Bioaerosol emissions from composting facilities as a potential health risk for composting workers

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Abstract: Exposure to bioaerosols in the occupational environment is associated with a wide range of adverse health effects. Composting is biological decomposition of organic waste material which necessarily leads to proliferation of microorganisms within the composting substrate, it is potential for these microorganisms to become airborne as the compost is being turned and screened. Exposure to bioaerosols could be a cause of respiratory symptoms and lung function impairment. The aim of this study was to assess worker exposure to bioaerosols emitted from a urban waste composting facility in Isfahan, Iran. To assess the concentration of bioaerosols, fungi and bacteria were collected using an Andersen biosampler from 8 point on–site and one point off-site as background sample. Air temperature, relative humidity and wind speed were also recorded at the time of sampling. Peak levels of both microorganisms were measured at composting pile windrows followed by screening site and storage piles. Total bacterial and fungal concentrations averaged 9307 cfu/m$^3$ and 764 cfu/m$^3$ for composting piles and 1113 and 130 cfu/m$^3$ for background samples, respectively. Concentration of fungi was lower than bacteria during all stages of the composting processes. There is a significant decreasing of bioaerosol concentrations with the distance of composting piles and 250 m downwind from the compost piles was the distance by which concentrations were found to reach the background concentrations. These results indicated that compost workers are at risk of developing chronic and acute respiratory health effects due to the exposure to bioaerosols from composting process.

Key-words: composting process, bioaerosol, emission, health risk, fungi, bacteria

1 Introduction
Composting is biological decomposition of organic waste material which necessarily leads to proliferation of microorganisms within the composting substrate. Whenever composting materials are handled, for examples during the shredding, turning and screening, the microorganisms could be aerosolized, forming what is termed bioaerosol [1]. Thus, the potential of exposure to large concentrations of bioaerosols at composting facilities exists and thereby poses a health problem for workers. Inhalation of bioaerosols can cause a variety of adverse health effects [2, 3, 4], especially in sensitized individuals. Allergic rhinitis and asthma, chronic bronchitis, extrinsic allergic alveolitis and organic dust syndrome (ODTS) are major groups of respiratory diseases associated with compost bioaerosol exposure [5, 6, 7]. The aim of this study was to assess worker exposure to bioaerosols emitted from an urban waste composting facility. A further aim of this study was to assess environmental conditions that could be effective in dispersion of bioaerosols from the composting facility.

2 Problem Formulation (Materials & Methods)
This study evaluated bioaerosol emissions at an urban waste composting facility in Isfahan, Iran, for a period of about six months. To assess the concentration of bioaerosols, fungi and bacteria were collected using an Andersen biosampler (N6 single stage viable cascade impactor) from 8 points at the composting site including; composting pile windrows, screening, storage piles, distances of 50, 100, 200, 250 meters downwind and 100 m upwind from the composting piles and one point out of the composting facility as the background sample. A total of 12 air samples were collected per location.

Weather conditions including temperature (°C), relative humidity (%) and wind speed (m/s) were also monitored and recorded through the use of a
plates were incubated for 3-5 days at 25ºC. Colonies growing on both media were enumerated and calculated as colony forming units per cubic meter (cfu/m³). Bacterial isolates were Gram-stained and fungal colonies were identified based on the colony characters and the morphological characteristics of spores.

3 Problem solution (Results)

Peak levels of both microorganisms were measured at composting piles followed by screening site and storage piles. The data are consistent with other composting studies that reported the high levels of bioaerosols emitted during the composting process such as shredding, turning and screening [1, 8, 9]. Bacterial and fungal concentrations at different points are showed in figure 1 and 2, respectively. Concentrations of airborne bacteria, fungal spores and Aspergillus fumigatus were significantly higher at composting piles compared to upwind and downwind concentrations. In comparison, bacterial levels were found to be higher than those of fungal spores. Bioaerosol concentrations was declined with distance from the composting piles and 250 m downwind from the compost piles was the distance by which concentrations were found to reach the background concentrations. Similar decreases in bioaerosol concentrations with distance at composting facilities have been reported [1]. Gram-positive bacteria were observed to be the predominant bacteria in all samples. The most common fungi were Aspergillus spp., yeasts, dematiaceous fungi (mostly Alternaria spp., Cladosporium spp. and Ulocladium spp.) and Penicillium spp., which were isolated from 100, 58, 42 and 33 percent of composting pile samples, respectively. Fusarium, Mucor, Rhizopus, Gloeocladium, Cryosporium, Scopulariopsis, Acremonium species and mycelium sterila were the other identified fungal genera.

The weather conditions ranged from 22°C to 37°C for ambient temperature with an average of 31°C, and from 10% to 28% with a mean value of 18% for relative humidity. The mean value of wind speed was 1.15 m/s. The statistical analyses showed a significant decrease of fungal concentrations with increasing of temperature (P <0.05).

4 Conclusions

Workers at composting facilities are potentially in exposure to high concentration of bioaerosols especially during the turning and screening of the compost. Since individuals may become increasingly sensitized to bioaerosols through repeated exposure, composting workers are at high risk of adverse health effects. In order to reduce occupational exposure, thus, certain practices such as wearing of respirators or isolating of the workers from spore –dispersing points of the processes are needed.

References:
Figure 1: Bacterial concentrations at different sampling points.

Figure 2: Concentration of fungal spores and \textit{Aspergillus fumigatus} at different sampling points.