

**Impact of copper sulfate footbath use on eastern Wisconsin's manure, soil, and forage copper concentrations**

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**Why copper sulfate?**

**Digital dermatitis (DD)**

- 70% of US Dairy herds have DD
- 95% of large herds have DD
- Rapid spread in the 1990s as herds grew and consolidated
- Causes lameness and reduced productivity
- Copper sulfate is a low-cost product that works well in cold temperatures

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**Footbath Use in Wisconsin**

<p><b>Dairyland Initiative Recommendations</b></p> <ul style="list-style-type: none"> <li>• Disinfectants           <ul style="list-style-type: none"> <li>• Copper sulfate – 2 to 5 percent</li> <li>• Formalin, zinc, premixes</li> </ul> </li> <li>• Changed after 150 to 300 cows</li> <li>• Offered at minimum 3 times per week</li> </ul>	<p><b>UW Survey of 45 farms in NE Wisconsin</b></p> <ul style="list-style-type: none"> <li>• Disinfectant           <ul style="list-style-type: none"> <li>• Copper sulfate most common – 65% of farms</li> <li>• Concentration of CuSO<sub>4</sub> <ul style="list-style-type: none"> <li>• 4 to 6% solution – 40% of farms</li> <li>• 12 to 30% solution – 27% of farms</li> </ul> </li> </ul> </li> <li>• Frequency           <ul style="list-style-type: none"> <li>• 1 to 3 times per week – 40% of farms</li> <li>• 4 to 7 times per week – 33% of farms</li> </ul> </li> </ul>
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## Copper – Soils and Plants

### Soils

- Elemental Cu naturally occurs in soil
  - Rarely deficient in Wisconsin
  - Background levels???
- Binds with SOM and clay
  - Once on farm, stays on farm
- Negatively impacts soil ecology

### Plants

- High soil Cu
  - Impair lateral root and seedling growth
  - Potential for increased plant concentrations
- Cu tolerance
  - Low – pasture grass and peas
  - Moderate – corn
  - High – alfalfa and small grains




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## Copper – Dairy Animals

- Dietary Cu requirements (NRC, 2001)
  - Dry and lactating cows 13 to 15 ppm Cu
  - Calves and heifers 15-25 ppm Cu
- Can become toxic above 100 ppm
  - Jerseys accumulate liver Cu faster than Holsteins
  - Most Cu is excreted (99%), the rest accumulates in soft tissues
- 2015 WVDL study found Cu accumulation in all ages of Wisconsin Holsteins
  - Oxidative liver damage
  - When stressed, Cu can be released from the liver into the bloodstream
    - Destruction of red blood cells and death






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## Liver Copper Concentrations in Dairy Michigan State University

Table 1. A comparison of hepatic copper concentrations (given on a dry tissue basis) in adult dairy cows from samples submitted to the Michigan State University Veterinary Diagnostic Laboratory (Lansing) from 2007 to 2015<sup>1</sup>

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015
N	24	33	66	48	49	82	198	119	165
Range (µg/g)	103-1,352	34-1,963	43-1,337	21-1,429	65-1,806	63-1,069	3-1,664	74-1,266	7-1,122
Mean (µg/g)	682	526	471	427	533	454	471	483	432
Median (µg/g)	647	403	432	382	507	444	438	478	427
SD	333	398	240	302	363	222	255	224	221
>500 µg/g (%)	75.0	42.4	39.4	33.3	31.0	39.0	38.3	43.7	39.9
>850 µg/g (%)	20.8	18.2	6.1	8.3	12.2	8.5	7.7	5.0	5.5

<sup>1</sup>According to the Animal Health and Veterinary Laboratory Agency, the upper end of the normal reference range is 500 µg/g for normal hepatic copper concentrations (Biden et al. 2012). Hepatic copper concentrations greater than 850 µg/g increase the risk for copper toxicosis.

Adequate – 75 to 300 ppm  
 Concerns – > 500 ppm  
 Toxicity Risk – > 850 ppm  
 Mean (2015) – 432 ppm




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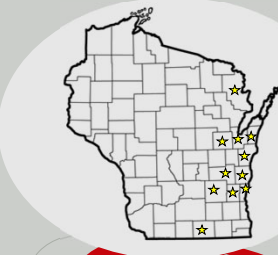
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### On-Farm Cu Levels on WI Dairy Farms

- 2022 field survey of established alfalfa
- 20 dairies that use copper sulfate footbaths
- Soil, alfalfa (1<sup>st</sup> and 3<sup>rd</sup> crop), and manure
  - Pre-first crop
    - Tissue (0-6") and whole plant alfalfa sample
    - 0-6", 6-12", 1-2", and 2-3" soil sample
  - Pre-third crop
    - Tissue (0-6") alfalfa
  - Post-third crop (if manure applied)
    - Manure sample
    - 0-6" and 6 to 12" soil sample
- UW Soil and Forage Testing Lab



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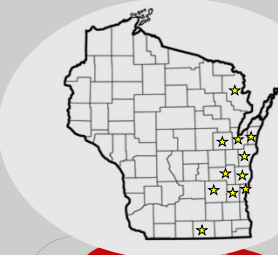
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### On-Farm Cu Levels on WI Dairy Farms

- Participating herds
  - 190 – 4,600 lactating cows
  - 20 dairies
  - 12 counties
  - Concentrated dairy area in Wisconsin
  - Variety of soil
    - Loam
    - Silt Loam
    - Shallow bedrock
    - Clays



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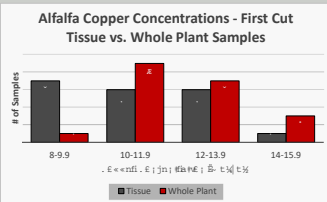
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### First Crop Alfalfa Concentrations

Alfalfa Copper Concentrations - First Cut  
Tissue vs. Whole Plant Samples



Concentration Range	Tissue (# of Samples)	Whole Plant (# of Samples)
8-9.9	~10	~2
10-11.9	~10	~12
12-13.9	~10	~10
14-15.9	~5	~8

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### Soil and Manure Copper Concentrations

- Manure Copper (DM basis, 6 farms)**
  - Average – 373 ppm
  - Range – 60 to 847 ppm
- Surface Soil Copper (0-6", 19 farms)**
  - Average – 6.1 ppm
  - Range – 1.0 to 13.5 ppm
  - pH – 7.2 to 7.6, SOM – 2.3 to 4.6%

Figure 4. Long term trends in copper content (DM basis) of liquid manure in VT

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### Liver Analysis of Participating Herd

- Liver samples collected from 26 Holstein cows**
  - 4,600 cow dairy consisting of primarily Holsteins
  - Livers collected at harvest
  - Lactations 1-6
  - Aged 4-9 years
  - Analyzed at Iowa State University Veterinary Diagnostic Lab

14

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### Liver Analysis of Participating Herd

- Conversions**
  - Michigan State analyzes heavy metals on a wet basis
  - Iowa State analyzes on a dry basis
    - Conversion is 2.5X

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### Liver Analysis of Participating Herd


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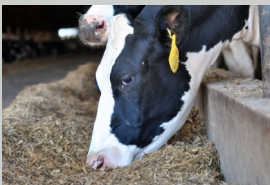

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### Forage Analysis of Participating Herd

- Six main TMR diets analyzed for copper
  - Evaluated at Dairyland Laboratories, Arcadia, WI
- Diets
  - 6-12-month-old calves
  - Breeding/Bred heifers
  - Dry cow
  - Close up/steam-up dry cow
  - Post-Fresh
  - Lactating

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### Forage Analysis of Participating Herd

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### Liver and Diet Analysis

- Diet is on the low end of Cu requirements
- Livers are moderate in Cu levels, but not necessarily correlated to age or lactation

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### Recommendations

- Know how much copper sulfate is used
  - (# bags of copper sulfate per year \* 25%) / number of acres applied
  - Test your manure \* application rate
- If copper applications are...
  - Less than 2 lbs/A/yr – buildup gradual
  - More than 5 lbs/A/yr – analyze crops and soils every 5 years
  - More than 10 lbs/A/yr – continue monitoring and strategize to reduce use



5% solution, 12'x2'x4" – 25 lbs CuSO<sub>4</sub> per bath  
 1,000 cow dairy – 4 changes per offering,  
 3 offerings per week  
 15,600 lbs CuSO<sub>4</sub> per year (25% Cu)  
**3,900 lbs Cu per year**



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### Farm Team Approach

**Nutritionist – monitor forage Cu**



- Reduce unneeded supplementation
- Monitor changes in forage Cu levels

**Agronomist – monitor soil and manure Cu**

- Manage manure applications
- Reduce/eliminate copper fertilization
- Maintain soil pH

**Veterinarian – Efficient footbath use**

- Concentrations of CuSO<sub>4</sub> and footbath frequency
- Consider alternating or replacing CuSO<sub>4</sub>
- Maintain hoof-trimming schedule
- Spot treat rather than whole herd

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### Take-aways

- No relevance/correlation in soil type compared to Cu concentrations
- 3<sup>rd</sup> crop showed higher Cu concentration compared to 1<sup>st</sup> crop
  - Likely due to plant being shorter (less plant material)
  - Hotter/dryer weather may lead to Cu concentrations to be higher in late July/Early August (higher plant transpiration)
- Plants have limited absorption capabilities
  - Once copper is in the soil, it stays there unless used by the plant

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### Limitations

- Soil samples were difficult to take in some locations – especially 3<sup>rd</sup> crop
- Targeted farms known to use copper sulfate footbaths
- Mostly herds more than 400 cows
- Liver samples could have been analyzed at Michigan State Veterinary Diagnostic Lab
  - Comparison of research data

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### Next steps

- Footbath management survey of participating farms
- Liver biopsies on farm or liver samples at a commercial slaughter plant with verified source cows
- Are there other heavy metals to follow?
  - Zinc?



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