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Improvement of calculations of the total characterization factor in the Usetox Model including a regional approach

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Abstract

The USEtox model as one of LCIA models is an instrument to characterize the human toxicity impact. The model measures the intake of metals by population with meat products. The USEtox is the only model including geographical separation and wide database with organic and nonorganic chemicals. However, the USEtox does not provide any regional information, as ecological or geological specifications of areas included into the model. There is also a lack of data about metals concentrations in the database. Current investigation proposes an approach to reduce these limitations using results of bioindication studying– chemical composition of pork meat samples. Results of bioindication express assessing and forecasting changes in biotas under the anthropogenic influence locally in 3 settlements of “Central Asia” district. We extrapolate them into the USEtox model database, to extend it with concentrations of heavy metals Cr, Zn and As in the meat of pork. Characterization factor is proposed to assess their potential toxicity in soil and air in the region “Central Asia”.

Keywords: LCIA, the USEtox, Bioindication, Heavy metals, Human health impact assessment

1. Introduction

Among all impact assessment models, the USEtox recommended by the European Commission, is the only LCIA model with geographic separation parameter. The model is widely used by researches (Ortiz de García, García-Encina, & Irusta-Mata, 2017; Peña, Antón, Kamilaris, & Fantke, 2018; Rosenbaum et al., 2008, 2011), and most importantly, it is recognized and recommended by the global scientific community. The USEtox proposes only indicators related to toxicity and ecotoxicity. Despite all the advantages of using the USEtox model in the life cycle impact assessment, this model does not include a high level of spatial resolution and coverage of a wide metal database (Fantke et al., 2017).

2. Methods

The method for calculating the characteristic coefficient in the USEtox model is used to assess the potential impact on the health of the population in of “Central Asia” area regions. The characteristic factor is modified using data obtained by instrumental neutron activation analysis (INAA). The method of calculation is already described in a previous publication (Belyanovskaya, Laratte, Perry, & Baranovskaya, 2019). Locations with mixed environmental conditions and different anthropogenic tension levels inside of area “Central Asia” are chosen for potential impact assessment. The USEtox model database contains a wide range of elements, included 25 non organic compounds. Thus, from this database for the human health impact analysis are chosen toxic trace elements Cr, Zn, Sb, As, Ba. These metals are also analyzed with INAA method in the pork meat sampled in studied locations. These elements were selected for a comparative analysis of toxicity due to the toxicity of their effects on a living organism; for example, all of these elements, with the exception of Ba, can cause mutations in mammals (Chernнн & Baeva, 2004). However, all soluble barium compounds are highly toxic, and lead to acute poisoning of the body, leading to a lethal outcome.

The potential toxic effect is calculated in the USEtox model version 2.02 and the corresponding guidelines (Fantke et al., 2017), using the results of its own research. Exceptional non-carcinogenic toxic effects were considered for these elements due to incomplete data on the carcinogenicity of the elements. Results of INAA are normalized to the clarke number (Glazovsky, 1982) and then extrapolated to the characterization factor calculation. Concentration ratios of chosen elements in the pork meat vary depending on chosen district (Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.).

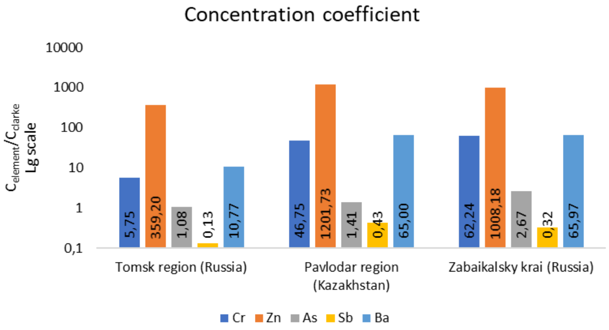

Figure 1. Concentration coefficient of elements in studied locations of "Central Asia" zone

3. Results and Discussions

A comparative analysis of the exposure factor for each of the studied regions is presented graphically in the form of diagrams (Figure 2).

The characteristic toxicity coefficient calculated using the modified exposure coefficient reflects the potential hazard of substances to human health, considering the environmental features of each region. According to the calculations, it can be noted that most of the elements have the highest level of toxicity in the Zabaykalsky Krai, both when ingested with air and with the soil. For most elements, the ranking of the toxicity index for entering from the territory through the soil and air is as follows: Zabaykalsky Krai> Palodar region> Tomsk Region. Arsenic makes a major contribution to pollution in the regions studied, and barium has a minimal effect.

Thus, the results of assessing the toxicity of elements in different study areas are consistent with previous studies, and show the potential toxicity of elements, not only depending on the concentration of elements in biomaterials, but also the size of the territory and population density.

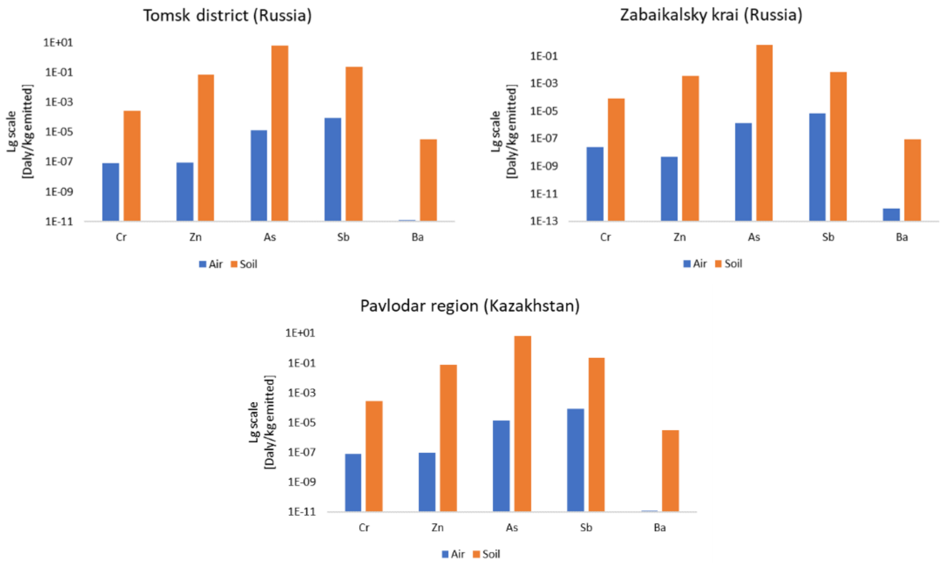

Figure 2. The characterisation factor calculated with extrapolated data [Daly/kg emitted]

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