Are Dairy Farmers Polluters?
Strategies Aimed at New Regulation Changes

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Definition of Pollution:
The presence in or introduction into the environment of a substance or thing that has harmful or poisonous effects.

The EPA defines a CAFO as an animal feeding operation (AFO) that:
(a) confines animals for > 45 days during a growing season
(b) in an area that does not produce vegetation
(c) meets certain size thresholds.

<table>
<thead>
<tr>
<th>Animal Sector</th>
<th>Large CAFOs</th>
<th>Medium CAFOs</th>
<th>Small CAFOs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle or cow/calf</td>
<td>1,000 or more</td>
<td>300-999</td>
<td>&lt; 300</td>
</tr>
<tr>
<td>Mature dairy cattle</td>
<td>700 or more</td>
<td>200-699</td>
<td>&lt; 200</td>
</tr>
</tbody>
</table>

CAFO
A Concentrated Animal Feeding Operation (CAFO) is a term that was first coined by the United States’ Environmental Protection Agency (EPA) to describe animal agricultural facilities that have a potential pollution profile.

Pollutants associated with CAFO waste include:
- Odorous/volatile compounds (NH₃, N₂O, etc.)
- Nitrogen and phosphorus
- Organic matter (manure) and solids
- Trace elements and salts
- Antibiotics, pesticides, pathogens, and hormones

2 main contributors to water pollution caused by CAFO are soluble nitrogen compounds and phosphorus
- Okeechobee Water Basin (FL)-P
- Chesapeake Bay (VA)-P, etc.

Human concerns with CAFO’s
- CAFOs may also be contributing to the drop in nearby property values due to potential risks of water contamination, odors, air pollution, and other health related issues.
- Public health concerns include water contamination and air pollution.
- Health effects from CAFOs air emissions include asthma, headaches, respiratory problems, eye irritation, nausea, weakness, and chest tightness.

Did you know?
Livestock operations are responsible for about 18% of greenhouse gas emissions globally and over 7% of greenhouse gas emissions in the US.
Ammonia Emissions from Agriculture

• Ammonia emission represent losses of nitrogen (N) from the farm and can be an indication of a lower efficiency of N use from the feeding program.
• 55% of the total ammonia emissions in the US is caused by animal agriculture

Ammonia Emissions from Livestock
tons/year

<table>
<thead>
<tr>
<th></th>
<th>US 2010</th>
<th>US 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cattle</td>
<td>565,892</td>
<td>546,666</td>
</tr>
<tr>
<td>Beef cattle</td>
<td>691,174</td>
<td>733,662</td>
</tr>
<tr>
<td>Poultry</td>
<td>648,200</td>
<td>869,348</td>
</tr>
<tr>
<td>Swine</td>
<td>484,223</td>
<td>518,082</td>
</tr>
<tr>
<td>Total</td>
<td>2,390,489</td>
<td>2,667,758</td>
</tr>
</tbody>
</table>

* USEPA, 2004

Ammonia Production in Dairy Animals

• The primary source of ammonia emissions by ruminants is the result of the conversion of urea-N in the urine to ammonia.
• Process
  — 30 – 70% of the total manure N excreted by dairy cattle is in the urine.
  — 50 – 90% of the total N in the urine is present as urea.
  — The floc portion of the manure contains the enzyme urease
  — 1 mole of urinary urea-N is converted to 2 moles of NH₃

How much ammonia do dairy cows emit?

• A review paper indicated that daily ammonia emissions averaged 59 g/cow with a range of 0.82 to 250 g/day — (Hristov et. al., 2010).
• Yearly ammonia emission factors used around the world for dairy cattle range from 22 to 38 kgs/cow/year — (Aneja et. al., 2008).

Dairy cattle rations and ammonia emissions

• Arias et al. (2010) fed diets containing 16.9, 15.9 or 14.1% CP to cows in a tie-stall barn and measured ammonia concentration on the barn floor.
  — 36.5% decrease in ammonia concentration on the barn floor when the lower CP diet was fed compared with the high CP diet
  — 1 unit decrease in diet CP reduced ammonia concentration on the floor by 13%
• Acuáire et al. (2010) conducted a trial using a commercial dairy herd fed rations averaging 18 or 16.5% CP. The NH₃-N concentration on the floor in this free-stall herd was 27% lower when the lower CP diet was fed.

Effect of dietary protein concentration on ammonia and greenhouse gas emitting potential of dairy manure

• Manure was prepared from feces and urine collected from lactating Holstein cows fed diets with 16.7% (DM basis; HCP) or 14.8% CP (LCP).
• Results
  — High CP manure had higher N content and proportion of NH₃ and urea-N in total manure N than LCP manure (DM basis: 4.4 vs. 2.8% and 51 vs. 30.3%, respectively.
  — The 10-hour cumulative NH₃ emission was 98% greater for HCP, compared with LCP manure (7.45 vs. 3.745 mg N/m², respectively.

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Using Mild Urea Nitrogen to Monitor Ammonia Emissions

- Monitor ammonia emissions from dairy cows:
  - MUN is a good indicator of ammonia emissions
    - van Dijk et al., 2003.
  - MUN also indicates to be a good predictor of urinary-N excretion
    - Burgos et al., 2004; Buskirk et al., 2004.
  - Linear increase in NH3 emission from manure as diet CP increased
  - Strong (R² = 0.83) between ammonia emissions and MUN.
  - Strong positive relationship (R² = 0.79) between urinary urea-N (g/day/cow) and MUN.
  - Relationship between diet CP% and MUN had an R² of 0.87.

Summary
1. Ammonia emission factors reported in the literature vary widely for dairy cattle and include nutritional, housing, and environmental factors.
2. A primary way to lower ammonia emissions from dairy cattle is to balance rations to meet, but not exceed, animal MP and RDP requirements. It has been estimated that a 1 unit decrease in ration CP to 16% will lower ammonia emissions by 20% (Keener et al., 2002).
3. Farm level ammonia emissions can be reduced up to 50 – 70% by utilizing a combination of ration, housing, manure storage, and manure application practices.
4. Milk urea nitrogen may be a practical and reliable tool to predict ammonia emissions on dairy farms.

Nitrous Oxide (N₂O) Emissions: Effects on global warming
- 4th largest greenhouse gas contributor
- 310x more global warming impact than CO₂ over 100-year period
- Animal agriculture produces 65% of human-related N₂O emissions. Changes in agricultural practices have changed manure production.
- N₂O is naturally produced via microbial processes of nitrification and denitrification.
- Two dissimilar pathways of nitrate respiration (ammonification and denitrification) form nitrate, but each has different end products: ammonia and N oxides.
- Agricultural practices that add N to soils (directly or indirectly) can increase N₂O production.

Nitrous Oxide Production in Soils Via ‘Denitrification’
- Bacteria catalyze denitrification reactions via enzymes (reductases for nitrate, nitrite, nitric oxide, nitrous oxide).
- Nitrous oxide reductases from denitrifying bacteria are key to the conversion of N₂O to N₂ and elimination of N₂O from the biosphere.

Alltech’s N-Platform

Optimizing N-utilization in Ruminants
Dissimilatory Nitrogen Metabolism in Soil Bacteria

- Key enzymes in the ‘Denitrification’ process have active metal sites.
- Abiotic reactions with soil minerals may increase N₂O consumption by soils.
- Selective inhibition of N₂O reductase could enhance nitrous oxide emission.
- Manganese stimulates ‘Denitrification’ potentially increasing the evolution greenhouse gases.
- Heavy metals such as Cu and Zn significantly inhibit nitrogen mineralization and nitrification.

General Characteristics

- Average daily milk production per farm was 30.9 ± 5.31 kilograms per cow.
- Average DMI per farm was 21.8 ± 2.2 kilograms per cow.
- Average number of lactating animals: 809
  - Ranging from 110 to 5,010 with a median of 523 cows.

Samples of mixed feeds and water were analyzed for the following minerals:
- Macros:
  - Ca, P, Mg, K, Na, Cl, Sulfur, and Sulfates
- Micros:
  - Cu, Zn, Fe, Mn, Se

Estimates of daily mineral intake, drinking-water mineral contribution and net mineral excretion in lactating cows on Merced County dairy farms (n=51)

Dairy Farm Study

- 51 dairy farms randomly selected from 2/2003 to 3/2004
- Information was obtained about nutritional management, herd characteristics and diet composition
- Water minerals were estimated based on the water’s mineral contents and daily drinking water intake
- Mineral excretions were calculated for lactating animals in different production groups or diets
All minerals

- Lactating dairy cows producing approximately 30 kg of milk per day might excrete 750 ± 17 grams of minerals per day, ranging from 451 to 1,019 grams/cow/day!

- Controlling these amounts could reduce manure production and minerals in land applications.

Trace minerals provided in organic forms are more available to the animal.

Can we lower mineral levels when feeding organic mineral sources?

Environmental Impact

- Effects of Excess Copper In Dairy Manure Applied to Cool Season Forage Grasses
  Fils et al, 2008

- Decreased growth rate & plant quality in Timothy and Orchard grass plots (root weight & new shoots)

Can we reduce trace mineral usage when we provide them as organic minerals?

Mineral Nutrition

Zinc deficient herds have increased risks of adults disorders

<table>
<thead>
<tr>
<th>Ingested Inorganic</th>
<th>Minerals</th>
<th>Low milk production</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

>1 elevated risk of adults disorders

Mineral inadequacy results in cows being more prone to:
- Incidence of mastitis
- Retained placenta
- Increased Somatic Cell Count (SCC)
- Reduced fertility
- Lameness

Selenium deficient herds have increased risks of adults disorders

<table>
<thead>
<tr>
<th>Ingested Inorganic</th>
<th>Minerals</th>
<th>Low fertility</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

>1 elevated risk of adults disorders

Risk factors for health and production problems in dairy cows associated with zinc or selenium status of the herd

Assayed Trace Mineral Content Levels (mg/kg)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Inorganic</th>
<th>Bioplex level (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Zn</td>
<td>60</td>
<td>42</td>
</tr>
<tr>
<td>Mn</td>
<td>77</td>
<td>54</td>
</tr>
<tr>
<td>Fe</td>
<td>85</td>
<td>59</td>
</tr>
<tr>
<td>Cu</td>
<td>5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

*Assumed sulfates would be 70% available (Leeson and Summers, 2001).
Responses to mineral treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wt gain (g)</th>
<th>F:G</th>
<th>Zn</th>
<th>Mn</th>
<th>Cu</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganics</td>
<td>2217</td>
<td>1.75</td>
<td>470</td>
<td>273</td>
<td>19</td>
<td>535</td>
</tr>
<tr>
<td>Bioplex</td>
<td>2351</td>
<td>1.70</td>
<td>318</td>
<td>217</td>
<td>17</td>
<td>523</td>
</tr>
<tr>
<td>Bioplex 60%</td>
<td>2239</td>
<td>1.73</td>
<td>295</td>
<td>185</td>
<td>18</td>
<td>517</td>
</tr>
<tr>
<td>Bioplex 40%</td>
<td>2285</td>
<td>1.72</td>
<td>37%</td>
<td>15%</td>
<td>15</td>
<td>512</td>
</tr>
<tr>
<td>Bioplex 20%</td>
<td>2185</td>
<td>1.74</td>
<td>52%</td>
<td>21%</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>± SD</td>
<td>97</td>
<td>0.03</td>
<td>37</td>
<td>13</td>
<td>1.7</td>
<td>50</td>
</tr>
<tr>
<td>Significance</td>
<td>NS NS NS NS NS NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* In: Zn 10 ppm; Mn: 40 ppm; Cu 5 ppm
  ** Zn 70 ppm; Mn: 83 ppm; Cu 15 ppm
  *** P<0.01, ** P<0.05 NS, not significant

Can we replace, and/or reduce, mineral sources in Dairy animals?

Experimental Design
- Location: Zootechnical farm, Pawłowicek, Poland
- Average milk production 9200 kg/lactation
- Diet:
  - Green silage, barley silage, sugar cane silage, brewer’s grains, hay, concentrate
  - Total Mineral Intakes
    - 300mg Cu/day, 1450mg Mn/day, 1694mg Zn/day (lactation)
    - 200mg Cu day, 917mg Mn day, 858mg Zn/day (dry period)
- 3 treatments (28 cows each group):
  - Group 1: 100% Inorganic via supplement (120mg Cu/day, 400mg Mn/day, 600mg Zn/day)
  - Group 2: 50% replacement by Bioplex Cu, Mn and Zn
  - Group 3: 100% replacement
- Duration: 6 weeks pre-calving through 305 day lactation

Bioplex Minerals Reduce Somatic Cell Counts

![](chart1.png)

Bioplex Minerals Increase Milk Yield

![](chart2.png)

Summary
- Decreased SCC of 100,000 + cells/ml
  - In High Bioplex Group
- Increased significantly milk yield by 2.7kg/day in 1st 100 days
- Increased significantly milk yield by 442 litres over 305 days
  - At 0.23 €/litre = 129 €
- Cost of Bioplexes = € 24
- Return of 5:1 on investment
**Effect of lowering trace mineral supplementation on lactation performance**

- Field trial with 8 herds in SE Pennsylvania fed by same nutrition company.
- Control herds: 50% of added TM from inorganic and 50% of added TM from Bioplex (Cu, Mn, Zn).
- Bioplex herds: No inorganic TM and same level of added TM from Bioplex.
- 6 month trial starting in May, 2005.
- 2 control and 2 Bioplex herds selected for blood and fecal mineral analysis (10 cows/ herd).
- Production parameters from downloaded DHI test data.

**Total replacement with organic mineral sources in dairy rations**

<table>
<thead>
<tr>
<th>Test Period</th>
<th>Control herds</th>
<th>Bioplex herds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cu</td>
<td>Mn</td>
</tr>
<tr>
<td>Inorganic (ppm)</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>Organic (ppm)</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Total (ppm)</td>
<td>20</td>
<td>57</td>
</tr>
<tr>
<td>% added from organic</td>
<td>25</td>
<td>12</td>
</tr>
</tbody>
</table>

**Lowering mineral levels did not increase SCC**

**Lowering mineral levels reduced fecal mineral output**

**Lowering mineral levels did not affect milk yield**

**Lowering mineral levels reduced fecal mineral output**
Lowering mineral levels reduced fecal mineral output

Improvement in mineral status in 21 Dairy Herds fed ‘HerdCare’

Other companies are using this “Total Replacement” approach...

Mastitis Cases

Challenge: Two-thirds of the cost of mastitis is derived from decreased milk production

Supplementing dairy cows with Bioplex and Sel-Plex throughout the dry period, SCC remained low and there were significantly fewer cases of mastitis.
Fertility Responses

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>All Cows prior to change</th>
<th>Cows Calved after Bioplexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Days to 1&lt;sup&gt;st&lt;/sup&gt; service</td>
<td>Days</td>
<td>68</td>
<td>62</td>
</tr>
<tr>
<td>Average Services per conception</td>
<td>N</td>
<td>2.01</td>
<td>1.37</td>
</tr>
<tr>
<td>Overall pregnancy rate</td>
<td>%</td>
<td>38</td>
<td>42</td>
</tr>
<tr>
<td>Expected Calving Interval (of pregnant cows)</td>
<td>days</td>
<td>394</td>
<td>356</td>
</tr>
</tbody>
</table>

* Cows were supplemented with Bioplex and Sel-Plex throughout the dry period (post-August 2006)

Thank you!

Mineral Management Opportunities for Reducing Environmental impact

- There are technologies available to help address N-utilization in Ruminants and thus greenhouse gas emissions.
- Control of minerals in animals can provide a tool for controlling not only trace mineral pollution, but also other pollution and greenhouse gas-associated problems.
- The use of organic forms of minerals (Bioplex/Sel-Plex), can be used to minimize the environmental impacts of animal agriculture.