XXXII Congresso Brasileiro de Ciência do Solo
"Trace Elements in Inorganic Fertilizers: Health Risk Assessment"

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ABSTRACT - Trace Elements are generally present in inorganic fertilizers as by-products or contaminants. There are however some trace elements (e.g., Zn, Cu, Fe, and Mn) that are plant nutrients and are intentionally included in fertilizer formulations. It is acknowledged a priori that exposure to high levels of trace elements (nutrient or not) could pose a health risk to humans. Therefore, this evaluation tries to establish safe limits of trace elements, referred to as Risk Based Concentrations, in inorganic fertilizers that are applicable to Brazilian conditions. The methodology used to develop the risk based concentration is a back-calculation of health risks and is standard for a screening level risk evaluation. This work follows the same approach of the document prepared by The Fertilizer Institute (TFI, United States) for the US scenario, entitled "Health Risk Evaluation of Selected Metals in Inorganic Fertilizers Post Application". The major purpose of this first attempt of establishing guideline values for concentration of trace elements in inorganic fertilizers in Brazil is to suggest limits (based on health risk assessment) that could be used as initial guidance for regulators seeking the protection of human health in the current scenario of fertilizers use in Brazil. The results obtained indicate that trace elements do not cause harm to human health when considering post application of inorganic fertilizers in Brazil (based on information for phosphate as well as Zn-carrying fertilizers). This study also suggests that the limits currently established by the Brazilian legislation are safe in terms of health risk assessment. It should be highlighted the need to increase the database for the construction of the Brazilian scenario, especially with respect to information concerning the concentration of trace elements in fertilizers marketed in Brazil. However, as more data are being collected, a new comparison with the risk based concentrations suggested in this study could be done to make this scenario closer to the Brazilian reality. Similarly, as more data are generated with respect to the parameters that make up the equation used to calculate the risk based concentrations for the Brazilian scenario, then, a review of currently estimated risk based concentrations could be made.

Key words: (heavy metals; food safety; soil contamination)

Introduction

An estimate of risk-based concentrations (RBCs) of trace elements (TE) provided by an industry-commissioned study (TFI, 2000) has shown that TE levels contained in commercial inorganic fertilizers are safe for consumers of farm products in the United States. A RBC is the amount of a TE in a fertilizer that is considered safe or protective of health.

We used the same methodology proposed by the TFI study in order to assess health risks of TEs in the current scenario of fertilizers use in Brazil (Guilherme & Marchi, 2007). Parameters such as application rates, soil accumulation factors, body weight, ingestion rates (crops), and plant uptake factors were adopted from the scientific literature. Data on inorganic fertilizers were taken from industry as well as literature studies. Other parameters, considered non-specific for the Brazilian population, were derived from the USEPA, according to TFI.

The aim of this work was to suggest limits (based on health risk assessment) that could be used as initial guidance for regulators seeking the protection of human health in the current scenario of fertilizers use in Brazil.

Materials and Methods

A. Risk Based Concentrations (RBCs) for Brazilian Fertilizers

Unit RBCs (normalized RBCs representing 1 percent fraction of nutrient content) were adjusted to represent Brazilian fertilizers. RBCs were calculated according to the equation 1 (Shown in the next page).

B. Screening Health Evaluation

The lowest RBC for TE were compared to the maximum concentration of metals of potential concern (MOPCs; e.g. As, Cd, Hg, and Zn). This comparison provided the most health protective estimate of health risk.

If the concentration of the MOPC in the fertilizer is below the RBC, there is no health risk. If the concentration of the MOPC in the fertilizer is above the RBC, further evaluation is warranted.

Results

RBCs for the Brazilian scenario (Figure 1) were lower than those shown at TFI report for As, Cd, Hg, and Zn due to higher Kd (L kg^{-1}) values for Brazilian soils.

RBCs for phosphate fertilizers applied to soils where

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roots are grown in the Brazilian scenario were also lower than those of the TFI report, as the application rates in Brazil are 2.5 times higher than those in the USA.

RBCs for zinc fertilizers were higher than in the TFI report due to doses 5.5 times lower applied in Brazilian agricultural soils than in the USA (Figure 2).

Discussion

A. Comparison of RBCs with TE concentrations in fertilizer products

There was only one sample exceeding the RBC for Cd in P-containing fertilizers (n = 111). For micronutrients containing Zn, only two fertilizers exceeded the RBC for Cu (n = 28).

B. Comparison of the RBCs with current Brazilian legislation (IN27)

Except for As in Zn fertilizers, all values based on health risk assessment for the Brazilian scenario were higher than those limits established in the Brazilian legislation. It means that in Brazil, the legislation is protective of human health.

Conclusions

The major purpose of this work was to set up guideline values (RBCs) for trace elements in inorganic fertilizers in Brazil. The results shown that trace elements concentration in P and Zn micronutrients fertilizers sold in Brazil are, a priori, safe.

The values for RBCs calculations will be updated and the database will be augmented with data from long term Brazilian experiments with fertilizers in a comprehensive way.

Acknowledgements

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References

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Equation 1.

$$RBC = \frac{\text{TR or THI}}{SACF * \{AR * 1/FON * [(\frac{ED * EF * IRs * RAFs * CF}{BW * AT} * TOX) + (\frac{ED * EF * SA * AF * ABS}{BW * AT} * TOX) + (\frac{ED * EF * IRc * RAFc}{AT} * PUF * TOX)]\}}$$

Where:

RBC	=	Risk Based Concentration (mg MOPC/kg product);
TR/THI	=	Acceptable Target Risk or Hazard Index (Unitless);
AR	=	Application Rate (g/m^2-year);
FON	=	Fraction of Nutrient (unitless);
SACF	=	Soil Accumulation Factor (m^2-year/g);
ED	=	Exposure Duration (years);
EF	=	Exposure Frequency (days/year);
BW	=	Body Weight (kg);
AT	=	Averaging Time (days);
CF	=	Conversion Factor ($1X\ 10^{-6}$ kg/mg);
IRs	=	Ingestion Rate Soil (mg/day);
SA	=	Surface Area (cm^2/event-day);
AF	=	Adherence Factor (mg/cm^2);
IRc	=	Ingestion Rate Crops (kg/day);
RAF	=	Relative Absorption Factor (RAF) (unitless);
ABS	=	Dermal Absorption Factor (unitless);
PUF	=	Plant Uptake Factor (unitless); and
TOX	=	Toxicity Values (mg/kg-day or mg/kg-day $^{-1}$).

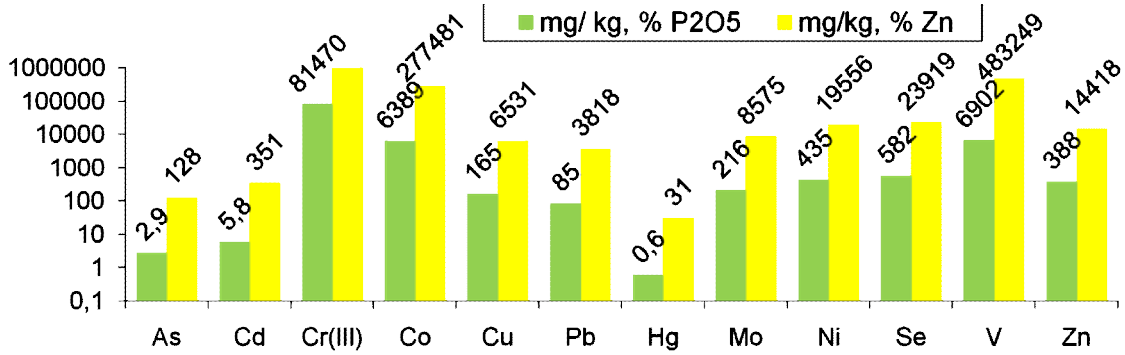

Fig. 1. Unit RBCs for fertilizers containing phosphorus (green), and zinc (yellow) calculated for the Brazilian scenario

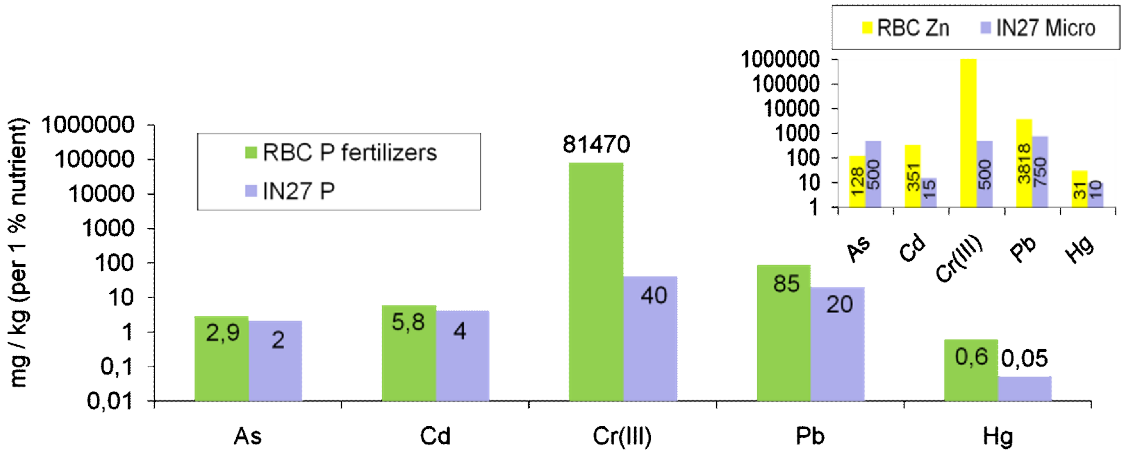

Fig. 2. RBCs for the Brazilian scenario (green) and Brazilian legislation values (blue) for P fertilizers. RBCs for the Brazilian scenario (yellow) and Brazilian legislation values (blue) for micronutrients fertilizers