

Exposure to volatile organic compounds in a composting plant

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ABSTRACT

Some previous studies have suggested that some of the volatile organic compounds (VOCs) found in composting plants may have a toxic effect that can influence, besides surroundings populations, workers from the composting plants. Impact of waste management to the environment and workers is already recognised as an environmental and occupational health concerns. Several studies regarding the VOCs and bioaerosols emissions from composting have been conducted all over Europe and also in Asia. However, in Portugal the studies developed are scarce and normally VOCs are not studied and recognize as a risk factor present in this occupational setting. Considering this, a study was developed in a Portuguese composting plant aiming to clarify if there was VOCs presence in the workplaces. Measurements were performed in six workplaces (Maintenance workshop, Centrifuges, Maturation Park, Pre-treatment, Control room and Waste screw) using a portable direct-reading equipment and done continuously for 5 min at each site. The mean, maximum and minimum values obtained in each location were considered. VOCs results showed that the workplaces called Waste Screw, Control Room and Pre-treatment obtained the higher values (mean values [ppm]: 20.8, 4.1 and 8.6, respectively). In this study, was not possible to identify the specific VOCs present in the different workplaces making impossible to recognize the specific emission sources, however, it was possible to confirm that in this occupational setting workers are exposed simultaneously to several VOCs and the health effects of possible synergetic reactions are not known and it is important to developed more research work about this matter. The results allowed the definition of a more detailed sampling strategy and to recognize the need of more specific and sensitive analytical resources to better characterize exposure to this specific risk factor in composting plants.

Keywords: composting plants, volatile organic compounds, occupational exposure

1. INTRODUCTION

Composting is an important process of solid waste management and it can be used for treatment of a variety of different wastes (green waste, household waste, sewage sludge and more). This process aims to reduce the volumes and to create a valuable product which can be recycled as a soil amendment in agriculture and gardening (Duquenne et al., 2012). The process is essentially divided into several steps involving proliferation of microorganisms to high concentration, complex succession of bacterial and fungal microflora and increase in temperature up to 60–70 °C (Duquenne et al., 2012). The handling of waste and compost that occurs frequently in the process (compost turning, shredding, and screening) has been shown to be responsible for the release of airborne microorganisms and their compounds in the air of the composting facilities. Therefore, dust, mesophilic and thermophilic microorganisms as well as volatile organic compounds, endotoxins and glucans have been found at high levels in numerous composting facilities and may present an exposure hazard especially for workers (Tolvanen et al., 2005; Schlosser et al., 2009; Domingo and Nadal, 2009; Persoons et al., 2010; Sykes et al., 2011; Duquenne et al., 2012).

The aim of the present study was to assess the exposure to volatile organic compounds in a totally indoor composting plant located in Portugal. An additional goal was to identify the workplace with higher level of contamination.

2. MATERIALS AND METHOD

2.1 – Description of the composting plant

The capacity of the studied plant is of 40 thousand tons of biowaste per year and can go until 60 thousand tons per year. The facility consists in a building where different composting operations are performed. Waste is unloaded in a reception area which is confined and prepared to receive trucks with the waste and to avoid the emission of odors for the outdoor environment. First phase of the process is a waste pre-treatment that intends to remove undesirable materials from the process: essentially glass, rocks, plastics and metals. The next phase is anaerobic digestion and after dehydration there is closet composting action, followed by an open composting with forced aeration. All the process takes thirteen weeks.

2.2 - Volatile organic compounds measurements

Measurements of volatile organic compounds (VOCs) were performed in six workplaces (Maintenance workshop, Centrifuges, Maturation Park, Pre-treatment, Control room and Waste screw) using a portable direct-reading equipment (Wolfsense IQ-610- Graywolf Sensing Solutions; range: 0–10,000 ppm; accuracy: 3%). Measurements were taken in the workstations where the workers spend more time and done continuously for 5 min at each site. The mean, maximum and minimum values obtained in each location were considered. All measurements were performed near the workers' nasal area, at a height of about 1.5 m, and during routine work.

3. RESULTS AND DISCUSSION

VOCs results showed that the workplace called Waste Screw obtained the higher values (mean – 20.8 ppm), probably due to the fact that in this place there is a huge amount of waste being crushed (Table 1).

Table 1 - VOCs results obtained in each workplace. The results are presented in ppm.

	Control Room	Pre-treatment	Waste screw	Maturation Park	Centrifuges	Maintenance Workshop
Mean	4.1	8.6	20.8	1.3	2.5	3.0
Range	2.5-7.9	1.2-12.2	16-27.1	1.1-1.7	2.3-3	3.2-2.9

The other two places that also had high VOC concentrations were the Control Room and Pre-treatment. Contamination in these two places is probably more problematic than in Waste Screw, taking in consideration that workers spend more time on them (Figure 1).

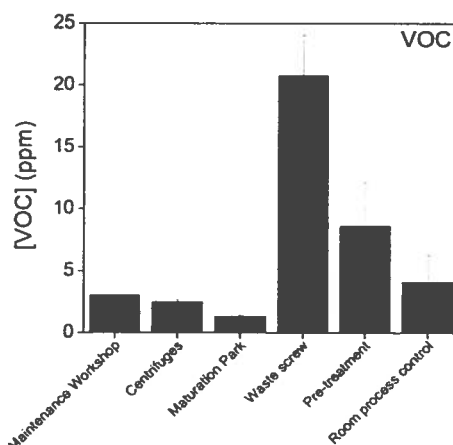


Figure 1 - VOCs results by workplace. The results are presented in ppm.

Several hazardous agents may be released during the waste composting process (Harrison, 2007; Kummer and Thiel, 2008; Nadal et al., 2009). Some of the contaminants in the form of bioaerosols that can be point out are for instance bacteria and fungi. Also, VOCs, such as benzene, styrene, formaldehyde among others are usually present and can represent concern regarding the possible health effects related (Déportes et al., 1995; Herr et al., 2003; Albrecht et al., 2008; Nadal et al., 2009). Presence of these contaminants is explained by accumulation and/or operational processes for treating the organic fraction of the waste (Déportes et al., 1995; Eitzer, 1995).

In more detail, the presence of VOCs in a composting plant can have different emission sources, namely resulting from the organic waste decomposition process, due to bacteria and fungi presence and, also, due to machinery (trucks, forklift) used to transport waste in the plant (exhaust gases). In this study, was not possible to identify the specific VOCs present in the different workplaces making impossible to recognize the specific emission sources. In addition, taking into consideration measurement equipment used, it's necessary to deal with uncertainty because of the non-specificity of the response for chemical mixtures. Therefore, for knowing the relative concentration of the mixture constituents a number of measurements by a specific method (e.g. charcoal tubes with chromatographic analysis) should be carried out in the future. Nadal and colleagues (2009) developed a study in a waste organic treatment plant, using the methods NIOSH 1501 and NIOSH 2016 and obtained more detailed results regarding VOCs contamination (NIOSH, 1994). For instance, in this last study, benzene, toluene, ethylbenzene, xylene (known as BTEX) and styrene were the dominant aromatics found. However, Tolvanen and colleagues (2005) developed a study in a drum composting plant in Finland and found other agents such as 2- Butanone, methyl acetate, limonene and others. Differences in the agents found in both studies are probably related with differences in the composting process, in the waste composition and also in the process phase or local where measurements took place. For instance, results from laboratory experiments indicate that yard waste primarily produce terpens, while food waste primarily produces acids and alcohols (Komilis et al., 2004).

Nevertheless, a common factor in both studies and probably also in our study can be stated: workers are exposed simultaneously to several VOCs and the health effects of possible synergetic reactions are not known and it is important to developed more research work about this matter. Considering the higher VOCs results obtained in some workplaces, such as Control Room and Pre-treatment, some actions must be developed due to the time spent by workers in those places (in Control room almost 7 hours by shift), such as improving ventilation systems through higher ventilation rates in the case of Control Room and substitute, when possible, the type of vehicles that make the transport of waste inside the building, avoiding the emission of exhaust gases.

4. CONCLUSIONS

The results obtained in this study claim the attention to the need of further research regarding occupational exposure to VOCs in composting plants. Additionally, the results allowed the definition of a more detailed sampling strategy and to recognize the need of more specific and sensitive analytical resources to better characterize exposure to this specific risk factor.

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