

## BIOFILTERS FOR POINT-SOURCE GASEOUS EMISSIONS FROM DAIRIES

### **Part 1: Potential point-source gaseous emissions from dairies**

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#### **Introduction**

Various point sources of gaseous emissions may be associated with modern dairy production. Though most of the generated emissions are benign; the emissions from these point sources may contain odorous, hazardous and greenhouse gas (GHG) emissions. These potential emissions have various impacts on air quality, the environment and the farm. Some of the more common emissions, their potential sources on the farm, health and environmental impacts are discussed below.

#### **Odor**

Some dairy point-sources can generate significant odor, with a single farm able to emit hundreds of different odorous emissions. While some are pleasant (e.g. haylage), others can be quite unpleasant (e.g. anaerobically decomposing manure). Most foul odorous emissions are generated by the microbial breakdown of organic matter under anaerobic conditions<sup>[1]</sup>. As such, anaerobic manure storages, which have been implemented for their improvement in nutrient management, protection of water quality, and improvements to farm sustainability, can have unintentional impacts on odor generation. Odorous emissions can also be more than simply a nuisance, with possible health implications for farm workers, impacts on the well-being of neighbors, and unsolicited public relations issues<sup>[1,2]</sup>.

#### **Hydrogen Sulfide**

Hydrogen sulfide ( $H_2S$ ) is a potent odorant generated from the anaerobic decomposition of manure. At high concentrations ( $>300$  ppm),  $H_2S$  is toxic. As  $H_2S$  is heavier than air, pits, confined spaces, manure storages, and poorly ventilated buildings are potential areas

where  $H_2S$  can accumulate. In the environment,  $H_2S$  can react with atmospheric oxygen and water vapor to form sulfuric acid, a potential contributor to localized acid deposition<sup>[3]</sup>. The deposition of this acid on farm infrastructure can also cause substantial corrosion and deterioration.

#### **Ammonia**

Ammonia ( $NH_3$ ) is also an odorous and potentially hazardous gas released directly from ammoniacal nitrogen in urine and from the transformation of urea in manure. Livestock production is the most significant source of anthropogenic  $NH_3$  emissions<sup>[4]</sup>. At low concentrations  $NH_3$  impairs respiratory function while high levels ( $>300$  ppm) can be acutely toxic. Due to a short atmospheric residence time,  $NH_3$  is typically deposited near its emission source. This  $NH_3$  deposition can contribute to localized eutrophication of surface waters. Ammonia can also impact the environment at greater distances by reacting with gaseous acids in the atmosphere to form fine particulate matter, a haze-producing secondary pollutant<sup>[4]</sup>.

#### **Particulate matter**

Particulate matter (PM) is a mixture of particles and liquid droplets  $< 10 \mu m$  ( $1/5$  the width of a human hair) along with their sorbed compounds, metals, bacteria and viruses<sup>[5]</sup>. Dairies can be a source of PM, and elevated levels can be detected downwind of farms during dry conditions<sup>[6]</sup>. Respiratory symptoms, asthma, and reduced lung and heart function are associated with PM inhalation; even at low levels. Environmentally, PM is a leading cause of haze. Particulate matter can also effect soil and water acidity, and lead to cloud formation, which has effects on localized climate<sup>[5,6]</sup>.

## Greenhouse gases

Of greater impact to climate than PM are the GHGs carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O); CH<sub>4</sub> and N<sub>2</sub>O having ~35× and ~300× times the heat trapping effect of CO<sub>2</sub> (known as CO<sub>2</sub> equivalents, noted CO<sub>2</sub>e), respectively, over a 100 year time period<sup>[7]</sup>. Almost all U.S. GHG emissions are from fossil fuel combustion; however, livestock production is a major source of U.S. anthropogenic CH<sub>4</sub> emissions. Although enteric fermentation and manure management account for 30.85% of total U.S. CH<sub>4</sub> emissions, in CO<sub>2</sub>e this represents only 3.28% of total U.S. GHGs. Methane emissions specifically to dairy make up 10.14% of total U.S. CH<sub>4</sub> emissions, only 1.09% in CO<sub>2</sub>e of total U.S. GHGs<sup>[8]</sup>.

## Volatile organic compounds

Dairy farmsteads may also emit volatile organic compounds (VOCs). Each VOC has unique characteristics and associated odor, impacts on ground level ozone formation, and levels of hazards. VOCs are generated by bacterial decomposition of organic materials with livestock barns, manure systems, and fermented feeds all potential sources<sup>[3]</sup>.

## Biofilters as an emissions mitigation tool

As dairies continue on the path towards improved environmental, economic and social sustainability, mitigation of point source emissions will become increasingly important. In addition to the strategies already used by farms to limit the formation of odorous, hazardous and greenhouse gas emissions<sup>[2]</sup>, mitigation technologies may be useful to further the protection of farm worker and community health, the environment, farm infrastructure and dairy profitability. Biotechnologies, like biofilters, are relatively low-cost mitigation technologies well-suited for the treatment of emissions from dairy farm point-sources<sup>[9]</sup>. *The applicability of biofilters to these emissions, their mode of operation, designs, required management and potential benefits to dairy farm sustainability are detailed throughout this fact sheet series.*

### FACT SHEET SERIES

#### Biofilters for Point-Source Gaseous Emissions from Dairies

**Part 1:** Potential point-source gaseous emissions from dairies

**Part 2:** Applicability of biofilters to dairy point-source emissions

**Part 3:** Basics of biofiltration

**Part 4:** Biofilter design information

**Part 5:** Biofilter media management considerations

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## REFERENCES

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