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 Nemeczek [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) \(\rightarrow\) high
• Real state of the chromium? \(\rightarrow\) different impact!
  • Cr (+VI) is a powerful oxidant
  • In the presence of organic components, Cr (+VI) \(\rightarrow\) Cr (+II)
  • Mineral fertilizer: chromium from rocks used for production \(\rightarrow\) Cr(+III)
• Test: if 95 % of the chromium emissions from fertilizers = Cr (+II) …
• Then impact divided by 7

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

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

References