BIOFILTERS FOR POINT-SOURCE GASEOUS EMISSIONS FROM DAIRIES

Part 3: Basics of biofiltration

September 2016

Introduction to Biofilters

Biofiltration is a low-cost, robust mitigation technology applicable to various agricultural emissions. Biofilters (Figure 1.) are essentially a pile of wood chips, mulch, compost or other porous, typically organic, media and its resident microorganisms used as an air 'filter'. As contaminated air is forced through the biofilter media, the resident microbes breakdown the contaminants, cleaning the air stream. Though complex microbial interactions underpin biofilter function, adequate media quality, media moisture content, and residence time (length of time the contaminated air is in contact with the media) can ensure effective microbial communities development and biofiltration. Since the 1990's, well-managed, farmer-constructed biofilters have been used with success to remove odor and other gaseous contaminants from livestock barn and manure treatment systems exhausts[1].

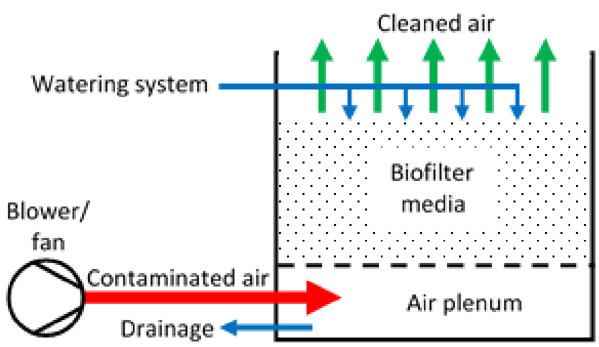

Figure 1. Simplified biofilter schematic.

Mitigation Capacities of Biofilters

Properly designed, constructed, operated and maintained biofilters can remove > 90% of emitted odor, hydrogen sulfide, and ammonia. High performing biofilters can also reduce many volatile organic compounds (VOCs), particulate matter, methane and aerosolized pathogens[1].

Mechanism of Biofiltration

Step 1. Pollutant capture

The first step to pollutant removal is physical and chemical capture ('sorption') of the contaminants by the media, free surface water, and/or directly by surface attached microbial growths ('biofilms', Figure 2.). For soluble contaminants (e.g. ammonia) capture can happen quite rapidly, for less soluble contaminants (e.g. methane) capture can be rate limiting and longer residence times may be required.

Figure 2. Biofilms on wood chip media[2].

Step 2. Biodegradation

Once the contaminant is captured, capable microbial cells in the biofilm oxidize the contaminants, a process that requires oxygen and generates carbon dioxide. Biofilms treating contaminated air from livestock operations are made up of diverse microbial communities. Many factors govern the abiliyt of the biofilm community including microbial establishment and acclimation, media conditions like moisture content, and the loading rate of the contaminants.

Microbiology of a Biofilter

Like the microbial communities of a cow gut, the complexity and importance of microbial communities to the function of a biofilter is just beginning to be understood. Biofilters using organic media typically possess highly diverse communities dominated by bacteria and fungi. Biofilter microbes can also be seeded by the contaminated airstream or in the case of open-bed system arrive from the local environment.

Moderate biofiltration capacity is typical of the initial biofilter community. This "lag-phase" is succeeded by an improvement in performance that typically occurs following microbial community shifts and acclimate to the biofilter environment. The adapted community will contain the biocatalysts or bacteria and fungi capable of directly metabolizing or co-metabolizing the contaminants. Other microbes in the biofilter may indirectly impact contaminant breakdown by degrading the media which provides nutrients to the biofilter microbial community.

Media conditions are thus important not only to the establishment of the microbial community but to their activity. To support a high level of biofilter activity, media must provide nutrients not acquired from the contaminated air stream, have an appropriate pH, be suitable for microbial attachment, and most importantly act as a reservoir of moisture.

Moisture content is one of the most critical management parameters for biofilter media[1]. If the media becomes desiccated, microbial biofilms will become reduced and cell activity, along with biofilter function, will halt. Biofilter performance will return when the media is rewetted but may undergo another lag-period following this stress. Saturated media is just as problematic as it may block air flow and create an unwanted anaerobic environment.

Microbial communities in the biofilter will also shift in response to contaminant loading rate. Understanding these microbial feedbacks could enable the fine-tuning of biofilters for robust treatment of particular effluents, but this goal is currently limited by an opaque understanding of biofilter microbial dynamics. In absence of microbial control, we can instead rely on their naturally ability to adjust to biofilter conditions by minimizing biofilter perturbations to create an environment where these microbial communities can self-regulate.

To learn more about biofilters see the other Fact Sheets in this 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

AUTHORS

Jason P. Oliver, PhD, jpo53@cornell.edu (607) 227-7943
Curt Gooch, PE cag26@cornell.edu (607) 225-2088

REFERENCES

[1] Chen & Hoff. 2009. Mitigating odors from agricultural facilities: A review of literature concerning biofilters. *Applied Engineering in Agriculture*. 25(5): 751-766. **[2]** Photo by Dr. Jonathan Schilling. **[3]** Cabrol et al. 2011. Integrating microbial ecology in bioprocess understanding: The case of gas biofiltration *Applied Microbiology & Biotechnology*. 90(3):837-49. **[4]** Kennes & Veiga. 2004. Fungal biocatalysts in the biofiltration of VOC-polluted air. *Jountal of Biotechnology*. 113(1-3):305-319.