Dairy Supplies L.L.C.
799 West 200 North
Paul, ID 83347

To:

National Organic Standards Board
Program Manager
USDA/AMS/TM/NOP, Room 4008-So., Ag Stop 0268
1400 Independence Ave. SW.
Washington, DC 20250
Phone: (202) 720–3252.
Fax: (202) 205–7808.

Petitioner:

Vantage Dairy Supplies, LLC
799 West 200 North
Paul, ID 83347
Phone: 208-312-3160 Fax: 208-297-5556
office@vancoproducts.com
Contact: Marty Van Tassell

Petition for Zinc Sulfate in Livestock Production

Item A – Please indicate which section or sections the petitioned substance will be included on and/or removed from the National List.

This petition is submitted, and includes all applicable information, under the following section: Synthetic substances allowed for use in organic livestock production, 205.603

Item B – Please provide concise and comprehensive responses in providing all of the following information items on the substance being petitioned:

1. *The substance's chemical name.*
   Zinc Sulfate.

2. *The manufacturer's name, address, and telephone number.*
   There are multiple manufacturers. The manufacturer for our product is:
   Uniprime International LLC, 243 Woodland Drive, Lincroft, NJ 07738.
   Phone: 732-784-3177

3. *The intended or current use of the substance.*

   Current Use: Already approved by NOSB for use as Micronutrients in Organic Crop Production, 205.601 (j) (6) (ii). Already approved by NOSB for use as Trace Minerals in Organic Livestock Production, 205.603 (d) (2).

   Intended Use: In conjunction with copper sulfate as a topical treatment, external parasiticide or local anesthetic as applicable, 205.603 (b). To be used in livestock foot baths for fungal and bacterial infection.

4. *A list of livestock handling activities for which the substance will be used. If used for livestock, the substance's rate and method of application must be described.*

   Each dairy can vary slightly in their treatment, but generally it will average .006 lbs. of zinc sulfate per cow which equates to .0021 lbs. of heavy metal zinc per cow mixed in the foot bath solution for each treatment. Then, like traditional straight copper sulfate treatments, it will be flushed out into the lagoon and ultimately onto their fields. The rate at which zinc would end up in the fields would depend upon the number of cows at the dairy and the number of acres across which they could spread the lagoon contents. Please see the "Petition Justification Statement" section for a detailed comparison of our zinc sulfate/copper sulfate blend and traditional straight copper sulfate treatments. It will be used as a treatment and prevention for hairy warts (digital dermatitis) and general hoof health in livestock.

5. *The source of the substance and a detailed description of its manufacturing or processing procedures from the basic component(s) to the final product.*

   Zinc Sulfate is made similarly to Copper Sulfate by reacting Zinc (from mining) with Aqueous Sulfuric Acid. Please see page 129 of ATSDR Toxicological Profile for Zinc (352 pages) for more detailed information on the mining process.

6. *A summary of any available previous reviews by State or private certification programs or other organizations of the petitioned substance.*

   It has been allowed with restrictions in crop and animal production. OMRI has zinc sulfate products approved for use in soils with a documented zinc deficiency.

7. *Information regarding EPA, FDA, and state regulatory authority registrations, including registration numbers.*

   Information does not exist.

8. *The Chemical Abstract Service (CAS) number or other product numbers of the substance and labels of products that contains the petitioned substance.*

   CAS #7733-02-0

   See attached label[2] of product that contains petitioned substance.

9. *The substance's physical properties and chemical mode of action including (a) Chemical interactions with other substances, especially substances used in organic production; (b) toxicity and environmental persistence; (c) environmental impacts from its use and/or manufacture; (d) effects on human health; and, (e) effects on soil organisms, crops, or livestock.*

   Physical Properties: Colorless solid granules.

   (a) Chemical interactions with other substances, especially substances used in organic production:
   It is corrosive to metals. Otherwise it is much less reactive than Copper Sulfate.

   (b) Toxicity and environmental persistence:
   Breaks down into its components of Zinc, Sulfur, and Water in soil. Zinc is a necessary nutrient for plant and animal growth; however excess application could disrupt essential nutrient balances in soils and in extremes could become toxic to plants or animals. Zinc Sulfate is toxic to fish and aquatic invertebrates. Direct application to water where these exist should be avoided.

   (c) Environmental impacts from its use or manufacture:
   Environmental impact from Zinc mining would be similar to Copper mining or any other mined mineral used in organic production. Impacts from its use would depend on the number of acres the lagoon materials would be spread across. However, with our Zinc Sulfate/Copper Sulfate blend and the reduced amounts of metals flushed onto fields compared to other footbaths, the risk of negative environmental impacts would be small. (See Justification Statement)

   (d) Effects on human health:
   See attached MSDS[1]. Also see the link below to the ATSDR Toxicological Profile for Zinc.

   (e) Effects on soil organisms, crops, or livestock:
   See (b) above.

10. *Safety information about the substance including a Material Safety Data Sheet (MSDS) and a substance report from the National Institute of Environmental Health Studies.*

    See attached MSDS[1].

11. *Research information about the substance which includes comprehensive substance research reviews and research bibliographies, including reviews and bibliographies which present contrasting positions to those presented by the petitioner in supporting the substance's inclusion on the National List.*

    ATSDR Toxicological Profile for Zinc (352 pages)

    a. http://www.atsdr.cdc.gov/toxprofiles/tp60.pdf

    Other Research (All are attached articles except where abstract only is noted)

[3] Desnoyers, N. et al. 2008. "An Investigation of Hairy Foot Wart Treatments and Associated Environmental and Public Health Risks" *www.uvm.edu* 2008.
[4] Downing et al. 2010. "Case Study: Use of Copper Sulfate and Zinc Sulfate in Footbaths on Oregon Dairies" *The Professional Animal Scientist* 26 (2010):332-334.
[5] Socha et al. "Alternatives to Copper Sulfate Footbaths" ftp://173.183.201.52/Inetpub/wwwroot/DairyWeb/Resources/PNWANC2007/Socha.pdf (Abstract and bibliography attached)

There is a lack of studies and information about Zinc Sulfate usage in footbaths. Copper Sulfate is more widely used in dairy footbaths, probably due to the fact that Zinc Sulfate is harder to dissolve in solution. This confirms the conclusion that there is also a lack of information about the effect of Zinc Sulfate being applied to fields after usage in footbaths because it is not so heavily used. There is greater wealth of information on Copper Sulfate because it is so heavily used. Some articles have been attached that deal with Copper Sulfate. **A quick search indicates great concern about potential soil toxicity from footbaths using Copper Sulfate, where the same search indicates little to no concern for potential soil toxicity from using Zinc Sulfate in footbaths.**

Two research publications are attached at the end of this petition concerning zinc sulfate footbaths and sheep. They show that zinc sulfate footbaths are effective in sheep, which is very important, given that copper cannot be safely used in sheep.

[12] Cross, R.F.; Parker, C.F., Zinc sulfate foot bath for control of ovine foot rot; JAVMA 1981, 178: 706-707
[13] Sheep Foot Health Farm Protocol
http://umaine.edu/sheep/files/2010/06/protocol-5-12.doc
Sheep Footrot Research Project, c/o Richard J. Brzozowski, PI, University of Maine Cooperative Extension, 75 Clearwater Drive, Falmouth, ME 04105
Richard.brzozowski@maine.edu, 207-781-6099

12. *A "Petition Justification Statement" which provides justification for the following action requested in the petition:*
Inclusion of a Synthetic on the National List 205.603.
This statement will:
   a. *Explain why the synthetic substance is necessary for the production or handling of an organic product.*
   b. *Describe any non-synthetic substances, synthetic substances on the National List or alternative cultural methods that could be used in place of the petitioned synthetic substance.*

c. *Describe the beneficial effects to the environment, human health, or farm ecosystem from use of the synthetic substance that support its use instead of the use of a non-synthetic substance or alternative cultural methods.*

Hairy heel warts (Digital Dermatitis) are a serious problem on dairies throughout the country. Please see this reference introduction[4]. Copper Sulfate is widely used for treatment of Digital Dermatitis on both organic and non-organic dairies. On non-organic dairies Zinc Sulfate "$ZnSO_4$ is used comparably in a limited fashion"[4]. Copper Sulfate has been allowed for use on organic dairies, despite being synthetic, because it is effective and there are no effective organic substances for the purpose of treating Digital Dermatitis. Copper Sulfate is being used so heavily that there is concern that it will become toxic to the soil and effect the growth of the plants as well as hurt the animals. Please see attached references[6, 7, 8, 9, 10]. In some areas of the country commercial dairies have had to resort to the use of Formaldehyde (a known carcinogen) for treatment because of the levels of Copper in their soil. Copper and Zinc are both essential to plant growth, but can become toxic if they are too prevalent. So, there is no reason to believe that Zinc Sulfate would not pose the same risk of toxicity to soil as Copper Sulfate when used as a standalone treatment the way that Copper Sulfate is. However, what I hope to show is that by using our Zinc Sulfate/Copper Sulfate blend as a treatment, we not only improve the results in treatment of Digital Dermatitis, we significantly decrease the amount of both substances being flushed out of dairy lagoons and onto fields. This will dramatically decrease, if not entirely eliminate, the chances of toxicity in the soils, and provide for much easier management of the nutrient balances in the soil.

I think it would be best to first explain how most foot baths are set up and operated on dairies. Different factors affect the exact amount of animal passes a foot bath can handle before the product used as a topical treatment becomes ineffective due to excessive organic matter deposited into the bath by several means. Some of those deposits include waste produced by a cow directly into the bath or tracked into the bath by the feet of the animal. Also, deposits can be made from organic material being flushed into the foot baths by washing or flushing procedures at specific locations. Below is an explanation of the numbers when a foot bath is flushed using common straight Copper Sulfate treatments compared to our Zinc Sulfate/Copper Sulfate blended treatment.

Current Option of Copper Sulfate (most commonly used)

- Basically the only effective Foot Bath TREATMENT on the market today for Organic Dairies is Copper Sulfate. Copper Sulfate is applied by dumping 50 lbs. of Copper Sulfate into a 100 gallon footbath full of water. Organic Dairies will do this and have approximately 500 cows walk through this foot bath before they flush the bath and refill the bath. Some dairies use a smaller 50 gallon foot bath but the rate is the same, they will add 25 lbs. of Copper Sulfate and generally refresh it after 250 cows. The Copper Sulfate contains generally 25.2 percent copper which means every time a footbath is flushed, 12.6 lbs. of heavy metals go down the drain to the lagoon and eventually onto the fields. Due to the large amounts of heavy metals being flushed, many places like Europe have outlawed Copper Sulfate as a topical treatment in foot baths because of what it does to the soils.

Copper Sulfate foot bath Treatment

- Treat approximately 500 cows.
  50 lbs. of Copper Sulfate
  1. 12.60 lbs. of Heavy Metal Copper (0.0252 lbs. per cow)

Zinc Sulfate/Copper Sulfate blended Treatment

- Treats approximately 1,000 cows.
- Zinc Sulfate/Copper Sulfate blend
  1. 2.016 lbs. of Heavy Metal Copper (0.002 lbs. per cow)
  2. 2.100 lbs. of Heavy Metal Zinc (0.0021 lbs. per cow)
- **4.116 lbs. TOTAL HEAVY METALS (0.004116 lbs. per cow – 84% LESS)**

Levels found when using the Copper Sulfate/Zinc Sulfate blend are within the reasonable rates some areas use for soil amendments, thus buildup should never be a factor.

This might not seem like a huge amount of Copper being deposited into the soils but let me clarify. Many of the Organic Dairies have become quite large. I will not divulge the name of a specific dairy but they are putting over 300,000 lbs. of Copper Sulfate out onto their soils every year, just from a single location. That is almost 75,000 lbs. of heavy copper metals deposited into the soil. Unfortunately this type of usage is very similar with all the large Organic dairies. I can't begin to explain how critical it is to be very proactive in finding an alternative solution as soon as possible. Once copper gets into the soil it is very immobile. **If we drag our feet and allow this to continue, it will eventually produce irreparable damages.** "The best long-term solution is to find new ways of preventing or treating hoof problems besides using $CuSO_4$."[4] Our blended treatment, while still including Copper Sulfate, is a long term solution to the growing problem of Copper residues in soils caused by treatment of Digital Dermatitis in livestock because of the drastic reduction in the amount of heavy metals being applied to the soil.

Please also see the attached chart for the results of our study in the comparison of 3 products used commercially for treating Digital Dermatitis[11]. The 3 products are our Zinc Sulfate/Copper Sulfate blend, straight Copper Sulfate(comparable to the treatments on Organic Dairies), and Formaldehyde.

While our desire is to use Zinc Sulfate in conjunction with Copper Sulfate in footbaths on dairies, there is another benefit to allowing Zinc Sulfate to be used in Organic Production of livestock. Currently Zinc Sulfate use in footbaths is more prevalent among commercial sheep producers than commercial dairy producers. The reason for this is that Copper Sulfate stains the wool of the sheep and is very toxic to sheep if ingested. Therefore, allowing Zinc Sulfate in Organic use would also benefit Organic sheep producers by giving them access to a product that circumvents the harmful effects of Copper Sulfate on their sheep.

I recommend that immediate action be taken to allow Zinc Sulfate to be used on Organic Dairies for livestock hoof treatment because of the huge positive impact it will have on the environment and farm ecosystem, as well as the positive impact it will have on the hoof health of the animals. Furthermore, I recommend that only feed grade Zinc Sulfate be allowed for this purpose because it is generally cleaner and lower in traces of undesirable minerals, similar to feed grade Copper Sulfate.

13. A commercial confidential information statement.

Not applicable.

Maine Organic Farmers and Gardeners Association

May 18, 2014

Dr. Lisa M. Brines
National List Coordinator
USDA National Organic Program
Standards Division
(202) 720-8405
lisa.brines@ams.usda.gov

Dear Dr. Brines,

On behalf of the Maine Organic Farmers and Gardeners Association (MOFGA), please accept this letter of support for the petition by Martin Van Tassell to add the livestock topical treatment material zinc sulfate **($ZnSO_4$)** to the National List of Allowed and Prohibited Substances under NOP § 205.603: Synthetic substances allowed for use in organic livestock production. Many farmers and agricultural professionals we work with at MOFGA want to show their support for this petition. We have included their names as signatories on this letter.

Zinc sulfate is the most valuable treatment for hoof scald and hoof rot in small ruminants and for hoof rot in cattle. For sheep, the use of copper sulfate, which is listed as an approved topical under NOP § 205.603, is not a recommended practice since copper is toxic to sheep, even at very low levels. Sheep are unique in that they accumulate copper in their liver at a much faster rate than other livestock species. Toxicity can cause anemia and even death. Since copper sulfate cannot be used safely on sheep, organic sheep farmers lack options for treating hoof diseases.

Farmers in the Northeast are often faced with hot and wet conditions when their animals are on pasture. These conditions increase the prevalence of hoof rot in animals. Sheep with foot rot may be unable to stand or walk effectively due to pain, often grazing while kneeling. The need for an effective treatment for animals that are required to be getting 30% of their feed from pasture is critical for animal health.

Zinc sulfate is already permitted in organic agriculture as a crop micronutrient and as a mineral supplement in livestock feed. We are not aware of any information to support that zinc sulfate poses any greater risk to the environment than copper sulfate. It should be noted that administering zinc sulfate internally to sheep is not effective in treating hoof scald and hoof rot; it is only effective as a topical. The referenced article by Cross and Parker, describes the use of zinc sulfate as a footbath for sheep. When the sheep have to cross through the

294 Crosby Brook Road, P. O. Box 170, Unity, Maine 04988 • ***Phone:*** *(207) 568-4142*
Fax: *(207) 568-4141* • ***Email:*** *mofga@mofga.org* • ***Web:*** *www.mofga.org*

footbath between the feed and water, it cures nearly all the cases of hoof rot in sheep. It is particularly effective when the treatment combines hoof trimming and other management methods. The research project also examined the use of ZnSo4 as a feed supplement and showed that feeding was not effective for curing hoof rot.

A foot rot treatment protocol established by Richard Brzozowski, University of Maine Cooperative Extension Small Ruminant and Poultry Specialist, is included in this petition. After many years of working with sheep farmers, he has established this protocol using zinc sulfate. He has found it to be a valuable treatment material.

For further information, two publications are included in Mr. Van Tassell's zinc sulfate petition. They are as follows:

Sheep Foot Health Farm Protocol
http://umaine.edu/sheep/files/2010/06/protocol-5-12.doc
Sheep Footrot Research Project, c/o Richard J. Brzozowski, PI, University of Maine Cooperative Extension, 75 Clearwater Drive, Falmouth, ME 04105
Richard.brzozowski@maine.edu, 207-781-6099

Cross, R.F.; Parker, C.F., Zinc sulfate foot bath for control of ovine foot rot; JAVMA 1981, 178: 706-707

We thank you and the National Organic Standards Board for your time considering this petition.

Sincerely,

Ted Quaday
Executive Director
Maine Organic Farmers and Gardeners Association

Enclosure: "Signatories to this Letter of Support for Zinc Sulfate Petition" attached

Signatories to this Letter of Support for Zinc Sulfate Petition

Diane Schivera, BS MAT, Organic Livestock Specialist, Maine Organic Farmers and Gardeners Association, Unity, ME

Anne Lichtenwalner, DVM PhD, Cooperative Extension and Director of the University of Maine Animal Health Laboratory

John and Mary Belding, Little Falls Farm, Harrison, ME

Elaine Frost, Frost Fire Farm, Washington, ME

Tom Settlemire, Professor Emeritus, Bowdoin College, Bowdoin ME

Carly DelSignore and Aaron Bell, Tide Mill Farm, Edmunds, ME

Seth Kroeck and Maura Bannon, Crystal Springs Farm, Brunswick, ME

Jeff Bragg, Rainbow Valley Farm, Sydney, ME

Richard J. Brzozowski, Small Ruminant & Poultry Specialist,
University of Maine Cooperative Extension

Eric and Becky Sideman, East Wind Farm, Strafford, NH

Webb Family Farm, Pittston, ME

Erin McWalters and Aktan Askin, Lor Farm, Thorndike, ME

Michael Johnson and Erin Anderson, Around the Well Farm, Whitefield, ME

Cheryl Wixson and Phillip McFarland, Rabbit Hill, Stonington, ME

Nicole Dehne, City Chicks, Burlington, VT

Caleb Harris, Harris Hills Organic Dairy, Union, ME

Ann Mefford, One Drop Farm, Cornville, ME

Paul Schultz and Amanda Provencher, King Hill Farm, Penobscot, ME

Jean Noon, The Noon Family Sheep Farm, Springvale, ME

Patti and Chris Hamilton, Hamilton Farm LLC, Whitefield, ME

Tim Brown, Farmer Brown Organics, Presque Isle, ME

Gillman Littlefield, Littlefield's Farm, Winterport, ME

Jim and Megan Gerritsen, Wood Prairie Farm, Bridgewater, ME

Andrew Chase, Chase Farm, Kingfield, ME

Adrienne Lee and Ken Lamson, New Beat Farm, Knox, ME

Ellen Johnson, Lamb Cove Farm, Robbinston, ME

Susan Littlefield, Yknot Farm, Morrill, ME

Robert Sullivan and Colleen Prentiss, Old Ackley Farm, Blue Hill, ME

Kees Overgaag, Charlies' Redhouse Farm, Winchendon, MA

Prentice Grassi and Polly Shyka, Village Farm, Freedom, ME

Aimee and Thomas Good, Good Dirt Garlic, Monticello, ME

Jake Galle and Abby Sadauckas, Apple Creek Farm, Bowdoinham, ME

Randall Bates, Springside Farms, New Vineyard, ME

Paul and Karen Volckhausen, Happy Town Farm, Orland, ME

1.

Science Lab.com
Chemicals & Laboratory Equipment

Health	2
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Zinc sulfate monohydrate MSDS

Section 1: Chemical Product and Company Identification

Product Name: Zinc sulfate monohydrate

Catalog Codes: SLZ1192

CAS#: 7733-02-0

RTECS: ZH5270000

TSCA: TSCA 8(b) inventory: Zinc sulfate monohydrate

CI#: Not available.

Synonym:

Chemical Name: Not available.

Chemical Formula: ZnSO4.H20

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Zinc sulfate monohydrate	7733-02-0	100

Toxicological Data on Ingredients: Zinc sulfate monohydrate LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects: Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

Skin Contact:
After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cold water may be used. Cover the irritated skin with an emollient. If irritation persists, seek medical attention.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Do not breathe dust. Wear suitable protective clothing In case of insufficient ventilation, wear suitable respiratory equipment If you feel unwell, seek medical attention and show the label when possible. Avoid contact with skin and eyes

Storage:
No specific storage is required. Use shelves or cabinets sturdy enough to bear the weight of the chemicals. Be sure that it is not necessary to strain to reach materials, and that shelves are not overloaded.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:

Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid.

Odor: Not available.

Taste: Not available.

Molecular Weight: 179.43 g/mole

Color: Not available.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Not available.

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans: Hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations:
Pennsylvania RTK: Zinc sulfate monohydrate Massachusetts RTK: Zinc sulfate monohydrate TSCA 8(b) inventory: Zinc sulfate monohydrate SARA 313 toxic chemical notification and release reporting: Zinc sulfate monohydrate CERCLA: Hazardous substances.: Zinc sulfate monohydrate

Other Regulations: Not available..

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC): R36/38- Irritating to eyes and skin.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 12:41 AM

Last Updated: 05/21/2013 12:00 PM

Uniprime International LLC

243 Woodland Drive, Lincroft, NJ 07738, USA Tel: 1-732-784-3177 Fax: 1-630-839-1856 Email: info@uniprimeinternational.com

CERTIFICATE OF QUALITY ANALYSIS

TO: SUNBELTCUSTOMMINERALS
1276 F M 2560, Sulphur Springs, TX 75482

INV. NO.: 30825
Date: AUG. 22, 2013

ZINC SULFATE MONOHYDRATE
PO#: 3137/3138

BATCH NO.: 4300FA013-1326
MANUFACTURING DATE: AUG. 22, 2013
EXPIRATION DATE: AUG. 22, 2014
PACKING: 2000 LBS BAG ON PALLETS & STRETCH WRAPPED
QUANTITY: 1 BAG / 1 PALLETS (2000 LB), TOTAL 44 BAGS/ 88,000 LBS

INDEX NAME	STANDARD	TEST RESULT
Zn:	35%Min	35.51%
Pb:	0.0015%	0.0009%
As:	0.001%	0.0002%
Cd:	0.001%	0.0003%
Chlorine:	0.5%	0.2%
Water Insoluble:	0.01%	0.008%
Test Method	Titration Method	

RESULT: MEET THE REQUIREMENTS

WE HEREBY CERTIFY THAT THE ABOVE PRODUCTS HAVE BEEN TESTED BY THE FACTORY IN CHINA.

Uniprime International LLC

2.

AdVANTAGE™ Copper Plus
"The 1 for 1 copper sulfate replacement"
To be used in tandem with your AdVANTAGE CONCENTRATE liquid footbath
INGREDIENTS
Contains Copper Sulfate, Zinc Sulfate and other inert ingredients
NET WEIGHT 50 LBS
COPPER PLUS
HOOF BATH ADDITIVE
Manufactured for Vanco Industries, LLC
Recommended Dose:
1 lb per 5 gallon of water
Examples:
50 gallon foot bath 10 lbs
80 gallon foot bath 16 lbs
Instructions for use:
1. Fill a 5 gallon pail full of water (hot preferred).
2. Add recommended dose of Copper Plus to pail of water.
3. Stir until dissolved.
4. Add ½ oz per gallon (foot bath size) of AdVANTAGE CONCENTRATE Liquid Foot Bath to pail and mix.
5. Place pail of mixture in foot bath, add hose to pail, & allow contents of pail to overflow into foot bath. Turn off hose when bath is near full. Empty pail into foot bath and remove pail. This allows product to completely mix.
WARNING:
Avoid contact with eyes
Avoid contact with skin
Avoid breathing dust
Do not swallow
Wash thoroughly after handling
Keep out of reach of children
FIRST AID:
Eye and skin contact – flush affected areas with large quantities of water.
PERSONAL PROTECTIVE EQUIPMENT RECOMMENDED
Use NIOSH-MSHA approved respirator, glasses, goggles, or face shields.
Gloves and protective clothing should be used.
Manufactured for:
VANCO INDUSTRIES LLC
EMERGENCY TELEPHONE NUMBER:
CHEM-TEL 1-800-255-3924
HEALTH RATINGS
HEALTH 1
FLAMMABILITY 0
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SPECIFIC HAZARD 0
PLEASE KEEP BAG CLOSED WHEN NOT IN USE.
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3.

AN INVESTIGATION OF HAIRY FOOT WART TREATMENTS AND ASSOCIATED ENVIRONMENTAL AND PUBLIC HEALTH RISKS

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Executive Summary:
Papillomatous Digital Dermatitis (PDD), commonly known as Hairy Foot Wart, is a condition plaguing the dairy industry throughout the United States. Extremely contagious and expensive to treat, hairy foot warts have major implications on the dairy industry causing a reduction of milk production ranging from 20 to 50% (Brown, et al., 2000). Furthermore, PDD can lead to reproductive problems, premature culling and dairy lameness. A study conducted by Brown *et al*. in 2000 on cattle in U.S. slaughterhouses concluded that almost 30% of cows had PDD.

The most effective treatment for the disease is through the use of topical antibiotics; however this is not practical or economical due to the large scale of most dairy farms. Instead, formalin and copper sulfate footbaths now serve as the most common treatments for the disease on dairy farms in Vermont and New York. Currently, there are no recommended disposal methods for these chemicals after they have been used. The baths are dumped out without regard to environmental, human, or animal safety. While studies have been conducted on the acute effects of these chemicals in a controlled environment, little is known about the potential long term chronic effects of dumping formalin and copper sulfate waste into the environment. Due to the harmful effects of acute exposure, the potential exists that the dumping of this chemical waste has serious negative impacts.

Problem Statement:
To combat hairy foot wart the dairy industry is using chemical solutions such as copper sulfate and formalin in foot baths for cattle, and then dumping the residual chemicals directly into the environment without any regulation, raising unknown environmental and health risks.

Background:
Hairy foot warts were first reported in the United States in the 1980's. Since then, the condition has spread rapidly and become a major management concern for dairy producers. A study conducted by Wells *et al.* in 1997 found that PDD was present in at least 30% of dairy operations across the United States (Figure 1.). In states such as Vermont, which are dependent on the dairy industry, the issue is of particular importance. As PDD continues to spread and becomes more prevalent across the U.S. and in Vermont, farmers will have to continue to protect their livestock in the most effective and economical way possible in order to maximize their profits. If the environmental impacts of these treatments are ignored for the sake of increased profit, serious consequences will inevitably result.

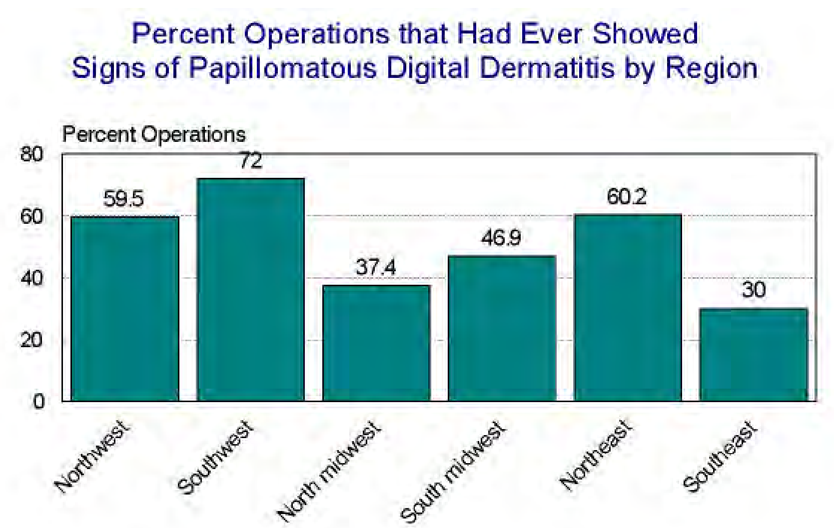

Figure 1. Livestock operations with confirmed PDD presence, by region (Wells *et al.* 1997)

Goal/Purpose:
The purpose of this report is to assess the potential environmental effects of current treatment for hairy foot wart and to investigate alternative means of disposal for used foot bath material.

Objectives:
In order to assess the potential effects of PDD treatment, this report will review literature covering formalin, copper sulfate, and alternative treatments. Examples of the effects of these chemicals on biota will be discussed as well as their potential to impact the environment when used as a treatment for PDD. Finally, an environmentally, economically, and socially acceptable solution to the hairy foot wart issue will be proposed.

Approach:

Scientific literature on PDD and its associated treatments was collected and reviewed. Web of Science, PubMed, Google Scholar, InfoTract, JSTOR, and LexisNexis were used to search for Hairy Foot Wart, Papillomatous Digital Dermatitis, formalin, copper sulfate, and PDD treatments.

Findings:

Formalin

Formalin, which is a 37-39% solution of formaldehyde, also known as methyl aldehyde, is a highly used effective treatment in controlling PDD in dairy cattle. The chemical formula for formaldehyde is CH_2O_3, however as it is used in the dairy industry as formalin. It is an aqueous solution, which has the formula CH_2O. When it breaks down it forms formic acid and carbon monoxide. It has a very strong pungent, hay or straw-like odor. Formalin is a non-corrosive, biodegradable chemical usually used in footbaths on dairy farms, which is not regulated by the EPA. Formalin breaks down rapidly when exposed to air and organic matter such as manure. (Sulivan, 2005). It has been strongly advised to prevent excess contamination of manure when using formalin to combat PDD. If formalin is applied directly to the PDD lesion it can be painful to the animal and cause chemical burning of the flesh. After it has been used in the cattle footbaths it is disposed of with all the manure on the crop lands.

According to the agency for toxic substances in the US department of health and human sciences regular formaldehyde dissolves easily and rapidly in water and does not build up contaminant residues in plants and animals. Formaldehyde is extremely soluble in water (Liteplo, 2002) and once it gets into groundwater it degrades rapidly depending on the amount of organic material. Formaldehyde is slightly persistent in water, having a half-life of approximately 2-20 days (ADEWR, 2007). According to the 2001 Canadian Environmental Protection Priority Substance List (PSL) Assessment Report, formaldehyde is decomposed in approximately 30 hours in lake water in aerobic conditions and approximately 48 hours in anaerobic conditions. Formaldehyde molecules are degraded by organic material before it is suspended in the sediment.

In the air formaldehyde molecules react with hydroxyl radicals in a photo-oxidation reaction and according to research done by Atkinson *et al* in 1990, formaldehyde has a daytime half-life of 7.1 – 71.3 hours, as cited in the PSL Assessment Report, 2001. This short half-life limits its long range distribution. The oxidation reaction can result in either hydrogen and carbon monoxide stable molecules, or formyl (HCO) radicals and a hydrogen atom (PSL Assessment Report, 2001). In 1993 the EPA reported that formyl radicals from the breakdown of formaldehyde are important in smog generation, especially in urban areas where nitric acid (HNO3) molecules are more prevalent, resulting from anthropogenic pollution.

Stills and Allen found that fish and shrimp analyzed for bioaccumulation of formaldehyde molecules showed no significant results, as cited in the PSL Assessment Report, 2001. The toxic effects of formaldehyde on fish seem to be variable with Striped Bass being the most sensitive. Reardon and Harrell found that in some fish formaldehyde caused the disruption of efficient gill functioning, as cited in the PSL Assessment Report, 2001. Laboratory tests have found that formalin can kill larvae of terrestrial invertebrates and nematodes. The PSL Assessment Report found no information or data with reference to toxicity effects on mammals, birds or reptiles. Animals exposed to formalin in the laboratory have indicated that it may enhance their sensitization to inhaled allergens (Tarkowski & Gorski, 1995), as cited in the PSL Assessment Report, 2001). Rats exposed to strong doses of formaldehyde in the lab have been observed with cell proliferation in the nasal and respiratory tract resulting in inflammation and ulceration, and ultimately increased occurrences of tumors. Montecello *et al*. conducted a bioassay to investigate the proliferative responses in the nasal epithelium tissue of rats, as cited in the PSL Assessment Report, 2001

(Figure 2). The results indicate that tumor incidence increased rapidly in the nasal cavity at formaldehyde concentrations greater than 7.2mg/m^3 (6ppm). Formaldehyde can also be absorbed into the gastrointestinal tract resulting in lowered food and liquid intake (Farwell, 2005). These effects are more likely a result of the high concentration of formaldehyde ingested in lab rats than the overall intake over time. If animals are exposed to high levels of formaldehyde they "may suffer chronic effects including: shortened lifespan, reproductive problems, lower fertility and changes in appearance or behavior" (ADEWR, 2007). Cassidy *et al*. observed male rats having sperm abnormalities from a single dose of formaldehyde in their diet, as cited in Farwell, 2005. With respect to research done by Krivanec *et al*., there was no evidence of carcinogenic effects from formaldehyde given orally to rats, as cited in the PSL Assessment Report, 2001.

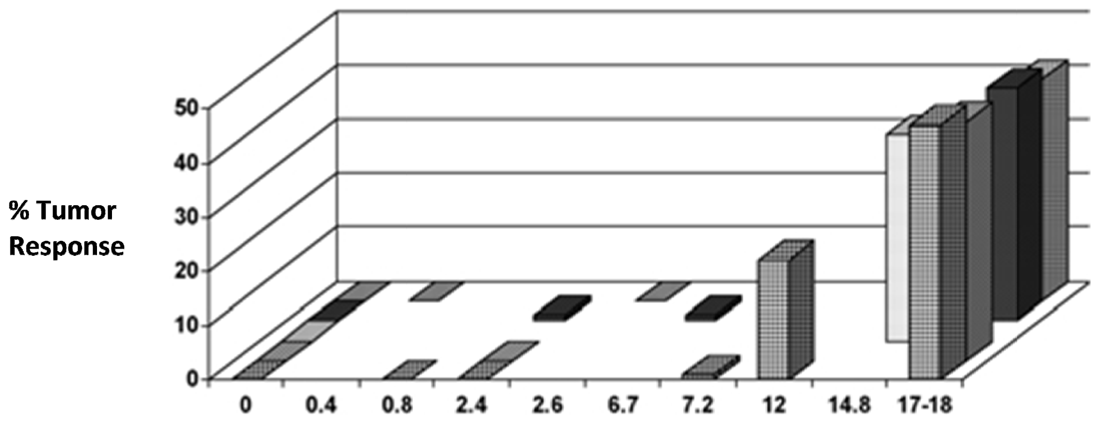

Figure 2. The response of tumor proliferation to increasing concentrations of formaldehyde in lab rats (Montecello *et al.,* 1996)

Algae are primary producers in aquatic ecosystems, which are consumed by zooplankton. Zooplankton is consumed by invertebrates, which are consumed by fish, etc. There does not seem to be sufficient research and/or data to support bioaccumulation levels in higher tertiary organisms. Marine algae were found to be sensitive to formalin, which had 40 – 50% mortality after 96 hours (PSL Assessment Report, 2001). Previous research by Bringmann and Kuhn (1995) reported that freshwater algae were slightly more tolerant of formaldehyde, as cited in the PSL Assessment Report, 2001.

Formalin can affect human health, causing irritation of the eyes, nose, and throat, and burning of the skin. If ingested it can cause severe abdominal pain, vomiting and even possible death (ATSD, 1999). Cancer of the nose and throat has been found to occur more often in people that have been exposed to formaldehyde. It can be assumed that formalin may have similar effects. There have been numerous reports of localized allergic reactions from formaldehyde in various household and personal care products, bank notes, and medical treatments. Higher exposure levels can cause throat spasms and a buildup of fluid in the lungs, leading to death (ADEWR, 2007). These symptoms may only occur long after exposure. It is because of this that formaldehyde and all its bi-products, including formalin, have been documented as possible carcinogens. Evidence of tumors was mostly found in the upper respiratory tract. Recent epidemiological studies by Hemminki *et al*. (1994) suggest that there is no evidence to support the hypothesis that spontaneous abortion is associated to maternal and paternal exposure, as cited in the PSL Assessment Report, 2001. Formaldehyde has been known to cause insomnia, lack of concentration, memory loss and loss of appetite.

The state of Vermont has standards for formaldehyde in the workplace. The Vermont Occupational Safety and Health Administration (VOSHA) enforce these standards, which relate mainly to industrial or commercial work settings (Vermont Dept. of Health, 2005). Agricultural businesses are rarely visited; however random inspections are carried out periodically. The state of New York does not seem to have as stringent regulations governing the use of formaldehyde, as long as it is used with precaution and with the correct safety equipment.

Copper Sulfate

Copper sulfate ($CuSO_4$) is commonly used in foot baths on dairy operations due to its high availability, ease of use, low cost and effectiveness in preventing PDD (Epperson & Midla, 2007). According to the Extension Toxicology Network (ETN), 1996, it is commercially available as a dust, wetable powder and liquid concentrate. Copper sulfate foot baths are typically made at five to ten percent concentration and are effective for 150 to 300 cow passes (Epperson & Midla, 2007). It is a general use pesticide and does not normally require a permit to use. However, because it is potentially detrimental to fish populations, it may require a permit for use in surface waters (ETN, 1996).

There is a danger to the farm workers that handle the copper sulfate to make and dispose of the foot baths. Copper sulfate is classified by the US Environmental Protection Agency as toxicity class 1- highly toxic. Great care must be taken when handling copper sulfate. It is extremely corrosive to the skin and eyes and is quickly absorbed through the skin on contact, causing burns. It is extremely caustic and thus has several severe acute symptoms upon ingestion (ETN, 1996). Although ingestion immediately causes a vomiting reflex that purges the chemical from the body, the repercussions of ingestion are severe if it remains in the stomach (which is typical if the victim loses consciousness). These symptoms include metallic taste in the mouth, burning pain in the chest and abdomen, intense nausea, diarrhea, headache, sweating, shock and discontinued urination leading to yellowing of the skin, and injury to the brain, liver, kidneys, stomach and intestinal linings (ETN, 1996). The oral LD50 of copper is 472 mg/kg in rats and the lowest documented amount of copper sulfate that has been toxic when ingested by a human is 11 mg/kg. There are also several chronic ailments associated with long-term exposure to copper sulfate. There are documented cases of vineyard workers that contracted liver disease after three to fifteen years of exposure to a copper sulfate pesticide. Other chronic conditions include anemia and damage to blood cells and kidneys (ETN, 1996).

Used copper sulfate foot baths are considered industrial waste and must be treated as such. However, as soon as the foot bath material is mixed with manure it no longer classifies as industrial waste and can be disposed of with the manure into a manure pit (Klinberg, 2005). Although the copper solution is diluted when mixed with manure, there is still great potential for copper build up in the soil and implications for harm to wildlife when the manure is spread on the fields. The average five percent copper sulfate footbath contains 62 gallons of water and 26 pounds of copper sulfate. This amounts to about six and a half pounds of copper being added to the soil with each foot bath disposal, which can lead to exceedence of the maximum loading rate for soil copper in as little as five years (Epperson & Midla, 2007). It is extremely important for dairies that use copper sulfate to have soil tests done regularly to check for copper loading. Constantly loading the soil with copper is highly discouraged because copper cycling is very slow and it takes a long time for copper to be removed from the soil by growing plants (Klinberg, 2005). In Vermont, it is estimated that between 1.4 and 2.1 pounds of copper per acre of farmland have been imported each year since 2002 (Epperson & Midla, 2007). Copper readily binds to most soils, especially those high in organic matter and clay. Since it is held so tightly in the soil it has low leaching potential, except in sandy soils. Copper does not bind to sand particles and readily leaches out of sandy soils due to its high water solubility (ETN, 1996).

Copper leaching into surface waters is of particular concern due to its high toxicity to aquatic species. Copper sulfate is highly toxic to fish and aquatic invertebrates. The ninety-six hour LC50 of copper sulfate to pond snails is 0.39 mg/L at twenty degrees Celsius. It is also documented as causing some behavioral changes such as secretion of mucous, and discharge of eggs and embryos (ETN, 1996). There is also the danger of copper leaching into groundwater wells, leading to exposure of those who drink the water. It has been experimentally determined that copper levels around three milligrams per liter cause acute exposure symptoms in humans. These symptoms include pain, nausea, vomiting and diarrhea (Fernando *et al*., 2001).

The unregulated disposal of copper sulfate foot baths on agricultural lands is an issue that is in the midst of a lot of research. The potential for unhealthy accumulation in the soil along with a suite of potential problems for humans and wildlife alike have drawn a lot of attention to the issue in the past ten years. The most current publications recommend using less copper sulfate on dairy farms or not using it at all. It is proposed that focusing efforts on improving hygiene, although more costly, can provide preventative protection equal to or better than the methods currently used (Epperson & Midla, 2007). It is also proposed that if copper sulfate must be used that the used foot bath material be collected and treated as industrial waste. This is obviously not a very attractive option as it carries significant handling and disposal costs (Klinberg, 2005).

Alternative Treatments

The use of formalin and copper sulfate footbaths is the traditional approach to handling the issue of PDD in dairy cows (Altenbrunner-Martinek *et al*, 2007). Due to the large number of dairy cows that need to be treated, developments of alternative measures are being tested for their efficiency in preventing and curing PDD. Largely, these methods are veering away from the mass footbath treatments and are focusing on more cow and worker friendly environments.

Prevention of PDD has resulted in several ways to alter the conditions and locations of a herd throughout the day. Since PDD is caused by bacteria, it is more likely for these bacteria to grow in dark moist locations. By changing the area that the cows will congregate in, one can alter their exposure level to becoming infected. The best management practice would be to keep living quarters clean and dry while exposing soils the cows stand in to air and sunlight to decrease the number of PDD causing bacteria (Sullivan, 2005). There has been research into what kinds of conditions favor clean and dry standing locations for cows as a PDD prevention method. In a study done on floor type and the prevalence of claw disorders, it was shown that cows being held in straw yards were up to 25% more unlikely to have claw disorders compared with cows standing on solid concrete floors. Cows that were kept on solid concrete had an 80% occurrence of a claw disorder (Somers *et al*, 2003). A new rubber-slat flooring system has also been tested in which it was designed to better drain feces and urine. This flooring system had a significantly lower risk or becoming dirty compared with a solid stall floor. This overall increased claw and foot health due to the cleanlier system (Hultgren *et al*, 2001). These new methods of prevention focus primarily on cleanlier and more cow friendly areas in which there is minimal environmental impact from this. This improves cow health and does not bring harm to farm hands. Although, providing cleaner areas for the cows does not fully eliminate the potential for PDD infection. Because these practices only reduce the probability of infection, other alternatives are required to provide a better protection against PDD.

There are many alternative treatment methods to combating PDD. Some of these methods still use the mass footbath approach but use different compounds while there are other treatments that deal with the individual application of products to the hooves. Some of the other chemicals used in footbaths other than formalin and copper sulfate are zinc sulfate, acidified sodium chlorite, bleach, iodine products, and peroxides. An issue using these alternatives is that all of them need to be correctly applied and monitored in the footbath. They all need to be able to kill the bacteria, have a long enough exposure period on the cows hooves, be kept at a certain concentration for the most efficient bacteria kill, and be kept fresh so that the active chemicals killing the bacteria is not neutralized by organic matter at the farm. In addition to maintaining these chemicals to kill the bacteria, there are also major concerns over the effectiveness and safety of using them (Sullivan, 2005).

Zinc sulfate has been found to effectively control the spread of PDD and treating mild lesions but is ineffective in treating major lesions. An issue with this chemical is that it becomes inactive when exposed to antibiotics (Sullivan, 2005). In regards to human health, this product is known to cause dermatitis, boils, conjunctivitis, and GI disturbances only if individuals are exposed to zinc sulfate fumes for at least six months (Hamilton, 1974). According to the Federal Insecticide, Fungicide, and Rodenticide Act, zinc sulfate poses no unreasonable risk to human health or the environment (USEPA, 1992).

Acidified sodium chlorite is a strong antimicrobial and can be used in a footbath as well as being topically applied to the hooves. This chemical is very easily inactivated by organic matter which means footbaths need to be kept clean. A problem with this is that it is a very acidic compound (pH 2.3-3.2). This can cause great harm to the cows and farm workers if improperly handled and due to the acidity, it can also be highly corrosive to steel (Sullivan, 2005).

Bleach is one of the cheapest and most readily available alternatives that could be used in a footbath. Once one looks past the cheap aspect of this product, it can be seen that its effectiveness in combating PDD is fairly weak. This is so because it requires a long contact time and becomes readily inactive in short periods of time after being diluted in water as well as when it is exposed to organic matter. Not only does it have a short shelf life, but it also can pose a major health risk to cows and workers alike. Bleach can cause painful lesions upon contact with skin and can also emit harmful gases (Sullivan, 2005).

Iodine products are commonly used in teat dips for milk production and are less commonly used for footbaths. Iodine is readily available to dairy operations but as a footbath product, this chemical requires a long contact time and the proof for its effectiveness at preventing PDD is questionable. A problem with this product in regards to health is that without emollient it can be irritating if it comes into contact with skin (Sullivan, 2005).

The last footbath alternatives are peroxides. These products are overall damaging towards all cellular life. That can be good in regards to killing bacteria, but can cause great risk to the cows and workers if skin was exposed to this. Another problem with peroxides is that most are not stable and become inactive when exposed to air and organic matter. There are other peroxide products that have longer lasting antimicrobial effects, but the same health concerns remain the same (Sullivan, 2005).

An effective alternative to formalin and copper sulfate footbaths is applying topical broad-spectrum antibiotics, such as oxytetracycline powder. An antibiotic that is effective against gram-positive and gram-negative bacteria. This is the most effective way at treating PDD, but this practice is very labor intensive and somewhat impractical to large herds. The reason for why topically applying antibiotics to the cow's hooves can work better than footbaths is that one knows that every cow is being treated. If footbaths are improperly managed, then it is possible that footbaths themselves will become a vector for infecting cows because it is possible that the footbath solution has become inactive due to exposure to organic material or just having sat out too long. A problem with using antibiotics is that there is the possibility of the PDD causing bacteria to become resistant over time (Sullivan, 2005).

A new system created to prevent PDD is a green disinfecting foam acid that was tested on thirty six dairy cows. This foam has been named Kovex Foam and this was used for a period of eight weeks in which it was applied twice a day during milking on alternate weeks. During the experiment, all cows tolerated moving through the foam, they did not attempt to ingest any foam, and their appetite and consistency of the feces remained the same. After the test period, heel horn erosion had significantly improved and individuals that previously had PDD lesions where cured by the end of the eight week trial. Overall this treatment had no noticeable side effects on the cows or workers and it had a high acceptance level among farm workers in comparison with having to use the older footbath method (Altenbrunner-Martinek *et al*, 2007).

Overall, the wide range of alternatives for combating PDD each have their benefits and costs while in comparison to formalin and copper sulfate footbaths. A trend with these alternatives is that farms are looking to break away from the older style of formalin and copper sulfate footbaths and are attempting to find new cleaner and healthier forms of PDD prevention. A factor that is keeping changes from occurring is that it takes funds to renovate existing dairy barns to new modern flooring systems and there are risks involved with switching to other alternatives. Any shift to these alternatives will cost time and money, and if improperly done, there is the potential to follow new procedures incorrectly which can then lead to new outbreaks of PDD.

Conclusions/Recommendations:

PDD infections have an enormous financial impact on the dairy industry in the US. The net economic impact of reduced milk production, maintenance and care associated with PDD in the dairy industry in the US is a loss of approximately \$190 million ± \$130 million (Losinger, 2005). With the great risk of economic loss in dairy farming, and the way most farmers think financially; by reducing the costs being of higher importance than trying to increase income.

Considering PDD infections on dairy farms and looking at the different methods, with varying efficiency (Kikta, 2005), at reducing its incidence and/or treating the infection, farmers are going to look more seriously at the method that is most financially feasible and practical. They will also look at the treatment that will destroy the infecting organism, preventing the infections spread, and healing the lesions as rapidly as possible. Approximately half the cows affected by PDD actually show signs of lameness, which means the prevalence is much higher on most farms, which is also most noticeable in the north eastern wetter climate.

PDD thrives most effectively in damp, dark, warm environments. In the northeast, depending on the size of the dairy and number of cows, we strongly recommend initially making sure that the barns are well ventilated – plenty of fresh air – and cow housing facilities are kept as clean and as dry as possible. Laneways need to be cleaned regularly. Alley-Scraper equipment would be a good suggestion, to automatically keep laneways clean at all times. This would be an important consideration if labor and time are in short supply. This can result in a large capital investment, which will pay for itself over time through reductions in labor and infection rates.

As far as actual treatment is concerned, neither formaldehyde nor copper sulfate should be used to treat PDD infections. Both methods, if used in footbaths may help reduce the spread of the infection or prevent the infection from occurring in the first place. There is no recorded evidence that copper sulfate has any effect on the lesion itself, once an infection has already occurred (Kikta, 2005). Copper sulfate can be expensive and cause environmental problems once in the environment, especially water resources. Most farms in Vermont use copper sulfate as a preventative, even though it is disapproved by the Vermont Department of Environmental Conservation (Vermont DEC). Formaldehyde is used more commonly in New York State because it is more effective than copper sulfate as a preventative treatment method. Vermont has strong regulations against the use of formaldehyde, especially releasing it into the environment. If used correctly under strict regulated procedures formalin is presently the most cost effective method of choice. It can be used most effectively at a concentration of one gallon of formalin to approximately 60 – 80 gallons of water, once per week for approximately 120 – 150 cows. When working with formalin, as in most formaldehyde products, the correct safety equipment needs to be used, such as chemical resistant gloves and a mask. Care must also be taken to prevent chemical burning of the cow's feet by increasing the rate or quantity of treatment. Table 1 compares the most recent costs of the different products. The labor time for all treatments is assumed to be equal. Whole bags of copper sulfate or zinc sulphate are used per footbath. A wrap is needed when applying oxytetracycline to hold the antibiotic in place. In Table 1, the application of oxytetracycline assumes that all four feet of an individual cow are treated. Many times only one or two feet need treating, which reduces the total cost. Formalin is the cheapest overall preventative treatment.

	Cost of product	**Amount of Product Used per Treatment**	**# of Cows Treated**		**Total Cost per Treatment**
Copper Sulfate	$80/50 lb	1 Bag/bath	200		$80
Zink Sulphate	$42/50 lb	1 Bag/bath	200		$42
Formalin	$250/ 55 Gal	1 Gallon/bath	120		$4.50
Oxytetracycline +	$85/80 oz	0.5 oz/foot	1 (4 feet)	$4.25	
Wrap	$1.30/wrap	o.5 wrap/foot		$2.60	$6.85
Kovex Foam					

Table 1. Papillomatous digital Dermatitis (PDD) treatment cost comparison

The most effective treatment of clinical PDD lesions is the topical application of an antibiotic, such as oxytetracycline powder, directly to the infected lesion and then covering with a bandage for two to three days. The infected area needs to be cleaned and the lesion gently scraped, bringing blood vessels to the surface, before the antibiotic application. It would be most advisable to use this method in conjunction with a footbath preventative treatment method of either formaldehyde or copper sulfate. It is not the most practical method, especially for larger herds – as individual dairy herd sizes are getting larger nationwide – and it can be costly, as each hoof needs to be wrapped individually.

Many other past suggestions, such as spraying feet with an antibiotic in solution, may not be practical. It dilutes very rapidly in the environment and a substantial amount is wasted as it drips off. Its use usually requires cattle to be sprayed in the parlor. To maximize milk production dairy cows should not be unnecessarily disturbed during the milking process. There is also a high risk of milk contamination. If carried out timing of spraying needs to coincide with the milking process.

We would also suggest the use of zinc sulfate as an alternative or as a replacement to copper sulfate. It can be used in very much the same method of application and its cost is a little less. Like copper sulfate, it does still pose an environmental hazard, especially in water sources.

Ultimately, the solution to the PDD problem comes down to time and money. It will take significant commitment of resources in order to find sustainable solutions that can be implemented in Vermont and the rest of the United States. Whether this funding comes from the farmers themselves, the state of Vermont, or the federal government depends on placing a higher value on long-term environmental and public health than on short term profits.

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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 $CuSO_4$ and $ZnSO_4$ 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 ± 6.6 ppm. Soil Zn concentrations ranged from 0.6 to 41.8 ppm, with an average of 10.1 ± 9.3 ppm. Forage Cu concentrations ranged from 1 to 10 ppm, with an average of 3.4 ± 2.1 ppm, and forage Zn ranged from 3 to 51 ppm, with an average of 13.8 ± 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 ± 12 ppm. The use of $CuSO_4$ and $ZnSO_4$ 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 $CuSO_4$ and $ZnSO_4$ 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 $CuSO_4$, $ZnSO_4$, and formaldehyde. Copper sulfate is the most commonly used footbath disinfectant and is considered safer than formaldehyde. Copper sulfate is bacterostatic by reacting Cu^{2+} with protein thiol groups in target bacteria (Lavern and Hunt, 2002).

Typically, footbath solutions are $CuSO_4$ mixed at a 5% solution and are effective for 150 to 300 cows. A 226-L footbath requires 11.4 kg of $CuSO_4$. Because $CuSO_4$ 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 $CuSO_4$ and $ZnSO_4$ 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 $CuSO_4$ being the most common treatment used in the footbath in all these dairies. Twenty-seven percent of dairies used $CuSO_4$ between 1 and 3 times a week, and 33% of the dairies surveyed used $CuSO_4$ the majority of the time. Thirty-three percent of dairies surveyed indicated that they used both Cu and Zn interchangeably. Two farms currently used $ZnSO_4$ as their product of choice for mixing the footbath solutions. Seven of the farms surveyed had used $CuSO_4$ and $ZnSO_4$ 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 ± 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 ± 9.3 ppm. Zinc manure concentrations ranged from 2 to 25 ppm in fresh manure, with an average of 4.2 ± 6 ppm, and from 0.2 to 1.5 ppm in liquid manure storage, with an average of 0.8 ± 0.012 ppm.

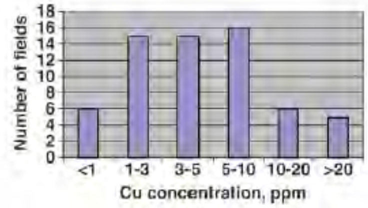

Figure 1. Soil Cu concentrations (ppm) on 30 dairy farms.

Copper concentrations in forages ranged from 1 to 10 ppm, with an average of 3.4 ± 2.1 ppm, and Zn ranged from 3 to 51 ppm, with an average of 13.8 ± 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 ± 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

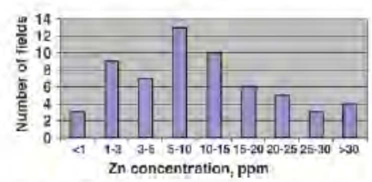

Figure 2. Soil Zn concentrations (ppm) on 30 dairy farms.

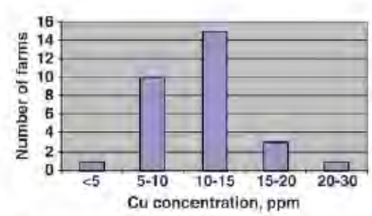

Figure 3. Copper concentrations (ppm) of home-grown forages for 30 dairy farms.

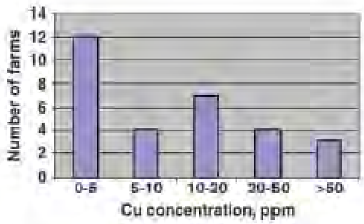

Figure 4. Copper concentrations (ppm) in liquid manure storage on 30 dairy farms.

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 $CuSO_4$ 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 $CuSO_4$ 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 $CuSO_4$.

IMPLICATIONS

Oregon dairies continue to look for successful management strategies to control or eliminate hairy warts. The use of footbaths with $CuSO_4$ solution is the most common metod of medication, and $ZnSO_4$ 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 $CuSO_4$. Estimates indicate that farms regularly using $CuSO_4$ 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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5.

ALTERNATIVES TO COPPER SULFATE FOOTBATHS

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Walk-through footbaths are used on dairies to help control and prevent infectious claw lesions such as digital dermatitis, foot rot, interdigital dermatitis and heel erosion. In addition, footbaths may help harden claw horn, making it more resistant to horn lesions. One chemical commonly used in footbaths is copper sulfate. Copper sulfate has been used to control foot problems for many years. However, due to concerns regarding disposal of the copper sulfate solution from footbaths, many producers are seeking alternative solutions for controlling infectious lesions in dairy cattle. This paper will review some alternative products to use in footbaths, present strategies to make footbaths more effective and review some alternative methods to control infectious claw lesions.

Footbath Solutions

Footbaths are used primarily to control infectious claw lesions. If the primary lesions on a dairy are non-infectious, use of walk-through footbaths may not be warranted or frequency of use may be reduced. However, this decision can not be made unless accurate records are kept on the incidence and types of claw lesions.

Efficacy of footbaths in preventing infectious lesions is dependent upon a number of factors including footbath solution, frequency of changing solutions, footbath dimensions and footbath placement. Effectiveness of a footbath solution in preventing infectious lesions is dependent upon antimicrobial activity of the solution and the impact of soil load (organic matter) on antimicrobial activity of the solution. For instance, chlorine has a broad spectrum of activity against bacteria (Russell and Keener, 2007). However, chlorine has limited utility in footbath solutions as organic material such as manure reacts with the chlorine, resulting in loss of antimicrobial activity (Russell and Keener, 2007).

Copper Sulfate: Five to 10% copper sulfate solutions are commonly used in footbaths. Copper sulfate is an antibacterial agent that also has a hardening effect on claw horn (Kloosterman, 1997). The bacterostatic properties of copper sulfate are attributed to Cu^{++} reacting with protein thiol groups in target organisms (Epperson and Midla, 2007). The popularity of copper sulfate footbaths can be attributed to both its relatively low cost per footbath and widespread perception among dairy producers that it effectively controls infectious lesions. Research has shown that using copper sulfate footbaths decrease both incidence and severity of foot lesions (Laven and Hunt, 2002; Bergsten et al., 2006). However, some data suggest that copper sulfate is rapidly neutralized by organic matter (Greenough, 1997).

Concerns with using copper sulfate in footbaths include metal corrosion, disposal of the copper sulfate solution and increased claw horn permeability. Assuming that a dairy producer is using a 50-gallon footbath containing a 5% copper sulfate solution, 4X/wk, changed every 200 cow passes, 21.7 lb copper sulfate/cow per year is discarded.

Potential concerns with this level of copper excretion include reduced crop yields due to phyto-toxicity and exceeding EPA and state guidelines for copper loading of agricultural land (Rankin, 2004; Thomas, 2001).

The EPA Standard 503 for agricultural land cites a cumulative loading limit for copper of 1339 lb/acre and an annual application limit of 67 lbs/acre (EPA, 1999). In most cases, producers will not exceed these limits when applying manure containing discarded copper sulfate footbath solutions. However, some states have much lower limits for copper application. For instance in New York, the lifetime loading limit is 75 lbs/acre, while in Illinois, the lifetime copper application limit is 250 lbs/acre (Thomas, 2001). In these states, producers may exceed these limits by applying manure containing discarded copper sulfate footbath solutions to agricultural land. Dairy producers are strongly encouraged to check with regulatory officials to determine the lifetime copper application limit in their state and to insure that they are in compliance. Even if producers are in compliance with state and federal limits, they still need to insure that applying manure with discarded footbath solutions of copper sulfate does not result in reduced crop yields .

Another concern with using copper sulfate in footbaths is increased permeability of claw horn. Scottish researchers found that horn tubules of heel and sole horn placed in copper sulfate solution for 24 h absorbed the solution (Kempson et al., 1998). Intertubular horn was penetrated 3-4 mm in the heel and 2 mm in the sole after being soaked in copper sulfate for 24 h. After 4 days, copper sulfate had fully penetrated the thickness of the heel and sole horn slices. It is believed that the copper salts form compounds with the fatty acids of the horn which disrupt the intracellular matrix thereby compromising horn integrity (Kempson et al., 1998).

Similarly, soaking heel and sole horn slices in manure slurry resulted in manure slurry fully penetrating the horn (Kempson et al., 1998). In contrast, soaking horn slices in formalin had no effect on horn permeability. It should be noted that micro cracks did develop in the horn soaked in formalin and this may be due to shrinkage caused by dehydration of the horn as a result of being placed in the formalin solution.

Formalin: In addition to not affecting horn permeability, other advantages of using a 3 to 5% formalin footbath are that it kills bacteria, hardens claw horn, is inexpensive, soluble, bacteria do not develop resistance and formalin eventually breaks down into water and carbon dioxide (Shearer et al., 2005). It is a powerful disinfectant that reacts with the amino, carboxylic, and sulfhydryl groups in proteins, thus changing the conformation and functionality of the protein (Epperson and Midla, 2007). Research has shown that formalin footbaths reduce incidence and severity of foot lesions (Arkins et al., 1986; Laven and Hunt, 2002) and formalin may retain its antibacterial activity for up to 330 cow passes (Holzhauer et al., 2004).

However, many dairy producers are hesitant to use formalin in footbaths as it is a suspected carcinogen, it must be used in a well ventilated area and the person mixing the footbath solution must wear eye protection (Shearer et al., 2005). In addition, formalin may not be effective below 50_{o}F and may slow healing of open claw lesions when treated cows are required to walk-through footbaths (Shearer et al., 2005). Support from these concerns is based upon information and clinical experience demonstrating chemical burns in cows caused by the use of formalin solutions in excess of 5% (Raven, 1989). This can be especially troublesome if concentrated formalin footbath solutions accidentally come in contact with the cow's udder and teats.

Zinc Sulfate: Anecdotal information suggests some success in controlling infectious claw lesions with the use of footbaths containing 5 to 20% zinc sulfate solutions. Zinc sulfate solutions do have antibacterial properties and may also act as a hardening agent. While zinc sulfate is relatively inexpensive to use in footbaths, it has not been widely used due to difficulty in dissolving most sources of zinc sulfate in water. Furthermore, controlled research on zinc sulfate footbaths for control of infectious foot skin lesions in cattle has not been conducted.

Poor solubility of zinc sulfate has prompted several companies to launch soluble zinc products for footbaths (Cook, 2007). The most notable of these products is a liquid zinc chloride product called Hoof Zink®. Field reports indicate Hoof Zink appears to be effective in preventing infectious claw lesions (Cook, 2007).

One advantage of using zinc based chemicals in footbaths is that zinc is commonly included in corn fertilization programs. Depending upon zinc content of soil, soil type and application method, up to 10 lb of zinc will be applied per acre (Shapiro et al., 2003). However, even dairy producers including zinc in corn fertilization programs, should be cautioned that if they are using a 50-gallon footbath containing 10% zinc sulfate solution, 4X/wk, changed every 200 cows, 17.6 lb zinc/cow per year will be dumped into manure and ultimately onto crop fields. According to EPA Standard 503, the cumulative loading limit for zinc is 2499 lbs/acre and an annual application limit of 125 lbs/acre (EPA, 1999).

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Copper Sulfate for Footbaths - Issues and Alternatives

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Summary

The control of digital dermatitis drives footbath use on U.S. dairy farms. Copper sulfate **($CuSO_4$)** and formalin are widely used as footbath disinfectants and show a positive effect in reducing lesions associated with digital dermatitis **(DD)**. Used copper sulfate solution has traditionally been mixed with manure slurry and disposed by land application. Once applied, copper **(Cu)** binds tightly to soil particles and accumulates, as crops withdraw very little copper. Because high copper may inhibit plant growth, regulators in some states have adopted limits on land application of copper. Dairy producers need to be aware that land application limits can be exceeded in time and should consider alternative strategies for DD control.

Introduction

Lameness is common on U.S. dairy farms, with a prevalence of 22% of cows affected (Cook, 2003; USDA, 2002). In the mid 1990's, it was estimated that 47% of herds experienced digital dermatitis (a.k.a. hairy heel warts, papillomatous digital dermatitis) and that 11.9% of the dairy cow population was affected with DD (USDA, 1997). More recent reports suggest that prevalence of digital dermatitis has increased (USDA, 2002).

The DD is associated with a mixed bacterial infection including *Treponema spp,* and application of antibacterials has resulted in rapid clinical improvement (Read and Walker, 1998). Dampness with maceration of the skin are predisposing factors for DD, and herd size, flooring type, access to pasture, purchasing replacement animals, and foot trimming management were associated with DD (Wells et al., 1999). Initial treatments of DD used antibiotics or disinfectants applied locally (under a bandage or sprayed on lesions directly) with success in relieving clinical signs (Moore et al., 2001; Hernandez and Shearer, 2000; Britt et al., 1996). However, lesions tended to reoccur in 60% of cases (Berry et al, 2004a). Control with vaccination has been attempted, but development of an effective vaccine for digital dermatitis remains elusive (Berry et al., 2004b).

Because DD tends to recur in spite of treatment, control is the management goal, rather than eradication. Whole herd post milking footbath application has become a favored control method.

Footbath Solutions

Footbaths can clean debris from feet and/or apply a disinfectant (or antibiotic) to the feet. In the U.S., footbaths are used largely in a preventive strategy and feature disinfectants. The most common disinfectants are formalin (2 to 5% concentration) and copper sulfate (5 to 10% concentration).

Formalin (2.5%) has been shown effective in DD control (Laven and Hunt, 2002). Formalin is an aqueous solution of formaldehyde and methanol.

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At the typical formaldehyde concentration of 37%, formalin is flammable. Formaldehyde has powerful disinfectant properties, and reacts with amino, carboxylic, and sulhydryl groups in proteins and enzymes, resulting in changes in conformation (Russell, 2003). Formaldehyde is a respiratory and contact irritant, and is considered a potential carcinogen. The main objection to formalin is the potential health hazard to farm workers, most of which is posed by the concentrated solution. Disposal of formalin presents no real environmental risk, and formaldehyde is said to be inactivated in air, water, and soil.

Copper sulfate has commonly been favored as a footbath disinfectant due to availability and ease of use, and it appears effective in reducing DD lesions (Bergsten et al, 2006; Laven and Hunt, 2002). Copper sulfate is bacterostatic by reaction of Cu++ with protein thiol groups in target organisms. Peracetic acid (1%) has also been shown to be effective in footbaths (Laven and Hunt, 2002).

A number of commercial products have become available for use as footbath disinfectants. Data on Double Action (WestAgro, Inc, Kansas City, MO) suggests it is effective in footbaths. Victory (WestfaliaSurge, Naperville, IL) and Hoof Pro Plus (SSI Corp, Julesburg, CO) were shown effective in direct topical application, and each of these has sister products for use in footbath solutions (Shearer and Hernandez, 2000; Britt et al., 1996). A myriad of other commercial products that are either non-Cu based or feature reduced copper concentrations are available. Testimonial or uncontrolled field trials suggest the possibility that they may be effective, but there is little peer-reviewed scientific evidence available (Laven and Logue, 2006). Producers contemplating use of these products must evaluate cost and perhaps perform a whole herd trial and forward their best estimate of effect.

Implications of Copper Sulfate Use

Typically, copper sulfate solution is considered effective for 150 to 300 cow passes. Used solution is mixed with manure waste and ultimately disposed by land application. Regulators in several states have expressed concern that soil copper could be increased to an unhealthy level by this practice and have established maximum (lifetime) loading rates of copper. An 8 ft x 2.5 ft x 5 inch foot footbath will contain approximately 62 gallons of water and 26 pounds of copper sulfate (charged at the 5% concentration). Since copper sulfate is 25% copper, each time the footbath is dumped, 6.5 pounds of copper is added to the disposal burden. The environmental effect of this copper depends on the volume of footbath solution disposed (a function of cow number and intensity of footbath use), concentration of copper sulfate, and the land area of application. Without careful attention, maximum soil copper loading rates may be exceeded by dairy producers in relatively short times (5 to 30 years). Plants require very little copper, so annual removal rates are less that 0.5 lb/acre for typical grain and forage crops. When copper sulfate is applied to soil, the copper has a high affinity for organic matter and accumulates in the upper soil layers (Stehouwer and Roth, 2004). In the period 1994 to 2004, the W.H. Miner Institute (Chazy, NY) estimates that approximately at 18% of the time, greater than 4 lb/acre of copper was applied to their agricultural land. A preliminarily report suggests that 4 lb/acre of copper supplementation may affect root development in certain grass plants under experimental conditions, though corn yields under similar circumstances were not affected (Flis et al, 2006a). A survey of Vermont dairy farms estimated that 1.4 lb/acre of copper was imported onto farm land in 2005, which was down from 2.1 lb/acre of copper in 2002 (Flis et al., 2006b). While this work is far from complete, it is clear that copper disposal from dairy farms can result in accumulation of soil copper in a short time, while soil copper will be naturally removed over several very long lifetimes.

Summary

Copper sulfate footbath use can radically change the copper disposal burden of a dairy farm. Producers must maximize foot health and should seek to decrease risk factors for infectious foot disease. Chief among these is improvement in environmental hygiene and exploring alternatives to footbath use in management of DD. When copper sulfate is used in footbath solutions, efforts to maximize effectiveness and minimize waste must be undertaken. Alternative products that feature reduced or no copper should be considered. Unfortunately, peer reviewed field trial data with most commercial footbath disinfectants is unavailable. Management consideration on the use and disposal of copper sulfate footbath solution requires immediate attention, as long-term high level use of copper sulfate footbaths, using conventional disposal, appears unsustainable.

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A Cautionary Note About Copper Footbaths for Dairy Cows

Many of Idaho's dairy cows wade through copper sulfate baths like this to help prevent foot infections. ARS scientists are studying how copper levels in the wastewater affect crop growth and soil microbes.
(D2630-1)

At least once a day, many of Idaho's 550,000 dairy cows wade through shallow copper sulfate baths to help prevent foot infections. Producers often discard the bath water into lagoons and eventually use the spent wastewater to irrigate corn and alfalfa.

"At some point, the buildup of copper in the soil could start to negatively affect crop production," says soil scientist Jim Ippolito, who works at the Agricultural Research Service's Northwest Irrigation and Soils Research Laboratory in Kimberly, Idaho. "By studying this issue now, we may be able to help producers develop irrigation management strategies that keep copper from getting to potentially harmful levels."

Ippolito joined with ARS soil scientist David Tarkalson and microbiologist Tom Ducey to study how copper levels in the wastewater affected crop performance and soil microbial activities. Tarkalson also works in Kimberly, and Ducey is with ARS's Coastal Plains Soil, Water, and Plant Research Center in Florence, South Carolina.

The scientists selected two soils common to south-central Idaho, where many dairies are located. Then they conducted a lab study of alfalfa growth in soils containing copper at levels of 50 parts per million (ppm), 100 ppm, 250 ppm, 500 ppm, or 1,000 ppm.

Copper sulfate at soil levels of up to 250 ppm had no effect on alfalfa growth, but alfalfa growth stopped when soil copper sulfate levels exceeded 500 ppm. The alfalfa plants took up higher levels of copper at both application rates, and from 48 to 80 percent of the added copper was still in the soil and available to plants at the end of the study.

The team also discovered that beneficial soil bacterial activity declined when the two soils accumulated available soil copper levels above 50 ppm. And a correlation analysis indicated that soil levels above 63 ppm of plant-available copper resulted in alfalfa copper concentrations that could potentially harm grazing livestock, according to guidelines established by the National Research Council.

Ippolito also conducted a laboratory study of whether biochar made from pecan shells could reduce copper levels in the spent wastewater. He tested the biochar in solutions with varying pH levels and found that the amount of copper adsorbed, or "captured," by the biochar could be as much as 40,000 ppm. He concluded that it might be possible to use biochar to clean up waters containing elevated copper levels, but that more studies would be needed to identify characteristics that would allow the biochar to capture the most copper.

Ippolito published his findings in the *Journal of Agricultural Science*, *Soil Science*, and the *Journal of Environmental Quality*.

"In our studies, we controlled how much copper was added to the soil. But in real-world conditions, soil copper accumulations and their effects will vary depending on a range of factors, including how often crops are irrigated, how much copper is in the wastewater, and how much copper remains in plant-available form," Ippolito says. "We might not see any negative impacts for anywhere from 15 to 75 years after irrigation begins. But producers should be proactive and work with us to address this issue sooner rather than later."—By **Ann Perry,** Agricultural Research Service Information Staff.

This research is part of Climate Change, Soils, and Emissions (#212), Agricultural and Industrial Byproducts (#214), and Water Availability and Watershed Management (#211), three ARS national programs described at www.nps.ars.usda.gov.

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Copper Sulfate Hoof Baths and Copper Toxicity in Soil

Posted: March 6, 2004

On most dairies spent hoof baths are dumped into the manure pit or lagoon so the copper ultimately gets spread on production ground with the manure. Recently there have been several reports in the dairy press regarding copper accumulation in soils from this practice.

Copper sulfate hoof baths are used on many dairies in Pennsylvania as part of their overall hoof hygiene program. On most dairies spent hoof baths are dumped into the manure pit or lagoon so the copper ultimately gets spread on production ground with the manure. Recently there have been several reports in the dairy press regarding copper accumulation in soils from this practice. It is possible that after several years copper could accumulate in soil to levels that become toxic to soil microbes and crops. This could slow organic matter decomposition and nutrient cycling in soil (especially conversion of organic nitrogen to plant available nitrogen) and crop production could be reduced because of direct toxic effects of copper on the plants as well as reduced soil fertility. Copper accumulation in soil and forage could become toxic to sheep, whose tolerance for copper is much lower than that of dairy cattle.

The potential for accumulation of toxic levels of copper in soil is a critical issue because there is no practical way to reverse the problem if it occurs. On the other hand, it is a problem that will take many, many years to develop and can easily be avoided. Copper is an essential element for all living organisms so plants and microbes need a constant small supply. All soils naturally contain some copper and it is only when the availability of soil copper becomes too large that toxicity could result. Thus two important questions for dairies that use copper sulfate hoof baths are: (1) How much copper can be added to soil before it reaches the toxic threshold, and (2) How long will it take to reach that threshold? Unfortunately there are no simple or clear answers to those questions. In this article we will look at factors that affect copper availability in soil and provide some guidance for dairies on how to deal with this issue.

The toxicity of copper in soil depends more on the available concentration of copper than it does on the total concentration. Available means that the copper is in a form that can be taken up by plants, microbes, or animals. For example, copper pipes are almost pure copper but are not toxic because the copper is not in a form that is available to living organisms. When water flows through the pipes, tiny amounts of copper dissolve in the water and that copper is available. The same holds true for copper in hoof baths, manure pits, and soil. Copper sulfate hoof baths are normally made as a 10% solution so the water contains about 25,000 parts per million (ppm) of copper. All of this dissolved copper is available, and at this high concentration is toxic to fungi and bacteria (intentionally so). As soon as the bath is dumped into the manure pit its toxicity decreases dramatically for two reasons. First, there is a huge dilution as a bath of a few gallons is mixed into thousands of gallons of manure. We have analyzed liquid manure from dairies using copper sulfate and found copper concentrations of 20 - 60 ppm, or about a 1,000-fold dilution. Secondly, copper becomes strongly bound to the organic matter in the manure pit. We have found that in liquid dairy manure about 90 - 95% of the copper is held on organic matter. When copper is bound to organic matter its availability is vastly reduced. Nevertheless, hoof baths do add a lot of copper to the manure - up to 1,000 ppm on a dry weight basis (sewage sludge normally has 300 - 500 ppm copper on a dry weight basis).

Ultimately all the copper ends up in the soil. Surface soils in Pennsylvania normally have total copper concentrations in the range of 15 - 30 ppm (mg/kg), or 30 - 60 lb/acre. When high copper manure is spread on the soil, copper is added to this natural background level. In the soil copper is strongly bound to soil organic matter and to clay particles. A lot of the copper gets bound so tightly that it is not available to microbes or plants and thus has no effect on toxicity. Copper availability is lowest at near neutral soil pH (6.5 - 7.5), but as pH decreases copper availability increases. Thus when high copper manure is added to soil, we would expect a greater increase in copper availability in a light textured soil with low organic matter and somewhat low pH than in a heavier textured soil with moderate organic matter and near neutral pH. In all soils, however, almost all added copper stays right where it is placed. Thus spreading high copper manure in soil year after year will steadily increase the total amount of copper in the topsoil. At one PA dairy that used a lot of copper sulfate we found total copper in the soil was 3-5 times higher than the normal range for topsoil in Pennsylvania. But corn growth on that field was excellent and the silage contained normal levels of copper suggesting there had been little increase in copper availability.

Another indicator of copper availability is how much copper is taken up by crop plants. Most agronomic crop tissues (leaves and stems) normally contain copper in the range of 5 - 30 ppm. The average copper content of corn silage in Northeast US is 7 ppm. If crop tissues contain copper at the high end of this range or above, this is evidence of increased copper availability, though not of toxicity. The classic foliar symptom of copper toxicity is interveinal chlorosis (pale green striping in corn leaves). The problem of crop tissue analysis as an indicator of copper toxicity is that copper will also stunt root elongation and development and may never be taken up into the above ground part of the plant. Thus a copper problem in the soil may not be seen above ground.

So we come back now to the question of how much copper can be added to soil before toxicity problems might arise? While almost no research has been conducted with high copper dairy manure, investigations of high copper swine manure and sewage sludge provide some guidance. Based on this research, if copper is added gradually (<10 lb of copper per acre each year) it appears that at least 150 lb of copper per acre could be added to light textured, low organic matter soils without causing crop toxicity. Heavier textured soils with moderate to high organic matter levels could likely receive at least 3 - 5 times as much copper without showing any crop toxicity. However, adverse effects on soil microbes might occur with smaller additions of copper. Unfortunately, no simple soil test has been developed that can reliably predict when copper toxicity might occur to plants or microbes. Thus, dairy farmers using copper sulfate hoof baths should determine how much copper they are adding to their fields each year, and should monitor their soils and crops for evidence of increased copper availability.

There are two ways to calculate how much copper is added to soil each year. One is based on the total pounds of copper sulfate used in a year for hoof baths. This total must be divided by 4 since the copper sulfate is ¼ copper by weight. Now divide that result by the number of acres the manure is spread on to get pounds of copper per acre per year. This calculation will give a good estimate of how much copper is being added to a field. However, since there are other sources of copper in the manure (from feed and water) a more precise method is to have the manure analyzed for copper. Then multiply the concentration of copper in the manure (lbs/ton or lbs/1,000 gal) by the application rate used (tons/acre or 1,000 gal/acre) to get lb of copper added per acre with each manure application. We have done these calculations at 4 PA dairies and found copper additions ranging from 2 up to 11 lbs of copper per acre per year. If the amount of copper added is less than 2 lb per acre, the buildup in soil will be extremely gradual (crop harvest will likely remove about ½ lb of copper per acre) and unlikely to cause a problem. Farms with annual copper addition of more than 5 lbs per acre should analyze soils and crops for copper every 5 years or so to monitor for any increases. Soils should be analyzed for total copper (strong acid digestion). The Agricultural Analytical Lab at Penn State can do these soil and tissue analysis as well as many other service laboratories. Farms where annual copper addition is 10 or more lbs per acre should attempt to reduce the amount of copper being used. This can be done by reducing the frequency of hoof bath use to the minimum needed to control hoof diseases, decreasing the concentration of copper sulfate used in the baths from 10% to 5%, and by placing a water bath ahead of the copper sulfate bath so that the copper sulfate bath will not need be changed as often. Dairies could also investigate alternative treatments to copper sulfate. Zinc sulfate baths are one alternative, but with long-term use zinc could accumulate to toxic levels just like copper.

Rick Stehouwer and Greg Roth, Department of Crop and Soil Sciences

How much copper are you putting down?

Dairy basics - Manure

Written by Gary Wegner

"The use of copper sulfate footbaths is no big deal. Don't worry about it!" Is this what you and your neighbors are saying? Let's evaluate that position and see if it holds water.

First, we need to understand that copper is an essential nutrient. Copper is an essential element for all living organisms so animals, plants and all life forms, including microbes, need a constant "small supply." We also might like to know that copper deficiency in the soil is a common problem.

If the cow needs copper and the soil needs copper, why could there be a problem? The problem arises when copper is in excess and the balance of nutrients is disrupted.

Too much copper can create toxicity. That is why copper sulfate is such a good bactericide and is used as a footbath to kill unwanted organisms. Yet it can also harm the dairy – from the soil to the cows.

Copper sulfate drained from footbaths can kill the beneficial bacteria in a dairy's manure lagoon.

If applied to the field, the copper will accumulate in the soil. Most agricultural labs typically advise two parts per million (ppm) in the soil as an adequate level of copper. Be sure to analyze for copper and zinc. The zinc level should be double the copper level.

How much is too much? Let's look at a simple example that you can apply to your dairy. Let's say your dairy milks 2,000 cows and uses 2 tons of copper sulfate per month. Two times 12 months is 24 tons of copper sulfate per year.

Copper sulfate is 25 percent copper; the rest is sulfur and oxygen. Divide that 48,000 pounds by four to give 12,000 pounds of pure copper. Then divide that by the number of acres of cropland where manure is applied. If the number of acres is 500, the result is 24 pounds of copper per acre per year.

One 200-bushel corn crop removes 0.15 pound of copper; or 24 pounds of copper is enough copper to produce a 200-bushel corn crop for 160 consecutive years.

Copper sulfate in footbaths is not the only source of copper on a dairy. A well-balanced ration will contain copper, as it is an essential nutrient. The manure from that balanced ration will provide the soil with adequate copper. That means that virtually all copper from copper sulfate is "excess copper" for the dairy farm soils.

The crops can also take up the excess copper from the soil and if not monitored in the ration, can lead to copper toxicity in the cows. The first clinical evidence of this is lameness. Toxicity makes cows lethargic, lose body condition, produce less milk and eventually die.

Rodney P. Kromann, animal nutritionist and biochemist in Grove City, Minnesota, shared with me a few years ago that there are many cows that are being poisoned by excessive dietary copper. A recent survey indicated that the liver copper concentrations in more than 50 percent of Holstein cows in Minnesota were in excess of the established normal ranges of liver copper concentration (75 to 300 ppm dry basis or 25 to 100 ppm, wet basis).

The high liver copper level is directly related to the excessive amount of copper ingested by the animal. Dietary nutrients in excess of requirements are more detrimental to the metabolism of the animal than slight deficiencies, he said.

In some herds with chronic copper toxicity, he witnessed cows with varying signs. The most prominent sign was that the cows were in very poor condition and did not gain body condition toward the end of lactation. Dry matter intake had decreased, and the cows sorted their ration. Salt consumption was excessive.

The cows had sunken and opaque-looking eyes. Hair coat colors were dull. Most cows had sore feet and had difficulty walking. Health problems were abundant because the immune system was impaired and displaced abomasums were excessive. Some cows had lesions and abscesses in the hock area.

In extreme cases, the cows were moaning and walked with humped backs. Reproduction was extremely poor, leading to extended days in milk. Calves were unthrifty, and in one case the calves died within 12 hours of birth.

Chronic copper poisoning is the result of an excess amount of copper ingested in relation to the recommended levels over a period of time. The period of time can be weeks, months or years, Kromann said.

Not only are cows lost to mortality, but also the effects on the remaining cattle are long-lasting. In Kromann's experience, herd production efficiency was damaged and the cows never regained the losses incurred. One dairy producer told him that the recovery of his herd took eight years.

Where do we go from here?

Most dairy farms find it very difficult to eliminate the use of copper sulfate because of hoof health problems. Answers lie in flush water and manure lagoon management. Spirochetes, a known causative agent related to hairy hoof warts, are propagated in typical stagnant lagoon water. The flush water can hang on hooves and create the perfect incubator for hairy hoof wart organisms.

Finding ways to clean flush water or alleyways is one alternative. When cows' hooves are clean, the need for copper sulfate can be eliminated. There are also alternative products that can be used as a direct spray to the hoof once or twice a week in lockup. Clean hooves eliminate the major cause of the problem.

The overuse of copper can cause damage on a farm. By looking into alternative processes and monitoring the amount of copper in the soil and ration, overuse of copper is a challenge that can be overcome. ***PD***

Gary Wegner
Nutritionist
CIRCUL8Systems

Copper Sulfate Use May Bite Us

Good crop and hoof health are possible with copper sulfate use. However, future regulations remain the wildcard.

By Mike Rankin
The author is a crops and soils agent with the University of Wisconsin Extension, Fond du Lac County.

When making farm decisions, what might seem like a good idea for cows might not be advisable for the crops.

Copper is an essential element for plant growth, but like most micronutrients it is needed in very small amounts. Most crops remove less than 0.1 pound per acre of copper per year from the soil.

The copper ion (Cu++) is held very tightly by soil minerals and organic matter. In fact, it is held so tightly that most soil copper remains unavailable for plant uptake. Once soil copper concentrations are increased through manure applications containing high copper levels, soil test copper levels will remain high for a long time. On the flip side, instances of plant copper toxicity and deficiency have been rare historically.

Calculating copper application rates . . .
Ev Thomas reported on the Miner Institute's experience in Chazy, N.Y., with land applications of spent copper sulfate foot bath solutions in Hoard's Dairyman's July 2001 issue (page 458).

The farm was using about 254 pounds of copper sulfate per week for their 160-cow herd. On an annual basis, they were applying about 7 pounds of copper per acre. The farm took several remedial actions and reduced the amount of copper being applied to cropland to about 2 pounds per acre.

A 2003 herd hoof health survey of 27 Fond du Lac County, Wis., dairy farms revealed copper sulfate usage averaged 77 pounds per week with a range of 12 to 200 pounds. Of course, that is only part of the story because we need to know how many acres that the solution is being applied to and how often an individual field receives manure. Table 1 shows calculations from several Wisconsin dairy farms based on the premise that copper sulfate contains 25 percent copper.

Knowing how much copper is being applied per acre is important. Indications are that it is not uncommon for rates to fall between 5 and 10 pounds of copper per acre per year. Table 2 can be used to estimate annual copper loading on a per acre basis. These estimates do not include the normal background amount of copper found in manure without any copper sulfate solution additions (about 150 ppm d.m. or 0.06 lb./1000 gal).

In the late 1990s, Wisconsin researchers reported on the trace element content of manure samples submitted to soil testing labs across several U.S. regions. The copper concentrations for dairy, swine, and poultry manure are presented in Table 3. The study did not distinguish farms adding spent copper sulfate solution to the manure.

Nevertheless, it is interesting to note that liquid swine manure was over three times greater and poultry manure was over two times greater in copper content than dairy manure.

Swine are routinely fed higher levels of copper in their diet. Several research studies have been done evaluating high soil copper loading rates with swine manure. In some cases, up to 250 pounds of copper per acre were added to the soil with no crop yield decreases and only a small increase in plant copper concentration. Much of the copper applied was converted to an unavailable form but was still present in the soil.

Penn State researchers reported checking the copper content of corn silage from fields with three to five times normal total soil copper but finding no increase in the forage copper concentrations. Even so, total soil copper concentrations will build up over time and are virtually irreversible.

Copper is sometimes used as an algicide in ponds, a fungicide for plants, and is a known bactericide. The latter has implications for dairy producers. High manure copper concentrations have been shown to have a detrimental effect on the operation of anaerobic manure digesters which depend on bacteria for the digestion process.

Regulation of copper land applications . . .
The Environmental Protection Agency (EPA) has guidelines for copper loading to agricultural land when sewage sludge or other biosolids are applied. Although most state enforcement agencies do not monitor copper applications from dairy manure, standards set for biosolids offer a guide and perhaps an indication of future regulations.

The EPA is beginning to take a closer look at practices and procedures followed on dairy farms. Recently, a large New Mexico dairy farm was cited as being in violation of their NPDES permit by Region 6 EPA for discharging copper sulfate into a manure storage unit. The citation stated that: “discharges to containment structures must be composed entirely of wastewater from the proper operation and maintenance of the animal feeding operation.”

A clean water foot wash ahead of the copper sulfate bath can extend the useful life of the copper sulfate solution.

The EPA 503 standard for application of biosolids to agricultural land cites a maximum lifetime loading limit for copper as 1,339 pounds per acre and an annual application limit of 66 pounds per acre. Neither of these guidelines is severely limiting for typical manure applications even where above average amounts of spent copper sulfate are added to the manure slurry. It should be noted that specific states may have more restrictive regulations. For example, Thomas reported New York has a lifetime cumulative loading limit of 75 pounds per acre and Illinois has a lifetime application limit of 250 pounds per acre.

What you should do . . .
It would seem the best approach regarding the use and management of copper sulfate for herd hoof health is to not use more than is absolutely necessary to maintain acceptable results. This can be accomplished by reducing the concentration in the foot bath solution, reducing the frequency of use, and substituting noncopper-containing hoof care products from time to time. Some veterinarians also suggest using a clean water foot wash bath ahead of the copper sulfate bath to extend the useful life of the latter.

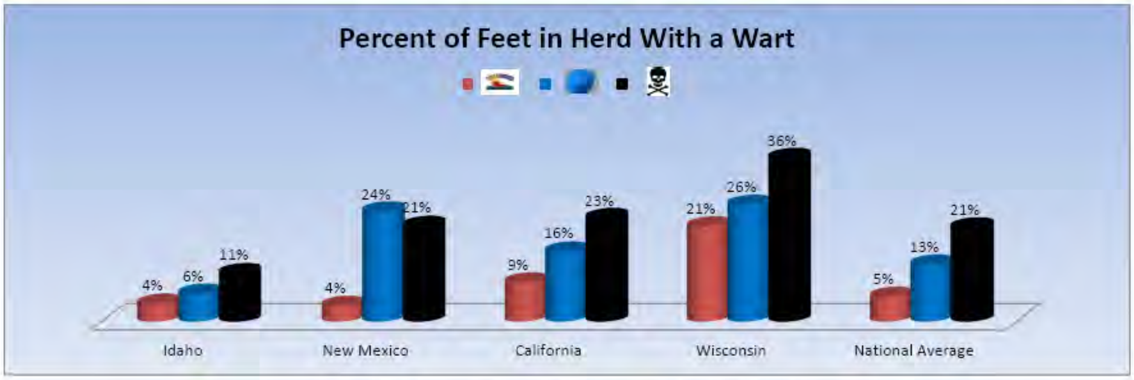
Producers need to know how much copper is actually being applied to their soil. A buildup to high levels is essentially irreversible. For this reason, don't concentrate spent copper sulfate foot bath solutions in small-volume holding facilities and then spread the waste on a relatively small land area.

At this point in time, dilution is the best solution for the disposal of the spent foot bath effluent. Analyze manure, soil, and feed copper levels to set a benchmark. Where high amounts of copper are being applied to land (more than 10 pounds per acre), continue to monitor copper levels every few years.

11.

Field Trial of 49,718 Cows
Four States, Four Months

= Copper/Zinc A
= Copper Sulfate C
= Formaldehyde F



All Milking Cows Inspected Each Month

State	Copper/Zinc # Cows	Copper/Zinc Total Warts	Copper/Zinc %	Copper Sulfate # Cows	Copper Sulfate Total Warts	Copper Sulfate %	Formaldehyde # Cows	Formaldehyde Total Warts	Formaldehyde %
Idaho	23,616	943	4%	20,744	1,279	6%	6,080	653	11%
New Mexico	8,582	302	4%	3,596	878	24%	3,674	782	21%
California	8,942	780	9%	10,764	1,678	16%	11,524	2,649	23%
Wisconsin	1488	315	21%	4,424	1,150	26%	2,452	890	36%
National Average	42,628	2,340	5%	39,528	4,985	13%	23,730	4,974	21%

Zinc Sulfate Foot Bath for Control of Ovine Foot Rot

R. F. Cross, DVM, PhD, and C. F. Parker, PhD

SUMMARY

A 10% zinc sulfate ($ZnSO_4$) solution was used as a foot bath to control foot rot in pastured lambs. When the foot bath was placed where infected lambs would walk through it each day, clinical evidence of foot rot was greatly reduced within 15 days, and the total number of cases detected after thorough foot trimming was greatly reduced within 30 days. When the foot bath was placed under the salt feeding box, it was not effective. Feeding $ZnSO_4$ at the rate of 0.5 to 0.75 g/head/day was not effective in controlling foot rot. Temperature and moisture conditions were favorable for foot rot transmission throughout the trials.

WHEN DEALING with an epizootic of ovine contagious foot rot, the major expense is often the cost of labor for individual treatment. Although effective topical and parenteral treatments are available,[1-4] any reduction in the number of times that sheep have to be handled individually would be economically beneficial. The present report evaluates the use of a 10% zinc sulfate ($ZnSO_4$) foot bath for flock treatment of foot rot.

Materials and Methods

Foot rot was induced in 5-month-old Targhee lambs by confining them in a wet pen for 1 week, scratching the axial surface of 1 digit of both right feet across the skin-horn junction, and rubbing freshly collected exudate into the scratches. Exudate was collected from an active case of foot rot. Lambs were kept an additional 2 weeks in the pen, examined, moved to a dry pen, kept there for 1 m week, and reexamined. The same source of exudate used to expose all lambs; all had active infections, and had been exposed 3 weeks before the start of the 1st tr

In the 1st trial, lambs were allotted to 3 groups were confined in adjacent pastures. The pastures w poorly drained and puddles persisted for 1 or 2 days af each heavy rain. Pasture 1 had 14 lambs (group A) with infected feet. This pasture was fenced into 2 sections, w a single opening between sections. A foot bath was pla in the opening in such a manner that lambs had to w through it when moving from 1 section to the other. Wa was available in 1 section, and pelleted feed[a] was placed the other section each day.

Pasture 2 had 13 lambs (group B) with 20 infected fe These lambs were fed 0.5 to 0.75 g of $ZnSO_4$/head/day 30 days. The $ZnSO_4$ was incorporated (1.1 g/kg) in pelleted feed.

Pasture 3 had 13 lambs (group C) with 24 infected f These lambs were untreated and were fed the unme cated feed at the same rate as in the other lots.

The foot bath was constructed with a 4 by 4-ft shee ¾-in exterior plywood forming the floor and 2 by boards forming the sides. It was waterproofed with a c of fiberglass mastic and filled with approximately 5 cm in) of wool and 40 L (10 gal) of 10% $ZnSO_4$ solution. Wh lambs walked through it, the wool squeezed between digits and swabbed them with solution. The foot bath unprotected from the weather and, as a result, r occasionally diluted it to approximately 5% and evapo tion occasionally concentrated it to approximately 20

The feet of all lambs were examined at the start of trial and after 15 and 30 days.

After 30 days, this trial was terminated and a 2nd tr was initiated. Group A ($ZnSO_4$ foot bath in pasture 1) removed from the pasture and withdrawn from experiment, and group C (untreated controls in pastur was moved into pasture 1 with the foot bath. Zinc sul was removed from the diet of the lambs in pasture 2 (gr B), and a duplicate foot bath was placed at the fence lin 1 corner. The foot bath was filled with wool and 10% Zn solution, and a salt box was fastened in the same corne such a way that lambs had to stand in the foot bath to salt. At the start of this trial, there were 13 lambs with infected feet in pasture 1 and 13 lambs with 18 infec

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[a]Ground shelled corn, 65%; alfalfa meal, 35%.

TABLE 1—Foot Rot Infections in Pastured Lambs Fed $ZnSO_4$ Daily or Exposed to a 10% $ZnSO_4$ Foot Bath Daily

	No. of foot rot infections detected					
	Day 0		Day 15		Day 30	
Group	Lambs	Feet	Lambs	Feet	Lambs	Feet
Foot bath	14	27	2	2	1	1
Oral zinc*	13	20	10	17	9	18
Untreated	13	24	12	21	11	20

*0.5-0.75 g of $ZnSO_4$/head/day

TABLE 2—Effect of Duration of Treatment on the Number of Foot Rot Infections Detected Before and After Foot Trimming

	No. of foot rot infections detected					
	Before treatment		After treatment			
			Before trimming		After trimming	
Duration of treatment*	Lambs	Feet	Lambs	Feet	Lambs	Feet
15 days	11	31	3	6	10	24
30 days	25	47	1	1	5	6

*Days lambs were confined in a pasture with a 10% $ZnSO_4$ foot bath in the only passage between water and supplemental food.

feet in pasture 2. Feet were examined at the start of the trial and after 15 days.

After 15 days, the foot bath in pasture 1 had been in continuous use for 45 days and was very dirty. It was drained, cleaned, refilled with wool and freshly formulated 10% $ZnSO_4$ solution, and the lambs from pasture 2 (group B, now 13 lambs with 31 infected feet) were added to the group already in pasture 1. The trial was continued another 15 days; thus, 1 group of 13 lambs with 31 infected feet (group B) was in the pasture for 15 days and 1 group of 13 lambs with 20 infected feet (group C) was in the pasture for 30 days. All feet were then examined for evidence of foot rot.

Because the feet were not trimmed before or during any of the trials, diagnosis was based on clinical appearance of the untrimmed feet. A foot was considered normal only if there was no visible sign of inflammation, no lameness, and no characteristic odor of foot rot. In order to detect nonclinical infections, the feet of all lambs were thoroughly trimmed and reexamined for foci of infection after they were removed from pasture 1.

Results

Results of the 1 trial are given in Table 1. When the untreated control group (group C) was moved into pasture 1 with the foot bath in the passage between water and supplemental food, the number of infected feet decreased from 20 to 6 within 15 days and no clinical infections were found at 30 days. When $ZnSO_4$ was removed from the diet of lambs in pasture 2 (group B) and a similar foot bath was placed under the salt box, the number of infected feet increased from 18 to 31 within 15 days. When this group was moved to pasture 1, the number of clinically infected feet decreased from 31 to 6 within 15 days.

Thorough foot trimming revealed previously unrecognized infections, and there was a considerably greater number of such infections found after 15 days' than after 30 days' exposure to the $ZnSO_4$ foot bath. Details are given in Table 2.

Discussion

Lambs with foot rot were not reluctant to walk through the $ZnSO_4$ foot bath to reach supplementary food or water but were reluctant to step into it to reach salt. Lambs made no effort to carry infected feet above the foot bath when walking through it, and no evidence of discomfort was shown when infected feet were in the solution. When the foot bath was located where lambs would walk through it each day, clinical evidence of foot rot was greatly reduced within 15 days and the total number of cases detected was greatly reduced within 30 days. Additional control measures were not used and feet were not trimmed until the conclusion of the trials. Weather and moisture conditions were favorable for foot rot transmission throughout the trials. There was usually heavy dew on the pastures in the morning; there were frequent showers, occasional heavy rains, and the weather was hot and humid. An awning over the foot bath probably would have been useful to prevent evaporation by sunshine and dilution by rain.

References

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Sheep Foot Health Farm Protocol

Revised December 8, 2010

All information between the research team and the flock owner is considered strictly confidential and no public use of names or information will be used that could identify individuals or farms.

The Goal

As a result of following the 4-week protocol described below, the sheep producer will develop a "foot healthy flock" with the support and assistance of the research team. The sheep producer will be trained in proper foot trimming and foot scoring with special emphasis on recognizing foot infections and foot structures that are commonly associated with "carriers" for the footrot bacteria. The producer will not only learn the procedures to create a flock with good foot health, but also the important practices that will maintain such a flock. To accomplish this goal, all animals in the flock must be included in the project.

One of the objectives of this program is to investigate the genetics of good foot health and resistance to footrot. We are using both a pedigree analysis approach and possibly DNA testing. To do this it is important that each farm have available sire/dam information for all breeding animals for at least two generations. The pedigree information will be needed on "Day 0" – the start of the protocol period.

Each farm will create a written biosecurity plan. The plan has the objective of identifying procedures to protect the flock from disease that may be brought to the farm by visitors, equipment and other means. The plan will also describe how and if new animals will be introduced to the flock.

Applicants who wish to become part of this project will agree to follow the procedure outlined below with assistance and cooperation of the research team.

Over the next 4 weeks, it is important to maintain the scheduled 7-day interval of interaction with the sheep to prevent lateral transmission of infection. Block off time in your calendar for this to take place.

Day 0 (First Day) – Responsibility: sheep producer and research team

The research team will meet with the flock owner(s) and discuss the program, objectives, protocol and answer any questions. In particular, the team will be interested in any past history of foot problems and how they have been addressed (treatments, vaccines, etc).

All animals in the flock will be included in the project. The farm will need a facility where the flock can be confined (panels, gates, working chute) which will allow individual animals to be easily caught and where each animal can be examined, feet trimmed and scored and blood samples taken. We have learned that proper foot trimming is a key to good foot health and will illustrate the use of both a trimming tool and foot knife. The research team will bring the tools and equipment needed.

As each animal is trimmed, each hoof will be scored to indicate a healthy foot, a foot that is infected or one that has structure abnormalities. A score sheet will be provided to record this data. The producer will be trained in the scoring procedure. Hoof color will also be recorded. Blood samples will be taken from each animal to be used to test for biochemical and genetic links that could possibly identify animals resistant to foot rot. We will also record the FAMACHA score for each sheep to determine degree of gastrointestinal parasite infection.

The animals then will be placed in a footbath to be provided by the farm. This can be a commercial or farm constructed bath. The footbath can be included as part of a working chute or baths that are larger in size where several animals at a time can be treated. We can provide plans to construct a foot bath. The research project will provide a supply of zinc sulfate powder and detergent that will be used to make a 10% zinc sulfate solution (8.5 # zinc sulfate/ 10 gallons of water + one cup detergent). It is best if old wool is available to place in the bottom of the footbath to create a "soaked pad" to reduce splashing and loss of zinc sulfate solution. Each sheep needs to stay in the bath for 3 to 5 minutes. After the footbath treatment, the sheep will be separated into (1) healthy, infection-free group or placed into (2) an affected/recovery group. Sheep in each group should be color coded with a suitable livestock marker. Sheep in the affected/recovery group are candidates for possible culling. These sorted sheep will be placed in one of two designated "drying" areas (well-bedded barn area or dry, hard surface such as a clean concrete pad or wooden floor). The animals need to stay in the drying area for a minimum of 30 minutes.

Each group will then be moved to separate pastures or barn areas where sheep have not been for two weeks (the length of time the causative bacteria for foot rot can live outside contact with sheep).

All of the above will be accomplished with the help of the research team on the first day (DAY 0).

Summary of Start Day Protocol: Sheep producer and research team working together

1. Pedigree information available.
2. All animals confined in an area with movable panels/working chutes to easily catch and handle individual animals.
3. Each animal's feet trimmed/scored (proper trimming is crucial-the use of hoof knife and trimmers will be demonstrated).
4. Each foot scored as to health, color and structure
5. Blood sample for possible DNA/antibody testing will be collected
6. FAMACHA score for degree of parasite infection
7. Zinc sulfate footbath treatment

    a. 3-5 minutes in bath
    b. 30 minutes in a drying area
8. Separated into one of two groups:
    a. Health Foot Group
    b. Recovery Group
9. Each group moved to a separate area where no sheep have been for two weeks.

DAY 7 – Responsibility: sheep producer

1. Each sheep will be treated in a footbath/drying protocol as described above.
2. All sheep should be carefully observed and any sheep in the Healthy Foot Group that is limping will be inspected and if any infection is found, feet trimmed if necessary and moved to the Recovery Group.

DAY 14- Responsibility: sheep producer

1. All sheep will be confined and each hoof scored and recorded by the sheep flock owner. The handler should check and trim hoof if needed. Animals that are in the Recovery Group that have healed and show no signs of infection or foot abnormality can be moved to Healthy Feet Group. Likewise, any sheep in the Healthy Group that show any infection or suspicious feet will be moved to the Recovery Group.
2. All sheep will again be treated using the footbath /drying protocol as described above.
3. Each group will be moved to separate pastures or areas where no sheep have been for 2 weeks.

DAY 21- Responsibility: sheep producer

1. All sheep will be treated in the footbath and drying protocol described above.
2. All sheep will be observed and any limpers in the Healthy Group will be checked and if any infection found, trim if necessary and moved to the Recovery Group.

DAY 28 – Responsibility: sheep producer and research team

At a date and time convenient to flock owner, the research team will return to the farm to help inspect all sheep, score each hoof and treat all animals in the zinc footbath/dry area protocol as described above. At the end of 4 weeks, the combination of proper trimming, zinc sulfate treatment and use of clean pastures will have allowed time for all sheep except carriers to heal. All animals that have not healed and animals classified, as carriers should be culled. <u>The culling step is crucial to creating and maintaining a flock free of foot rot.</u>

This procedure is one that has been shown to be effective in eliminating foot rot and creating a "foot healthy sheep flock". It combines careful, detailed hoof trimming, hoof scoring, weekly zinc sulfate footbaths, dry time protocol and

putting animals onto clean pastures or areas where the foot rot causing organism will not be present. The procedure is designed to optimize cure where cure is possible and identification of carriers which must be culled if a flock is to truly become footrot free.

Your efforts will create a healthier flock and one that will have more value for meat sales and/or breeding stock. The research team is pleased you are making this effort to create a foot healthy sheep flock. Your cooperation to allow us to work with you, to collect blood samples for possible sera and genetic work is appreciated. We encourage you to contact us with any question.

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