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The Dose Makes the Poison

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The Tri State Dairy Conference is an excellent conference and I have to say that each year I get the most value out of Dr. Bill Weiss's presentation. This year was no exception. Dr. Weiss is a professor at The Ohio State University. His topic this year addressed mineral tolerances of animals. The bottom line is that everything, even required nutrients, can be toxic when consumed in large enough quantities. That even goes for water I suppose.

Weiss states that mixing errors (misplaced decimal points or errors involving elemental vs. formulated product are common culprits) generally result in a short period of excessive consumption with adverse effects that are often attributed to something else. While serious, there is little that can be said to correct a one time human error.

On the other hand, slight to moderate overfeeding is a more common mistake and one that can and should be addressed. It may not cause any adverse effects in the short term, however livestock may show signs of toxicity after prolonged consumption or when the dose is increased.

Overfeeding one nutrient may cause a deficiency of another or it may cause serious damage to vital organs, like the liver. It could also cause a reduction in feed or water intake which in turn results in reduced growth or production. Elevated concentrations of some nutrients may also carry over to meat or milk creating a risk to humans.

Below is a summary of his discussion of MTL's (Maximum Tolerable Levels) of minerals that are most likely to be over fed and some of the problems that may cause. He cautioned that MTL can mean a concentration in the diet or water (ppm or %) or intake (grams/day). Depending on the circumstances, dietary MTL may differ, i.e. single dose, acute (<10 days) or chronic (> 10 days). MTL can be influenced by the chemical form or source of the mineral as well as by the presence and levels of other minerals in the diet. He also cautioned that water should be sampled annually to determine it's influence, if any, on the dietary MTL since some water may contain large amounts of sulfates, nitrates, salt, iron or manganese.

Minerals with Medium Health Concerns when overfed for a prolonged period of time – Calcium, iron, phosphorus, potassium & zinc

❑ Calcium
- MTL is 1.5% of dietary DM (~2x NRC requirement).
- May cause slight reduction in intake at that level with greater reduction in intake and production at higher levels.

❑ Iron
- MTL is 500 ppm (about 10x NRC requirement) or lower if high Fe is fed for a prolonged period of time.
- May cause deficiency of copper, selenium and/or vitamin E.
- High Fe from Iron Sulfate or Iron Chloride are readily available and are of concern.
- High Fe caused by soil contamination will cause few Fe toxicity problems since it is in the oxide form which is unavailable for the most part.

❑ Phosphorus
- MTL is 0.7% (about 2x the NRC requirement).
- Excess P may reduce Mg absorption and reduce milk yield slightly.
- Adverse animal health levels are unlikely at slightly elevated levels but overfeeding P may result in serious pollution problems.

❑ Potassium
- MTL is 2% (about 2X NRC requirement).
- High K diets reduce Mg absorption and increases the incidence of milk fever, especially in dry cows.
- High K diets can be fed to lactating cows without adverse effects if magnesium is supplemented.

❑ Zinc
- MTL is 500 ppm (about 10 X NRC requirement).
- Excess Zn can result in copper deficiency.
- Excess Zn can reduce rates of gain in cattle.

Minerals with Substantial Health Concerns (Diets should contain less than the MTL) - Copper, Molybdenum, Selenium, Salt (sodium chloride) and sulfur.

❑ Copper
- MTL is 40 ppm or ~4X NRC requirements.
- Chronic consumption of excessive amounts causes liver damage.
- Copper can accumulate to fatal concentrations in the liver over time until it reaches a critical concentration.
- Certain breeds of cattle are more sensitive (Jersey's).
- Source of copper is important.
  - Copper oxide is highly unavailable & will be safe even at high dietary levels.
  - Copper from copper sulfate or copper chloride is highly available.
- The copper MTL will be higher for diets high in dietary sulfur or molybdenum.

❑ Molybdenum
- MTL is 5 ppm even though no dietary requirement for Mo has been established.
  - Excessive Mo in the diet can result in Cu deficiency.
  - True Mo toxicity probably occurs at ~ 100 ppm.
  - Feeding copper supplements may be sufficient to counteract the negative effects of feeding diets with a high Mo concentration.

❑ Selenium

- MTL is 5 ppm (17X the NRC requirement).
  - Based on data from animals consuming Se accumulator plants not found in the eastern states.
  - An MTL of 10 ppm is more realistic with sodium selenite, sodium selinate and selenium yeast.
- Se can be very toxic, often resulting in death within hours of consuming a toxic dose.
- Chronic exposure to lower doses can also lead to death.

❑ Salt (sodium chloride)

- MTL is 3% of dietary DM.
- Feeding diets with a higher salt content can reduce feed intake and milk production.
- Water with 0.25% salt will reduce milk yields as well.

❑ Sulfur

- MTL is 0.3% for high concentrate diets and 0.6% with high forage diets.
- The dietary requirement for sulfur is 0.2%.
- Higher levels can reduce availability of copper and selenium.
- Higher levels may increase hydrogen sulfide content in the rumen and may result in damage to the central nervous system, convulsions and death.

Dr. Weiss concluded that it is important to feed enough nutrients but not too much and that twice as much does not mean twice as good. In fact, for some minerals, the difference between adequate and damaging concentrations is not large.

Minerals with a maximum tolerable level (MTL) established for cattle by NRC (2005)

Mineral	Health Concern	Dietary MTL
Excessive Exposure Possible		
Calcium (Ca)	Medium	1.5%
Cobalt (Co)	Low	25 ppm
Copper (Cu)	High	40 ppm
Iodine (I)	Low	50 ppm
Iron (Fe)	Medium	500 ppm
Magnesium (Mg)	Low	0.6%
Manganese (Mn)	Low	2000 ppm
Molybdenum (Mo)	High	5 ppm
Phosphorus (P)	Medium	0.7%
Potassium (K)	Medium	2%
Selenium (Se)	High	5 ppm
Salt (NaCl)	High	3%
Sulfur (S)	High	0.4%
Zinc (Zn)	Medium	500 ppm
Excessive Exposure is Rare		
Aluminum (Al)	Low	1000 ppm
Boron (B)	Medium	150 ppm
Bromine (Br)	Medium	200 ppm
Cadmium (Cd)	High	10 ppm
Chromium (Cr)	Low	100 ppm
Lead (Pb)	High	100 ppm
Lithium (Li)	Low	25 ppm
Mercury (Hg)	High	2 ppm
Nickel (Ni)	Low	100 ppm
Silicon (Si)	Low	0.2%
Strontium (Sr)	Low	2000 ppm
Tin (Sn)	Low	100 ppm
Tungsten (W)	Low	20 ppm
Vanadium (V)	Low	500 ppm

Health concerns considers both the likelihood of a toxic exposure (including accidental) and severity of animal response. The MTL are for cattle and are on a Dry Matter Basis. Numerous factors affect MTL including bioavailability of mineral, duration of exposure, animal factors, and water concentrations. Data from this table should not be the sole source of information. Readers should consult the appropriate section of the NRC (2005).

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