THE INNOVATION OF THE HUMAN EXPOSURE FACTOR ESTIMATION FOR LCA

The 11th of October 2018

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CONCEVOIR DEMAIN

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1 SCIENTIFIC BACKGROUND

The preparation of this work is managed by TPU Russia and ENSAM France

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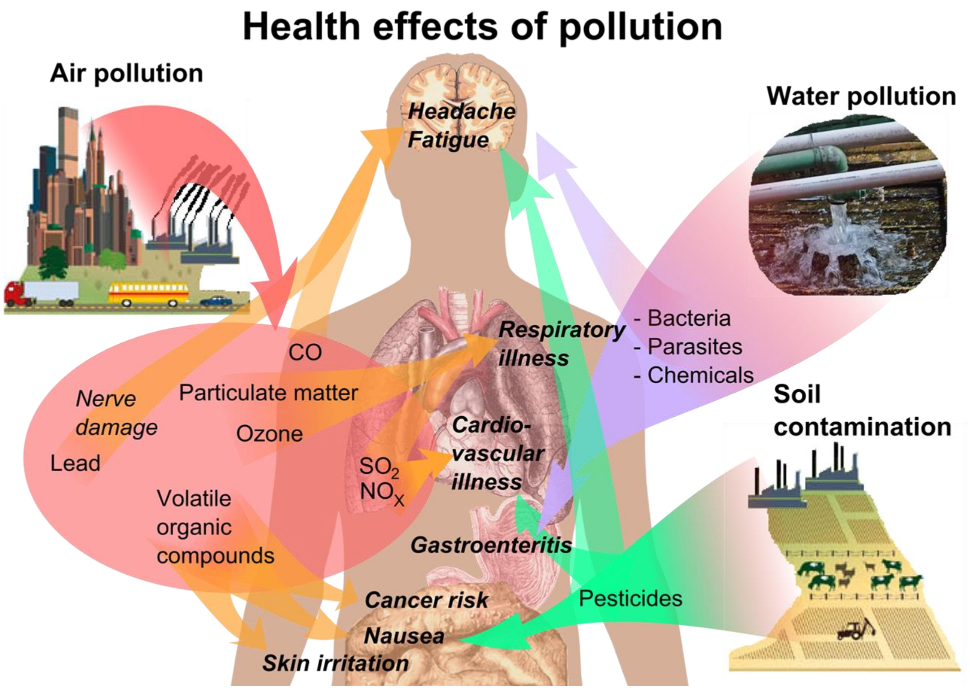
Contexte



Research questions

How can we analyze the chemical elements content in biological materials?

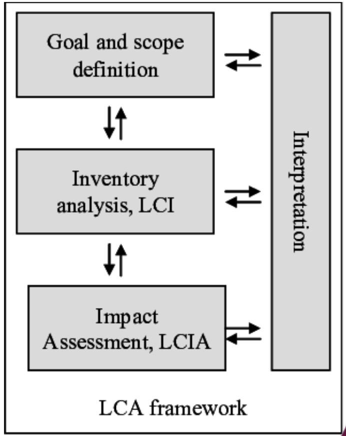
What are the main sources of negative influence on human health?

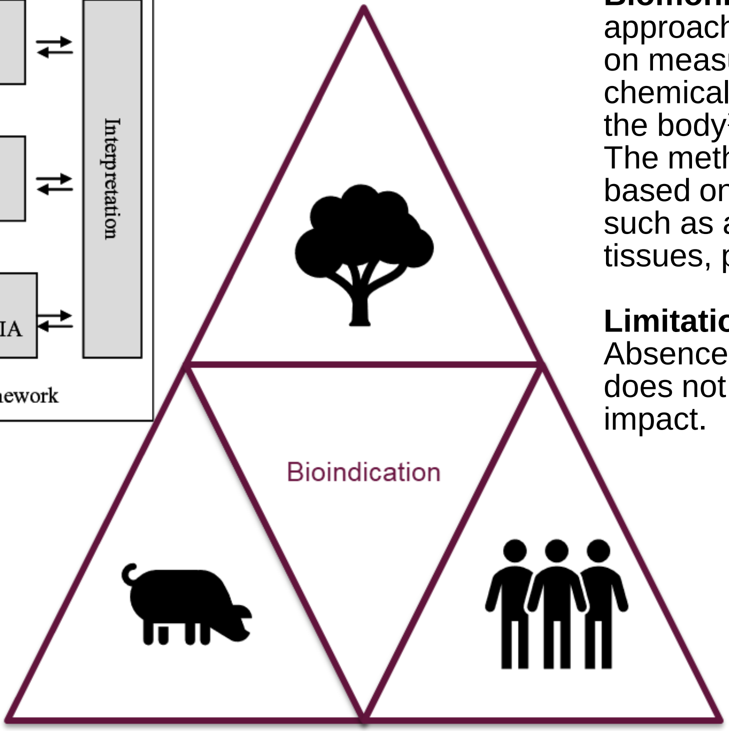
Which methods should we use to assess chemicals' impact on population?

Which methods should we use to assess chemicals' impact on population?

Life Cycle Impact Assessment (LCIA) is vital phase of any LCA. Life cycle impact assessment (LCIA) aims at understanding and quantifying the magnitude and significance of the potential environmental impacts of a product or a service throughout its entire life cycle.
LCIA models (e.g. the **USEtox**) is a sufficient tool to model the human health and ecosystems impact.

Limitations of the method:
Lack of spatial differentiation





Biomonitoring is an analytical approach which focuses directly on measuring the volume of toxic chemical compounds present in the body[1].
The methods of **bioindication** is based on analysis of the biota such as animal and human tissues, plants or microorganisms.

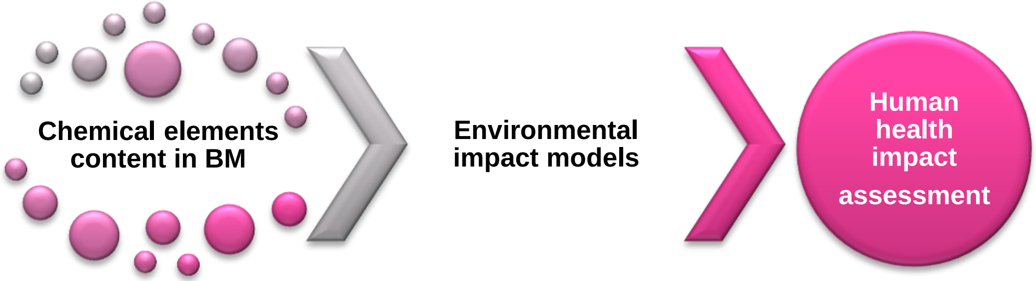
Limitation of method:
Absence of scale of impact, that does not allow to normalize the impact.

1. Standards, T. I. International Standard ISO 14040 1991, *1991*.
2. The International Standards Organisation INTERNATIONAL STANDARD ISO 14044 assessment Requirements and guilelines. *Int. J. Life Cycle Assess.* **2006**, *2006*, 652–668, doi:10.1007/s11367-011-0297-3.
3. Fantke, P.; Bijster, M.; Guignard, C.; Hauschild, M.; Huijbregts, M.; Jolliet, O.; Kounina, A.; Magaud, V.; Margni, M.; McKone, T.; Posthuma, L.; Rosenbaum, R. K.; van de Meent, D.; van Zelm, 2, R. *USEtox® 2.0, Documentation version 1*; 2017; ISBN 978-87-998335-0-4.

1 - Kowalski, 1974; Glazovskaya, 1988; Saet et al., 1990; Alekseenko, 2006; Rikhvanov et al., 2006; Yazikov et al., 2010; Strakhovenko, 2011; Baranovskaya et al., 2015

Which methods should we use to assess chemicals' impact on population?

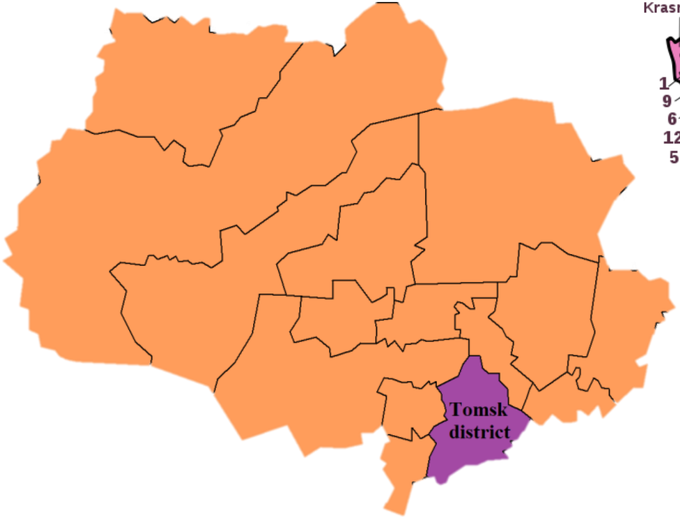
How can we assess the technological environmental impact and human health impact?
According to the previous investigations we have a wide massive of analytical data of chemical elements content in biomaterials in the studied areas.



Research methods

Modeling part:	Characterization factor modification and calculation
Experimental part:	Measurement of the concentration coefficient of Cr

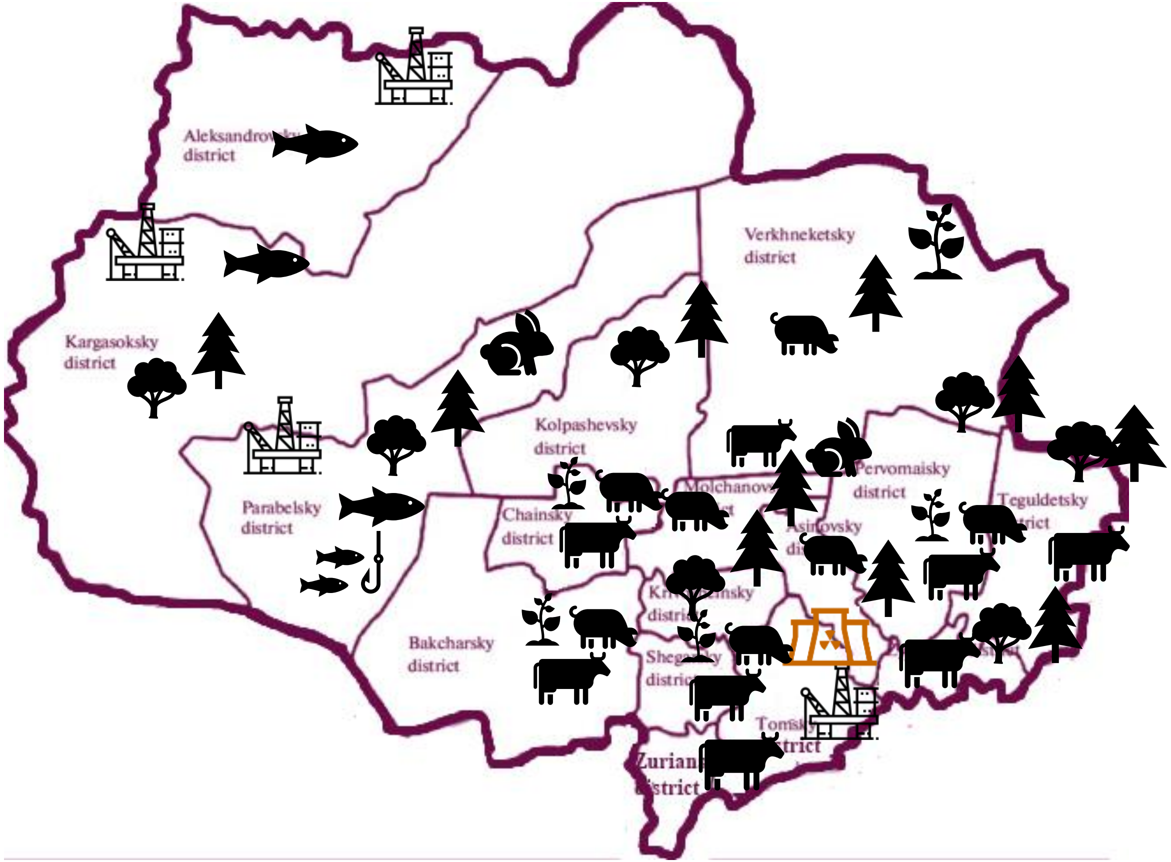
The experimental part



Sampling area

Tomsk district of Tomsk region in Russia

The experimental part

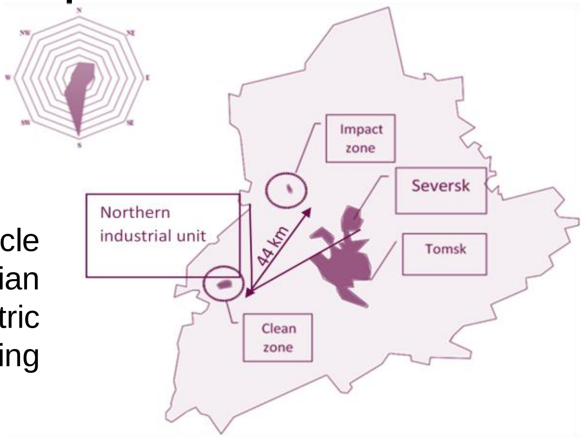


The experimental part

Sampling areas

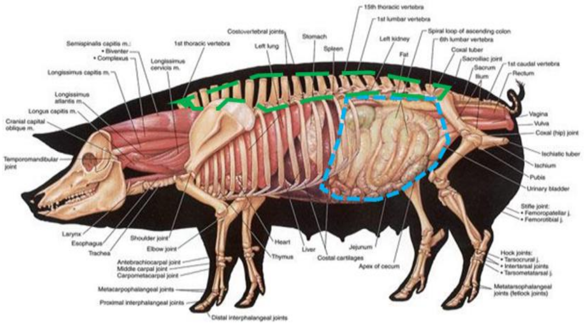
Why those areas?

- High level of risks of water use;
- A large number of fuel cycle facilities (NFC “The Siberian Chemical Combine”, hydroelectric power station, fossil fuel burning power station);
- Natural anomalies.

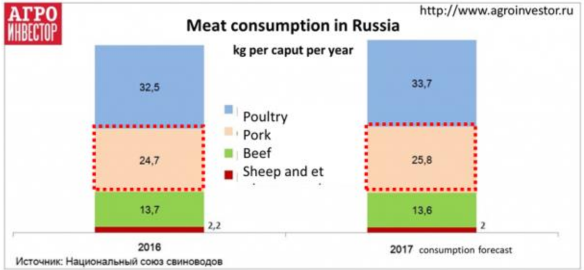


Samples of 2 pigs are taken in two districts of Tomsk region Russia.

Samples are taken



Subject of study biological material (BM) (organs and tissues) of Sus scrofa domesticus



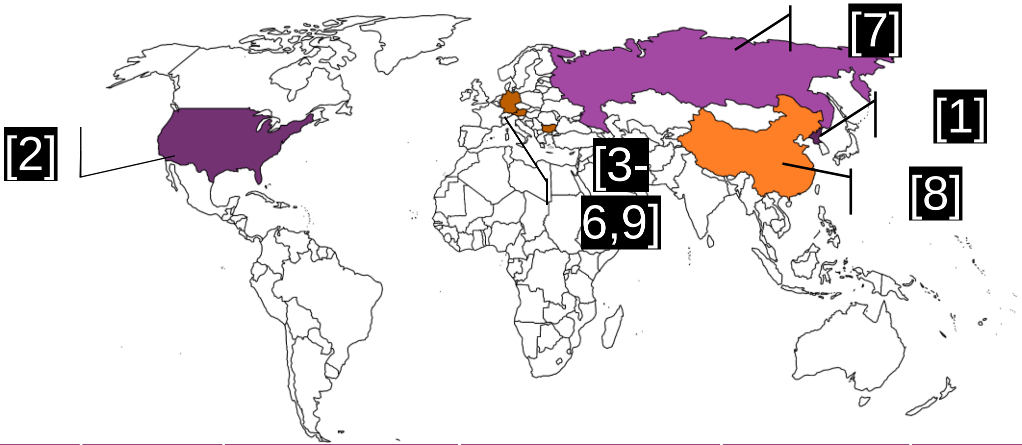
Pork occupies 37% of the world's meat production

According to the Food and Agriculture Organization (FAO) classification, pork is one of the most indispensable foods.

Methods of analysis of samples

The samples were analyzed by the method of inductively coupled plasma mass spectrometry (**ICP-MS**) in the analytical center of OOO "Chemical-Analytical Center" Plasma", 18 samples in total amount.

Sampling map of pork meat according to own investigation and literature references



1. Korea; 2. USA; 3. Germany; 4. Austria; 5. Netherlands; 6. Belgium; 7. Russia; 8. China; 9. Serbia

Country	Cr mean, [mg/kg]	St. deviation	Number of samples	Data of sampling [year]	Geo zone in USEtox model	Reference
Korea	0,003	0,0001	227	2016	Japan and Korean peninsula	Kim, J. S.; Hwang, I. M.; Lee, G. H.; Park, Y. M.; Choi, J. Y.; Jamila, N.; Khan, N.; Kim, K. S. Geographical origin authentication of pork using multi-element and multivariate data analyses
USA	0,0009	0,0001	36	2016	USA and southern Canada	
Germany	0,0006	0,0001	12	2016	Europe	
Austria	0,00007	0,00001	15			
Netherlands	0,0005	0,0001	14			
Belgium	0,0005	0,00001	19			
Serbia	0,08	0,01	192	2017		Nikolic, D.; Djinovic-Stojanovic, J.; Jankovic, S.; Stanisic, N.; Radovic, C.; Pezo, L.; Lausevic, M. Mineral composition and toxic element levels of muscle, liver and kidney of intensive (Swedish Landrace) and extensive (Mangulica) pigs from Serbia.
China	2,01	0,2	100	2016	Southern China	Zhao, Y.; Wang, D.; Yang, S. Effect of organic and conventional rearing system on the mineral content of pork

Modeling part

$$IS = \sum_i \sum_x CF_{x,i} \times M_{x,i}$$

Modification

$$CF = EF \times XF \times FF$$

Default values given by the USEtox model

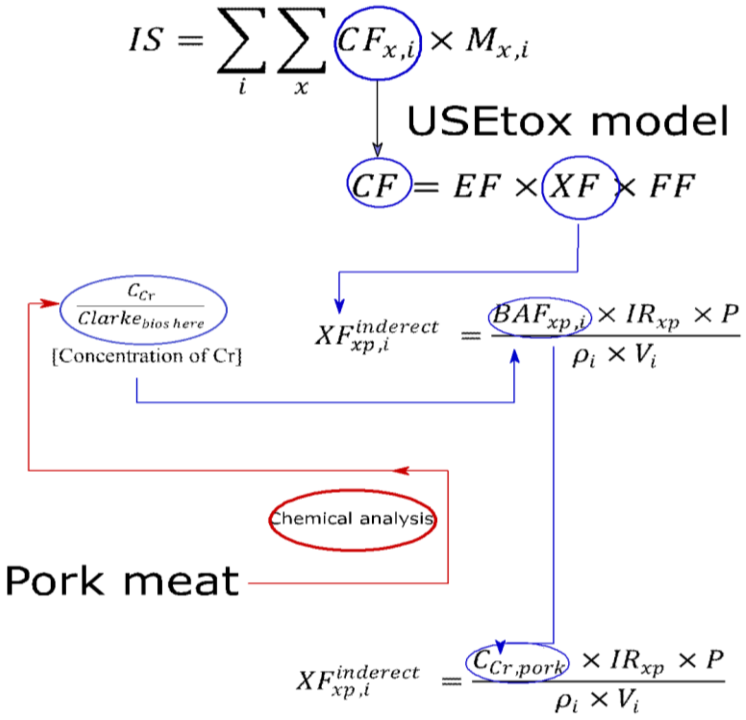
- **Fate factor** (FF) [$kg_{in\ compartment}$ per $kg_{emitted}$/day] represents the persistence of a chemical in the environment (e.g. in days) as well as the relative distribution, and the exposure factor expresses the availability for human or ecosystem contact represented by the fraction of the chemical transferred to the receptor population in a specific time period such as a day.
- **Exposure factor** (XF) [kg_{intake}/day per $kg_{in\ compartment}$] describes the effective human intake of a specific environmental medium – air, water, soil – through inhalation and ingestion.
- **Effect factor** (EF) [kg_{intake}/day] reflects the impact on human health and the state of ecosystems due to the arrival of a chemical element / substance in the living organism in various ways (through air, water, soil or food).

The framework of calculations inside the model

The clarke concentration ($Clarke_{biosphere}$) expresses the average concentration of metal in biosphere.

$Clarke_{biosphere} = 7*10^{-5}$

Macroelements ($n\cdot10^{-3}$%...$n\cdot10$ %) Microelements($<n\cdot10^{-3}$%)				Microelements ($<n\cdot10^{-3}$)			
Elements	%, content	Elements	%, content	Elements	%, content	Elements	%, content
O	70	Mn	$9{,}6\cdot10^{-3}$	Pb	$1\cdot10^{-4}$	Be	$4\cdot10^{-6}$
C	18	Al	$5\cdot10^{-3}$	Ni	$8\cdot10^{-5}$	Ga	$2\cdot10^{-6}$
H	10,5	Zn	$2\cdot10^{-3}$	Cr	$7\cdot10^{-5}$	Se	$2\cdot10^{-6}$
N	$3\cdot10^{-1}$	Sr	$1{,}6\cdot10^{-3}$	V	$6\cdot10^{-5}$	Ag	$1{,}2\cdot10^{-6}$
Ca	$5\cdot10^{-1}$	Ti	$1{,}3\cdot10^{-3}$	Li	$6\cdot10^{-5}$	W	$1\cdot10^{-6}$
K	$3\cdot10^{-1}$	B	$1\cdot10^{-3}$	Co	$4\cdot10^{-5}$	U	$8\cdot10^{-7}$
Si	$2\cdot10^{-1}$	Ba	$9\cdot10^{-4}$	La	$3\cdot10^{-5}$	Hf	$5\cdot10^{-7}$
Na	$2\cdot10^{-1}$	Cu	$3{,}2\cdot10^{-4}$	Y	$3\cdot10^{-5}$	Sb	$2\cdot10^{-7}$
P	$7\cdot10^{-2}$	Zr	$3\cdot10^{-5}$	Mo	$2\cdot10^{-5}$	Cd	$2\cdot10^{-7}$
S	$5\cdot10^{-2}$	Rb	$2\cdot10^{-4}$	I	$1{,}2\cdot10^{-5}$	Hg	$<n\cdot10^{-7}$
Mg	$4\cdot10^{-2}$	Br	$1{,}6\cdot10^{-4}$	Sn	$1\cdot10^{-5}$	Au	$n\cdot10^{-8}$
Cl	$2\cdot10^{-2}$	Br	$1{,}6\cdot10^{-4}$	As	$6\cdot10^{-6}$	Ra	$n\cdot10^{-12}$
Fe	$1\cdot10^{-2}$	F	$1{,}4\cdot10^{-4}$	Cs	$6\cdot10^{-6}$		



The framework of calculations inside the model

$$BAF_{xp,i} = \frac{C_{xp}}{C_i}$$

Calculation of bioaccumulation factor,

Where:

•C_{xp} is a concentration of Cr in the food substrate corresponding to exposure pathway *xp* – such as meat or milk

•C_i a specific compartment *i* such soil, air, water.

$$CC_{Cr} = \frac{C_{Chromium}}{C_{Clarke\ in\ bioshire}}$$

Calculation of concentration coefficient,

Where:

- $C_{Chromium}$ is a concentration of Cr (C_{Cr}) in the pork meat (according to the chemical analysis)
- $C_{\text{Clarke in bioshepere}}$ is a clarke concentration of Cr in biosphere

2 RESULTS

1. Results of statistical analysis
2. Results of the modeling part

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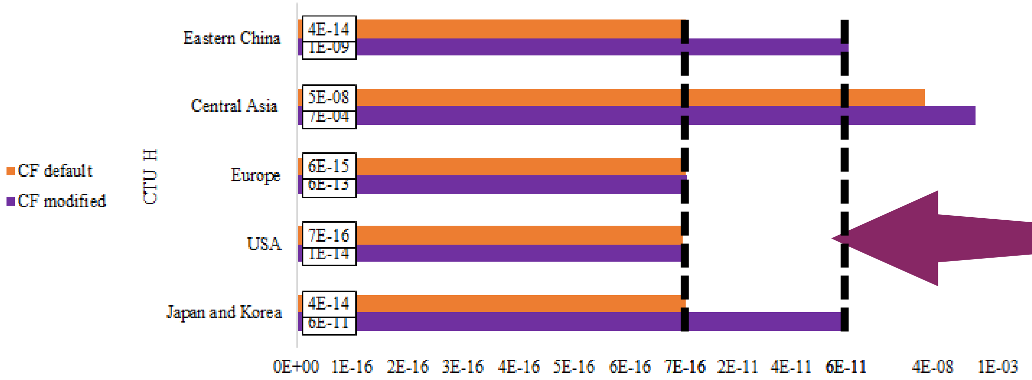
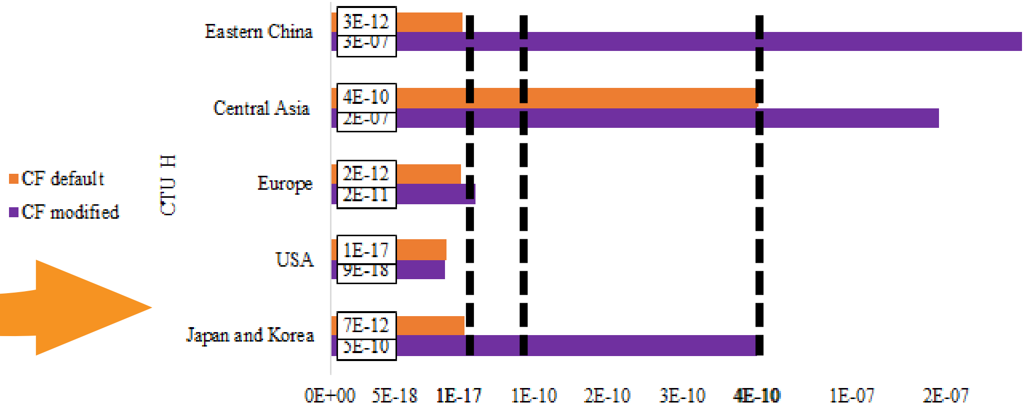
Results of data extrapolation

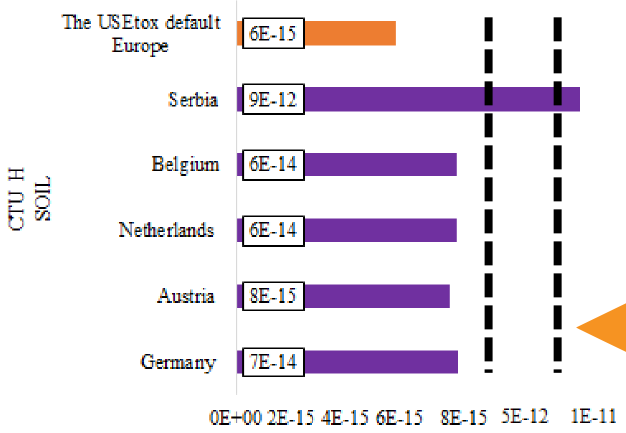


The Characterization factor of chromium in pork meat via soils, CTU_H

The Characterization factor of chromium in pork meat via air, CTU_H

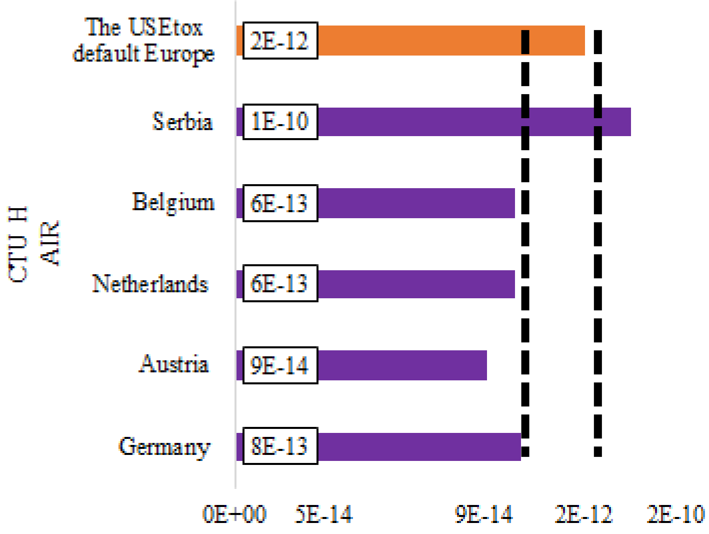


Results of data extrapolation



The Characterization factor in the geo zone “Europe” of chromium in pork meat via soils (right), CTU_H

The Characterization factor in the geo zone “Europe” of chromium in pork meat via air, CTU_H



Conclusions

General conclusions:

1. Integration of experimental data into the USEtox model is prepared
2. The total Characterization factor is modified with Concentration coefficient of Chromium

Specific conclusions:

1. The significant difference between $CF_{modified}$ and $CF_{default}$ is find out. As in the level of s region, as in level of a country factor proposed be the USEtox model is lower then factor calculated with experimental results. Possibly the model underestimates results because it does not include the local data. The importance of the local data is proved by the fact, the CF is able to vary greatly within one administrative unit.
2. The variation of CF inside of the small administrative areas can be connected with ignorance of geographical and ecological specifications of each geo are presented in the model. Information provided by the USEtox model reflects transfer of metals just with specific influence as dust or coal pollution.
3. The analytical method can be complemented by the regional aspect to specify the anthropogenic influence.

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THANK YOU FOR ATTENTION!

The 11th of October 2018

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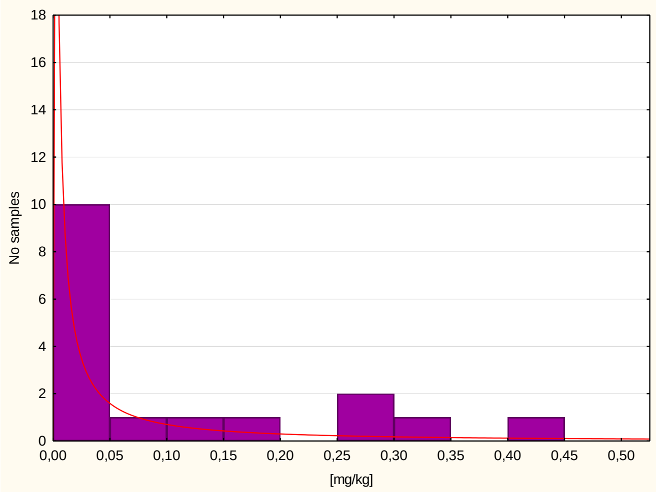
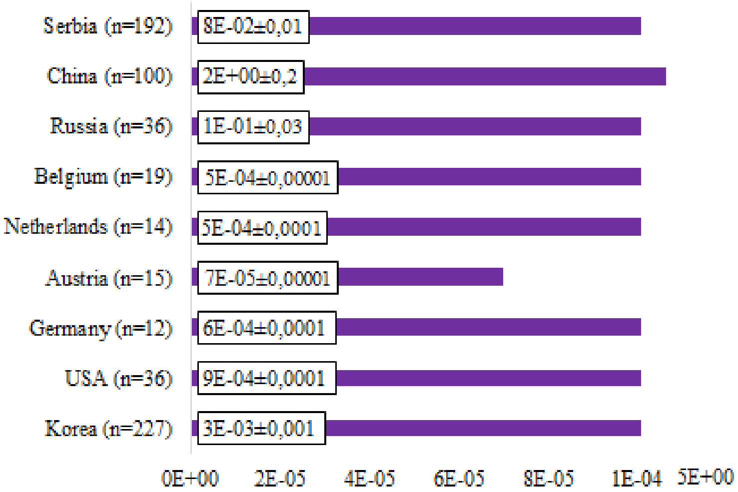
Results of statistical analysis



Statistical analysis of results of ICP-MS (mg/kg) of pork meat, 18 samples in total



Concentration of Cr in the pork meat, in the different geo zones by method of ICP-MS [mg/kg]