Texas Natural Resource Conservation Commission

INTEROFFICE MEMORANDUM

To:	Camarie Perry Toxicology & Risk Assessment Section Office of Permitting, Remediation & Registration (OPRR)	**Date:**	October 9, 2001
From:	Joseph T. Haney, Jr. Toxicology & Risk Assessment Section OPRR		
Subject:	Evaluation of the Potential Health Impacts of Exposure to Iron, Calcium, Magnesium, Potassium, Sodium, and Phosphorus through Soil Ingestion		

The Toxicology & Risk Assessment Section (TARA) has had inquiries about whether or not iron, calcium, magnesium, potassium, sodium, and phosphorus should be considered chemicals of potential concern (COPCs) for soil remediations. In order to determine whether or not it was necessary to develop soil cleanup levels for these essential elements, TARA evaluated the potential health impacts associated with exposure via the soil ingestion pathway. TARA focused on exposures through soil ingestion and intentionally did not evaluate dermal contact with soil, inhalation exposures, or uptake into crops. This approach was taken because the soil ingestion pathway is expected to be the primary route of exposure. In addition, there are technical limitations to evaluating uptake of essential elements in crops because of the significant difficulties/uncertainties inherent in modeling the environmental transport of these ubiquitous, essential plant nutrients. Therefore, with the soil ingestion pathway as the focus, TARA first compared the soil ingestion rates used to establish risk-based cleanup levels for several different types of receptors (i.e., adult and child residents, commercial/industrial workers) to the respective Recommended Dietary Allowance (RDA; National Academy of Sciences, 1989), or the lower end of the RDA range, if applicable. Results from these comparisons and other analyses are discussed below.

Adult Residents and Commercial/Industrial Workers

Table 1 shows the results of our comparison of the soil ingestion rate for adult residents to the RDA for each of the essential elements that were evaluated. As can be seen, the RDAs for adults for calcium, magnesium, potassium, sodium, and phosphorus are significantly higher than the soil ingestion rates for adult residents and commercial/industrial workers. This indicates that even if the soil were 100% of the constituent, daily intake would not approach the respective RDA. These results suggest that for adult residents and commercial/industrial workers, soil concentrations of calcium, magnesium, potassium, sodium, and phosphorus would not be expected to be of health concern. Therefore, calculation of human health Protective Concentration Levels (PCLs) under the Texas Risk Reduction Program (TRRP) was determined to be unnecessary.

A more in-depth evaluation was required for iron since the RDA was determined to be significantly less than the adult resident and commercial/industrial worker soil ingestion rates. To do so, Equation 1 was used to calculate the soil concentration at which daily intake from soil ingestion would be equivalent to the RDA for adults.

Equation 1: $$SC = \frac{RDA}{((IR \times CF1 \times CF2 \times EF \times ED)/AT)}$$

where:

SC = soil concentration where intake from soil ingestion equals the RDA (mg/kg)
RDA = recommended daily allowance (mg/day)
IR = ingestion rate (adult residents 100 mg soil/day, commercial/industrial workers 50 mg soil/day, children 191 mg soil/day)
CF1 = conversion factor (10^{-6} kg/mg)
CF2 = conversion factor (year/365 days)
EF = exposure frequency (residential 350 days/year, commercial/industrial 250 days/year)
ED = exposure duration (adult residents 30 years, commercial/industrial workers 25 years, children 6 years)
AT = averaging time (adult residents 30 years, commercial/industrial workers 25 years, children 6 years)

Based on the adult residential soil ingestion rate, the soil iron concentration at which the RDA would be reached was calculated to be approximately 104,000 mg/kg. Given that iron concentrations are typically lower than 104,000 mg/kg in Texas soils, and even in steel slag (see Table 2), as well as the fact that a child exposure scenario is more sensitive than the adult resident scenario and serves as the basis for the development of soil PCLs for non-carcinogenic chemicals of concern in the TRRP rule (30 TAC §350), calculation of human health PCLs for adult residents was determined to be unnecessary.

Based on the commercial/industrial worker soil ingestion rate, the soil iron concentration at which the RDA would be reached was calculated to be approximately 292,000 mg/kg. It is highly unlikely that iron would ever be present in soil at concentrations approaching 292,000 mg/kg, even at sites highly contaminated with steel slag (see Table 2). In addition, even at soil concentrations slightly above the level corresponding to the RDA, iron intake from soil ingestion is insignificant relative to iron intake from dietary sources and mineral supplements. Therefore, soil iron levels are not generally expected to be of health concern for commercial industrial workers, and calculation of human health PCLs for commercial/industrial workers was determined to be unnecessary. However, if soil iron concentrations significantly exceed 292,000 mg/kg, further evaluation may be warranted on a site-specific basis.
Camarie Perry

<u>Child Soil Ingestion versus RDA Results</u>

Table 1 shows the results of our comparison of the soil ingestion rate for children to the RDA for each of the essential elements being evaluated. As can be seen, the RDAs for calcium, potassium, sodium, and phosphorus are higher than the child soil ingestion rate. This indicates that even if the soil were 100% of the constituent, daily intake would not reach the respective RDA. These results suggest that for children, soil concentrations of calcium, potassium, sodium, and phosphorus would not be expected to be of health concern. Therefore, calculation of human health PCLs was determined to be unnecessary.

A more in-depth evaluation was required for magnesium since the RDA is less than the child soil ingestion rate. To do so, Equation 1 was used to calculate the soil concentration at which daily intake from soil ingestion would be equivalent to the RDA for children. Based on the child soil ingestion rate, the soil magnesium concentration at which the RDA would be reached was calculated to be approximately 437,000 mg/kg. Since it is highly unlikely that magnesium would ever be present in soil at concentrations approaching 437,000 mg/kg, even at sites highly contaminated with steel slag (see Table 2), magnesium is not expected to be of health concern for children. Therefore, calculation of human health PCLs was determined to be unnecessary.

A more in-depth evaluation was also required for iron since the RDA is significantly less than the child soil ingestion rate. To do so, Equation 1 was used to calculate the soil concentration at which daily intake from soil ingestion would be equivalent to the RDA for children. Based on the child soil ingestion rate, the soil iron concentration at which the RDA would be reached was calculated to be approximately 55,000 mg/kg. Most Texas soils contain iron levels below 55,000 mg/kg (the U.S.G.S. reported 70,000 mg/kg as the upper end of the range for iron in Texas soils), including soils contaminated with steel slag. Even at soil concentrations slightly above the level corresponding to the RDA, iron intake from soil ingestion is insignificant relative to iron intake from dietary sources and mineral supplements. Therefore, soil iron levels are not generally expected to be of health concern for children, and calculation of human health PCLs was determined to be unnecessary. However, if iron concentrations significantly exceed the upper range of those historically measured in Texas soils (i.e., 70,000 mg/kg), further evaluation may be warranted on a site-specific basis.

Table 1: Recommended Dietary Allowances (RDA) & Soil Ingestion Rates

Essential Element	RDA [1] (mg/day)	Adult Residential Soil Ingestion Rate [2] (mg/day)	Child Residential Soil Ingestion Rate [2] (mg/day)	Commercial/Industrial Worker Soil Ingestion Rate [2] (mg/day)
Iron	10	100 *	191 *	50 *
Calcium	800	100	191	50
Magnesium	280 adult 80 child	100	191 *	50
Potassium	2,000 adult 1,000 child	100	191	50
Sodium	500 adult 225 child	100	191	50
Phosphorus	800	100	191	50

* An asterisk indicates that the soil ingestion rate is greater than the corresponding RDA and therefore further evaluation was necessary.

[1] The RDA shown is the RDA or lower end of the RDA range for adults ($18 years of age) and children (1-6 years of age) as published in *Recommended Dietary Allowances, 10th Edition* (National Academy of Sciences, 1989).

[2] Soil ingestion rates were obtained from the *Exposure Factors Handbook, Volume 1, General Factors* (U.S. Environmental Protection Agency, 1989).

Table 2: Maximum Texas Background Soil Concentrations and Steel Slag Concentrations

Essential Element	Highest Texas Soil Background Concentration [1] (mg/kg)	Highest Steel Slag Concentration [2] (mg/kg)
Iron	70,000	86,700
Calcium	116,700	190,000
Magnesium	30,000	34,100
Potassium	35,000	< 1,000
Sodium	20,000	400

[1] As reported in *Chemical Analyses of Soils and Other Surficial Materials of the Conterminous United States* (U.S. Department of the Interior, 1981).

[2] Highest metal concentration in six steel slag samples from Structural Metals, Inc., Seguin, Texas.

cc: Toxicology & Risk Assessment Section Via E-Mail, Board, File

References

Looker, A, Sempos, CT, Johnson, C, and EA Yetley (1988): *Vitamin-Mineral Supplement Use: Association with Dietary Intake and Iron Status of Adults.* J Am Diet Assoc 88: 808-814.

National Academy of Sciences (1989): *Recommended Dietary Allowances, 10th Edition.* National Academy of Sciences, National Research Council. National Academy Press, Washington, DC.

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