Health risk from accidental fire in a plastics recycling facility

D.A Sarigiannis\textsuperscript{1,2}, A. Gotti\textsuperscript{2}, S. Karakitsios\textsuperscript{1}

\textsuperscript{1} Chair of Environmental Health Engineering, Institute of Advanced Study, Pavia 27100, Italy

\textsuperscript{2} Environmental Engineering Laboratory, Department of Chemical Engineering, Aristotle University of Thessaloniki, GR-54124, Thessaloniki, Greece

http://www.enve-lab.eu
Introduction and background

- Waste recycling is one of the main cornerstones of the EU waste management strategy, contributing to the circular economy and the sustainable and efficient use of natural and man-made resources.

- However, waste recycling facilities may be associated to adverse health outcomes in the aftermath of industrial accidents involving the inadvertent generation of toxic chemicals and their release into the environment.

- One of the major concerns associated to accident in plastic recycling plants are the emissions of dioxins and furans (PCDDs/PCDFs) - these compounds are characterized by a high carcinogenic potency.

- Since PCDDs/PCDFs act like a potent and persistent hormone agonist, information may be obtained from steroid receptor action and from molecular data on the Ah receptor.

- This receptor based toxicity, results in sex-dependent sensitivities, as a result of a set of sex-specific PCDDs/PCDFs -responsive genes.

- An obstacle for assessing cancer risk related to accidental events is that a short term external exposure event, has to be translated into long term risk estimates.
The case study
Plastic recycling plant fire
In Aspropyrgos, Greece

- Accidental fire in a plastics recycling plant in June 6, 2015
- The fire resulted in significant particle and gaseous emissions of several compounds related to plastic industry, PCDDs/PCDFs among them
- What is the related health burden for the population leaving nearby (50-100m)?
Study design

- Select of a slope factor for PCDDs/PCDFs
- Translate this slope factor into an equivalent lifetime internal dose / area under the curve (AUC)
- Estimate the background exposure to PCDDs/PCDFs from biomonitoring data
- Translate this biomonitoring data into an external daily uptake through exposure reconstruction
- Re-run forward the model, for assessing lifetime AUC for estimating the background cancer risk
- Run the scenario of the accidental event, for estimating the new AUC due to the higher uptake resulting from the fumes emitted by the accidental fire
  - Estimate the additional intake for adults
  - Estimate the additional intake for the developing fetus of mothers exposed in the fumes emitted from the accidental fire
  - Estimate the additional intake for breast-fed infants
INTEGRA computational platform

Advanced reverse dosimetry scheme for exposure reconstruction

HBM database

Life-stage PBTK model including gestation and lactation

Internal exposure (probabilistic assessment)

QSARs for PBTK parameterization → covering a large chemical space

QSARs

GI tract → portal vein

Liver → heart

Brain → muscles

Skin

Kidneys

Adipose

Bones

Breast

Uterus - ovaries

Arterial blood

Lungs

Venous blood
Generic lifetime PBBK model

- Lifetime evolving parameters
  - Organ volumes
  - Blood flows
  - Age-dependent clearance
- Mother – Fetus interaction
- Breast feeding
EPA has classified 2,3,7,8-TCDD as a Group B2, meaning a probable human carcinogen and has calculated an inhalation cancer slope factor of $1.5 \cdot 10^5 \text{ (mg/kg/d)}^{-1}$ that corresponds to inhalation unit risk estimate of $3.3 \cdot 10^{-5} \text{ (pg/m}^3\text{)}^{-1}$.

This external intake is translated to an AUC of $2 \cdot 10^{-7} \text{ (pg/g}\_\text{l lipid})\cdot\text{h}$

For the rest of the congeners, a Toxic Equivalent Factor (TEF) has been used
PCDD/Fs ambient air levels

PCDDs and PCDFs (TEQ)

Concentration (fg/m³)

- 5%-95%
- Median
- Mean

Rural areas  City centre  Industrial area  Landfield fires  Aspropyrgos fire
Internal exposure burden

Fetus - newborn

Blood concentration (pg/g lipids)

30 years

Fetus - non exposed
Fetus breast fed - non exposed
Fetus - exposed
Fetus breast fed - exposed
Cancer risk estimates

Cancer risk

- Background risk
- Post-accidental risk / adults
- Post-accidental risk / neonates
- Post-accidental risk / breast fed

Risk

- 5%-95%
- Median
- Mean

Risk levels:
- 10^{-6}
- 10^{-7}
- 10^{-8}
Concluding remarks

- Although waste recycling is considered one of the most environment friendly and sustainable waste management options, accidental events might result in significant contamination of the surrounding area, affecting adversely the population living nearby.

- Translating a short term exposure event into a long term exposure estimate is a major challenge; internal exposure assessment is the key.

- For estimating the associating risks, the concept of TEQ for the mixture of PCDDs/PCDFs was employed, using as a TEF reference compound 2,3,7,8-TCDD, which has a well-established slope factor.

- Based on the above, an average increase of 13% of cancer risk attributed to PCDDs/PCDFs was estimated.

- A key finding of the study was that neonates and breast fed infants face even higher lifetime risks, and also that these risks were quantified (20% and 24% respectively).