

# CASE STUDY: Use of Copper Sulfate and Zinc Sulfate in Footbaths on Oregon Dairies

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## ABSTRACT

Dairy farmers use footbaths to control diseases of the hoof. When the footbaths are changed, the solutions are dumped into the dairy manure handling system and applied to fields in the liquid manure system. The objective for this project was to survey 30 dairy farms in Oregon to evaluate  $\text{CuSO}_4$  and  $\text{ZnSO}_4$  use in footbaths. Soil samples were collected from 2 major fields at 15 cm deep and all samples were analyzed for Cu and Zn. Forages grown on the farm were sampled and analyzed for Cu and Zn, and manure was collected directly from milk cows and from the liquid manure storage system. All forages, soils, and manure were analyzed for Cu and Zn. Soil Cu concentrations ranged from 0.7 to 34.7 ppm, with an average of  $5.7 \pm 6.6$  ppm. Soil Zn concentrations ranged from 0.6 to 41.8 ppm, with an average of  $10.1 \pm 9.3$  ppm. Forage Cu concentrations ranged from 1 to 10 ppm, with an average of  $3.4 \pm 2.1$  ppm, and forage Zn ranged from 3 to 51 ppm, with an average of  $13.8 \pm 10.3$  ppm. Copper concentrations in fresh manure directly from milking cows were very consistent, at 10 ppm, and Cu in the manure storage ranged from 2 to 58 ppm, with an average of  $10.3 \pm 12$

ppm. The use of  $\text{CuSO}_4$  and  $\text{ZnSO}_4$  in footbaths on dairies in Oregon continues to be a common practice. More than 75% of dairy soils tested were considered high ( $>2$  ppm) in Cu concentration and 38% were extremely high ( $>5$  ppm). Using  $\text{CuSO}_4$  and  $\text{ZnSO}_4$  in footbaths is creating potential long-term environmental and cropping challenges on many Oregon dairies.

**Key words:** copper sulfate, footbath, hairy wart, zinc sulfate

## INTRODUCTION

Lameness is a common problem on US dairy farms, with 22% of cows reported as being affected (USDA, 2002; Cook, 2003). It has been reported that 59% of dairies larger than 200 cows in the United States use footbaths to control diseases of the hoof, such as hairy heel warts (USDA, 1997). Between 1991 and 1994, the frequency of infection on California dairies increased from 31 to 89% (Read and Walker, 1998). In addition to being extremely contagious, hairy heel warts are also a very expensive problem. Shearer and Hernandez (2000) reported that hairy heel warts cause 20% of all dairy lameness cases, with each case of lameness costing \$90 to \$130.

Medicated footbaths are a common technique for treating foot problems on dairies. An advantage of using a footbath is that it can be located in the exit lanes of the milking parlor, so milk cows are treated with little direct labor input. Although footbaths can be less labor intensive than individual applications, footbaths must be properly managed to be effective. The most commonly used medications are  $\text{CuSO}_4$ ,  $\text{ZnSO}_4$ , and formaldehyde. Copper sulfate is the most commonly used footbath disinfectant and is considered safer than formaldehyde. Copper sulfate is bacterostatic by reacting  $\text{Cu}^{2+}$  with protein thiol groups in target bacteria (Lavern and Hunt, 2002).

Typically, footbath solutions are  $\text{CuSO}_4$  mixed at a 5% solution and are effective for 150 to 300 cows. A 226-L footbath requires 11.4 kg of  $\text{CuSO}_4$ . Because  $\text{CuSO}_4$  is 25% Cu, 2.8 kg of elemental Cu is disposed of into the manure systems of dairies each time the footbath is changed. A farm using a footbath for 300 cows could use up to 2.8 kg Cu per milking. One study of 4 dairies in Wisconsin indicated that Cu application rates from footbath disposal ranged from 5 to 11.3 kg of Cu/ha annually (Rankin, 2009).

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Plants require very little Cu, with annual removal rates for most crops of approximately 0.11 kg/ha (Schulte and Kelling, 1999). Soil Cu loading rates can easily exceed crop use and can potentially be toxic to plants and microbes. However, no simple soil test has been developed that can reliably predict when Cu toxicity might occur (Stehouwer and Roth, 2004). Copper applied to soils is strongly bound, and exchangeable Cu is held much tighter than other cations. This strong binding potential typically keeps Cu from leaching from soil, resulting in an accumulation in the soil surface. Copper is not taken up easily in plants, so there are increased Cu levels in plant roots grown in high-Cu soils. Plant Cu toxicity often results in reduced root growth and damage to root cell membranes.

The objectives of this study were to survey 30 dairies in Oregon to measure  $\text{CuSO}_4$  and  $\text{ZnSO}_4$  use in footbaths and to sample soils, liquid manure, fresh manure, and farm-grown forages for Cu and Zn.

## MATERIALS AND METHODS

Thirty dairies in Oregon participated in this project. Approximately half the dairies were located in the Willamette Valley and the other half were located along the north coast in Tillamook County. Dairy producers were surveyed concerning their use of Cu or Zn and their current program for controlling hoof diseases on their dairies. Within each dairy, 2 fields that were considered major manure application fields were selected for soil sampling, and one soil sample was taken in each field at a depth of 15 cm. Manure samples were collected from the liquid manure storage facilities and directly from cow facilities. Samples of forage grown on the dairy were taken. Soils, manure, and forages were sent to Agri-check Inc. (Umatilla, OR) and analyzed for Cu and Zn.

## RESULTS AND DISCUSSION

### Survey Information

Hoof health concerns were recognized as a major issue for most the surveyed dairies. The largest single health issue observed was hairy or strawberry warts, followed by foot rot and abscesses. Few dairies had sufficient records to analyze these issues adequately. Footbaths were used on 90% of the surveyed dairies, with  $\text{CuSO}_4$  being the most common treatment used in the footbath in all these dairies. Twenty-seven percent of dairies used  $\text{CuSO}_4$  between 1 and 3 times a week, and 33% of the dairies surveyed used  $\text{CuSO}_4$  the majority of the time. Thirty-three percent of dairies surveyed indicated that they used both Cu and Zn interchangeably. Two farms currently used  $\text{ZnSO}_4$  as their product of choice for mixing the footbath solutions. Seven of the farms surveyed had used  $\text{CuSO}_4$  and  $\text{ZnSO}_4$  in the past but had stopped in recent years. One producer indicated he had stopped specifically because of concerns about accumulating Cu in the soil. Quantities of Cu being used ranged from zero to an estimated 6 kg/ha of Cu annually.

### Laboratory Analysis

Figure 1 illustrates the Cu concentration (ppm) in dairy soils taken at a 15-cm depth by the number of fields. Soil Cu concentrations from all dairies taken at 15 cm deep ranged from 0.7 to 34.7 ppm, with an average of  $5.7 \pm 6.6$  ppm. Generally, soil Cu levels greater than 2 ppm are considered high, and values greater than 5 ppm are considered extremely high. Figure 2 illustrates the Zn concentration (ppm) in dairy soils taken at a depth of 15 cm. Soil Zn concentrations ranged from 0.6 to 41.8 ppm, with an average of  $10.1 \pm 9.3$  ppm. Zinc manure concentrations ranged from 2 to 25 ppm in fresh manure, with an average of  $4.2 \pm 6$  ppm, and from 0.2 to 1.5 ppm in liquid manure storage, with an average of  $0.8 \pm 0.012$  ppm.

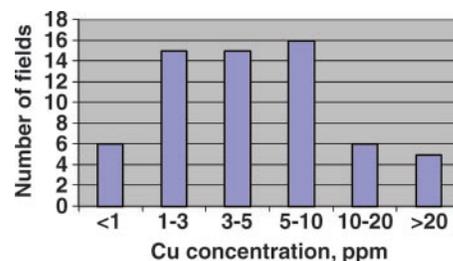


Figure 1. Soil Cu concentrations (ppm) on 30 dairy farms.

Copper concentrations in forages ranged from 1 to 10 ppm, with an average of  $3.4 \pm 2.1$  ppm, and Zn ranged from 3 to 51 ppm, with an average of  $13.8 \pm 10.3$  ppm. Manure Cu concentrations directly from milk cows were very consistent, at 10 ppm, and Cu concentrations in manure storage ranged from 2 to 58 ppm, with an average of  $10.3 \pm 12.02$  ppm. These results are shown graphically in Figures 3 and 4, respectively.

It is important to note that no toxic levels of Cu have been reported in forages produced on dairies in the United States. However, agronomists agree that continual use of Cu, without any accounting for accumulations, will eventually cause problems with plant productivity. Copper requirements for a Holstein cow producing 70 lb milk/d (31.8 kg/d) are predicted to be 10 mg Cu/d or, depending on the

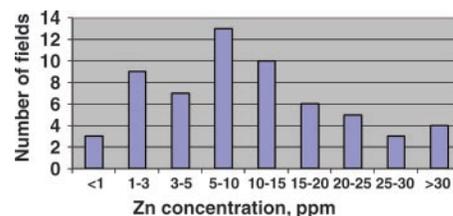


Figure 2. Soil Zn concentrations (ppm) on 30 dairy farms.

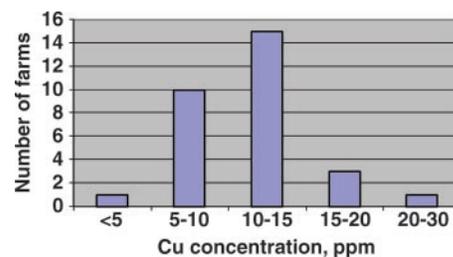
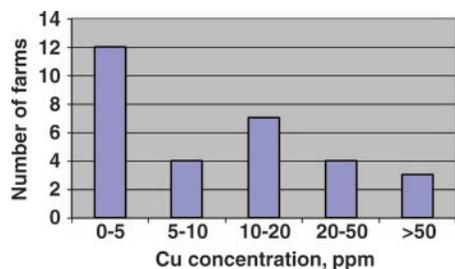


Figure 3. Copper concentrations (ppm) of home-grown forages for 30 dairy farms.



**Figure 4.** Copper concentrations (ppm) in liquid manure storage on 30 dairy farms.

digestibility of the Cu fed and other mineral interactions, the diet should include approximately 13 to 15 ppm Cu (Weiss, 2010). Diets that contain 40 to 50 ppm Cu have produced toxicity in some studies (Auza et al., 1999).

### Management Recommendations

1. Understand current Cu soil levels on your farm. If it is important to continue using  $\text{CuSO}_4$  in footbaths, include Cu analysis as part of regular soil testing, at least to understand the current situation. Dispose of Cu solutions across the total acres of the farm to reduce loading on smaller tracts of land.
2. Consider reducing the concentration and frequency of footbath use to address herd foot health needs, but reduce the total Cu used annually. A clean water footbath directly before the footbath with  $\text{CuSO}_4$

can improve the efficacy of the footbath. Organic matter binds Cu and reduces its effectiveness. The best long-term solution is to find new ways of preventing or treating hoof problems besides using  $\text{CuSO}_4$ .

## IMPLICATIONS

Oregon dairies continue to look for successful management strategies to control or eliminate hairy warts. The use of footbaths with  $\text{CuSO}_4$  solution is the most common method of medication, and  $\text{ZnSO}_4$  is used comparably in a limited fashion. One-third of the 30 farms included in this study used footbaths the majority of the time. No actual usage data existed on farms regularly using  $\text{CuSO}_4$ . Estimates indicate that farms regularly using  $\text{CuSO}_4$  could be applying as much as 4 to 6 kg of Cu/ha annually from the disposal of footbath solutions, which is considered as much as 45 to 50 times the annual Cu needed for most crops.

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