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San Francisco Recreation and Parks Department
San Francisco, CA

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PREFACE

The Field Studies Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

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

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**Health Hazard Evaluation Report 96-0252
San Francisco Recreation and Parks Department
San Francisco, CA
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SUMMARY

In August 1996, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation (HHE) from the San Francisco Recreation and Parks Department, San Francisco, California to evaluate the Parks Department's composting operation. Their request indicated that one of the three employees assigned to the composting site had experienced respiratory problems, nausea, shortness of breath, and muscle soreness. In addition, NIOSH was also asked to evaluate the effectiveness of the enclosed cabs on the heavy equipment used at the compost site. On September 4, 1996, two NIOSH Industrial Hygienists conducted a site visit to the composting site and conducted limited air samples during simulated turning operations.

The San Francisco Recreation and Parks Department operates a small composting operation which is located adjacent to the San Francisco Zoo. The material which is composted at this site consists of leaf, and green waste which is mixed with manure from the zoo. The green waste is collected at the city's parks and is trucked to the composting site. The zoo manure (zoo-doo) from herbivores is collected and also trucked to the site for mixing with green waste.

During the surveys conducted at these composting sites, work area air samples were collected for total dusts and bioaerosols. Samples were collected during simulated operations at the compost site. Total sampling times for the samples collected were approximately two hours, and therefore, do not reflect an eight-hour time weighted concentration. Air samples were collected at locations upwind and downwind of the site, and inside and outside of the cabs of the chipper and front-end loader.

Total bacteria concentrations measured inside and outside the chipper cab were 9250 and 6.06×10^6 colony forming units per cubic meter of air (CFU/m³), respectively. Fungi concentrations were 9.7×10^3 CFU/m³ inside the cab and 6.8×10^5 CFU/m³ outside the cab. The total dust concentration inside the cab of the loader was 0.68 milligram per cubic meter of air (mg/m³) compared to 6.69 mg/m³ outside the cab. Bacteria concentrations inside and outside the loader cab were 2.6×10^4 and 3.5×10^6 CFU/m³ respectively. Fungi concentration were lower inside the loader cab as compared to outside the cab, but not as pronounced as that seen for total dust and bacteria. Fungal concentrations inside and outside were 3.2×10^4 CFU/m³ and 4.6×10^4 CFU/m³, respectively.

The results from this health hazard evaluation have shown that the enclosed machinery cabs can reduce exposures. However, these controls will be ineffective if the cab windows or doors are opened during operation.

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. To reduce this potential hazard it is important to reduce worker exposures using either engineering controls or a combination of engineering controls and respiratory protection.

The results from this health hazard evaluation indicate that enclosed machinery cabs on the equipment at the San Francisco Recreation and Parks Department sites reduce exposures to airborne fungi and bacteria.

Microorganisms play such an important role in composting. Acceptable levels of airborne microorganisms have not been established. Lack of standardized exposure assessment techniques, inability to measure non-viable organisms, and inter-individual variability in response have confounded efforts to set such standards. To reduce this potential hazard it is important to minimize worker exposures using either engineering controls or a combination of engineering controls and respiratory protection.

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

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INTRODUCTION

In August 1996, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation (HHE) from the San Francisco Recreation and Parks Department, San Francisco, California to evaluate the Parks Department's composting operation. Their request indicated that a former employee assigned to the composting site had experienced respiratory problems, nausea, shortness of breath, and muscle soreness, which might have been Organic Dust Toxic Syndrome (ODTS). In addition, NIOSH was asked to evaluate the effectiveness of the enclosed cabs on heavy equipment used at the compost site. On September 4, 1996, two NIOSH Industrial Hygienists conducted a site visit to the composting site and conducted air samples for total dust and bioaerosols.

BACKGROUND

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 San Francisco Recreation and Parks Department operates a small composting operation

which is located adjacent to the San Francisco Zoo. The material which is composted at this site consists of leaf, and green waste which is mixed with manure from the nearby zoo to produce a "Class A" compost. Class A 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 55⁰ Centigrade or higher for 15 days or longer for pathogen reduction.⁽²⁾ This compost is only available to the commercial/industrial users.

The green waste is collected at the city's parks and is trucked to the composting site. The zoo manure (zoo-doo) from herbivores is collected and trucked to the site for mixing with the green. Manure from carnivores and monkeys is not used for composting, rather it is trucked to the city dump for disposal.

Green waste is chipped using a enclosed cab chipping machine. Greens are loaded into the chipper drum by the machine's articulating arm that has jaws attached at the end for grabbing and picking-up material (Figure 1). The chipped green material is discharged from the drum by a boom conveyor and piled. A front-end loader mixes the chipped greens with the zoo-doo into compost piles. The front-end loader is also used to turn the compost piles when dictated by temperature and moisture to maintain active composting. Finished compost is loaded into a screener for sizing. Once screened, the finished compost is trucked to the parks for use in landscaping and gardening.

On September 4, 1996, two NIOSH Industrial Hygienists conducted a site visit to the composting site and conducted air samples for total dust and bioaerosols. Samples were collected inside and outside of the equipment cabs, as well as upwind and downwind locations. Two employees were assigned to this composting site; a loader operator and a chipper operator. These two employees only work at the composting site on an as-needed basis. Typically, they may only spend 4-6 hours a day, one or two days per week at the site, depending on work loads. During the NIOSH visit, there was no work

scheduled at the composting site; however, the two employees simulated typical operations.

METHODS

During the survey conducted at this composting site, work area air samples were collected for total dusts, and bioaerosols. The following is a brief 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. Area air samples were collected throughout the sites and submitted via overnight mail to a NIOSH contract laboratories for microbial analysis.

Aliquots of each sample were inoculated onto a yeast-malt extract agar (YMA), inhibitory mold agar with gentamicin and chloramphenicol (IMAgc), a yeast malt extract with gentamicin and chloramphenicol (YMEgic), and a tryptic soy agar (TSA), with lecithin and polysorbate 20, and blood agar. These plates were incubated at $23^{\circ}\text{C} \pm 2$ for 10 days and were examined after 10 days for the isolation of mesophilic bacteria and molds. Aliquots of each sample were also plated on buffered charcoal yeast extract agar (BCYA) and TSA with lecithin and polysorbate 20; these plates were

incubated at $52^{\circ}\text{C} \pm 2$ for 10 days and then examined for the isolation of thermophilic bacteria and molds.⁽⁴⁾

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 illness only when the 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 infections caused by airborne bacteria. Bacteria and their products can also cause hypersensitivity pneumonitis, an immunological 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), hypersensitivity 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.

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, according to the 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/m³ and 5.0 mg/m³ 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/m³ (total dust, 8-hour TWA). Such exposure criteria can be applied *only* to particulates that are known to produce no irritation, irreversibly affects, or pulmonary disease.

RESULTS

The results of the air sampling conducted during this health hazard evaluation are presented in Table 1. Total sampling times for the samples collected were approximately two hours; therefore, these results do not reflect an eight hour time-weighted concentration.

Upwind Results

Total dust concentrations for the sample collected upwind of the composting site was non-detectable (ND), with a detection limit of 0.001 mg/m³. Total bacteria concentration were 1.2 x 10⁴ colony forming units per cubic meter of air (CFU/m³). The predominant bacteria identified on the sample was *Arthrobacter*. Thermophilic actinomycetes were identified at 285 CFU/m³ on the upwind sample. Fungal results for the upwind sample was 1.4 x 10³ CFU/m³, with *Clasdosporium* identified as being predominant.

Downwind Results

Downwind total dust was also ND. Bacteria concentration downwind were 1.0 x 10⁴ CFU/m³, with *Corynebacterium* and *Curtobacterium* being the predominant genera. Thermophilic actinomycetes was identified at 862 CFU/m³. Fungi concentration for the downwind sample was 287 CFU/m³, and consisted of *Aspergillus*.

Chipper Results

The total dust sample collected inside of the cab of the chipper was voided because the sampling cassette disconnected from the sampling pump during operations. Total dust level measured outside the cab was 0.89 mg/m³. Total bacteria concentrations measured inside and outside the cab were 9.3 x 10³ and 6.06 x 10⁶ CFU/m³, respectively. The predominant bacteria identified on the samples were *Corynebacterium* and *Bacillus*. Thermophilic actinomycetes were identified on both samples at 1.0 x 10³ CFU/m³ for the inside cab sample; and 2.6 x 10³ CFU/m³ for the outside cab sample. Fungi

concentrations were 9.8×10^3 CFU/m³ for inside the cab and 6.8×10^5 CFU/m³ outside the cab. The predominant fungi identified on both samples was *Aspergillus*.

Front-end Loader Results

Total dust concentration inside the cab of the loader was 0.68 mg/m³ compared to 6.69 mg/m³ outside the cab. Bacteria concentrations inside and outside the loader cab were 2.6×10^4 CFU/m³ and 3.5×10^6 CFU/m³, respectively. The predominant bacteria identified on the samples was *Bacillus*. Thermophilic actinomycetes were lower inside the cab (7.8×10^3 CFU/m³) as compared to outside the cab (4.6×10^4 CFU/m³). Fungi concentration were lower inside the loader cab as compared to outside the cab, but not as pronounced as that seen for total dust and bacteria. Fungal concentrations inside and outside were 3.2×10^4 CFU/m³ and 4.6×10^4 CFU/m³, respectively. The predominant fungi identified on the samples was *Aspergillus*.

DISCUSSION/ CONCLUSIONS

This health hazard evaluation was requested by the San Francisco Recreation and Parks Department because of their concerns for potential occupational exposures to their compost workers; and the need to assess if enclosed equipment cabs reduced potential exposures. Since microorganisms play such an important role in composting, there is a potential for occupational exposures to these organisms or their by-products to pose an occupational health 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. The high populations of many different species of molds

and fungi in an active compost process can cause allergic reactions in sensitive individuals, though most experience no adverse reaction.

During the NIOSH visit, there was no work scheduled at the composting site; however, the two employees simulated typical operations for the duration of our air sampling. The results from the air samples collected have shown that the enclosed machinery cabs can be effective means of exposure control. However, these controls will be ineffective if the cab windows or doors are opened during composting handling operations. Also, the sampling results may indicate the need for cleaning the inside cab of the loader. The bacteria and fungi results seen in the loader's inside cab samples were not that different from the outside cab results. This may be an indication that the cab air filters may not be efficient to remove the small fungal spores or need to be changed.

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 1-800-35NIOASH. 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 on 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). 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.

REFERENCES

1. NIOSH [1994]. Preventing Organic Dust Toxic Syndrome. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-102.
2. Code of Federal Regulations [1998]. 40 CFR 503. Washington, DC: U.S. Government Printing Office, Federal Register.

3. NIOSH [1994]. NIOSH manual of analytical methods, 4th. ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health (NIOSH) Publication No. 94-113.
4. ACGIH [1989]. Guidelines for the assessment of bioaerosols in the indoor environment. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
5. NIOSH [1992]. Recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.
6. ACGIH [1998]. Threshold limit values and biological exposure indices for 1998. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
7. Code of Federal Regulations [1998]. 29 CFR 1910.1000. Washington, DC: U.S. Government
8. ACGIH [1986]. Documentation of threshold limit values and biological exposure indices for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

Table 1.

Air Sampling Results

San Francisco Recreation and Parks Department

San Francisco, CA

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Sampling Location	Bacterial Identification	Bacteria Concentration (CFU/m ³)		Fungal Identification	Fungal Concentration (CFU/m ³)		Total Dust (mg/m ³)
		[Total]			[Total]		
Upwind Off-site	<i>Arthrobacter</i> <i>Micrococcus</i> Unidentified golden Gm+rod <i>Thermophilic actinomycetes</i>	8.5x10 ³ 2.0x10 ³ 1.4x10 ³ 2.8x10 ²	1.2x10 ⁴	<i>Cladosporium</i>	1.4x10 ³	1.4x10 ³	ND
Downwind	<i>Corynebacterium</i> <i>Curtobacterium</i> <i>Clavibacter</i> <i>Sphingobacterium</i> <i>Bacillus</i> <i>Thermophilic actinomycetes</i>	2.9x10 ³ 2.8x10 ³ 1.7x10 ³ 1.4x10 ³ 2.9x10 ² 8.6x10 ²	1.0x10 ⁴	<i>Aspergillus</i>	2.8x10 ²	2.8x10 ²	ND
Chipper - Inside Cab	<i>Corynebacterium</i> <i>Clavibacter</i> <i>Bacillus</i> <i>Thermophilic actinomycetes</i>	5.0x10 ³ 2.5x10 ³ 7.5x10 ² 1.0x10 ³	9.3x10 ³	<i>Aspergillus</i> <i>Penicillium</i>	7.2x10 ³ 2.5x10 ³	9.8x10 ³	voided
Chipper - Outside Cab	<i>Bacillus</i> Unidentified golden Gm+rod <i>Thermophilic actinomycetes</i>	5.0x10 ⁶ 1.0x10 ⁶ 2.6x10 ³	6.0x10 ⁶	<i>Aspergillus</i>	6.8x10 ⁵	6.8x10 ⁵	0.89
Loader - Inside Cab	<i>Bacillus</i> <i>Thermophilic actinomycetes</i>	1.8x10 ⁴ 7.8x10 ³	2.6x10 ⁴	<i>Aspergillus</i> <i>Penicillium</i> <i>Rhizopus</i>	2.3x10 ⁴ 7.9x10 ³ 5.3x10 ²	3.2x10 ⁴	0.68
Loader - Outside Cab	<i>Bacillus</i> <i>Curtobacterium</i> Unidentified golden Gm+rod <i>Staphylococcus</i> <i>Thermophilic actinomycetes</i>	1.2x10 ⁶ 15x10 ⁶ 3.7x10 ⁵ 3.7x10 ⁵ 4.6x10 ⁴	3.5x10 ⁶	<i>Aspergillus</i> <i>Penicillium</i> <i>Mucor</i>	3.9x10 ⁴ 5.5x10 ³ 1.8x10 ³	4.6x10 ⁴	6.69

Figure 1.
Chipping / Grinding Machine
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