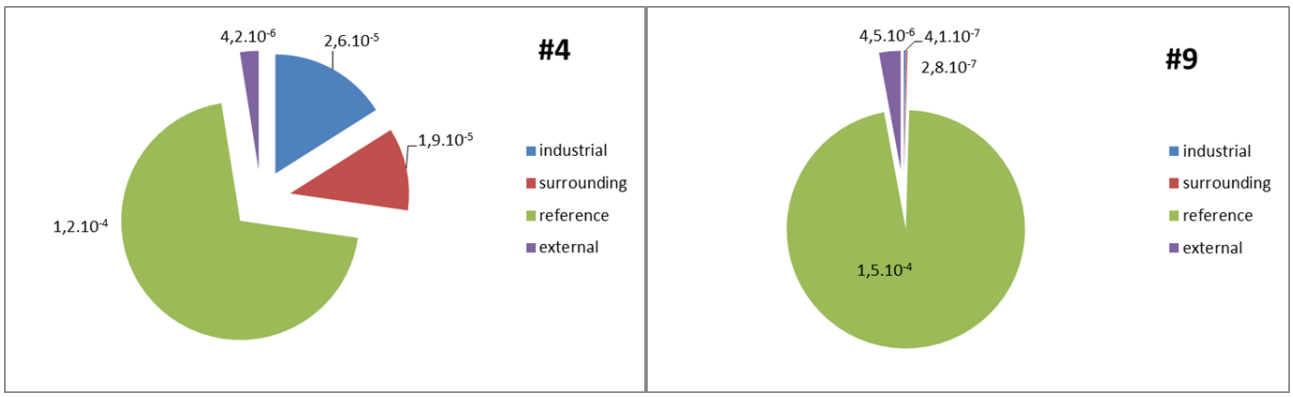

Figure 1: Comparison of the relative contribution of dust ingestion in different areas for 2 different individuals living in the reference area.

Whereas the variability that is observed between measured and predicted urinary arsenic concentrations for each individual subject may relate to variability in behaviour, in the contaminated media contacted, and in physiological parameters that influence the toxicokinetics of arsenic, other plausible explanations for differences between measured and predicted urinary arsenic concentrations for an individual include uncertainty on soil/dust and dietary ingestion rates, urinary volumes, arsenic concentration in food, and the soil and dust data collection methods. Moreover, some sources of arsenic or exposure routes have been ignored in the current simulations, such as passive smoking and dermal exposure. In short, variability comes from differences in outcome due to inter-subject variation in factors contributing to risk; uncertainty comes from lack of knowledge in the underlying science. The methods to perform sensitivity analyses in MERLIN-Expo could be used to elucidate these matters but this is outside the scope of this paper.

4. Conclusions

Human exposure to arsenic has been studied in a site-specific residential setting, based on measured levels of iAs in the surrounding environment. The individual-level assessment approach improves on more commonly performed generic exposure assessments at population level, by including intake of iAs from local and purchased food products, and taking into account the mobility of participants, mobility in and between areas, resulting in a comprehensive assessment of individual recent intake of inorganic arsenic. Modelling exposure at individual level allows risk assessors to attribute the relative contribution of different exposure routes at various locations, reconstructing the exposure history for each individual.These results constitute a first and partial verification of the model performance of MERLIN-Expo when dealing with iAs in a complex site-specific exposure scenario, and demonstrate the robustness of the modelling tool for these situations.

5. References

[1] Ciffroy P, Alfonso B, Altenpohl A, et al. 2016 Modelling the Exposure to chemicals for Risk assessment: a comprehensive Library of multimedia and PBPK models for Integration, Prediction, uNcertainty and Sensitivity analysis – The MERLIN-Expo tool. J. Tot. Env. 568:770-784..

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