A spatial analysis approach combining multi-media and human models to map the lead exposure of children in a French region

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CONTEXT AND OBJECTIVES

The last decade has witnessed an increasing interest in assessing health risks caused by contaminants present in several environmental media, i.e. soil, air, and water. To that end, mathematical models describing the fate of compounds in the environment (multi-media models) and in the human body (toxicokinetic models) can be combined to simulate realistic exposure scenarios of human populations. These models can also be integrated in a Geographic Information System (GIS) to produce maps of exposure and reveal spatial patterns. The aim of this study was to **develop a spatial stochastic multimedia and human exposure model for detecting vulnerable populations and analyzing exposure determinants** at a fine resolution and regional scale. This approach was applied to the **exposure to lead of children in the Region Nord-Pas-de-Calais in France**.

METHODS

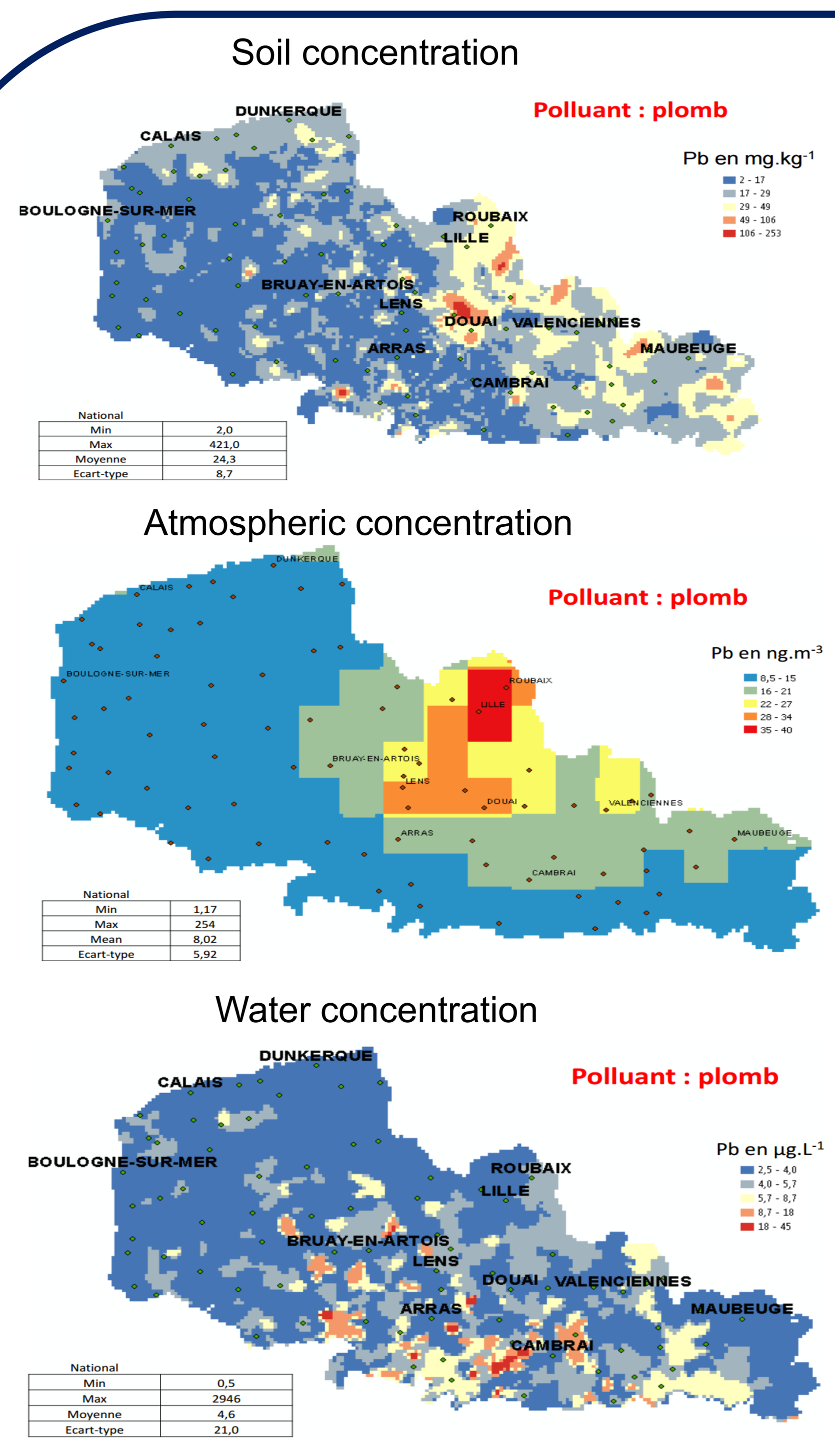

Fig1: Concentration of lead in environmental media

+ population characteristics and national data

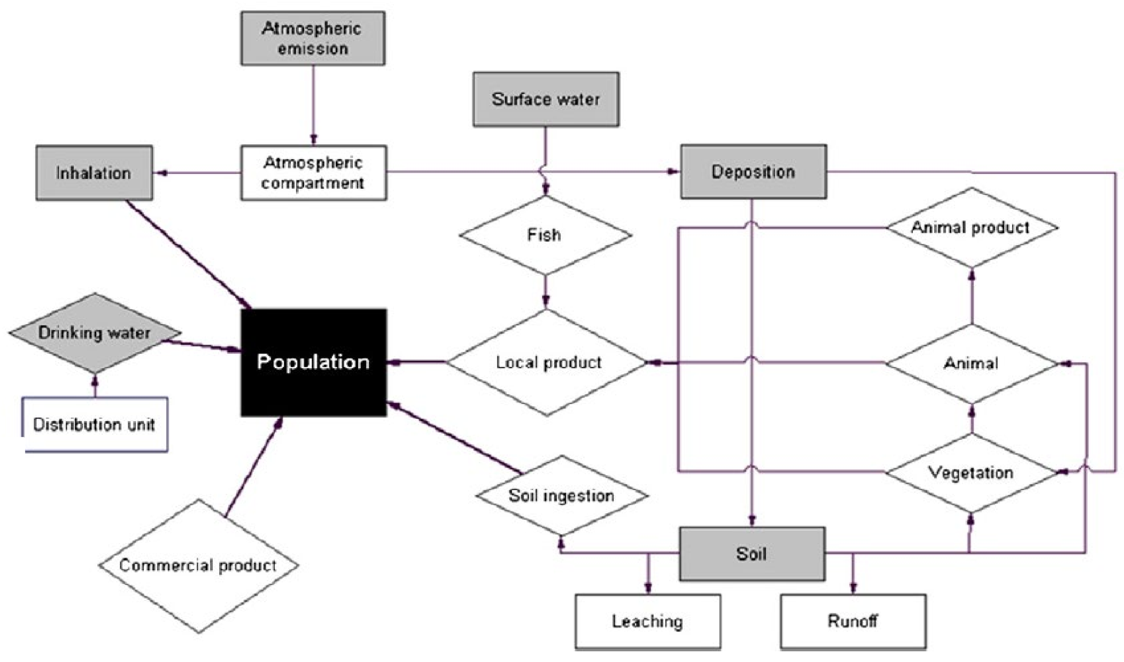

Fig.2: Concentration of lead in environmental media

Daily intakes and concentration in atmosphere

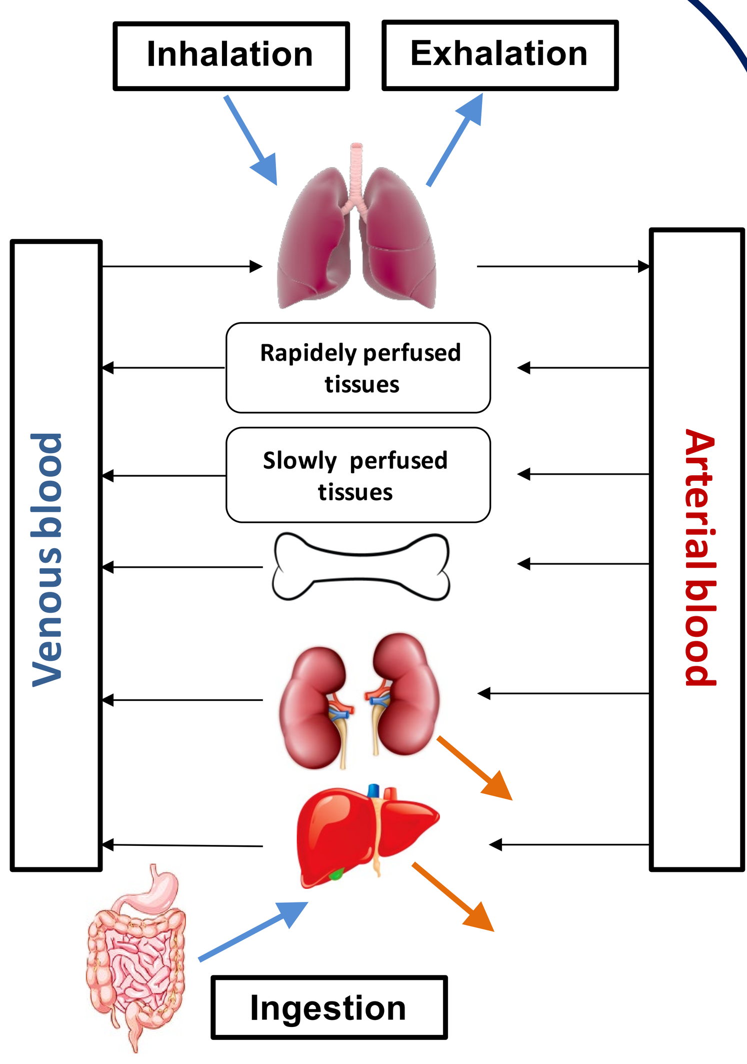

Fig.3: The structure of the PBPK model for lead

A **GIS-based modeling platform** for quantifying human exposure to chemical substances was used to build and discretize environmental and population variables collected from different sources on a 1 km^2 regular grid. Inhalation and ingestion exposure via contaminated food, drinking water, and soil were taken into account (Fig.1). Either direct observations or **multi-media models** were used to compute daily intakes for different reference groups (age, dietary habits, and the fraction of food produced locally). In each cell of the grid, Monte-Carlo simulations were performed to generate a sample of 1000 daily intakes (Fig.2). These latter were then used as input in a **physiologically based pharmacokinetic (PBPK) model for children** to simulate the associated blood lead levels since birth (Fig.3).

RESULTS & CONCLUSIONS

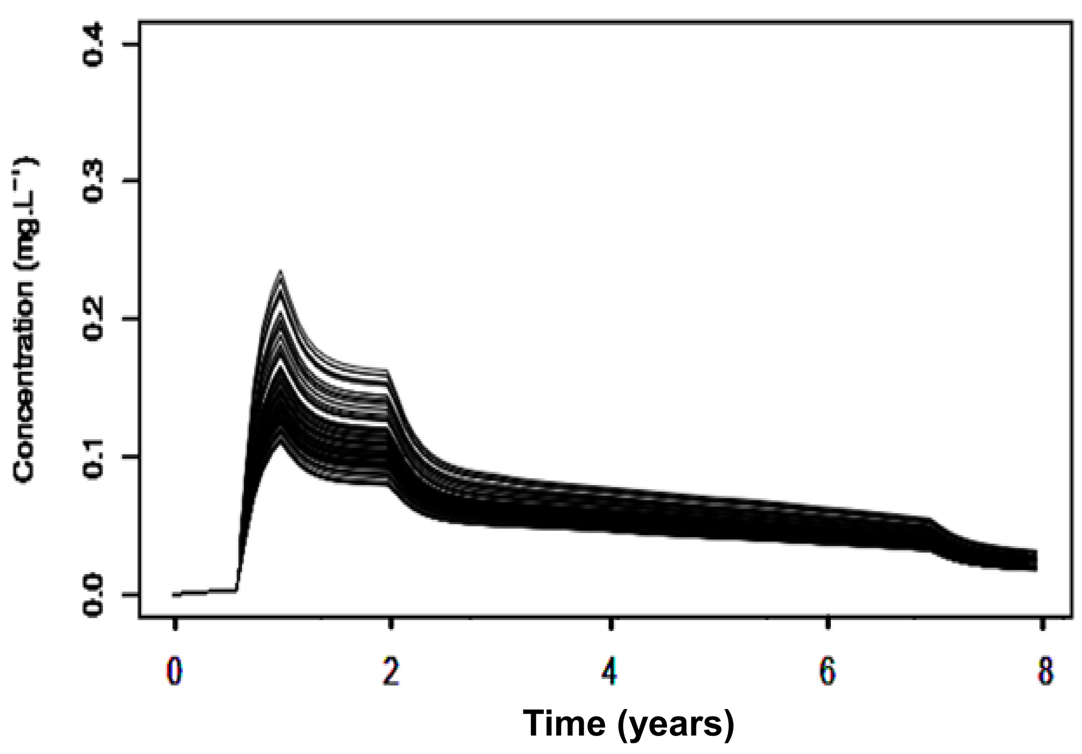

Fig 4: Simulated BLL for 1000 children between 0 to 8 years old

Maps of the simulated blood lead levels (BLL) for children aged from 1 to 11 years old were generated for year 2015 (Fig 4 and Fig 5). The 95th percentile of the distribution of BLL for each age was used to compute the risk of exceeding the reference value of 5µg/dL, a threshold used by DDASS (French Departmental Directorate of Health and Social Affairs). Our results showed that **the majority of the predicted BLL fell under the reference value for children of 5 years old and over** (Fig 4**).** However, the predicted BBL for children under 3 exceed this value. Several hotspots were detected as a former industrial site and Lille, the capital of the region (Fig 6). Drinking water and surface soil were identified as the main determinants of the children BLL.

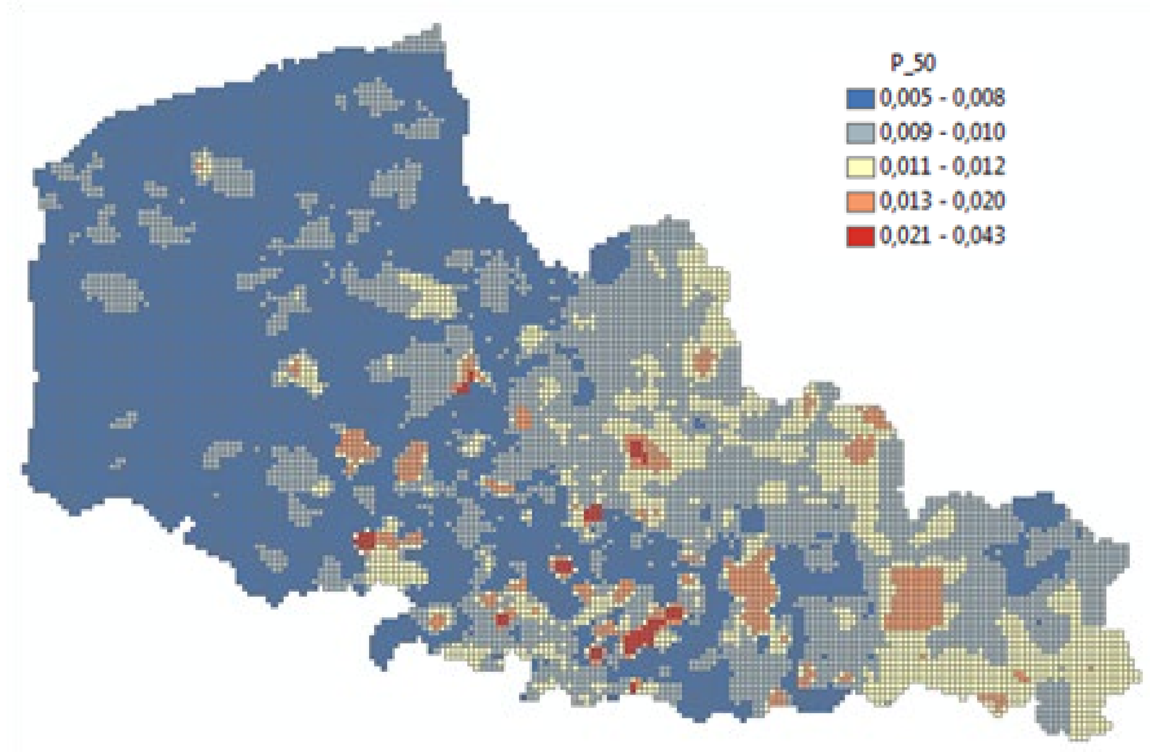

Fig 5: Median BLL for 11 year-old children in 2005

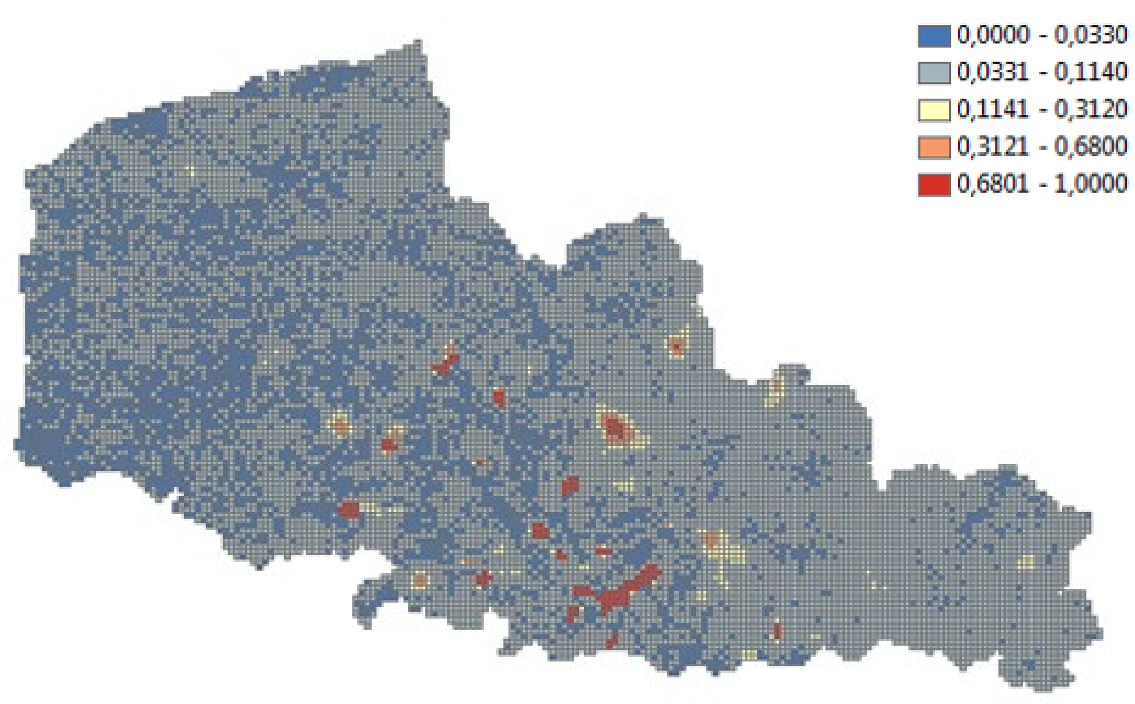

Fig 6: Probability of exceeding the BLL of 5 µg/dL for 5 year-old children

Exposure maps are a valuable tool in risk assessment to explore changes in disease patterns potentially associated with changes in environment quality and to better characterize the links between the sources of pollution and health effects. Future developments will consider the integration of health data in our approach.

References

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M. Sharma, et al.. Dietary and Inhalation Intake of Lead and Estimation of Blood Lead Levels in Adults and Children in Kanpur, India. Society for Risk Analysis – Vol.25, n°6, p.1573-1588, 2005.

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