Cobalt: Updated Revision to Risk Based Concentration

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History of RBC Development

- Weinberg Group developed a document in 2000 entitled *Health Risk Evaluation of Select Metals in Inorganic Fertilizers Post Application*

- That report details the evaluation of potential human health risks and the corresponding development of risk-based concentrations (RBC) for non-nutritive elements in fertilizer

- Of the three risk assessment conducted on the topic (EPA, CDFA, TFI) only the TFI risk assessment included cobalt; the Canadian standards for fertilizers also include cobalt

History of RBC Development, Cobalt

- TFI standards were based on human ingestion pathway (diet)
- Human ingestion pathway almost always the most sensitive
- Exception - US EPA 503 Rule, the foraging animal ingestion pathway gave a lower limit for one metal, **molybdenum**
- Direct plant toxicity was the most sensitive pathway for a few other metals (e.g., zinc and copper)

Risk Based Concentrations

- RBC values were subsequently re-evaluated and, where applicable and revised to incorporate more recent information on soil adsorption (Kd) and plant uptake factors (PUF)
- In 2002 the RBCs became the basis for guideline limits for NPK and micronutrient fertilizers adopted and published by the American Association of Plant Food Control Agents (AAPFCO) as SUIP #25
- 12 metals were evaluated in the original risk assessment; cobalt was not updated in 2002 as the new Suave/US EPA plant uptake factors did not include it (*nine were included in the revisions which lowered the RBC levels*)

SUIP #25 – RBC Levels

Metal	ppm per 1% P_2O_5 in NPK products	ppm per 1% micronutrient in micronutrient products
arsenic	13	112
cadmium	10	83
cobalt	3,100	23,000
lead	61	463
mercury	1	6
molybdenum	42	300
nickel	250	1,900
selenium	26	180
zinc	420	2,900

Collaboration with USDA

- Discussions with Dr. Rufus Chaney, Senior Scientist at USDA indicated that research he has developed suggested that the cobalt RBC should be lower based on the foraging animal pathway

- Cobalt occurs naturally in many different chemical forms throughout our environment; but availability is mainly controlled by soil pH and binding of manganese oxides

Cobalt: Why Update the RBC?

- Chaney's research explored potential pathways relative to ruminant toxicity
- Plants can accumulate up to 50 ppm Co before they have symptoms of toxicity
- Ruminants can suffer toxicity at 10 ppm Co in forages
- The average concentration of cobalt in world soils - 8 ppm. Urban lands can reach an upper limit of 17 ppm
- The revised risk assessment held soil cobalt constant at not greater than 10 ppm

Plant Uptake Factor Discussion

- Plant uptake Factor (PUF) remains dominant variable in the equation
- PUF value utilized in **TFI 2000 risk assessment** was:

  - **0.02** for grains
  - **0.03** for root crops
  - **0.05** for vegetables

Reevaluation of Cobalt RBC

- Concentrations in vegetation typically do not exceed 1 ppm, and high cobalt concentrations are almost never found in fruits or seeds
- TFI surveyed states informally; USDA confirms that few if any cases of cobalt toxicity in ruminants have been observed
- Cases that do exist typically are sporadic – range animals eating a variety of different plants
- Cobalt in soils is strongly sorbed and even co-precipitated with the manganese oxides (McKenzie, 1972). Availability of soil Co to plants is controlled by two major factors, MnO_2 in soils and soil pH

Reevaluation of Cobalt RBC

- Only a few plant species accumulate Co above the 100 ppm which causes severe phytotoxicity.
- These ‘hyper-accumulators’ of Co have been found which contain over 1% Co in dry leaves
- Based on these findings with soil, plants and animals, Co should be able to cause toxicity to ruminants grazing healthy Co-rich forages.
- Monogastric animals should not be injured because grain and fruit tissues are only somewhat Co-enriched when Co-phytotoxicity causes visual crop damage

Reevaluation of Cobalt RBC

- Individuals consuming large amounts of leafy vegetables grown on Co-toxic soils may be at risk
- None of these risks have been observed in nature, they should be studied to learn whether even the worst case can cause Co-toxicity in any animals
- The food-chain appears not to be protected from Co toxicity by the “Soil-Plant Barrier”
- Research needed on all aspects of Co in waste-soil-plant-animal systems to determine whether this is an actual risk even under worst case conditions

Reevaluation of Cobalt RBC

- **Central Question**: What concentration in fertilizer can be present that when applied will not yield a concentration that exceeds the reference plant concentraiton of 10 mg/kg (ppm)?
- PUF we used is a point estimate, therefore there is no fluctuation/variance in the relationship between soil and plant cobalt
- We commissioned three separate runs of the probabilistic risk assessment (working with Dr. Dan Woltering and Lee Shull of Montgomery Watson Harza, MWH)

- Co plant = **Co fertilizer x application rate x soil accum x PUF**

Previous and New RBCs

- Team utilized PUFs provided by Chaney; all three separate runs produced very consistent results

- **Newly Proposed RBCs utilize 95th percentile as an additional safety factor:**

136 ppm per 1% P2O5 in NPK fertilizers (3,100 ppm)

2,228 ppm per 1% micronutrient fertilizer (23,000 ppm)

Conclusion

Suggestion - Circulate these values as tentative for the next year, then go final