UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
901 NORTH 5TH STREET
KANSAS CITY, KANSAS 66101

OCT 26 2005

MEMORANDUM

SUBJECT: Zinc Toxicosis in Horses
Cherokee County Superfund Site/Tri-State Mining District

FROM: Venessa Madden (Venessa Madden 10-26-05)
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TO: Dave Drake
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Per your request, the effect of elevated soil zinc concentrations on horses has been researched. Communications with Dr. Nelson Beyer of the U.S. Fish and Wildlife Service have been very helpful in determining how to approach the issue of zinc toxicity in horses. The following information may be useful in writing a fact sheet on the subject. In addition, two soil PRGs for zinc have been calculated. These PRGs represent a lower and upper limit of concentrations in which effects on horses are possible.

SUGGESTED WORDING FOR FACT SHEET

Zinc poisoning in horses in the Tri-State mining district has been reported for decades. The local term for the condition is "alkali disease." However, the use of this term may cause confusion because there is also an "alkali disease" of livestock that is associated with selenium toxicity or with exposure to alkaline waters.

Toxic concentrations of zinc in foals induce copper deficiency, which causes a weakening and thinning of cartilage and subsequent erosion in the joints. Young horses, in particular, have been found to be especially susceptible to zinc poisoning near mines and smelters. The signs of zinc poisoning in foals are lameness, enlarged joints, stiffness, twisted legs, shortened bones, walking on the tips of the hooves, body sores, and a rough coat.

The critical time for a foal is when it is a few months old, has been weaned, is growing rapidly, and is let out into pasture. Grown horses are not as sensitive to zinc exposure as foals. Injury to growing foals can be avoided by providing hay brought in from an uncontaminated source and limiting exposure to contaminated soils.

Pastures where foals have been affected contain zinc concentrations ranging from 1,300 ppm to 20,000 ppm. The highest concentrations were detected in areas where vegetation was stunted. Adequate zinc in the diet of horses is 40 to 100 ppm a day, with toxic concentrations ranging from 3,600 to 5,400 ppm a day. However, lower concentrations (1,000 to 2,000 ppm) have been shown to cause lameness in 3-month old foals.

Two assumptions were made when calculating soil concentrations that may potentially cause zinc toxicity in horses. First, foals are more sensitive than adults, so body weights were adjusted accordingly. Second, as soil zinc concentrations increase and vegetation becomes stunted, horses will be ingesting ever increasing amounts of soil in an attempt to forage for adequate amounts of food. Lowest-Observed-Adverse-Effect-Level (LOAEL) doses were used to back-calculate to a soil concentration that is likely to cause an effect in foals. This calculation is done by inserting a soil concentration into the Average Daily Dose equation that results in a dose that is equal to the LOAEL. Based on this calculation, a soil concentration of 8,500 ppm zinc represents a concentration in which there is a high potential for zinc toxicity in horses.

No-Observed-Adverse-Effect-Level (NOAEL) doses were used to back-calculate soil concentrations that are not likely to affect foraging foals. This calculation is done by inserting a soil concentration into the Average Daily Dose equation that results in a dose that is equal to the NOAEL. Based on this calculation, a soil concentration of 1,000 ppm zinc represents a concentration below which horses are likely to be unaffected. Calculations and assumptions can be found in the attachment to this memo.

Assumptions

- 4-month old weanling weighing 200 kg
- LOAEL is equal to 1,000 – 2,000 ppm zinc in diet (based on a study in which Cu deficiencies were seen within 5-6 weeks and lameness resulted within 6 weeks in 3-month old foals (Puls, 1994))
- 4-month old foals consume 3% of their body weight in food per day
- LOAEL: (1000 mg Zn /kg food x 6 kg food/day) / 200 kg BW = 30 mg/kg/day
- NOAEL: LOAEL x 0.10= 3 mg/kg/day

Average Daily Dose Calculations

$ADD = [(C_s \times FRs \times NIR) + (C_p \times FR_p \times NIR)] \times AUF$

Where:

- C_s = Average contaminant concentration in soil
- FR_s = Fraction of Diet that is incidental soil ingestion (assumed to be 2-5%)
- C_p = Average contaminant concentration in plants (calculated using a soil-to-plant uptake factor of 0.07 based on co-located soil and plant data from the Big River Site)
- FR_p = Fraction of Diet that is plant ingestion (assumed to be 95-98%)
- NIR = Normalized Ingestion Rate of 0.03 kg/kgBW-day
- AUF = Area Use Factor (assumed to be 1)

Back-Calculations to Soil Concentrations

30 ppm = [(**8,500** x 0.05 x 0.03)] + [(595 x 0.95 x 0.03)] x 1 = 16.95 + 12.75 = 29.7 ppm

3 ppm = [(**1,000** x 0.02 x 0.03)] + [(70 x 0.98 x 0.03)] x 1 = 0.6 + 2.06 = 2.7 ppm