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Central Maui Composting Facility
Maui, Hawaii

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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

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Health Hazard Evaluation Report 95-0203
Central Maui Composting Facility
Maui, Hawaii
June 1999

Joseph E. Burkhart, MS, CIH

SUMMARY

On March 28, 1995, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation from the Maui County Council, Maui, Hawaii. The Council asked NIOSH to evaluate their composting operation since they recently began receiving complaints of poor working conditions from former employees, as well as complaints from neighboring business (Kahului Airport) about odors emitting from the composting site. There was no indication that any current employees have or had any health problems associated with the compost operation. This request was also prompted by the NIOSH Alert pertaining to Organic Dust Toxic Syndrome (ODTS).[1]

On May 11, 1995, NIOSH investigators conducted an initial site visit to the composting facility. During that site visit, the composting operation was toured, and area air samples were collected for total dusts, bacteria, fungi, and endotoxin. 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. The contractor operating the site was in the process of ending his contract with the County, so very little work was being accomplished at that time.

On September 11-13, 1995, a return visit was made to the composting facility to conduct a comprehensive industrial hygiene survey. During that survey, the old contractor was still in the process of leaving and the new contractor preparing to take over operations. During that transition, old contractor was loading and removing product, while the new contractor was focusing on reducing the stock-pile of accumulated green waste and sewage sludge by mixing one static windrow of compost.

A final survey was conducted during June 24-26, 1996. During that survey, the composting site was fully operational under the new management. Many positive changes to the site were obvious, including the reduced stock pile of sewage sludge and green waste, a new office trailer, and most importantly, new front-end loaders equipped with air conditioned enclosed cabs. Other equipment used consisted of a compost mixing truck, a screener, and a new chipper/grinder. Water was also now available from the nearby quarry to spray on the compost and the roads to keep dust down.

Total dust concentrations from the samples collected upwind ranged from 0.2 to 21.5 mg/m^3, with the highest level measured on the outside of the loader working the greens. Other samples of note were the total and respirable samples collected inside and outside of the cab of a front end loader loading in the greens area. Total dust concentrations inside the cab were 0.69 mg/m^3, while concentrations measured outside were 21.5 mg/m^3.

Respirable dust concentrations inside and outside the cab were 0.3 ands 0.72 mg/m^3, respectively with the highest level measured on the access road to the landfill.

Bacteria concentrations ranged from none detected (ND) to 8.0×10^7 colony forming units per cubic meter of air (CFU/m^3), with the highest levels also measured on the loader at the greens. The primary bacteria identified was *Bacillus.* Thermophilic bacteria was only detected on the sample collected near the workshop. Fungi concentrations ranged from ND to 2.8×10^6 CFU/m^3, with the highest levels measured near chipper/grinder. The primary fungi identified from the samples were *Aspergillus and Penicillium.* Endotoxin concentrations ranged from none detected (ND) to 3.0×10^5 endotoxin units per cubic meter of air (EU/m^3), with the highest concentration measured near the greens chipper/grinder.

To reduce this potential hazard it is important to reduce worker exposures by means of either engineering controls (e.g., enclosed cabs), respiratory protection, or a combination of engineering controls and respiratory protection. Samples collected showed that the enclosed cabs, when used properly such as keeping the windows closed, can reduce worker exposures. However, these controls are relatively ineffective if the cab windows are opened during compost handling operations. 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.

The results from this health hazard evaluation has shown that the enclosed machinery cabs on the equipment can reduce exposures. Also, these results show that individuals in the general area of the chipper/grinder should wear respiratory protection during operation.

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. Just as individuals vary in their resistance to disease, a few individuals may be particularly sensitive to some of the organisms in compost.

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

TABLE OF CONTENTS

INTRODUCTION

On March 28, 1995, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation from the Maui County Council, Maui, Hawaii. In their request, the Council asked NIOSH to evaluate their composting operation since they had received complaints of poor working conditions from former employees, as well as complaints from neighboring business (Kahului Airport) about odors emitting from the composting site. There was no indication that any current employees have or had any health problems associated with the compost operation. This request was also prompted by the NIOSH Alert pertaining to Organic Dust Toxic Syndrome (ODTS).[1]

On May 11, 1995, NIOSH investigators conducted an initial site visit to the composting facility. The composting operation was toured, and baseline area air samples were collected for total dusts, bacteria, fungi, and endotoxin. On September 11-13, 1995, a return visit was made to the composting facility to conduct a comprehensive industrial hygiene survey. A final survey was conducted during June 24-26, 1996.

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 in organic dusts as well as other microbiological agents, are suspected etiologic agents.[1]

In June 1993, the County of Maui contracted a consultant to develop a Compost Research and Demonstration project using sewage sludge and green waste. Both components of the compost are trucked into the site from all over the island. The composting site developed is located within an area of the island's sanitary landfill, which is also adjacent to the Kahului Airport to the north and a quarry/mill to the east.

The site was developed using a windrow method of composting. Sewage sludge is mixed with the green waste and piled into long windrows for composting. Each windrow would be frequently turned using a Scarab. The final composting product produced was a "Class A" compost which is used for County government landscaping projects. 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 commercial/industrial users.

On May 11, 1995, NIOSH investigators conducted an initial site visit to the composting facility. The composting operation was toured, and area air samples were collected for total dusts, bacteria, fungi, and endotoxin. Bulk samples were collected of the various compost products for microbiological analysis. The purpose for collecting these samples was to determine the microbial activity of the compost. The contractor and one of his employees were working at the site during this visit. Additional people (mainly family and friends of the contractor) could be brought in to help if necessary. The contractor operating the site was in the process of ending his contract with the County, so very little work was being accomplished at that time. At the time of this survey, the Scarab used at this site was not operational, so the windrows were turned by front-end loaders. The chipper grinder was also not operational, so the green waste was stock piled. Two, open cab, front end-loaders were working at the site. The two loader operators were observed wearing handkerchiefs over their noses and mouths in an attempt to protect themselves from the dust. No water was available at the site for personal use, or for dust control. Since the contractor was in the process of leaving the site, it was decided that a return visit would be made once the new contractor took control of the site.

Midway through this HHE, a new contractor was hired to operate the composting site. The new contractor planned on utilizing negative flow static pile methods to produce compost, thereby eliminating the need for a Scarab to turn the windrows. The negative flow static method consisted of pulling air through the compost piles by means of PVC pipes attached to large air pumps.

On September 11-13, 1995, a return visit was made to the composting facility to conduct a comprehensive industrial hygiene survey. During that survey, the old contractor was still in the process of leaving and the new contractor preparing to take over operations. During that transition, old contractor was loading and removing product, while the new contractor was focusing on reducing the stock-pile of accumulated green waste and sewage sludge by mixing one static windrow of compost. Four open-cabbed front end loaders and a mixing truck were being used at the site. Work area air samples were collected for total dusts, bacteria, fungi, and endotoxin on the loaders operating at the site. Samples were also collected at different areas of the site, as well as, upwind and down wind of the site. The County Council representative was informed of the situation at the site, and NIOSH suggested a return visit after the new contractor was fully operational. It was anticipated that it would be approximately six months to a year before the new contractor would be fully operational and producing compost.

A final survey was conducted during June 24-26, 1996. During that survey, the composting site was fully operational under the new management. Many positive changes to the site were obvious, including the reduced stock pile of sewage sludge and green waste, a new office trailer, and most importantly, new front-end loaders equipped with air conditioned enclosed cabs. Other equipment used consisted of a compost mixing truck, a screener, and a new chipper/grinder. Water was also now available from the nearby quarry to spray on the compost and the roads to keep dust down. Area air samples were collected for total dusts, respirable dust, bacteria, fungi, and endotoxin during operations. Samples were collected at various areas on and off the composting site, as well as inside and outside of equipment cabs.

METHODS

Over the course of the health hazard evaluation, work area air samples were collected for respirable dusts, total dusts, ammonia, bioaerosols and endotoxin. Bulk samples were collected of 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.

Respirable Dust

Work area samples for the estimation of respirable dusts were collected on pre-weighed, 37-millimeter (mm) diameter, 5-micron (µm) pore size, polyvinyl chloride (PVC) membrane filters, mounted in series with 10-mm Dorr-Oliver nylon cyclones. Air was drawn through the filter at a flow rate of 1.7 liters per minute (lpm) using a battery-powered sampling pump. Respirable dust content was analyzed gravimetrically according to NIOSH Method 0600.[3]

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 (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. 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 52ºC ± 2 for 10 days and then examined for the isolation of thermophilic 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 parts per million (ppm).

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.

Total / Respirable 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, p. 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.

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.

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]

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. [12] 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.[13,14] 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

May 1995 Survey

The results from the work area samples collected during the May 1995 survey are shown in Table 1. Area air samplers were set-up at nine locations; three downwind (near the quarry, ½ mile off-site, and 1 mile off-site), two within the site, the greens sites, the sludge pit, the workshop, and on an open cab front-end loader. Area air samples were collected for total dusts, bacteria, fungi, and endotoxin. Bulk samples were collected of the various compost products for microbiological analysis. Sampling times were 2 - 4 hours and do not reflect full shift time weighted average concentrations.

Total dust concentrations ranged from 0.22 to 3.0 mg/m^3, with the highest levels located downwind near the quarry. The open cab end loader had a dust exposure of 1.47 mg/m^3. Total dust samples collected downwind of the composting site were low at less than 0.5 mg/m^3.

Bacteria concentrations ranged from 5.0 x 10^3 to 2.9 x 10^5 colony forming units per cubic meter of air (CFU/m^3), with the highest levels measured near the workshop. The primary bacteria identified was *Bacillus*. Thermophilic bacteria were only detected on the sample collected near the workshop. Fungi concentrations ranged from 2.0 x 10^3 to 3.1 x 10^5 CFU/m^3, with the highest levels also measured near the workshop. The primary fungi identified from the samples were *Aspergillus and Penicillium*.

Endotoxin concentrations ranged from none detected (ND) to 284 endotoxin units per cubic meter of air (EU/m^3), with the highest concentration measured on the front end loader moving compost. The specific amounts of microorganisms found in the bulk samples of the composts varied with 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.

September 1995 Survey

The air sampling results from the September 1995 survey are presented in Table 3. Area air samplers were set-up upwind, downwind, near the chipper/grinder, and on the front end loaders. Sampling times were 2 - 4 hours, and therefore do not reflect a full shift time weighted average concentration. Work area air samples were collected for total dusts, bacteria, fungi, and endotoxin.

Total dust concentrations from the samples collected upwind ranged from 0.21 to 3.6 mg/m^3, with the highest level measured on the access road to the landfill. The range of total dust concentrations for the downwind samples were 0.64 and 0.70 mg/m^3. The results for the total dust samples collected on the loaders ranged from 2.0 to 6.0 mg/m^3, with the highest levels measured on a loader moving finished compost. Total dust concentrations for the three samples collected at the operator's position along side of the chipper/grinder were 3.8, 5.4, and 15.3 mg/m^3.

Bacteria concentrations ranged from ND to 3.4 x 10^6 CFU/m^3, with the highest levels also measured at the chipper/grinder. The primary bacteria identified was *Bacillus*. Fungi concentrations ranged from 1.5 x 10^3 to 2.8 x 10^6 CFU/m^3, with the highest levels measured near the chipper/grinder. The primary fungi identified from the samples was *Aspergillus*. Endotoxin concentrations ranged from none detected (ND) to 3.0 x 10^5 EU/m^3, with the highest concentration measured at the chipper/grinder.

June 1996 Survey

Air sampling results for the June 1996 survey are shown in Table 4. During this three day survey, samples were collected at upwind and downwind locations, inside and outside of composting equipment (loaders and the mixing truck), at the screener, near the chipper/grinder, by the sludge pile, and inside the office trailer. Area air samples were collected for total dusts, respirable dust, bacteria, fungi, and endotoxin during work operations.

Total and respirable dust concentrations from the samples collected upwind ranged from 0.16 to 1.12 mg/m^3 and 0.05 to 0.2 mg/m^3, respectively. Sample collected downwind of the composting ranged from 0.17 to 1.56 mg/m^3 for total dusts, and 0.01 to 0.07 mg/m^3 for respirable dusts. Other samples of note were the total and respirable samples collected inside and outside of the cab of a front-end loader loading in the greens area. Total dust concentrations inside the cab were 0.69 mg/m^3, while concentrations measured outside were 21.5 mg/m^3. Respirable dust concentrations inside and outside the cab were 0.3 and 0.72 mg/m^3, respectively.

Bacteria concentrations ranged from ND to 8.0×10^7 CFU/m^3, with the highest levels also measured outside the cab of a loader working at the greens. In comparison, the bacteria concentration measured inside the loader's cab was 2.5×10^3 CFU/m^3. The primary bacteria identified were *Micrococcus* and *Bacillus*. Fungi concentrations ranged from ND to 9.4×10^4 CFU/m^3, with the highest levels also measured outside of the green's front end loader. Fungal concentrations measured inside the cab were 3.2×10^2 CFU/m^3. The primary fungi identified from the samples was *Aspergillus*. Endotoxin concentrations ranged from 1.6 to 208 EU/m^3, with the highest concentration outside the loader working the greens. Ammonia concentrations measured during turning operations ranged from <5 parts per million (ppm) to a high of 20 ppm.

DISCUSSION/ CONCLUSIONS

This health hazard evaluation was requested by the Maui County Council, 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. Over the course of the evaluation, many positive changes were obvious, including the reduced stock pile of sewage sludge and green waste, a new office trailer, and most importantly, new front-end loaders equipped with air conditioned enclosed cabs. Water was also available from the nearby quarry to spray on the compost and the roads to keep dust down.

Since microorganisms play such an important role in composting, there may 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 measure 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 using engineering controls (e.g., enclosed cabs), respiratory protection, or a combination of engineering controls and respiratory protection.

The results from this health hazard evaluation and other studies has shown that the enclosed machinery cabs, when used properly with windows closed, can reduce worker exposures. However, these controls are relatively ineffective if the cab windows are opened during compost handling operations. 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.

Air 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.

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, especially near the chipper/grinder - 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.

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Table 1

May 1995 Air Sampling Results

HETA 95-0203

Maui Composting

Maui, Hawaii

Sampling Location	*Bacterial Identification*	*Bacteria Concentration (CFU/m³)*	*Total*	*Thermophilic Bacteria (CFU/m³)*	*Fungal Identification*	*Fungal Concentration (CFU/m³)*	*Total*	*Total Dust (mg/m³)*	*Endotoxin Units (EU/m³)*
Front End Loader - Open Cab	*Bacillus*	2.5×10^4	2.5×10^4	*ND*	*Aspergillus* *Penicillium*	4.0×10^4 2.5×10^4	6.5×10^4	1.47	284
Front Workshop Bldg	*Bacillus* *Micrococcus* *Streptomyces* *Klebsiella*	1.6×10^5 1.0×10^4 5.1×10^4 5.1×10^4	2.8×10^5	5.0×10^5	*Aspergillus* *Penicillium* *Cladosporium* *Acremonium* *Geotrichum* *Microsporium*	1.2×10^5 1.0×10^5 5.1×10^4 1.0×10^4 1.0×10^4 1.0×10^4	3.1×10^5	0.6	122
Sludge Pit	*Bacillus* *Streptomyces*	5.6x104 6.0x103	6.2×10^4	*ND*	*Aspergillus* *Penicillium* *Cladosporium*	3.4×10^4 3.0×10^4 2.0×10^3	6.6×10^4	1.3	193
Downwind near Quarry	*Enterobacter* *Bacillus*	9.0×10^3 6.8×10^3	1.6×10^4	*ND*	*Aspergillus* *Penicillium* *Cladosporium*	2.5×10^3 5.0×10^3 9.0×10^3	1.7×10^4	3.0	3.7
Mid-Pad - Windrow (mature compost)	*Bacillus*	2.6×10^4	2.6×10^4	*ND*	*Aspergillus* *Penicillium*	9.0×10^3 2.1×10^3	1.1×10^4	0.3	35.4

Mid-Pad Windrow (½ life age)	*Bacillus* *Streptomyces*	$3.2x10^4$ $4.3x10^3$	$3.7x10^4$	*ND*	*Cladosporium*	$2.2x10^3$	$2.2x10^3$	2.7	12.2

Table 1 (continued)

May 1995 Air Sampling Results

HETA 95-0203

Maui Composting

Maui, Hawaii

Sampling Location	*Bacterial Identification*	*Bacteria Concentration (CFU/m^3)*	*Total*	*Thermophilic Bacteria (CFU/m^3)*	*Fungal Identification*	*Fungal Concentration (CFU/m^3)*	*Total*	*Total Dust (mg/m^3)*	*Endotoxin Units (EU/m^3)*
Greens Waste	*Bacillus* *Streptomyces*	$1.0x10^5$ $1.2x10^4$	$1.1x10^5$	*ND*	*Aspergillus* *Penicillium* *Cladosporium*	$2.0x10^4$ $2.0x10^4$ $2.5x10^3$	$4.3x10^4$	0.4	18.5
Off-Site - Downwind (½ mile)	*Bacillus*	$3.6x10^4$	$3.6x10^4$	*ND*	*Cladosporium* *Penicillium* *Aspergillus*	$1.9x10^4$ $2.7x10^3$ $2.7x10^3$	$2.5x10^4$	0.2	*ND*
Off-Site - Downwind (1 mile)	*Bacillus*	$5.2x10^3$	$5.3x10^3$	*ND*	*Cladosporium* *Penicillium* *Aspergillus*	$1.0x10^4$ $5.2x10^3$ $2.6x10^3$	$1.8x10^4$	0.4	6.3

Table 2

May 1995 Bulk Sample Microbial Results

HETA 95-0203

Maui Composting

Maui, Hawaii

Sampling Location	*Primary Bacteria*	*Bacteria Concentration (CFU/g)*	*Thermophilic Bacteria Concentration (CFU/g)*	*Primary Fungi*	*Fungal Concentration (CFU/g)*
Fresh Sewage Sludge	*Acinetobacter*	2.2×10^{9}	ND	*Geotrichum*	1.2×10^{8}
Newly mixed compost	*Bacillus*	2.0×10^{8}	ND	*Penicillium*	2.5×10^{3}
Aged 1 week compost	*Streptomyces*	2.0×10^{8}	1.8×10^{6}	ND	
Finished Compost	*Flavobacterium*	3.7×10^{8}	1100	*Penicillium*	1.6×10^{3}

Table 3

September 1995 Air Sampling Results

HETA 95-0203

Maui Composting

Maui, Hawaii

September 11, 1995

Sampling Location	*Bacterial Identification*	*Bacteria Concentration (CFU/m^3)*	*Total*	*Fungal Identification*	*Fungal Concentration (CFU/m^3)*	*Total*	*Total Dust (mg/m^3)*	*Endotoxin Units (EU/m^3)*
Upwind	*None Detected*			*Fusarium*	$1.0x10^3$			
				Verticillium	$5.3x10^2$			
				Cladosporium	$2.6x10^2$	$1.8x10^3$	0.21	None Detected
Downwind	*Bacillus*	$2.0x10^3$	$2.0x10^3$	*Cladosporium*	$1.3x10^3$			
				Rhizopus	$2.2x10^2$	$1.5x10^3$	0.70	9.4
Front- End Loader -Compost	*Bacillus*	$1.5x10^4$	$1.5x10^4$	*Aspergillus*	$2.2x10^3$			
				Penicillium	$5.5x10^2$			
				Verticillium	$3.6x10^2$			
				Fusarium	$3.6x10^2$			
				Yeast	$1.1x10^4$	$1.5x10^4$	2.43	113.6
Front- End Loader (Moving greens to sludge area)	*Bacillus*	$2.9x10^4$		*Aspergillus*	$2.3x10^4$			
	Curtobacterium	$1.3x10^4$	$4.3x10^4$	Yeast	$1.7x10^4$	$4.1x10^4$	3.95	366.8
Front- End Loader (Loading greens into chipper)	*Bacillus*	$6.1x10^4$	$6.1x10^4$	*Aspergillus*	$5.4x10^4$			
				Yeast	$2.1x10^4$	$7.6x10^4$	2.77	461.3
Near Chipper / Grinder	*Bacillus*	$3.4x10^6$	$3.4x10^6$	*Aspergillus*	$9.4x10^5$			
				Penicillium	$2.2x10^5$			
				Yeast	$1.3x10^6$	$2.8x10^6$	5.45	$3.0x10^5$

Table 3 (continued)
September 1995 Air Sampling Results

HETA 95-0203
Maui Composting
Maui, Hawaii

September 12, 1995								
Sampling Location	*Bacterial Identification*	*Bacteria Concentration (CFU/m^{3})*	*Total*	*Fungal Identification*	*Fungal Concentration (CFU/m^{3})*	*Total*	*Total Dust (mg/m^{3})*	*Endotoxin Units (EU/m^{3})*
Upwind	None Detected			*Fusarium*	$1.3x10^{6}$	$1.3x10^{6}$	0.53	None Detected
Downwind	*Bacillus*	$4.5x10^{2}$	$4.5x10^{2}$	*Cladosporium* Yeast	$1.3x10^{3}$ $9.0x10^{2}$	$2.3x10^{3}$	0.6	70
Front- End Loader -Compost	None Detected			*Aspergillus*	6.0x1004	$6.0x10^{4}$	2.0	311
Front- End Loader (Loading greens into chipper)	*Bacillus* *Streptomyces* *Curtobacterium*	$2.2x10^{4}$ $1.1x10^{4}$ $1.1x10^{4}$	$4.5x10^{4}$	*Aspergillus*	1.1x1004	$1.1x10^{4}$	1.73	127
Exhaust from static windrow fan	*Bacillus* *Streptomyces*	1.7x103 5.1x102	$2.3x10^{3}$	None Detected			0.8	11
Near Chipper / Grinder	*Bacillus*	$1.0x10^{6}$	$1.0x10^{6}$	*Aspergillus* *Penicillium* *Cladosporium*	$1.0x10^{5}$ $2.5x10^{4}$ $5.1x10^{3}$	$1.3x10^{5}$	15.3	$2.8x10^{3}$

Table 3 (continued)
September 1995 Air Sampling Results

HETA 95-0203
Maui Composting
Maui, Hawaii

September 13, 1995								
Sampling Location	*Bacterial Identification*	*Bacteria Concentration (CFU/m^3)*	*Total*	*Fungal Identification*	*Fungal Concentration (CFU/m^3)*	*Total*	*Total Dust (mg/m^3)*	*Endotoxin Units (EU/m^3)*
Upwind - offsite (near road towards landfill)	*Bacillus* *Curtobacterium*	4.9x10^3 2.0x10^3	7.0x10^3	*Aspergillus* *Cladosporium*	2,083 520	2.6x10^3	3.85	None Detected
Upwind - onsite	None Detected			*Aspergillus* *Cladosporium* *Acremonium* *Penicillium*	1.0x10^3 8.7x10^2 4.3x10^2 4.3x10^2	2.8x10^3	0.8	65
Downwind	*Bacillus*	1.3x10^3	1.3x10^3					
Front- End Loader -Compost	*Bacillus* *Curtobacterium*	3.6x10^4 2.1x10^4	5.7x10^4	*Aspergillus*	1.2x10^4	1.2x10^4	6.0	421
Inside Mixing Truck	*Bacillus*	8.0x10^5	8.0x10^5	*Aspergillus* *Penicillium* *Cladosporium* Yeasts	1.5x10^3 43.x10^2 4.3x10^2 7.6x10^5	7.6x10^5	1.3	117
Near Chipper /Grinder 70 feet downwind	*Bacillus*	1.3x10^6	1.3x10^6	*Aspergillus*	5.8x10^4	5.9x10^4	3.8	None Detected

Table 4
June 1996 Air Sampling Results

HETA 95-0203
Maui Composting
Maui, Hawaii

June 24, 1996										
Sampling Location	*Bacterial Identification*	*Bacteria Concentration (CFU/m³)*	*Total*	*Fungal Identification*	*Fungal Concentration (CFU/m³)*	*Total*	*Total Dust (mg/m³)*	*Respirable Dust (mg/m³)*	*Endotoxin (EU/m³)*
Downwind	*Bacillus* *Rhodococcus*	$3.0x10^3$ $2.0x10^2$	$3.2x10^3$	*Aspergillus* *Cladosporium*	$8.0x10^2$ $4.0x10^2$	$1.2x10^3$	1.5	0.07	3.6
Upwind	None Detected			*Cladosporium*	1.9x102	$1.9x10^2$	1.1	0.20	3.4
Mixing Truck	*Bacillus* *Rhodococcus*	$2.0x10^2$ $2.0x10^2$	$4.0x10^2$	*Aspergillus*	$4.0x10^2$	$4.0x10^2$	0.6	0.07	6.4
Loader at Screener	*Bacillus*	$9.0x10^3$	$9.0x10^3$	*Aspergillus* *Fusarium*	$8.0x10^2$ $4.0x10^2$	$1.2x10^3$	1.5	0.14	21.6
Downwind of Screener	CDC Group A-5 (MCB spp.) *Bacillus*	$2.0x10^5$ $1.2x10^5$	$3.2x10^5$	*Penicillium* *Syncephalastrum* *Cladosporium* Bipolartis	$2.3x10^3$ $2.3x10^3$ $7.1x10^2$ $2.3x10^2$	$5.7x10^3$	14.9	0.16	27.1

Table 4 (continued)
June 1996 Air Sampling Results

HETA 95-0203
Maui Composting
Maui, Hawaii

June 25, 1996									
Sampling Location	*Bacterial Identification*	*Bacteria Concentration (CFU/m³)*	*Total*	*Fungal Identification*	*Fungal Concentration (CFU/m³)*	*Total*	*Total Dust (mg/m³)*	*Respirable Dust (mg/m³)*	*Endotoxin (EU/m³)*
Downwind Pad	*Bacillus*	$5.7x10^2$	$5.7x10^2$	*Aspergillus*	$1.4x10^2$	$1.4x10^2$	0.17	0.07	2.0
Downwind ½ mile	*Bacillus*	$2.1x10^3$	$2.1x10^3$	None Detected					
Downwind 1 mile	*Bacillus*	$1.4x10^2$	$1.4x10^2$	*Cladosporium*	$1.4x10^2$	$1.4x10^2$			
Upwind	None Detected			None Detected			0.45	0.05	1.6
Upwind ½ mile							0.16		4.8
Mixing Truck	*Bacillus*	$1.8x10^4$	$1.8x10^4$	*Cladosporium* *Aspergillus*	$2.7x10^4$ $2.0x10^4$	$4.9x10^4$	0.44	0.05	9.7
Greens Chipper/Grinder	*Bacillus*	$1.1x10^4$	$1.1x10^4$	*Aspergillus*	$4.3x10^4$	$4.3x10^4$	0.46	0.33	30.3
Loader at Screener	Unidentified *Bacillus* *Rhodococcus*	$1.5x10^4$ $3.3x10^3$ $1.3x10^2$	$1.9x10^4$	*Aspergillus* *Rhizopus*	$1.3x10^2$ $1.3x10^2$	$2.8x10^2$	1.5	0.14	21.6
Downwind of Screener	*Bacillus*	428	$4.3x10^2$	*Aspergillus*	$1.4x10^2$	$1.4x10^2$	0.14	0.01	3.1

Table 4 (continued)
June 1996 Air Sampling Results

HETA 95-0203
Maui Composting
Maui, Hawaii

June 26, 1996										
Sampling Location	*Bacterial Identification*	*Bacteria Concentration (CFU/m³)*	*Total*	*Fungal Identification*	*Fungal Concentration (CFU/m³)*	*Total*	*Total Dust (mg/m³)*	*Respirable Dust (mg/m³)*	*Endotoxin (EU/m³)*
Downwind Pad	*Micrococcus* *Rhodococcus* *Bacillus*	$8.0x10^3$ $3.2x10^3$ $8.0x10^2$	$1.2x10^4$	*Cladosporium*	$1.6x10^2$	$1.6x10^2$	0.23	0.01	2.5
Upwind	None Detected			None Detected			0.45	0.05	1.6
Near Sludge Pile	None Detected			None Detected			0.23		3.9
Mixing Truck (inside cab)	*Bacillus*	$1.4x10^3$	$1.4x10^3$	*Cladosporium*	$1.6x10^2$	$1.6x10^2$	0.50	0.8	13.8
Mixing Truck (outside cab)							1.78		119.7
Greens loader (inside cab)	*Bacillus*	$2.5x10^3$	$2.5x10^3$	*Aspergillus*	$3.2x10^2$	$3.2x10^2$	0.69	0.30	9.1
Greens loader (outside cab)	*Micrococcus* *Bacillus*	$7.8x10^7$ $2.2x10^6$	$8.0x10^7$	*Aspergillus*	$9.4x10^4$	$9.4x10^4$	21.5	0.72	208.1
Office	*Bacillus*	$6.7x10^2$	$6.7x10^2$	None Detected			0.73		2.3

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