

# HEALTH RISK ASSESSMENT OF AMBIENT LEAD LEVELS IN LISBON, PORTUGAL: A FULL CHAIN STUDY APPROACH



Elsa Casimiro<sup>1,2</sup>, Philippe Ciffroy<sup>3</sup>, Pedro Serpa<sup>1</sup>, Erik Johansson<sup>4</sup>, Charlotte Legind<sup>5</sup>, Céline Brochot<sup>6</sup>

<sup>1</sup> CCIAM/FFCUL, Faculty of Sciences, University of Lisbon, Portugal

<sup>2</sup> INFOTOX Environmental Risk Consultants, Lisbon, Portugal

<sup>3</sup> EDF, Paris, France

<sup>4</sup> Facilia AB, Bromma, Sweden

<sup>5</sup> DTU, Technical University of Denmark, Denmark

<sup>6</sup> INERIS, Institut National de l'Environnement Industriel et des Risques, France

ecasimiro@infotox.pt

## INTRODUCTION

The multi-causality interactions between environment and health are complex and call for an integrated multidisciplinary study approach. Emerging computational toxicology tools that link toxicology, chemistry, environmental sciences, biostatistics, and computer sciences are proving to be very useful for integrated full-chain human health risk assessments.

In this study we use a newly developed computational tool – the 2FUN player to conduct a full-chain assessment combining measured ambient air lead (Pb) concentrations with multimedia modelling and PBPK simulations to estimate the health risks from ambient air levels of Pb in air-borne particulates (PM10) in Lisbon, Portugal.

## METHODS

### Study area

The study area is the municipality of Lisbon. It is capital of Portugal and the westernmost capital in mainland Europe (Figure 1). Lisbon is located north of the Tagus estuary and in close proximity to the Atlantic Ocean. It is the largest urban area in Portugal with a population of about 0.5 million. About 30% of local residents live in townhouses. Consumption of homegrown fruits and vegetables is common and with a tendency to increase.

Services are the main economic sectors in the city, although there is some industrial activity. The latter includes textiles, chemicals, steel, oil and sugar refining, shipbuilding and waste incineration units. However, traffic is the main source of local atmospheric emission. Apart from road traffic, the international airport located in the north of the city is also a significant contributor to local emissions.

### Input data

Ambient air Pb concentrations for 2001-2003 and 2008-2009 were obtained from the Portuguese Environmental Agency. For periods where no data was available, relevant monthly datasets were reconstructed through random sampling from the PDF generated from actual data collected in 2001-2003 and 2008-2009. Hourly temperature, precipitation and wind Lisbon were obtained from the European Climate Assessment & Dataset (ECA&D). These were transformed into daily and monthly datasets.

### Modelling process

Monthly ambient air Pb concentrations were used together with climate variables in the 2FUN atmospheric model to calculate the amount of Pb deposited (wet & dry) onto soil. The Pb concentration in various biota/food (leafy vegetables, root vegetables, grain, potatoes, fruits, milk, and meat) produced in the area were modeled as indicated in the matrix in Figure 2. This process accounted for (i) the interception by leaves of a fraction of deposited Pb, (ii) the distribution of Pb between soil particles and soil porewater; (iii) the infiltration of soil porewater and associated Pb during high rainfall events (water budget is calculated at each time considering rainfall and evapotranspiration and eventual water excess is lost by infiltration); (iv) root uptake of Pb present in soil porewater; and (v) the transfer of Pb from grass to cow milk and beef meat.

Key parameters such as dry deposition velocity and scavenging washout ratio were parameterized from a literature review specific for Pb. The Pb distribution coefficient (i.e. ratio between concentration in soil particles and in soil water respectively) was correlated with soil local pH. Transfer factors from soil to plants were taken from a literature review. These parameters are all included and referenced in the 2FUN database.

Once the Pb concentrations for each biota were estimated we proceeded to model the amount of Pb a typical adult would inhale and ingest during this ten year assessment period. The PBPK model of the 2FUN player was used to calculate the Pb levels in the various body systems. For these calculations generic intake rates by humans were considered. The resulting arterial Pb concentration is presented here.



Figure 1 – Map showing the study area of Lisbon in red block

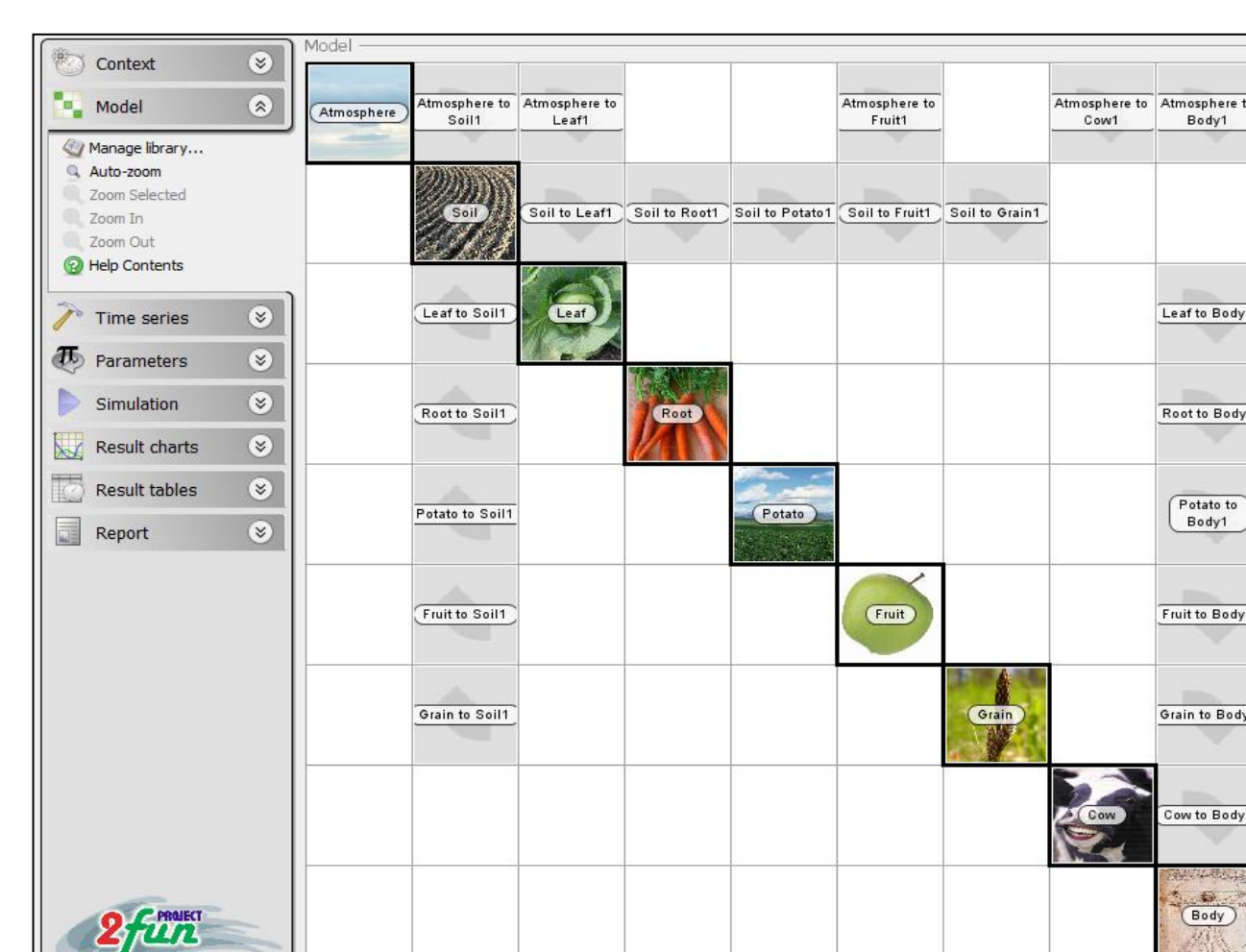


Figure 2 – 2FUN player interaction matrix showing links between models used in this assessment

## RESULTS & DISCUSSION

During the assessment period the mean Pb ambient air concentration (Figure 3) in the study area was 0.01µg/m<sup>3</sup>, well below the national limit value of 0.5µg/m<sup>3</sup>. The deposition of air-borne lead onto soil resulted on an average added soil Pb concentration (Figure 4) of 0.28mg/kg, reaching a maximum of 0.53mg/kg (for a 10 years simulation period). This is well below the national limit for urban areas of 120mg/kg as well as the more conservative agricultural soil limit for Pb of 45mg/kg. It is however important to note that background soil concentration was not considered – hence we only estimate the added risk.

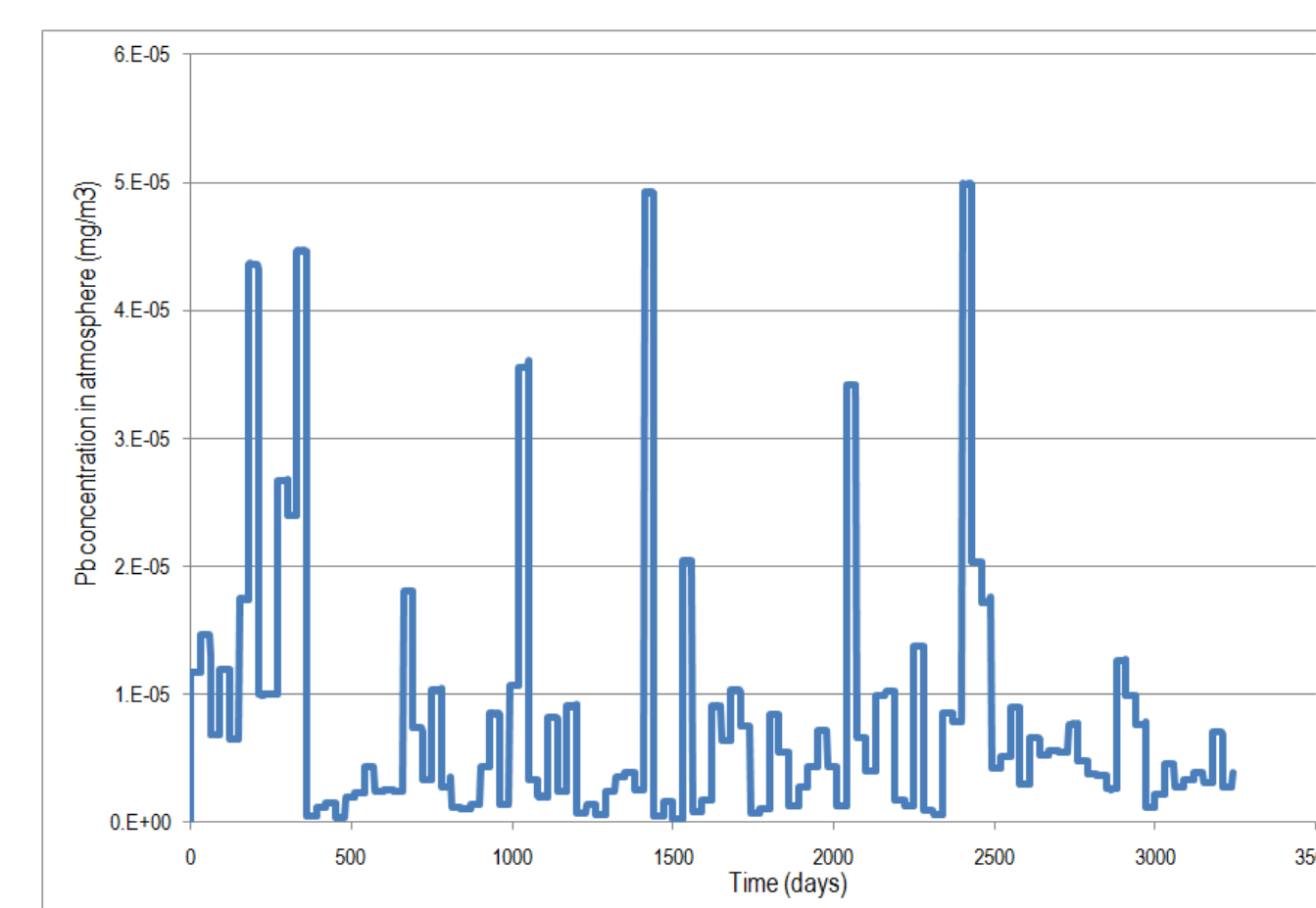


Figure 3 – Ambient air lead concentrations for Lisbon during 2001-2009

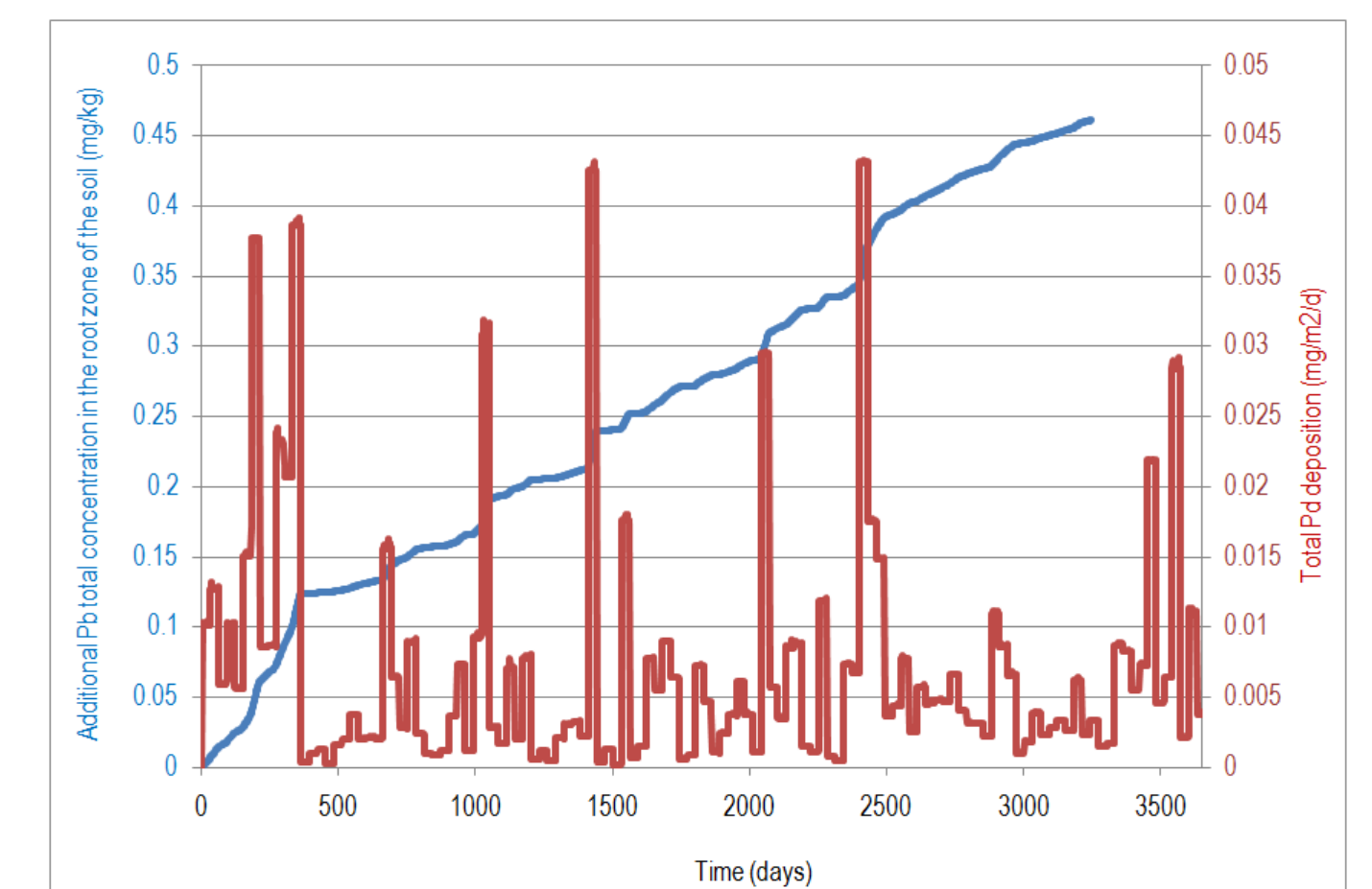


Figure 4 – Total Pb deposition and soil lead concentrations for Lisbon

Figure 5 shows the modelled Pb concentrations in the various biota throughout the assessment period. These results clearly show that the Pb levels in fruits and leafy vegetables to be significantly higher than in the other biota assessed. The Pb concentration in biota was always below the national limit values of 0.02mg/kg for milk, 0.2mg/kg for cereals, 0.3mg/kg for leafy vegetables, and 0.1mg/kg for fruits and other vegetables. It is however, interesting to note that the maximum Pb concentrations obtained in this case study for fruits (0.06mg/kg) and leafy vegetables (0.07mg/kg) were 60% and 25% of the respective limit values.

In Figure 6 we show the results of Pb in the arterial blood of a typical adult from ingestion of produce grown in the study area. The maximum blood Pb level obtained was 0.025mg/L (2.5µg/dL) which is 25% of the limit value of 10µg/dL indicating a very low health risk.

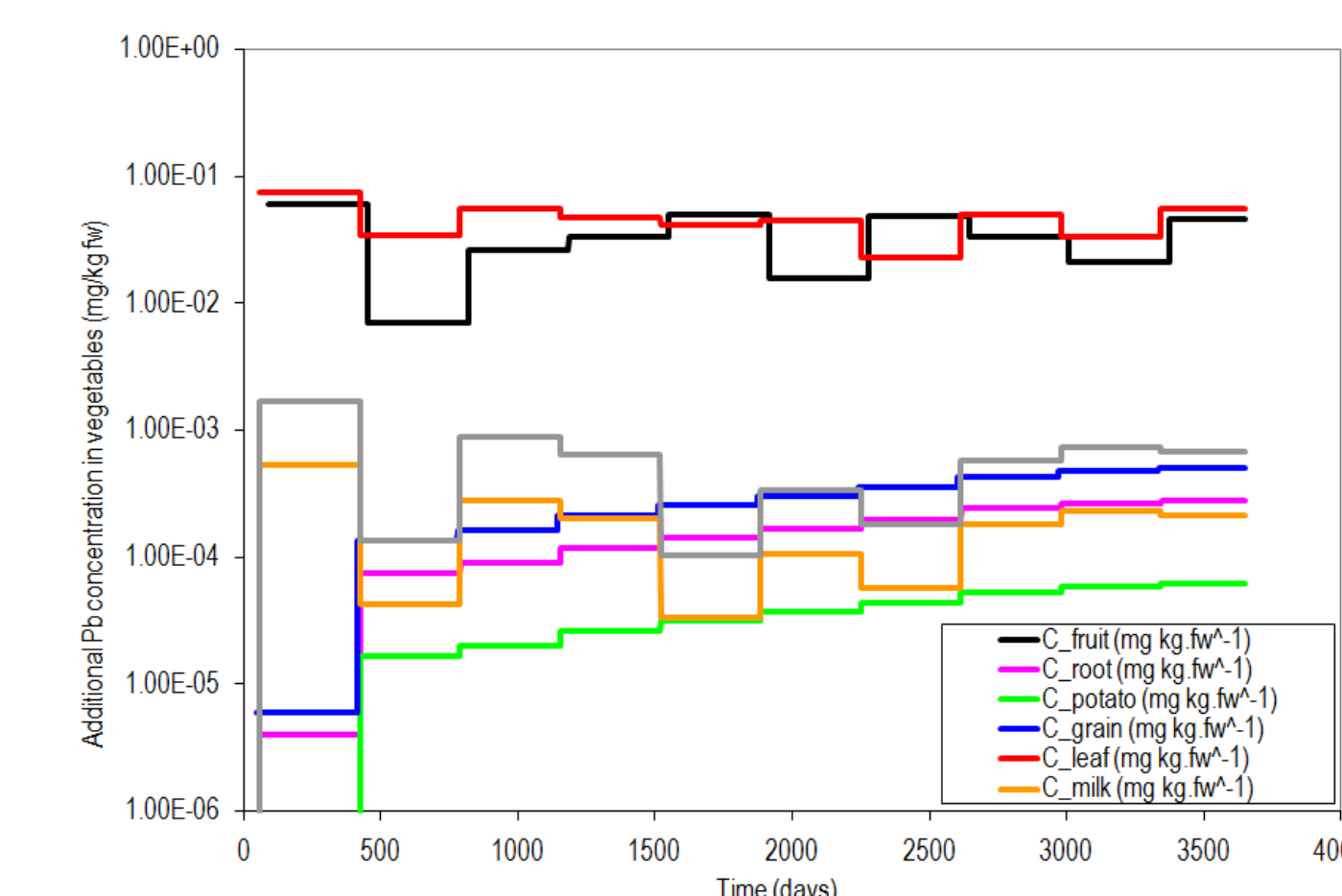


Figure 5 – Pb concentrations in foods produced in study area.

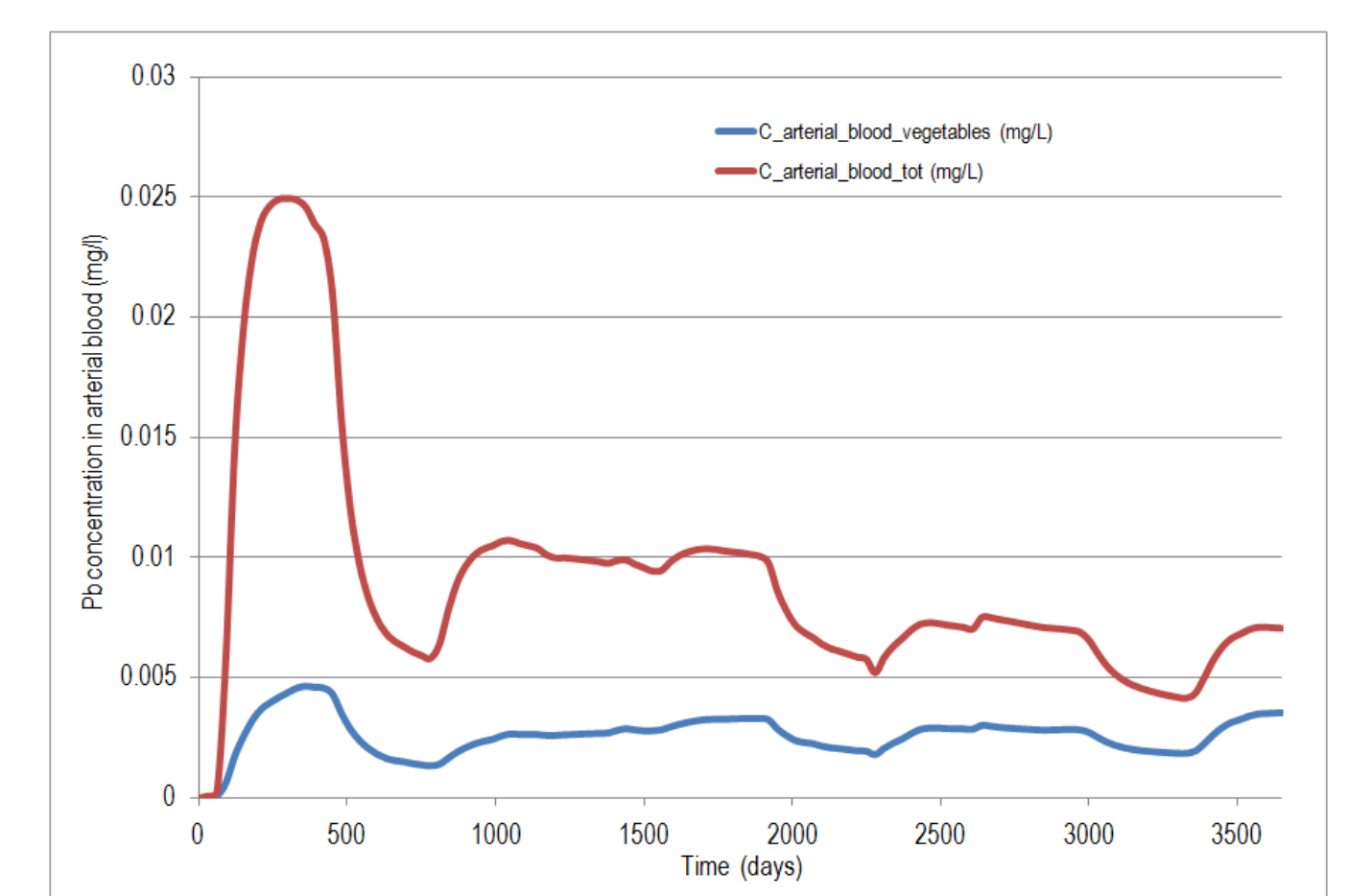


Figure 6 – Pb concentrations in adult arterial blood from exposure to food produced in study area

## CONCLUSION

- This full chain assessment showed that population exposure to ambient air Pb levels in Lisbon pose a low health risk.
- In this study we also showed that the ingestion of leafy vegetables (i.e. lettuce, cabbage, and spinach) and fruits are the produce likely to have higher Pb concentrations from ambient air Pb pollution.
- The full chain assessment approach of the 2FUN player is likely to be very useful for local health risk assessment studies (i.e. EIA and SEA studies).
- The tool is also likely to be useful in selection process of the most suitable environmental and human biomonitoring samples.