Cornell University
Dairy Environmental Systems Program
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PRO-DAIRY

BIOFILTERS FOR POINT-SOURCE GASEOUS EMISSIONS FROM DAIRIES
Part 4: Biofilter design information

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Design flexibility and the capability to operate across a range of conditions makes biofilters suitable for point-source gaseous emissions from dairies (Table 1.).

Table 1. Typical biofilter parameters. Data based on a review by Chen & Hoff[1].

Parameter	Typical value
Media depth	0.5-3.5 ft*
Media area	2-3550 ft^2
Media water content	40-60%
Media temperature	45-100°F
Media pH	6-8
Empty bed residence time	2-20 s, up to 120 s
Pressure drop	0-475 Pa
Inlet odor concentration	100-3,000 OU†
Inlet H_2S concentration	0-25,600 ppb
Inlet NH_3 concentration	0-75 ppm
Odor removal efficiency	30-100%
H_2S removal efficiency	40-100%
NH_3 removal efficiency	30-100%

* Media depth of 6 ft. are used by some systems.
† Odor unit; based on odor detection threshold of olfactometry panelist, standardized to butanol.

Biofilter designs are based on the flow rate of the air to be treated and characteristics of the contaminated air (the air contaminants and their concentrations). Biofilter size constraints, media availability, maintenance requirements and cost are all parameters that must also be considered during the design process.

Configuration

Open-bed biofilters are simple, open-air designs where media is piled over an air distribution system (plenum). These systems typically use shallow media (~ 2 ft.) and up-flow gas configurations (Figure 1.). While low-cost, lack of control systems and limited buffering of environmental conditions can result in performance fluctuations[1].

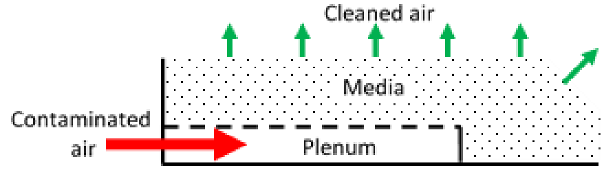

Figure 1. Open-bed biofilter design.

Closed-bed biofilters are more complex, closed to the atmosphere and configured for better control of operational parameters (e.g. temperature, water content, pH). These systems may use deeper media depths (2-6 ft.), up-flow or down-flow gas configurations (Figure 2.) and are typically higher cost[1].

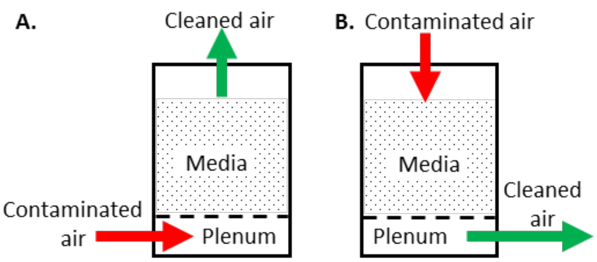

Figure 2. Closed-bed biofilter designs of A. up-flow and B. down-flow gas configuration.

Airflow Rate & Sizing

A biofilter should be designed based on the maximum required ventilation air flow rate, which is typically the summertime ventilation needs for livestock housings. Using a known ventilation rate (Q, ft^3/min.) and the 5 to 10 s empt bed residence time (EBRT, s) 'rule-of-thumb', a biofilter volume (V, ft^3) can be calculated that is effective for the mitigation of dairy housing and manure storage emissions[2].

$$V = (EBRT \times Q)/\ 60\ s/min \qquad (1)$$

Once the volume is calculated, biofilter size decisions can be made. If the space is available a shallow media depth and large footprint open-bed biofilter can be used, which have a small associated pressure drop and lower operating costs. If space is limited, a small footprint, thick media depth closed-bed biofilter will be required, which has a larger associated pressure drop requiring larger, more expensive blowers to meet ventilation needs[2].

Media

Ideal biofilter media is high in 1) surface area for microbial attachment and contaminant capture; 2) porosity for air flow; 3) bulk-density and durability to minimize compaction and associated pressure drop; and 4) moisture holding capacity for absorption and microbial activity. Additionally, media provides nutrients, carbon, and pH buffering for the microbes. Most biofilters treating farm emissions use wood chips or mulch as media as they meet most of the above mentioned requirements, are readily available, and low-cost. Agricultural by-products (e.g. corn cobs) have also be used. Synthetic media have been developed but are typically high cost and require nutrient additions and pH buffering[3].

Watering Systems

Ideal media moisture content is 40-60% on a wet basis. Drier conditions desiccate media, reduce microbial activity, and channel gas flow. Wetter conditions fill pore spaces reducing gas capturing surface area, increasing pressure drop, and create anaerobic zones altering microbial contaminant breakdown[4].

To maintain adequate media moisture content water irrigation and humidification are used. Irrigation systems typically consist of sprinklers or soakers hoses and can be controlled manually or automated. With down-flow gas configurations irrigation water is delivered with the contaminated air and particulates can accumulate and cake the biofilter inlet. With up-flow gas configurations, the irrigation system can be used to flush particulates accumulated at the inlet as media watering is opposite the air inlet, however, inlet media drying can occur when watering and gas loading are counter-flow. Humidification systems can be used to prevent this inlet drying by wetting the contaminated air, but must be used with irrigation as humidification alone is insufficient to maintain adequate media moisture content. Open-bed system moisture can also be maintained by precipitation, but heavy rains can cause the media to become too wet, stifling performance. A simple roof over an open-bed system is thus advisable to prevent media saturation[1].

For more guidelines on designing a biofilter, see the University of Minnesota biofilter design webpage: www.extension.umn.edu/agriculture/manure-management-and-air-quality/air-quality/biofilter-design-information

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

[1] Devinny et al. 1999. Biofiltration for Air Pollution Control. Lewis Publishers. Boca Raton, FL, USA. **[2]** Schmidt et al. 2004. Biofilter design information. Biosystems and Agricultural Engineering Update (BAEU-18), *University of Minnesota Extension Service* **[3]** Delhomenie & Heitz. 2005. Biofiltration of air: A review. *Critical Reviews in Biotechnology*. 25(1-2): 53-72. **[4]** Chen & Hoff. 2009. Mitigating odors from agricultural facilities: A review of literature concerning biofilters. *Applied Engineering in Agriculture*. 25(5): 751-766.