Impact of heavy metals on human toxicity using LCA: a case study for Walloon corn

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Introduction: Databases, inventories, methodologies = black boxes?

Corn:
- An important cereal with a lot of applications in the feed and food industries (e.g. starch production)
- Growing context of biobased products, a better understanding of the impact of its production is needed, using Life Cycle Analysis (LCA)

USEtox:
- Developed by the UNEP/SETAC Life Cycle Initiative for characterizing ecotoxicological and human impacts of chemicals
- Recommended by the ILCD to evaluate the toxicological aspect when performing an LCA [1]
- The human toxicity is expressed in CTUh, the comparative toxic unit for human toxicity impacts
- The characterization factors (CF) = effects [cases/kg intake] * intake fraction [kg intake/kg emitted] [2]

Corn production in Wallonia (South Belgium)

- *Functional unit = 1 hectare of corn crop in Wallonia*
- Primary data are taken from Van Stappen et al. (2017) [3]. The LCI data are based on current agricultural practices recorded in farms' accounting data.
- The field emissions due to the application of inputs: by emission models as recommended by Nemecek (2013) [4]
  - The emission of trace metals are calculated using the SALCA-Schwermetall Swiss model developed by Freiermuth (2006) [5] adapted to local conditions using the trace metal content of mineral and organic fertilizers provided by Piazzalunga et al. (2012) [6]
  - Pesticides are assumed to end up entirely in the agricultural soil
- Modelled in GaBi 7 using GaBi datasets: Belgian datasets when available, if not, European datasets are used, and if no European, German ones.

Human toxicity, cancer effect: the case of chromium

- Large impact of chromium emissions in freshwater and in soil - organic and mineral fertilizers (Figure 1)
- All chromium emissions = chromium unspecified emissions
  - Only total chromium is dosed during the fertilizers analysis
- Chromium = Cr (+III) or Cr (+VI) but toxicological impact is different:
  - No impact for Cr (+III) and tremendous impact for Cr (+VI)
  - In USEtox, CF for unspecified chromium = average of Cr (+III) (small) and Cr (+VI) (very high) ➔ high
- Real state of the chromium? ➔ different impact!
  - Cr (+VI) is a powerful oxidant
    - In the presence of organic components, Cr (+VI) ➔ Cr (+III)
    - Mineral fertilizer: chromium from rocks used for production ➔ Cr(+III)
- Test: if 95 % of the chromium emissions from fertilizers = Cr (+III) …
  - **Then impact divided by 7**

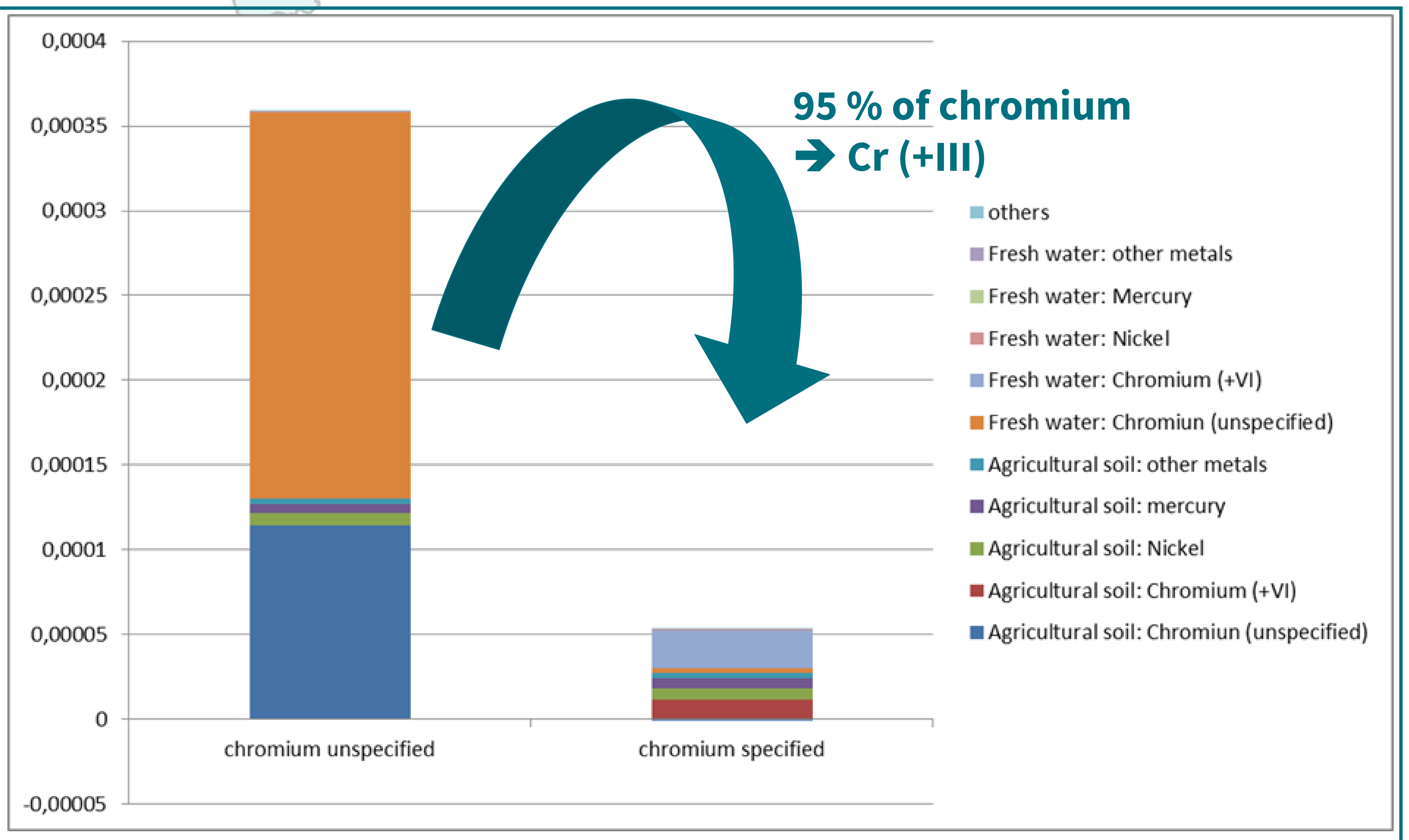

Figure 1. Impact on human toxicity, cancer effects: Influence of the speciation of chromium

Human toxicity, non-cancer effect: the case of zinc

- Large impact of zinc emissions in soil (Figure 2)
- CF for emissions in agricultural soil high: effect factor small (in comparison to other metals) but intake fraction is high
  - the metal with the largest emissions in soil
  - Organic fertilizers (pig manure) and, in a lesser extent, mineral fertilizers.
  - Abundant and an important trace element in the human body:
    - Useful for growth, bone and brain development, etc.
    - Mammals are able to eliminate zinc

➔For human, only exposure to high doses = toxic effects (interferes with copper uptake)

- No zinc: **impact divided by 12**

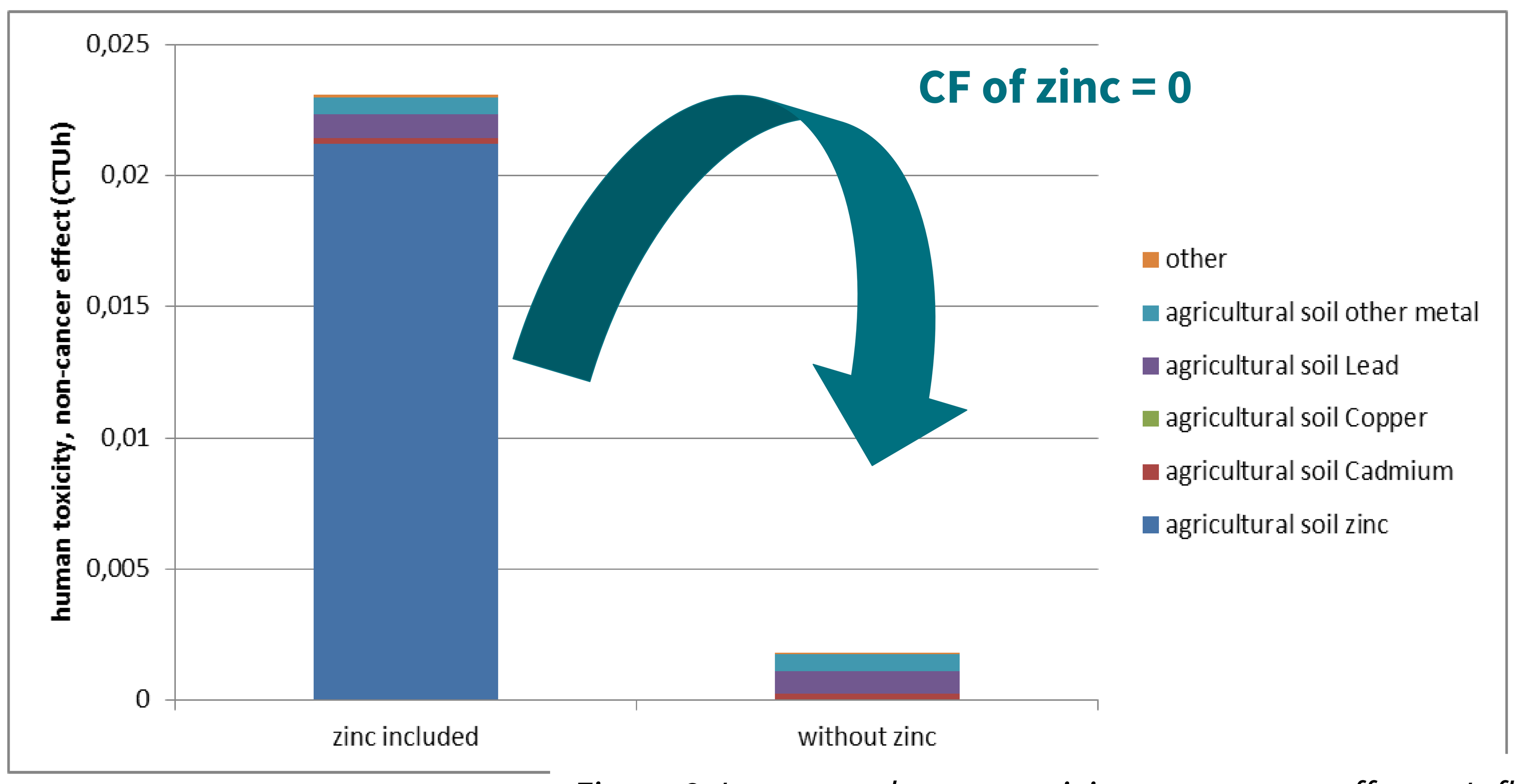

Figure 2. Impact on human toxicity, non-cancer effects : Influence of zinc.

The pesticides?

- The emissions of pesticides in the soil < 1 % of the total impact in both cases
- Their total amount is larger than the amount of metal emissions in soil, water and air
  - Some of them have no CF
  - Around 2.2 kg of pesticides (all included) applied by hectare
  - Only 1.2 kg is characterized in USEtox.
  - Most of them have only CF in human toxicity non-cancer effect
  - CF of the pesticide presented in this study is small compared to the CF of metals for emissions in agricultural soil

Conclusions

- Uncertainties related to human toxicity in LCA
- Importance of speciation for some elements (accurate data): example of chromium
- Need of deep analysis of CF in the study specific situation: example of zinc and pesticides

➔ Databases, inventories, methodologies ≠ black boxes

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[3] Walloon Agricultural Research Centre (CRA-W), ALT4CER project. 2014.
[4] Nemecek, T., 'Estimating direct field and farm emissions', Agroscope Reckenholz - Tänikon Research Station ART, Editor (2013): 31.
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