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[1]. 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[1,2].

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[3]. 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[4]. 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[4].

Particulate matter
Particulate matter (PM) is a mixture of particles and liquid droplets < 10 µm ($^1/_5$ the width of a human hair) along with their sorbed compounds, metals, bacteria and viruses[5]. Dairies can be a source of PM, and elevated levels can been detected downwind of farms during dry conditions[6]. 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[5,6].

Greenhouse gases

Of greater impact to climate than PM are the GHGs carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O); CH_4 and N_2O having ~35× and ~300× times the heat trapping effect of CO_2 (known as CO_2 equivalents, noted CO_2e), respectively, over a 100 year time period[7]. Almost all U.S. GHG emissions are from fossil fuel combustion; however, livestock production is a major source of U.S. anthropogenic CH_4 emissions. Although enteric fermentation and manure management account for 30.85% of total U.S. CH_4 emissions, in CO_2e this represents only 3.28% of total U.S. GHGs. Methane emissions specifically to dairy make up 10.14% of total U.S. CH_4 emissions, only 1.09% in CO_2e of total U.S. GHGs[8].

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[3].

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[2], 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[9]. *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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