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City of Springfield
Department of Public Works Composting Facility
Springfield, MO

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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Joseph E. Burkhart, of the Respiratory Disease Hazard Evaluations and Technical Assistance Program, Division of Respiratory Disease Studies (DRDS). Field assistance was provided by Chris Piacitelli, and Dan Yereb. Desktop publishing was performed by Terry Rooney.

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Health Hazard Evaluation Report HETA 95-0198
City of Springfield, MO
Department of Public Works Composting Facility
June 1999

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SUMMARY

On March 27, 1995, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation from the City of Springfield, MO, to assess any possible employee health effects from operation of the city's composting facility. There were no indications that employees have or had any health problems associated with the compost operation. This request was prompted by the publication of the NIOSH Alert pertaining to Organic Dust Toxic Syndrome (ODTS).[(1)]

The City of Springfield has two separate composting operations. The first operation was located on a large asphalt pad (adjacent to the sewage treatment plant) and consisted of windrows of mixed sewage sludge and saw dust/wood chips which produced a "Class A" compost.

The second site, also adjacent to the sewage treatment plant, was a more conventional composting operation where city residents disposed of their yard waste, the yard waste piled and turned as necessary to produce compost. The finished compost is available to city residents for their home use. Loading of the finished composted product is done by the residents in their own vehicles.

During the three surveys conducted at these composting sites, work area air samples were collected for total dusts, ammonia , bioaerosols and endotoxins. Also, real-time monitoring of respirable dust was accomplished inside and outside of equipment used to turn the compost piles. Finally, bulk samples were collected of various compost products and analyzed for microorganisms.

Overall, total dust concentrations ranged from Non-detectable (ND) to 22.5 milligrams per cubic meter of air (mg/m^3), with the highest samples being located downwind from the sites. Bacteria concentrations ranged from ND to 6.02×10^4 colony forming units per cubic meter of air (CFU/m^3), with the highest concentrations measured during compost turning operations. The most predominant bacteria found on the samples was *Bacillus*. Fungi air samples ranged from ND to 2.7×10^5 CFU/m^3, with the highest concentrations measured downwind of the green waste compost site. The predominant fungi identified on the samples was *Aspergillus*. Endotoxin results ranged from ND to 381 endotoxin units per cubic meter of air ($EU/m^{3)}$, with the highest levels measured during compost turning. Ammonia concentrations were measured as high as 20 ppm during compost turning operations.

Samples collected indicate that the enclosed equipment cabs, when used properly by keeping the windows closed, can reduce worker exposures. However, these controls are relatively ineffective if the cab window are opened during composting handling operations.

City residents were observed shoveling compost into their own vehicles, digging through the compost piles in search of finer material, shoveling hot or cooking compost with their bodies positioned into the steam rising from the piles, and loading their vehicles while in close proximity to end-loaders turning piles. Residents may be at a greater risk of developing ODTS than the city's workers since they are most likely uninformed of the health effects of breathing organic dust, use no respiratory protection, or because of a pre-existing medical condition that may make them more susceptible. Since ODTS is not a widely recognized illness, the syndrome might be misdiagnosed by community physicians.

The results from this health hazard evaluation have shown that enclosed machinery cabs on the equipment can reduce exposure when used properly by keeping the windows closed. Also, these results show that individuals in the general area of the composting pads or those not operating enclosed equipment, should stay upwind during turning operations.

However, controlling exposures to city residents at the green waste composting site may pose a more difficult problem. Residents may be at a greater risk in developing ODTS since they are most likely uninformed of the health effects of breathing organic dust, use no respiratory protection, or because of a pre-existing medical condition that may make them more susceptible. Since ODTS is not a widely recognized illness, the syndrome might be improperly diagnosed by community physicians. Recommendations are provided.

Keywords: SIC code: 2875, composting, sewage sludge, green waste, microorganisms, agriculture, bioareosols

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INTRODUCTION

On March 27, 1995, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation from the City of Springfield, MO, to assess any possible employee health effects from operation of the city's composting facility. There was no indication that employees have or had any health problems associated with the compost operation. This request was prompted by the publication of the NIOSH Alert pertaining to Organic Dust Toxic Syndrome (ODTS).[1]

On April 27, 1995, NIOSH investigators conducted an initial site visit to the Springfield composting facilities. During that visit, the city's composting operations were toured and area air samples were collected for total airborne dust, ammonia, and microbiological analysis. A second survey was conducted at the composting sites during August 1995. That survey focused on attempting to evaluate the protection afforded by enclosed cabs of composting equipment. A final survey conducted on September 4, 1996 to collect additional samples for ones lost from the August 1995 survey. Dust samples from inside and outside the equipment cabs were also collected using direct reading meters.

BACKGROUND

The City of Springfield's request was prompted by the NIOSH Alert pertaining to Organic Dust Toxic Syndrome (ODTS). Although there was no indication that employees have or had any health problems associated with the compost operation, the city was concerned over the potential for employees to develop ODTS.

ODTS is an acute respiratory illness seen in workers who inhale organic dusts contaminated with microorganisms. Compost is considered to be an organic dust. The syndrome is characterized by fever occurring 4 to 12 hours after exposure and flu-like symptoms such as general weakness, headache, chills, body aches, and cough. Shortness of breath may also occur. These symptoms are self-limiting and recovery is common in approximately 24 - 72 hours, although recurrent episodes can occur and are common on re-exposure. Progression to chronic respiratory disease has not been demonstrated. ODTS typically follows massive exposures to organic dusts. Exposures to hays, oats, and wood chips contaminated with large numbers of microorganisms have been associated with the development of disease. Bacterial endotoxin and possibly other microbial toxins are suspected etiologic agents.[1]

The city operates two composting sites. The first site, located on a large asphalt pad (adjacent to the sewage treatment plant), consisted of windrows of mixed sewage sludge and sawdust/wood chips to produce an EPA "Class A" compost. Class A sewage sludge compost meets the EPA's requirements on pathogen limits for use in land application. In order to be classified as a Class A compost, the temperature of the sewage sludge compost must be maintained at 55^0 Centigrade or higher for 15 days or longer for pathogen reduction.[2] This compost is only available to the commercial/industrial users.

The second site, also adjacent to the sewage treatment plant, was a more conventional composting operation where city residents disposed of their yard waste, the yard waste piled and turned as necessary to produce compost. The finished compost is available to city residents for their home use. Loading of the finished composted product is done by the residents in their own vehicles.

There were 6 workers assigned to these sites during this evaluation. These workers typically work 6-8 hours a day, 2-3 days per week at the composting sites. When not working at the composting site, they are assigned other duties at the sewage treatment plant. Equipment used at the sites included Scarabs (a machine used to turn compost windrows), front-end loaders, and mixing trucks. The Scarab and end-loaders were equipped with enclosed cabs, which filtered and air conditioned the air.

On April 27, 1995, NIOSH investigators conducted an initial site visit to the Springfield composting facilities. During that visit, the city's composting operations were toured and area air samples were collected for total airborne dust, ammonia, and microbiological analysis. These samples were collected while a scarab was turning compost windrows. Sampling locations were upwind, downwind, and near the center of the pads. Bulk samples were collected of the various compost products for microbiological analysis. The purpose for collecting theses samples was to determine the microbial activity of the compost.

A second survey was conducted at the composting sites during August 1995. That survey focused on attempting to evaluate the protection afforded by the enclosed cabs. Dust and microbial air samples were collected from inside and outside of the equipment cabs. Area samples were also collected at the perimeter of the sites, both upwind and downwind to determine the potential for off-site exposures. Also during this survey, various methods of collecting samples for microbial analysis was tested. Microbial samples were collected on duplicate filters, one filter was sent to a contract lab for analysis and the other filter was plated on agar media in the field. Samples were also collected in all glass impingers for plating in the field. It was subsequently determined that the agar plate plates used in the field were contaminated and the data unreliable.

A final survey was conducted on September 4, 1996 to collect additional samples for ones lost from the August 1995 survey. Dust samples from inside and outside the equipment cabs were also collected using direct reading meters.

METHODS

During the surveys conducted at these composting sites, work area air samples were collected for total dusts, ammonia, bioaerosols and endotoxins. Real-time monitoring of total dusts was conducted inside and outside of equipment cabs. Bulk samples were collected of the various compost products and analyzed for microorganisms . The following is a description of the industrial hygiene sampling methods used in support of this health hazard evaluation.

Total Dust (Particulates not otherwise regulated)

Work area samples for total dusts were collected on pre-weighed 37 millimeter (mm) diameter, 5 micrometer (µm) pore size, polyvinyl chloride (PVC) filters, housed in closed-face two piece cassettes. Air was drawn through the filter at a flow rate of 2.0 liters per minute (lpm) using a battery powered sampling pump. Time-integrated samples were collected in the work area for the duration of the operations being performed, generally 2-3 hours. Total dust content was analyzed gravimetrically according to NIOSH Method 0500.[3]

Bacteria and Fungi

Air samples were collected onto 37 mm diameter polycarbonate (PC) filter media, housed in closed-face two piece cassettes at a flowrate of 2.0 lpm.[4] Sampling times ranged from 30 - 120 minutes. Both area air samples and the bulk samples of the composting materials were collected throughout the sites and submitted via overnight mail to a NIOSH contract laboratories for microbial analysis. Each bulk sample collected was placed in a paper bag for overnight shipment to the laboratory. Bulk samples that were submitted consisted of sewage sludge, mixed sludge and wood chips, leaf waste, and various degrees of aged sludge and leaf composts.

The appropriate dilutions for each sample were inoculated onto a yeast-malt extract agar (YMA), inhibitory mold agar with gentamicin and chloramphenicol (IMAglc), a yeast malt extract with gentamicin and chloramphenicol (YMEglc), and a tryptic soy agar (TSA), with lecithin and polysorbate 20, and blood agar. These plates were incubated at 23ºC ± 2 for 10 days and were examined after 10 days for the isolation of mesophilic bacteria and molds. The appropriate dilutions were also inoculated onto buffered charcoal yeast extract agar (BCYA) and TSA with lecithin and polysorbate 20; these plates were incubated at 52ºC ± 2 for 10 days and then examined for the isolation of thermophilic and thermotolerant bacteria and molds. [4]

Endotoxin

The total dust air samples were analyzed for endotoxin content by the chromogenic modification of the Limulus amebocyte lysate gel test.[5]

Ammonia

Samples for the estimation of ammonia concentration were collected using Dräger 2/a direct reading detector tubes (Cat.#67 33231). Ammonia chemically reacts with a reagent layer in the tube. This chemical reaction results in a color change of the reagent layer. The limit of detection for the detector tubes was 2 ppm.

Real-time Particulate Monitoring

Real-time particulate monitoring for respirable and total dusts were accomplished using TSI DustTrack monitors. These monitors operate on the principle of near-forward light scattering technology and were set-up to collect samples at 1 second intervals. The measurements are collected and stored electronically an then intergrated to produce a concentration profile by time or work activity.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[6], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®)[7] and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs)[8]. However , acceptable levels of airborne microorganisms have not been established. Lack of standardized exposure assessment techniques, inability to quantitate non-viable organisms, and inter-individual variability in response have confounded efforts to set such standards.

Bacteria

Most environments (air, water, and solid surfaces) contain a wide variety of bacteria. The types and concentrations are influenced by prevailing conditions. In general, human-source bacteria are dominant indoors (*Micrococcus, Staphylococcus*) while gram-negative leaf surface organisms (e.g., Pseudomonas) are most abundant outdoors. For the most part, the bacterial components of a naturally occurring flora usually cause human respiratory illness only when bacteria that can produce disease are selectively amplified in an environmental reservoir and these organisms or their products become airborne and successfully reach the breathing zone of susceptible humans. Legionnaires' disease, other pneumonias, and tuberculosis are common airborne infections caused by bacteria. Bacteria and their products can also cause hypersensitivity pneumonitis, an immunologically mediated pulmonary disease resulting from sensitization and recurrent exposures to a number of original dust constituents.[4] Currently, there are no ACGIH, NIOSH, or OSHA occupational exposure standards or recommendations for bacteria.

Fungi

Fungi are a common constituent of agricultural dusts and are a recognized exposure hazard. While fungi are ubiquitous, overexposure to fungi can cause human health problems in several ways; these include direct fungal infections (mycoses), allergic reactions (e.g., asthma), other immunologic reactions (e.g., hypersensitivity pneumonitis), and by the production of toxic metabolites called mycotoxins. Respiratory exposures to fungi and organic dusts containing fungal constituents can cause many of the occupational respiratory diseases described above. Those respiratory diseases commonly associated with fungal exposures would include asthma, hypersensitivity pneumonitis, and organic dust toxic syndrome (ODTS).[4] Currently, there are no

ACGIH, NIOSH, or OSHA occupational exposure standards or recommendations for fungi.

Endotoxin
Endotoxins are lipopolysaccharide substances contained in the cell wall of Gram-negative bacteria. The inhalation of endotoxin can induce a variety of biological responses including inflammatory, immunological, and hemodynamic activity. The pulmonary macrophage is extremely sensitive to the effects of endotoxins and a primary target cell for endotoxin induced pulmonary injury following respiratory exposure. Exposures to endotoxin have been reported to cause acute fever, dyspnea, chest tightness, coughing, and decreases in pulmonary function. Illnesses possibly associated with endotoxin exposure include byssinosis, HP, asthma and ODTS. There are no OSHA, ACGIH, or NIOSH standards or criteria for occupational exposures to endotoxin. The scientific literature contains research describing human threshold exposure limits for endotoxins. The lowest endotoxin exposure reported to cause adverse pulmonary response was measured in exposure studies among subjects sensitive to cotton dusts, 9 nanograms of elutriated endotoxin per cubic meter of air (ng/m^3). This concentration is equivalent to approximately 90 endotoxin units per cubic meter of air (EU/m^3). Threshold endotoxin exposures among healthy human subjects exposed to cotton dusts are reported by Rylander as approximately 1000 to 2000 EU/m^3 for an across shift acute pulmonary response (decline in FEV_1) and 5000 to 10,000 EU/m^3 for fever.[9-11] The Netherlands has recently adopted a recommended endotoxin exposure limit of 50 EU/m^3 based on inhalable dust sampling. This limit was established as about half of the 90 EU/m^3 level that induces measurable airways obstruction. .[12]

Total Dust (Particulates, not otherwise classified)
Often, the chemical composition of the airborne particulate does not have an established occupational health exposure criterion. It has been the convention to apply a generic exposure criterion in such cases. Formerly referred to as nuisance dust, the preferred terminology for the non-specific particulate ACGIH TLV criterion is now *"particulates, not otherwise classified (p.n.o.c.),"* [or *"not otherwise regulated"* (p.n.o.r.) for the OSHA PEL].

The OSHA PEL for total particulate, n.o.r., is 15.0 mg/m^3 and 5.0 mg/m^3 for the respirable fraction, determined as 8-hour averages. The ACGIH recommended TLV for exposure to a particulate, n.o.c., is 10.0 mg/m^3 (total dust, 8-hour TWA). Such exposure criteria can be applied *only* to particulates that are known to produce no irritation, irreversible affects, or pulmonary disease.

Ammonia
Ammonia is among the most common odors found at composting facilities. Ammonia is common when composting high nitrogen materials such as fresh grass clippings or manure. [13] Ammonia is a severe irritant of the eyes, respiratory tract and skin. It may cause coughing, burning, and tearing of the eyes; runny nose; chest pain; cessation of respiration; and death. Symptoms may be delayed in onset. Exposure of the eyes to high gas concentrations may produce temporary blindness and severe eye damage. Exposure of the skin to high concentrations of the gas may cause burning and blistering. Repeated exposure to ammonia gas may cause chronic irritation of the eyes and upper respiratory tract.[14,16] The NIOSH REL for ammonia is 25 ppm for a 10-hour TWA. The NIOSH short-term exposure limit (STEL) for ammonia is 35 ppm. ACGIH has set limits of 25 ppm as an 8-hour TWA and a STEL of 35 ppm. The OSHA PEL for ammonia is 50 ppm for an 8-hour TWA.

RESULTS

April 1995 Survey
The results from the work area samples collected during the April 1995 survey at both the Sewage Sludge and the Green waste sites are shown together in Table 1.

Green Waste Composting Site
Area air samplers were set-up at three locations at the Green Waste composting site; an upwind location; a

center of pad location; and a downwind location. It is important to note in reviewing these results that no work was being conducted at this site during sample collection and that sampling duration was short at approximately 2 hours. Total dust sampling results from two locations, the center and downwind locations were low, 0.04 and 0.23 mg/m^3, respectively. No upwind total dust sample was collected.

Bacteria concentrations ranged from 17 to 8.5 x 10^3 colony forming units per cubic meter of air (CFU/m^3), with the highest levels measured at the downwind location. The primary bacteria identified on the samples was *Bacillus*. Fungi concentrations ranged from 24 to 1.3 x 10^4 CFU/m^3 , with the highest levels measured at the center pad location. The primary fungi identified from the samples were *Cladosporium* and *Aspergillus*. Endotoxin analysis was conducted on each total dust sample. Endotoxin concentrations from the two locations, center pad and downwind, were low at 15.3 and 32.7 endotoxin units per cubic meter of air (EU/m^3), respectively.

Sewage Sludge Composting Site

Area air samplers were set-up at five locations at the Sewage Sludge composting site; a upwind corner pad location (NE); a upwind corner pad location(NW); a center pad location; a downwind corner pad location (SE); and a downwind corner pad location (SW). As with the other site, no work was being conducted at this site during sample collection and sampling duration was short at approximately 2 hours. Total dust sampling results for all samples were low at 0.04 mg/m^3. Bacteria concentrations ranged from None Detected (ND) to 2.3 x 10^3 CFU/m^3, with the highest levels measured at the downwind SE corner location. The primary bacteria identified on the samples were *Klebsiella* and *Pseudomonas*. Fungi concentrations ranged from ND to 6.0 x 10^3 CFU/m^3 , with the highest levels also measured at the downwind SE corner location. The primary fungi identified from the samples were *Cladosporium* and Yeast. No endotoxin were detected on any of the samples collected at the sewage sludge composting site.

Bulk sample analysis

The specific amounts of microorganisms found in the bulk samples of the composts varied as a result of the age of the compost. Table 2 outlines the results of the bulk samples that were analyzed for microbial content. As expected, both types of compost contained various bacteria, including thermophilic bacteria, as well as fungal spores. The primary bacteria genera identified on all samples was *Bacillus*. Fungi identified from the bulks were comprised mainly of yeasts, *Scedosporum*, and *Aspergillus* species.

August 1995 Survey

Air sampling results for the August 1995 survey is shown in Table 3. During this three day survey, two days were spent at the sewage sludge composting site and the remaining day at the greens composting site. At both sites, 2 to 4 hour samples were collected at upwind and downwind pad locations, inside and outside of composting equipment cabs, and at an off-site trailer park located downwind from the composting operations.

Sewage Sludge Composting Site

Total dust concentrations from the samples collected upwind and downwind at the sewage sludge compositing operation were 0.02 and 0.06 mg/m^3, respectively. The results for the total dust samples collected inside and outside of a sacrab turning windrows were, at first, questionable. The total dust concentrations measured outside of the Scarab ranged from 0.02 to 0.1 mg/m^3 , while levels measured inside the operators cab were 0.41 and 0.53 mg/m^3. It was observed that during sampling, the sacrab operator smoked inside the cab. Smoking most likely accounted for the higher particulate levels measured inside the cab as compared it the outside samples.

Samples for bacteria were somewhat higher on the upwind sample as compared to the downwind sample, 62 and 17 CFU/m^3 respectively. Bacteria samples from outside the cab of the scarab (windows closed) ranged from ND to 318 CFU/m$^{3.}$. Inside cab sample concentrations for bacteria were 43 and 45

CFU/m^3. The primary bacteria identified on all the samples from the sewage sludge composting site was *Streptomyces*.

Fungal concentrations were similar to those for bacteria. The fungal concentrations were slightly higher on the upwind sample (43 CFU/m^3) as compared to the downwind sample (11 CFU/m^3). Outside scarab samples ranged from 9 to 426 CFU/m^3, while the inside cab samples were 9 and 24 CFU/m^3. The primary fungi identified on the samples were yeasts, *Cladosporium* and *Aspergillus*. Endotoxin levels were low on all samples, ranging from ND to 7.2 EU/m^3.

Short-term ammonia concentrations were measured at various distances downwind of the scarab turning sewage sludge compost windrows. Ammonia concentrations ranged from <5 parts per million (ppm) to a high of 20 ppm. No ammonia sampling was done inside the Scarab cab.

Green waste Composting Site

In most instances, sample concentrations from the greens composting site were much higher than the sewage sludge composting site. Total dust concentrations were not detectable from both the upwind and downwind samples. A total dust sample collected near the fence line, adjacent to a roadway was 22.5 mg/m^3. The results from that sample most likely was due traffic dust from vehicles entering and leaving the sites. Total dust samples were also collected from inside and outside a front-end loader turning greens compost. The total dust concentration inside the cab were non-detectable, while outside the cab were 2.45 and 3.19 mg/m^3.

Bacteria and fungal concentrations were orders of magnitude higher at the greens site as compared to the sewage sludge site. Bacteria concentrations from the greens site ranged from ND to 6.0 x 10^4 CFU/m3. Upwind and downwind bacteria concentrations were ND and 926 CFU/m^3, respectively. Fungal concentrations for the same locations were 30 and 2.9 x 10^5 CFU/m^3, respectively. Inside cab concentrations of bacteria and fungi was significantly lower, 23 and 171 CFU/m^3, than the levels measured outside the cab. Bacteria concentrations measured outside were 1.4 x 10^3 and 6.0 x 10^4 CFU/m^3. Fungal concentrations outside were 1.0 x 10^3 and 1.5 x 10^5 CFU/m^3. The primary bacteria identified on the samples were *Streptomyces* and *Bacillus*. The primary fungi identified on the samples was *Aspergillus*.

Endotoxin concentrations ranged from ND to 381 EU/m^3. The lowest endotoxin concentration (ND) was measured at the pad sites, while the highest (381 EU/m^3) was measured outside the cab of the front end loader. No endotoxins were detected from the sample collected from inside the cab of the front loader. No ammonia samples were collected at the green waste composting site.

To assess the downwind impact from the composting site, samples were collected at the first housing area or business located downwind from the composting sites, in this case an off-site trailer park. Samples collected from this site were negative for all bacteria, fungi, endotoxin, and total dust levels were non detectable.

September 1996 Survey

During this survey, one day was spent collecting 4-6 hour samples for respirable dusts, total dusts, fungi, and real-time monitoring of dust levels. However, it was necessary to void the results for the respirable and total dust samples because of high background weights found on sample control media (control media are samples that are unused and submitted with field samples as a quality control check of the analytical method). The results of the fungi samples collected during this survey are presented in Table 4. Real-time respirable dust levels measured simultaneously inside and outside of the scarab are presented in Figure 1.

Sewage Sludge Composting Site

Fungal concentrations ranged from 4.5 x 10^2 to 2.1 x 10^5 CFU/m^3, with the highest levels measured downwind from the composting site. Results of the sample collected inside the scarab cab was 5.0 x 10^2 CFU/m^3, as compared to 1.6 x 10^5 CFU/m^3 for the sample collected outside of the cab. Samples were also collected inside and outside of a front end loader loading sewage sludge into the mixing wagon. The fungal concentration inside the cab was 1.7×10^2 CFU/m^3, as compared to 4.1×10^3 CFU/m^3 for the outside cab sample. The primary fungi identified in the samples were *Aspergillus* and *Cladosporium*.

The data from the real-time monitors (Figure 1) follow the same trend as the results of the fungal samples; that is, concentrations were higher outside the cab relative to inside the cab. It is speculated that the peak concentrations seen on the inside cab are probably attributed to cigarette smoke from the operator rather then dust entering the cab as a result of the turning operations. Peak concentrations observed outside the cab are most likely attributed to the scarab turning into the wind.

Green waste Composting Site
Fungal results for the three samples collected at the green waste composting site ranged from 3.21×10^3 - 4.6×10^5 CFU/m^3. Fungal samples were collected inside and outside of the cab while the front-end loader was turning compost piles. The fungal concentration measured inside the cab was 3.3×10^5 CFU/m^3, as compared to 4.6×10^5 CFU/m^3 for the outside cab sample. The primary fungi identified on the samples was *Aspergillus*. During sampling it was observed that the operator of the loader had the cab window open during compost turning operations.

Overall Summary
Overall, total dust concentrations ranged from ND to 22.5 mg/m3, with the highest samples being located downwind from the sites. Bacteria concentrations ranged from ND to 6.0×10^4 CFU/m^3, with the highest concentrations measured during compost turning operations. The predominant bacteria found on the samples was *Bacillus*. Fungi air samples ranged from ND to 2.7×10^5 CFU/M^3, with the highest concentrations measured downwind of the green waste compost site. The predominant fungi identified on the samples was *Aspergillus*. Endotoxin results ranged from ND to 381 EU/m^3, with the highest levels measured during compost turning. Ammonia concentrations downwind of the scarab were measured as high as 20 ppm during compost turning.

DISCUSSION/ CONCLUSIONS

This health hazard evaluation was requested by the City of Springfield, in part, because of their concerns for potential occupational exposures to their compost workers, and because of information presented in the NIOSH Alert pertaining to Organic Dust Toxic Syndrome. Since microorganisms play such an important role in composting, there will always be a potential for occupational exposures to these organisms, or their by-products, which may pose an occupational respiratory hazard.

Acceptable levels of airborne microorganisms have not been established. Lack of standardized exposure assessment techniques, inability to quantitate non-viable organisms, and inter-individual variability in response have confounded efforts to set such standards. Just as individuals vary in their resistance to disease, a few individuals may be particularly sensitive to some of the organisms in compost. To reduce this potential hazard it is important to reduce worker exposures by means of either respiratory protection or engineering controls.

The results from this health hazard evaluation have shown that enclosed machinery cabs, when used properly by keeping the windows closed, can be effective in reducing exposures. Samples collected showed inside cab levels of bacteria were reduced by a factor of about 5 - 25 on average (range 2 - 2600). Similarly, fungal levels inside cabs were reduced by about 10 times on average (range 1 - 880). Owing to the small number of samples, the estimates are not difinitive, but do give an indication of the level of protection that might be achievable by using cabs. Also, these results show that individuals in the general area of the composting pads or those not operating enclosed equipment, should either wear respiratory protection or stay upwind during turning operations.

Controlling exposures to city employees working at the composting site can be easily be achieved by either of the methods mentioned. However, controlling exposures to city residents at the green waste composting site may pose a more difficult problem. We observed residents shoveling greens compost into their own vehicles, digging through the compost piles in search of finer material, shoveling hot or cooking compost with their bodies positioned into the steam arising from the piles, and loading their vehicles while in close proximity to end-loaders turning piles. Air and bulk samples collected at the greens site showed predominantly *Aspergillus sp*. As outlined in the NIOSH Alert on ODTS, exposures to *Aspergillus sp.*, particularly *A. fumigatus*, can cause serious respiratory illnesses. Residents may be at a greater risk in developing ODTS since they are most likely uninformed of the health effects of breathing organic dust, use no respiratory protection, or because of a pre-existing medical condition that may make them more susceptible. Since ODTS is not a widely recognized illness, the syndrome may often be misdiagnosed by community physicians.

RECOMMENDATIONS

The NIOSH Alert "Request for Assistance in Preventing Organic Dust Toxic Syndrome" should be used as a guide to informing employees and minimizing risk. This alert is available free of charge and can be requested by calling NIOSH at 1-800-35NIOSH. Other specific recommendations based on our evaluation are:

- Exposures to organic dust should be controlled, preferably through the use of engineering controls (e.g., enclosed machinery cabs), rather than solely through the use of respiratory protective equipment. For outdoor composting operations, machinery such as front end loaders should be equipped with enclosed cabs that isolate workers from the source of organic dust. To be effective, each cab should be supplied with positive pressure, filtered air. Air conditioning and ventilating system filters need to be inspected and changed an a regular basis. Standard cab filters should be replaced with higher efficiency filters, provided these do not restrict or unbalance the cab airflow (resulting in a loss of cab pressurization). Seals around doors and windows should be periodically inspected and replaced if defected.

- The existing engineering controls - enclosed cabs - should be supplemented with the use of appropriate NIOSH-approved respirators, until it is determined that proper filtration and well maintained cabs virtually eliminate exposures to organic dusts. The machinery cabs used at this site reduced, but did not eliminate exposures. Because exposures outside the machinery cabs can vary substantially in both concentration and content, and because the cabs did not eliminate exposures, the prudent course of action is to supplement the cab attenuation with respiratory protection.

- When exposure to organic dust cannot be avoided - for example, when working outside the machinery cabs - workers should be protected using NIOSH-approved respirators. Because exposures can vary substantially - depending upon the activity, the prevailing environmental conditions, and position of the worker - and because there are no applicable exposure limits for organic dusts containing microorganisms, NIOSH recommends that exposed workers wear the most practical respirator with the highest assigned protection factor (APF).

- *The minimum level of respiratory protection* should be equal to the disposable N95 filter respirator certified by NIOSH (42 Code of Federal Regulations (CFR) 84). High efficiency particulate filter (HEPA) respirators certified by MSHA/NIOSH under 30 CFR 11 or other N, R, and P filter respirators certified by NIOSH under 42 CFR 84 may also be selected. (Respirator manufacturers and/or suppliers should be able to provide assistance in the selection of respirators consistent with these recommendations, and also guidance regarding establishing a respiratory protection program (described next)).

- When respirators are used, the employer must establish a comprehensive respiratory protection program, as outlined in 29 CFR 1910.134 of the OSHA standard. The basic elements of a respiratory protection program are:

  – A medical evaluation to determine if each worker is capable of performing work while wearing a respirator
  – Respirator fit testing
  – Regular training of workers and supervisory personnel in the correct usage of respirators
  – Periodic environmental (exposure) monitoring (usually done by industrial hygienists or other specially trained personnel)
  – Proper maintenance, inspection, cleaning, and storage of each respirator
  – Selection of the appropriate respirator(s), using only respirators that are certified by NIOSH
  – Regular evaluation by the employer of respiratory protection program.

- Signs should be posted at the green waste site to inform residents of the hazards of breathing organic dusts, and means of prevent exposure (e.g. use of respirators when handling compost, and wetting compost to keep dust levels down).

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Table 1.

April 1995 Air Sampling Results

HETA 95-0198

City of Springfield

Springfield, MO

Sampling Location	Bacterial Identification	Bacteria Concentration (CFU/m^3)	[Total]	Fungal Identification	Fungal Concentration (CFU/m^3)	Total]	Total Dust (mg/m^3)	Endotoxin (EU/m^3)
April 27, 1995 - Green Waste Composting Area								
Upwind Corner (NE) Pad	*Bacillus*	$3.1x10^3$	$3.1x10^3$	*Cladosporium*	$2.0x10^3$	$2.0x10^3$	ns	ns
Center of Pad	*Streptomyces*	$1.7x10^1$	$1.7x10^1$	*Cladosporium* *Aspergillus*	$1.0x10^4$ $3.1x10^3$	$1.3x10^4$	0.04	15.3
Downwind Corner (SW) Pad	*Bacillus*	$8.5x10^3$	$8.5x10^3$	*None detected*	8	24	0.23	32.7
April 27, 1995 - Sewage Sludge Composting Area								
Upwind Corner (NE) Pad	None detected	0	0	None detected	0	0	0.04	None detected
Corner (NW)of Pad	None detected	0	0	None detected	0	0	0.04	None detected
Center of Pad	None detected	0	0	None detected	0	0	0.04	None detected
Downwind (SE) Corner	*Klebsiella* *Pseudomonas*	$1.4x10^4$ $9.0x10^3$	$2.3x10^4$	*Cladosporium* *Paecilomyces*	$3.6x10^3$ $2.4x10^3$	$6.0x10^3$	0.04	None detected
Downwind (SW) Corner	*Klebsiella*	$9.5x10^3$	$9.5x10^3$	Yeast *Cladosporium*	$3.0x10^3$ $1.3x10^3$	$4.3x10^3$	0.04	None detected

Table 2.

Bulk Sample Microbial Results

HETA 95-0198

City of Springfield

Springfield, MO

April 27, 1995 - Bulk Samples (Green Waste Composting Area)					
Sampling Location	*Bacteria Identification*	*Bacteria Concentration (CFU/g)*	*Thermophilic Bacteria Concentration (CFU/g)*	*Fungi Identification*	*Fungal Concentration (CFU/g)*
Public Leaf Compost, Ready to Go	*Bacillus*	$4.50x10^7$	$3.57x10^7$	*Penicillium*	$2.86x10^5$
Public Leaf Compost, Ready to Go	*Bacillus*	$3.03x10^9$	ND	*Aspergillus*	$5.00x10^3$
Public Leaf Compost, Ready to Go	*Bacillus*	$3.27x10^9$	$3.33x10^7$	*Aspergillus*	$1.18x10^6$
Leaf Compost	*Bacillus*	$3.81x10^9$	$3.13x10^7$	Yeast	$8.44x10^8$
Leaf Compost	*Bacillus*	$2.15x10^9$	$3.70x10^7$	Yeast	$3.33x10^8$
Leaf Compost	*Bacillus*	$2.24x10^9$	$5.88x10^7$	*Aspergillus*	$3.24x10^3$
April 27, 1995 - Bulk Samples (Sewage Sludge Composting Area)					
Fresh Sludge	*Flavobacterium* *Klebsiella* *Bacillus*	$2.08x10^8$	ND	Yeast	$4.55x10^2$
Wood Chips / Saw Dust	*Bacillus*	$1.74x10^9$	$6.82x10^7$	Yeast	$2.27x10^{12}$
New Sludge Compost	*Acinetobacter* *Bacillus*	$3.38x10^6$	ND	*Scedosporum* *Aspergillus*	$5.01x10^4$
Sludge compost windrow, Front	*Bacillus*	$3.03x10^8$	$1.32x10^7$	*Scedosporum*	$6.57x10^2$
Sludge compost windrow, Middle	*Bacillus*	$1.40x10^8$	$7.35x10^6$	*Scedosporum*	$1.99x10^4$
Sludge compost windrow, End	*Bacillus*	$1.92x10^8$	$9.62x10^4$	Non-sporulating white	$1.92x10^2$

Table 2 (continued)

Bulk Sample Microbial Results

HETA 95-0198

City of Springfield

Springfield, MO

April 27, 1995 - Bulk Samples (Sewage Sludge Composting Area - continued)					
Sampling Location	*Bacteria Identification*	*Bacteria Concentration (CFU/g)*	*Thermophilic Bacteria Concentration (CFU/g)*	*Fungi Identification*	*Fungal Concentration (CFU/g)*
Sludge compost, new	*Bacillus*	$4.63x10^{7}$	ND	*Scedosporum*	$9.20x10^{1}$
Sludge compost, aging	*Bacillus*	$2.18x10^{8}$	$7.04x10^{6}$	*Scedosporum*	$2.89x10^{4}$
Sludge compost, near complete	*Xanthomonas* *Bacillus*	$1.14x10^{9}$	$9.26x10^{6}$	Yeast (pink & yellow)	$3.70x10^{7}$
Sludge compost, near complete	*Bacillus*	$3.67x10^{8}$	$1.67x10^{5}$	Scedosporum	$8.50x10^{5}$
Sludge compost, ready to go	*Bacillus*	$1.14x10^{9}$	ND	ND	ND

Table 3.

August 1995 Air Sampling Results

HETA 95-0198

City of Springfield

Springfield, MO

August 8, 1995 - Sewage Sludge Composting Area									
Sampling Location	*Bacterial Identification*	*Bacteria Concentration (CFU/m³)*	*Total*	*Fungal Identification*	*Fungal Concentration (CFU/m³)*	*Total*	*Total Dust (mg/m³)*	*Endotoxin Units (EU/m³)*
Upwind on Pad				*Cladosporium*	8			
				Yeast	31			
	Streptomyces	62	62	*Aspergillus fumigatus*	4	43	0.02	None Detected
Downwind on Pad	*Streptomyces*	17	17	Yeast	11	11	0.06	1.3
Scarab inside Cab				*Cladosporium*	8			
				Yeast	8			
	Streptomyces	43	43	*Aspergillus fumigatus*	8	24	0.41	None Detected
Scarab outside- Left Front				*Aspergillus fumigatus*	13			
				Penicillium	4			
	Streptomyces	80	80	*Alternaria*	4			
				Yeast	31	52		Not Sampled
Scarab outside- Right Middle				*Geotrichum*	4			
	Streptomyces	118	118	*Alternaria*	4			
				Aspergillus niger	4	12	0.02	7.2
Scarab outside- Right Front				*Aspergillus fumigatus*	16			
	Streptomyces	37	37	*Aspergillus flavus*	4			
				Cladosporium	20	40	0.1	2.5

Table 3 (continued)

August 1995 Air Sampling Results

HETA 95-0198

City of Springfield

Springfield, MO

August 9, 1995 - Green Waste Composting Area									
Sampling Location	*Bacterial Identification*	*Bacteria Concentration CFU/m³)*	*Total*	*Fungal Identification*	*Fungal Concentration (CFU/m³)*	*Total*	*Total Dust (mg/m³)*	*Endotoxin Units (EU/m³)*
Perimeter - NW Fence line	None Detected	n/a		Yeast *Aspergillus fumigatus*	83 10	93	22.5	4.2
Upwind	None Detected	n/a		*Cladosporium* *Alternaria*	27 11	38	0	Not Detected
Downwind ~ 100 yards	*Bacillus species*	926	926	*Aspergillus fumigatus* *Aspergillus flavus* *Aspergillus niger*	$1.9x10^5$ $9.3x10^4$ $1.9x10^4$	$3.0x10^5$	0	Not Detected
Inside Front End Loader's Cab	*Enterobacter cloacae*	23	23	*Aspergillus fumigatus* *Aspergillus flavus* *Aspergillus niger*	92 56 23	171	0	Not Detected
Outside Front End Loader - Right side	*Streptomyces* *Bacillus species*	$5.6x10^4$ $4.6x10^3$	$6.0x10^4$	*Aspergillus* *Rhizopus*	$5.1x10^4$ 92	$1.5x10^5$	3.19	381.5
Outside Front End Loader - Left side	*Enterobacter cloacae*	$1.4x10^4$	$1.4x10^4$	*Aspergillus fumigatus* *Aspergillus flavus* *Cladosporium*	619 353 88	1060	2.45	315.5

Table 3 (continued)

August 1995 Air Sampling Results

HETA 95-0198

City of Springfield
Springfield, MO

August 10, 1995 - Sewage Sludge Composting Area								
Sampling Location	*Bacterial Identification*	*Bacteria Concentration (CFU/m³)*	*Total*	*Fungal Identification*	*Fungal Concentration (CFU/m³)*	*Total*	*Total Dust (mg/m³)*	*Endotoxin Units (EU/m³)*
Offsite - Trailer Park	None detected	n/a	n/a	None Detected	n/a	n/a	0	None Detected
Water Truck loading platform	*Streptomyces*	60	60	*Aspergillus* (gray) Yeast	9 189	198	0.13	None Detected
Scarab inside Cab	*Streptomyces*	45	45	*Aspergillus niger*	9	9	0.53	None Detected
Scarab outside- Left Front	*Streptomyces*	71	71	*Alternaria*	9	9	0.04	2.2
Scarab outside- Right Front	None Detected	n/a	n/a	*Geotrichum* *Cladosporium* *Aspergillus fumigatus* Yeast	17 9 9 53	88	0.09	None Detected
Scarab outside- Rear	*Streptomyces*	318	318	*Cladosporium* *Alternaria* *Acremontum*	236 109 81	426		4.1

Table 4.

September 1996 Air Sampling Results

HETA 95-0198

City of Springfield

Springfield, MO

September 1996 - Sewage Sludge Composting Area		
Sampling Location	*Primary Fungi*	*Fungal Concentration (CFU/m^3)*
Ambient Air - Upwind	*Aspergillus* *Cladosporium*	4.49×10^2
Ambient Air - downwind	Yeast *Cladosporium* *Aspergillus*	2.14×10^5
Sludge Mixing Wagon	*Penicillium* *Paecilomyces*	5.17×10^3
Sludge End Loader - inside cab	Alternaria	1.72×10^2
Sludge End Loader -outside cab	*Paecilomyces* *Aspergillus* *Cladosporium*	4.11×10^3
Scarab - inside cab	*Paecilomyces*	5.00×10^2
Scarab - outside cab	*Cladosporium*	1.58×10^3

Table 4 (continued)

September 1996 Air Sampling Results

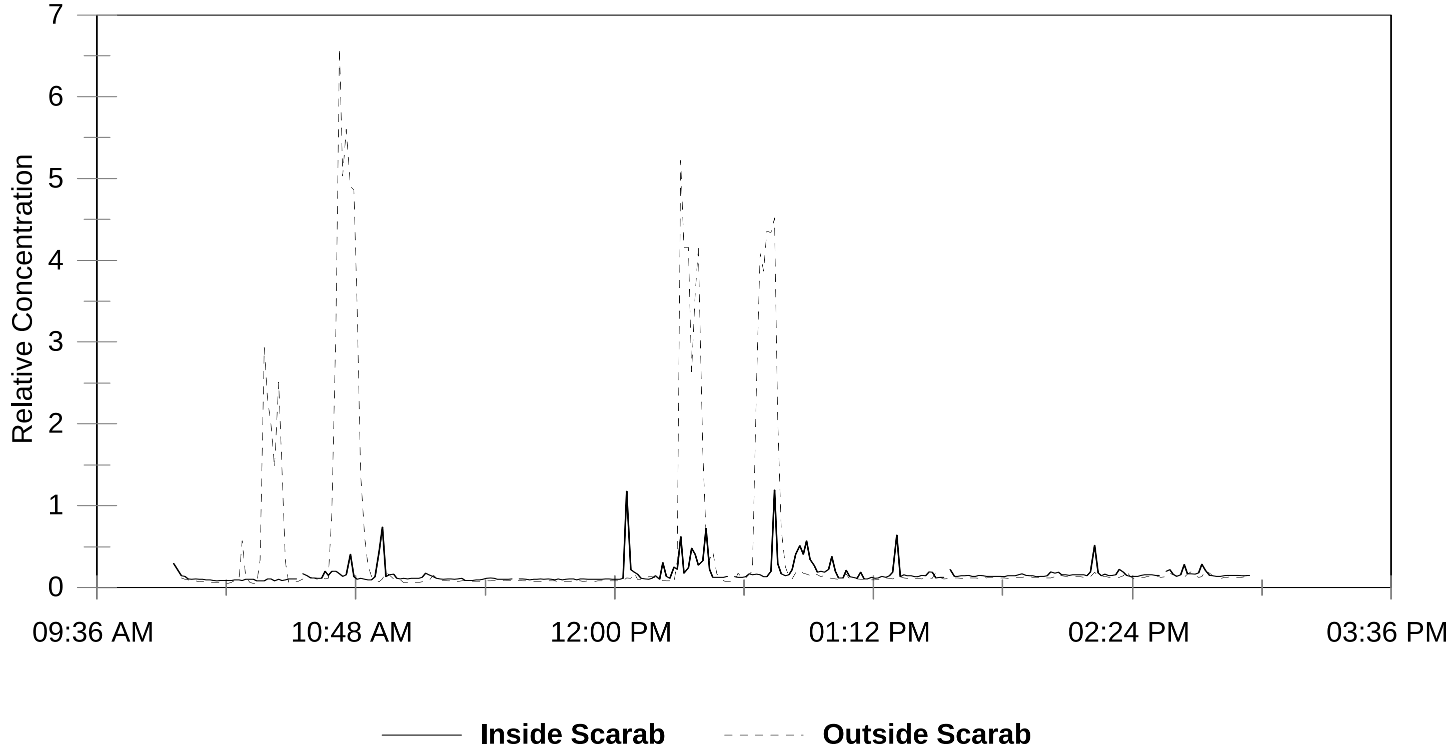
HETA 95-0198

City of Springfield

Springfield, MO

September 1996 - Green waste Composting Area		
Sampling Location	*Primary Fungi*	*Fungal Concentration (CFU/m^3)*
End Loader - inside cab	*Aspergillus*	$3.27x10^5$
End Loader -outside cab	*Aspergillus*	$4.60x10^5$
Contract Loader - finished product	*Aspergillus*	$3.16x10^3$

Figure 1.
Real-Time Respirable Dust Sampling Results
September 1996
HETA 95-0198
City of Springfield



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