

Copper in Dairy Footbaths: A Problem for Crops and Cows?

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Most dairies in Colorado use copper sulfate in foot baths to control hoof infections. After use, the foot baths are usually channeled into the wastewater lagoons along with the runoff water and flush water from the milking parlors. Then, the lagoon effluent is usually applied to forage crops being grown to feed the cows.

An article in Hoard's Dairyman by E.D. Thomas in July 2001 brought this issue to the forefront with special concern for copper accumulation in forage crops and subsequent toxicity to dairy cows.

Regulations

At this time, there are no regulations that pertain to copper applications to crops in the form of dairy effluent. However, both the biosolids and hog regulations require regular soil sampling and analysis for copper. In addition, The Colorado Department of Health and Environment limits the annual and cumulative application of metals in biosolids, including copper. The annual limit for copper application in this form is 67 lbs/acre, and the cumulative or lifetime loading limit is 1340 lbs copper per acre. Officially, these limitations do not apply to dairies, unless they use biosolids. However, the wise milk producer will pay attention to these regulations as possible precedents for dairy regulation in the future.

Copper Quantities

We calculated typical copper usage by Colorado dairies and found a range from about 1000 lbs Cu/year up to over 10,000 lbs Cu/year. This calculation is based on the following information: 5-10 lbs copper sulfate is dissolved in 25 gallons of water, copper sulfate is 25% copper, footbaths hold 25-75 gallons of water and are changed about nine times per day and used two to three times per week. So is 1000-10,000 lbs Cu/yr a problem? Obviously, the answer will depend on how much acreage the effluent is spread on. If the effluent is all applied through one center pivot onto 125 acres, this is equivalent to 9 to 84 lbs Cu/yr. The high end of the range is over the biosolids annual loading limit, so these values are high enough to warrant further consideration.

Toxicity to Bacteria in Lagoons

The first potential hazard of the copper could be to bacteria in the wastewater lagoons. Some copper may re-precipitate or settle out into the lagoon sludge, thus reducing the copper levels in the effluent itself. However, effluent copper levels may still be toxic to bacteria, and this is important because most lagoons are sites for either aerobic or anaerobic treatment of waste by bacteria. One large Colorado dairy recently had difficulty with low bacterial populations and determined that this was probably due to the copper sulfate footbaths.

Toxicity to Crops

When copper is applied to our soils, it is strongly bound. Exchangeable copper is held much more tightly than other cations, and is not readily available to plants. Organic matter also binds copper, so the more organic matter and clay that a soil has, the greater the potential for copper adsorption will be. In addition, increasing soil pH reduces copper availability to plants, allowing greater soil copper accumulation without subsequent plant toxicity in our high pH soils. Because of its strong binding, copper leaches very little, and accumulates in the soil surface.

Copper is not readily mobile in plants, resulting in higher copper levels in roots than in shoots. Therefore, copper toxicity often results in decreased root growth and damage to root cell membranes. Researchers have found that high levels of calcium can alleviate copper's toxic effects on membranes, which is fortunate for Coloradans who generally have high soil calcium levels. Copper toxicity may also induce iron deficiencies or general chlorosis in plants.

There is tremendous variability in plants' ability to tolerate high copper levels. In general, a level of 20-30 ppm in the leaves may be considered toxic, but this is a broad generality across all plant species and should not be applied to specific crops without additional information. Some researchers have noted that legumes, such as alfalfa, are more sensitive to copper toxicity than grasses, so care should be taken when growing alfalfa on soils that receive Cu-enriched effluent.

Toxicity to Livestock

The maximum tolerable level of copper in diets of lactating dairy cows is 100 ppm, while the minimum is 10 ppm. Therefore, when copper sulfate is being used in footbaths and the waste is channeled to the lagoon and applied to land, producers should have copper analyzed in their forages before feeding them, as part of their normal forage testing program. Be aware that other types of livestock have different critical levels; for example, 20 ppm copper can be toxic to sheep.

Actions to Consider

- Calculate your copper use and land application rate.

- Consider alternatives to copper sulfate (tetracycline or more soluble coppers that allow lower copper use rates).

- Divert the footbath water, so it does not enter the lagoons.

Analyze the copper content of forage grown on land that receives effluent with copper in it. Monitor forage copper levels annually to see if they are increasing.

- Increase the acreage of crops receiving the lagoon effluent, in order to dilute the copper over more area.