



# Enclosure of Composting Operations to Minimize Bioaerosol Emissions into Ambient Air—Part 2

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## Abstract

*A fungal (spore trap) air sampling evaluation was performed under springtime conditions at a composting facility where all mechanical agitation of composting materials occurred in an enclosed, negatively pressurized structure in which air was filtered before being discharged into the atmosphere. During a previous evaluation under wintertime conditions when snow and ice covered outdoor soil and botanical materials, it was determined that the enclosed facility did not add to the bioaerosol burden in nearby ambient air. In the springtime evaluation, Penicillium–Aspergillus and Chaetomium were the dominant kinds of identified fungal spores found in the air within the processing areas of the facility. Cladosporium dominated the spores found in the ambient air around the facility. The concentration of Penicillium–Aspergillus spores in ambient air was 1½ order of magnitude less than that in air within compost processing areas and Chaetomium was not detected outdoors. The results suggested that composting within the enclosed facility during springtime conditions does not add fungal spore burden into nearby ambient air.*

## Key Words

*Aspergillus*, biofilter, biosolids, *Chaetomium*, compost, engineering controls

## Introduction

In a previous publication (Morey & Hoffman, 2003), we reported that enclosure of composting operations within a negatively pressurized building resulted in no detectable additional fungal burden in nearby ambient air. The air sampling during the previous evaluation was performed at a time when the ground around the composting facility was covered in snow and ice, minimizing the confounding effect of emissions of fungi from natural outdoor soil and botanical sources. Two years later under springtime conditions we had the opportunity to collect airborne fungi by spore trap in and around the same facility. The objective of the second evaluation was to determine if fungal spores from the composting process were contained within the enclosed facility at a time of the year when natural outdoor soil and botanical sources of fungi were also present.

## Facility and Methods

The operational characteristics of the Rochester, New Hampshire facility described previously (Morey & Hoffman, 2003) were unchanged at the time of the second evaluation (April 22, 1996). Waste water treatment residuals were being mixed with botanical materials at an approximate 1.5 to 1 wet weight basis. The facility was continuously depressurized by exhausting air from the processing area through a biofilter into ambient air (Kuter et al., 1993).

Airborne fungal spores were collected in the processing area and in the ambient air around the facility with a personal Burkard spore trap operating at a flow rate of 0.01 m<sup>3</sup>/minute. Sampling times in the ambient air around the facility (all locations within 100 m of the facility) varied from 4 to 8 minutes (limit of detection for individual samples 12 to 25 spores/m<sup>3</sup>). Sampling times within the facility processing areas were from 1 to 4 minutes (limit of detection 25 to 100 s/m<sup>3</sup>). Fungal spores were identified to genus level (Burge & Otten, 1999) according to morphological characteristics as seen by direct microscope observation using an oil immersion 100x objective.

Temperature and relative humidity were measured with a Solomat (Norwalk, CT) MPM 4100 meter. Airborne respirable particulate was measured with a TSI<sup>®</sup> Dust Trak<sup>™</sup> (St. Paul, MN) Model 8520 monitor.

## Results and Discussion

Air sampling for fungi was performed within and around the composting facility on April 22, 1996 during early springtime conditions (ambient air temperature range 72° to 82°F) when snow and ice had melted. Ambient air samples were collected 10 to 100 m from the facility at sites such as on roadways, at the weight station, at the edge of the biofilter, and near the discharge bay doors. Some ambient air samples were collected north, south, east, and west of the facility. Prevailing wind direction on April 22, 1996 was variable but predominantly from the south and east. Air sampling for fungi within the composting facility was carried out in the mixing area, in walkways between composting vessels, and in the discharge area (site where finished compost was piled prior to removal from the building).

*Penicillium-Aspergillus* was the dominant kind of identified spore (approximately 53% of the average total count of about 9,300 s/m<sup>3</sup>) detected in processing areas (Table 1). Six of the seven processing area samples also contained *Chaetomium* spores (average concentration of 560 s/m<sup>3</sup>). *Cladosporium* at a lower average concentration of 250 s/m<sup>3</sup> was also identified in processing area samples. Smuts, *Perconia*, and myxomycetes (these morphologically similar spores

were possibly derived from the wood chips and yard wastes utilized at this facility), basidiospores, and ascospores as well as unknown spores were all detected in samples collected in the processing areas within the facility (Table 1). Total particulate levels in the air in processing areas averaged 500 µg/m<sup>3</sup> (relative humidity 80% to 95%; temperature 78° to 83°F).

The average total concentration of fungi in ambient air around the composting facility was about 600 s/m<sup>3</sup> (Table 1). *Cladosporium* was the dominant kind of identified spore (average concentration of 230 s/m<sup>3</sup>) present in ambient air. *Penicillium-Aspergillus* spores were present in six of the 12 ambient air samples (average concentration of 80 s/m<sup>3</sup>; Table 1). *Penicillium-Aspergillus* spores were not detected in at least one ambient air sample collected in the north, south, east, and west quadrants around the composting facility. *Chaetomium* was not detected in any ambient air sample. At the time of sampling the average total particulate level in ambient air was 35 µg/m<sup>3</sup> (relative humidity 20% to 35%; temperature 72° to 82°F).

Current (Table 1) and past (Morey & Hoffman, 2003) air sampling data, although limited to one wintertime and one summertime evaluation, showed that the engineering controls at the Rochester facility prevented the addition of fungal burden into the nearby ambient air. Thus, fungi in ambient air around this facility were dominated by low levels of *Cladosporium* (a leaf-sourced fungus; a desirable or normal condition). *Penicillium-Aspergillus* spores which were commonly emitted into ambient air at open windrow compost sites (Kothary et al., 1984; Millner et al., 1980; State of New York, 1994) were well contained within the enclosed Rochester, NH facility.

Malodor and health effect concerns are often raised by residents living near compost facilities (State of New York, 1994). The engineering controls (enclosed processing areas; depressurization of work area; exhaust of air from processing area through a biofilter) used in the Rochester facility appear to provide a technology to limit bioaerosol exposure in nearby neighborhoods.

*Chaetomium* species are well-known cellulolytic fungi that can cause biodeterioration of materials such as paper-faced wallboard and cotton fabrics

(Flannigan & Miller, 2001). *Chaetomium* spores are readily detectable in spore trap samples (spores have distinct morphologies; see Samson et al., 2001) but are also at best found only infrequently in outdoor air samples (Kozak et al., 1985). *Chaetomium* spores were identified in six out of seven air samples collected in the processing area of the Rochester composting facility (Table 1). Sampling studies using spore traps have heretofore emphasized the occurrence of *Aspergillus–Penicillium* spore types as an indicator of contamination of ambient air by emissions from composting facilities (State of New York, 1994). The presence or absence of *Chaetomium* spores in ambient air around a composting site (we detected none in the ambient air around the Rochester, NH facility) may be useful in future studies as a marker for the impact of composting emissions on nearby residential neighborhoods, especially if compost feed stock is rich in cellulose.

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**Table 1**

Rank Order Kinds and Average Concentrations of Fungi Collected by Spore Trap Within and Around the Composting Facility (s/m<sup>3</sup>)

**Within Facility (N = 7)**

<i>Penicillium–Aspergillus</i>	5,000
Smuts, <i>Perconia</i> , Myxomycetes form group	1,900
Unidentified spores	1,100
<i>Chaetomium</i>	560
Unidentified basidiospores	340
<i>Cladosporium</i>	250
Unidentified ascospores	150
<i>Alternaria</i>	20

**Ambient (Outdoor) Air (N = 12)**

<i>Cladosporium</i>	230
Unidentified ascospores	140
<i>Penicillium–Aspergillus</i>	80
Smuts, <i>Perconia</i> , Myxomycetes form group	75
Unidentified basidiospores	60
<i>Alternaria</i>	3
<i>Torula</i>	3
Rusts	2

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