LOW COST BIOFILTERS FOR ODOR CONTROL IN MINNESOTA

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Summary

The size of an open faced biofilter depends on airflow rate, residence time, and available area. Residence time can be adjusted by varying the biofilter depth. Four test biofilters were constructed with media comprised of yard waste compost and brush chips to compare 8 s and 4 s residence time by changing the depth from 12 in. to 6 in. Biofilter performance was monitored for ten months by measuring pressure drop, moisture content, odor threshold, hydrogen sulfide, and ammonia concentrations. Odor reduction efficiency for the 8 and 4 s residence time biofilters was 91% and 87% respectively. Hydrogen sulfide reduction efficiency was 97% and 96%. Ammonia reduction efficiency was 82% and 74%. Statistically there was no significant difference between an 8 s and a 4 s empty bed contact time for odor, hydrogen sulfide, and ammonia removal. Based on current information, the recommended design residence time for biofilters on swine buildings is 4 to 5 s. Further research is needed to determine the minimum effective residence time for open face biofilters on livestock facilities.

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COMPARISON OF BIOFILTER RETENTION TIME

INTRODUCTION

Pork production facilities generate odors. Those odors can be a nuisance to nearby rural and urban neighbors. In a growing number of cases, concerns about odors and potential odors have caused the pork industry to experience governmental restrictions on growth and negative relations between residential neighbors and producers. These restrictions on growth and potential conflicts with neighbors will limit the business opportunities for the pork industry.

Most of the odor reduction research in the past has focused on emissions from outside manure storages. One alternative to outside storages is to store manure below slatted barn floors in deep pits. Odors from barns with deep pits as well as barns where the manure is removed are a major part of the total odors coming from a pork production site (Jacobson et al., 1997).

Biofilters reduce odor emissions (Janni et al., 1996). Since many biofilter applications are in the industrial market, little information is available for designing low cost systems for agriculture use. Nicolai et al. (1997) developed a low cost biofilter for swine production facilities. Average odor and hydrogen sulfide removal for that design was between 75 and 90 percent.

One critical factor in determining biofilter size is the residence time. An indicator of the residence time is empty bed contact time, which is determined by dividing the volume of the empty filter bed by the airflow rate. An 8.8 s empty bed contact time was used to achieve the odor reduction levels with the Nicolai et al. (1997) design. Zeisig (1987) reported adequate odor reduction could be achieved with 5 s empty bed contact time.

PROJECT OBJECTIVES

The original objectives of this research was to determine the effect that media depths and media moisture control (addition) had on odor, hydrogen sulfide, and ammonia emissions from low cost biofilters on a mechanically ventilated swine nursery. A moisture addition system was not installed because a satisfactory sensor was not found for monitoring moisture content in the field.

MATERIALS AND METHODS

Figure 1 shows the layout of four 5ft x 7ft biofilters constructed in September, 1997 next to a 640 head capacity deep pitted nursery barn. An air mixing duct was constructed to receive exhaust air from three 1200 cfm pit fans. Four 250 cfm blowers mounted inside the air mixing duct moved air to each biofilter. Excess air from the pit fans was allowed to exit from one end of the mixing duct.

Each biofilter consisted of a 6 in. deep plenum beneath a media support floor. This plenum received air from the blowers in the mixing duct. Two of the four biofilters had 12 in. deep media and two had 6 in. deep media. The empty bed contact time for these two depths is 8 and 4 s.

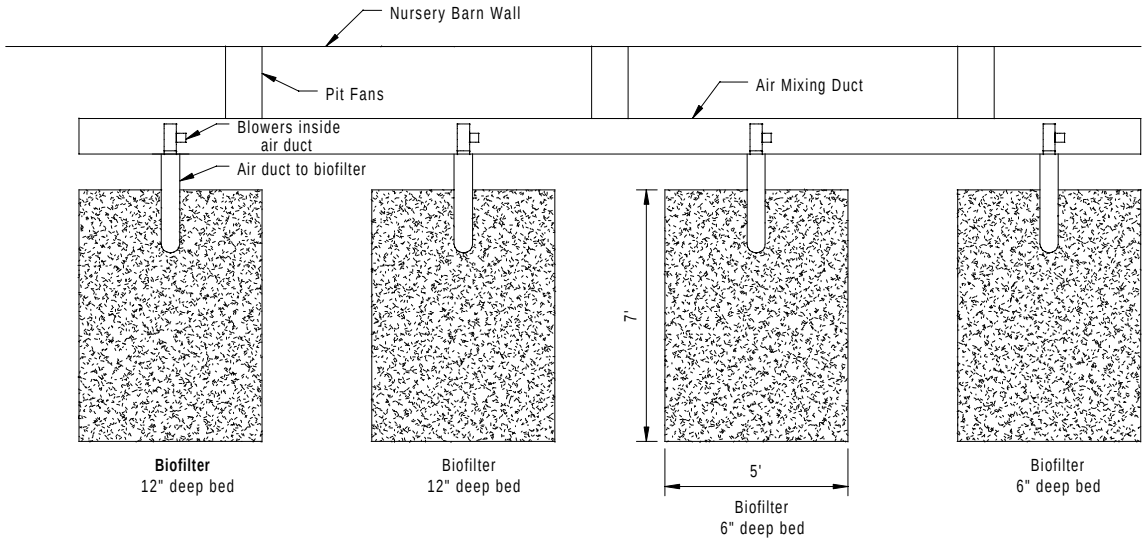

Figure 1 Layout of four-cell biofilter.

The biofilter media was 50% by weight yard waste compost and 50% brush wood chips. These biofilters were open face and followed the type of construction developed by Nicolai and Janni (1997). They were operated for 10 months and exposed to Minnesota weather conditions during that time. Samples were taken over a ten month period from September 1997 until June 1998.

Biofilter performance was monitored by comparing untreated air samples from each end of the air mixing duct to treated air samples which were collected from beneath a 1 m square flux hood on top of each biofilter. Air samples were analyzed using a dynamic olfactometer to determine odor detection threshold (Nicolai et al., 1997). Hydrogen Sulfide gas concentration was measured with a Jerome™ meter. Ammonia gas concentration was measured with NH_3 detector tubes. Air pressure differential across one blower, bed temperature, untreated air temperature, and treated air temperature were continuously recorded on a dataloger system. Biofilter media moisture content was determined by drying media samples. Media moisture contents were reported as a percent of wet matter.

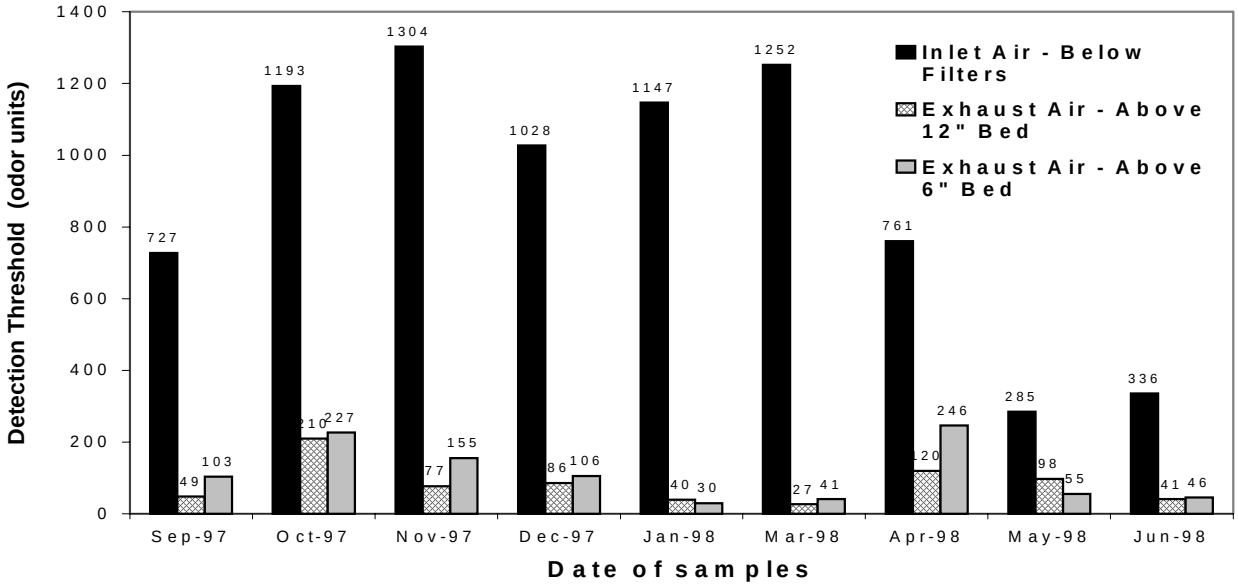

Figure 2 Odor detection thresholds of inlet and exhaust air from 12" and 6" deep biofilters.

RESULTS AND DISCUSSION

Odor threshold levels

Figure 2 is a graph showing odor detection threshold levels of air samples from before and after biofilter treatment. Odor levels are reported in odor units, which is the maximum dilutions of the sample air in clean air that will still allow trained odor panelists to detect the presence of an odor.

Odor was reduced an average of 91% for the 12 inch deep biofilter and 87% for the 6 inch deep biofilter. The probability of variation in depth was 0.3750 using the nova statistical analysis. Thus, there was no significant difference in odor reduction between the two depths at the 5% level.

Odor reduction efficiency improved from 82% to 97% for both biofilter media depths from startup to January. This efficiency increase was expected as the microorganisms, which oxidize the VOC's, multiplied and adapted to their new environment. Odor reduction efficiency for April was less then average (reductions of 84% for the 12 in. biofilter and 68% for the 6 in. biofilter). Warmer and dryer weather conditions during this period caused the biofilter media moisture content to be reduced. Inlet odor values were lower during the summer months as additional wall fans operated, thereby increasing the nursery ventilation rates.

Hydrogen Sulfide

Figure 3 shows hydrogen sulfide concentration through the two different biofilter media depths. Hydrogen sulfide is reported in ppb. Hydrogen sulfide emissions were reduced an average of 97% for the 12 in. deep biofilter and 96% for the 6 in. deep biofilter. The

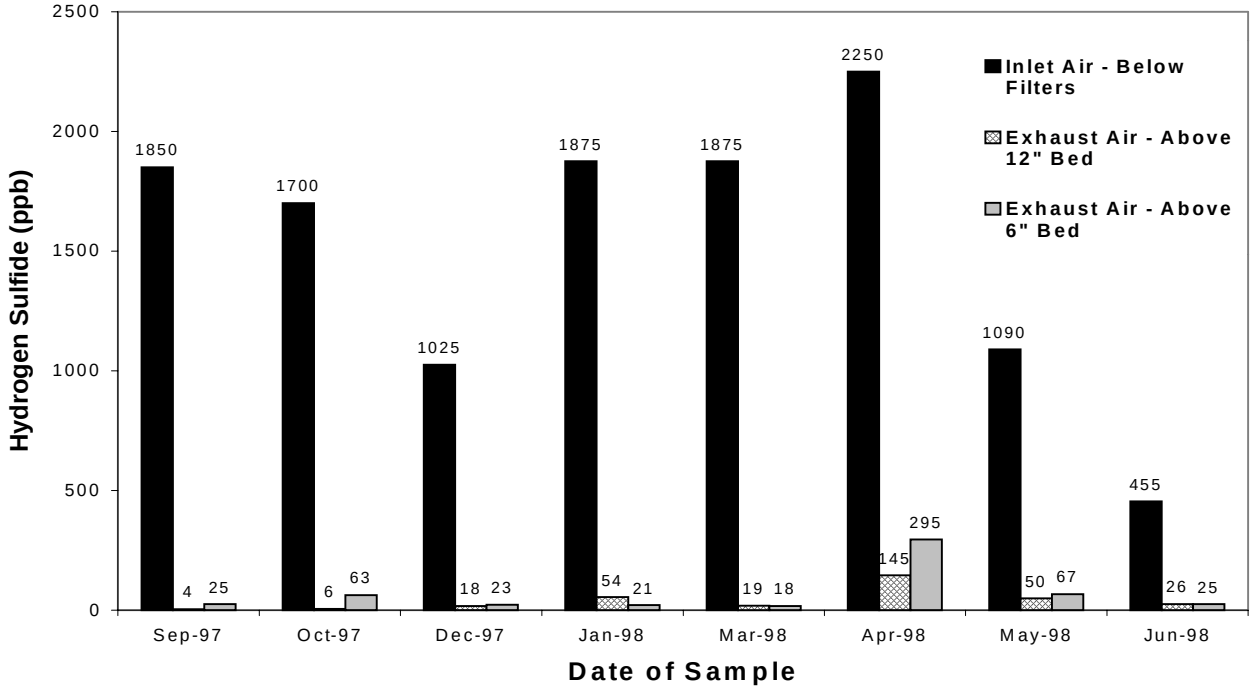

Figure 3 Hydrogen sulfide concentrations of inlet and exhaust air from 12" and 6" deep biofilters.

probability of variation in depth was 0.3875 using the nova statistical analysis. Thus, there was no significant difference in hydrogen sulfide reduction between the two media depths at the 5% level. Since the biofilters had lower moisture contents during April the hydrogen sulfide removal efficiency was reduced.

Ammonia

Figure 4 shows ammonia concentration of inlet and exhaust air from the 12 in. and the 6 in. deep biofilters. Ammonia is reported in ppb. The average ammonia reduction for each biofilter type was 82% for 12 in. and 74% for 6 in.. The probability of variation in depth was 0.1041 using the nova statistical analysis. Thus, there was no significant difference in ammonia reduction between the two depths at the 5% level.

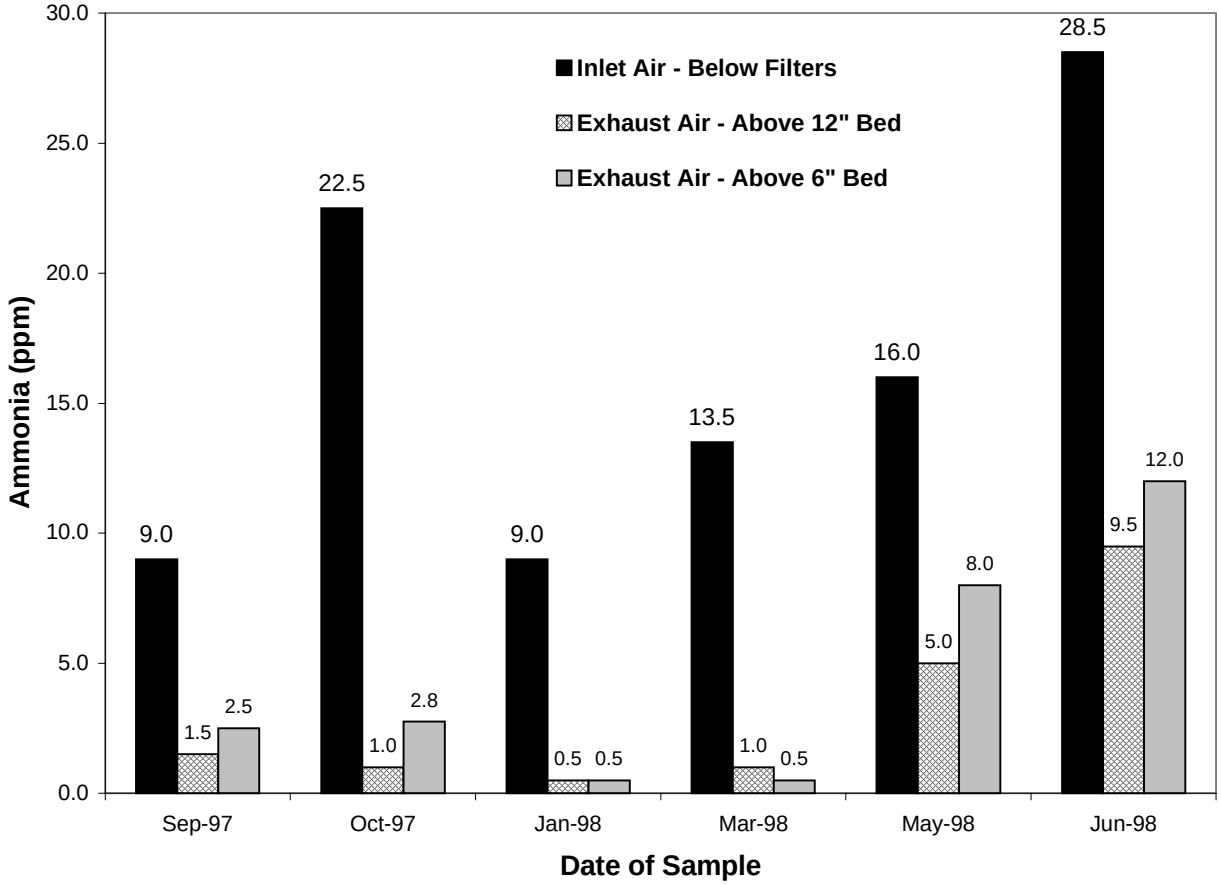

Figure 4 Ammonia concentrations of inlet and exhaust air from 12" and 6" deep biofilters.

Pressure Drop

Average pressure drop across the 12 in. biofilters was .045 in. of water and across the 6 in. biofilter it was .025 in. of water. Laboratory pressure tests with this media at 250 cfm air flow rates show the pressure drop per foot of depth to be between .04 and .1 in.

Media Moisture Content
Moisture content in all biofilters remained above 40% except during April when they were near 30%. No additional water sprinkling was provided for the biofilter beyond naturally occurring precipitation.

One 6 in. biofilter was covered to prevent moisture addition for one month during June 98. The media dried to 5.25% moisture. This reconfirms Medina et al. (1994) findings that beds with peat or compost media, which tend to hold moisture, will dry out due to high air flow rates. Odor, hydrogen sulfide, and ammonia removal percentages after drying were 75%, 71%, and 33% respectively.

CONCLUSION

Significant odor, hydrogen sulfide, and ammonia reduction was achieved by the biofilters. There was no significant difference between an 8 s and a 4 s empty bed contact time for odor, hydrogen sulfide, and ammonia removal. Therefore, the recommended empty bed contact time for swine facilities is 4 to 5 s. Further research is needed to determine the minimum effective residence time for open face biofilters on livestock facilities.

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