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The identification and health risk assessment of odor emissions from waste landfilling and composting

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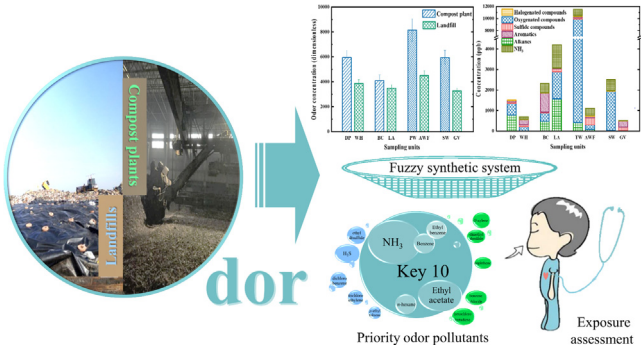
HIGHLIGHTS

- Odor emissions from working landfill/compost plant of same MSW were distinguished.
- Priority odor pollutants and the occupational exposure were initially screened and assessed.
- The critical odorants in landfilling/composting were different, with H_2S and NH_3, respectively.
- Non-carcinogenic risk of H_2S was serious for on-site workers at landfill.

GRAPHICAL ABSTRACT



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ABSTRACT

Odor nuisance is the main incentive for Not In My Back Yard campaigns around municipal solid waste (MSW) waste disposal facilities, and the odor identification is of significance for the understanding of the odor properties from MSW with different disposal methods. In this study, odor emissions from different stages at two large-scale working MSW disposal facilities, i.e., landfill (LF) and compost plant (CP), were distinguished with the same MSW feedstock in one city. It was found that CP suffered the heavier odor pollution and the characteristics of odorants changed significantly, especially the pile-turning workshop. Sulfides and aromatics were the main concentration contributors for LF, while that for CP were NH_3 and oxygenated compounds. Significant correlations between odor concentration and halogenated compounds, sulfides ($r^2 = 0.945, 0.898$, $p<0.05$, $n = 12$) were merely observed in CP. The priority odor pollutants of LF were H_2S, benzene and NH_3, while that of CP was NH_3, ethyl acetate and benzene with a descending order. With regarding to their contributions for occupational exposure, the carcinogenic risk was negligible for these facilities, but H_2S of LF might bring non-carcinogenic risk to on-site workers.

1. Introduction

In 2016, around 196.7 million tons of MSW was collected and treated in China, and Not In My Back Yard campaigns became the headache problem for the managers of MSW disposal facilities (NBSC, 2017). Landfill and compost, typical under anaerobic and aerobic conditions, were one of the main MSW disposal technologies, especially in

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developing countries (Lou et al., 2015a, 2015b, NBSC, 2017). However, the surrounding residents are troubled by the malodorous emissions from MSW disposal facilities, and the nuisance odor complaints account for 30.6% of air pollution issues, of which some 55% are associated with landfills or compost plants according to the records of environmental protection hotline of China in 2017 (ECC-MEEC, 2017).

As the complex compounds, the properties of odorants rely on the MSW composition, the treatment condition, and other factors (e.g., meteorology, geography, analysis methodology, etc.) significantly (Dincer et al., 2006; Hudson and Ayoko, 2009; Wu et al., 2017). Many works have been reported on these fields. For instance, the organic fraction of municipal solid waste (OFMSW) greatly contributes to the release of terpenes, acids, esters and NH_3 (Gallego et al., 2012; Gutiérrez et al., 2017; Lu et al., 2015). Fruit waste is the main source for NH_3, and food waste is the main contributor for NH_3 and H_2S in mixed-MSW (Lou et al., 2015a, 2015b). The odorants, e.g., terpenes and aromatics, are markedly affected by meteorological factors, e.g., temperature, wind, precipitation, etc. (Zou et al., 2003). The geographical difference, which may result in various climates, customs, diets, and policies, can influence the odor emissions from MSW significantly. A higher level of aromatics and halogenated compounds was observed in the MSW landfill in China (Liu et al., 2016; Wu et al., 2017). Odor emissions from landfills have been reported mainly with sulfides (e.g., H_2S, dimethyl sulfide, methyl mercaptan), aromatics (e.g., styrene, toluene and xylene), terpenoids (e.g., *a*-pinene), NH_3 and oxygenated compounds (e.g., acetone, methanol, *n*-butyl aldehyde) under anaerobic digestion processes (Duan et al., 2014; Fang et al., 2012; González et al., 2013), and high levels of NH_3, alcohols (e.g., ethanol, 1-propanol), acids (e.g., acetic acid), esters (e.g., ethyl acetate, propyl acetate, ethyl propionate) and terpenoids (e.g., *D*-limonene) were found in some aerobic composting process (Colón et al., 2017; Gallego et al., 2012; Gutiérrez et al., 2015; Huang et al., 2017; Soobhany et al., 2017). However, the difference between odor emissions from these two MSW disposal facilities are still unclear, especially on the same MSW feeding and the field scale treatment plants, which makes a big barrier for the selection of odor mitigation methods.

It is interesting to investigate exactly how the oxidation-reduction environment influence the evolution of VOCs emitted from the same MSW feeding, which would contribute to the specific deodorization management, e.g., deodorant spray or sorbent. Due to the complexity of odor compounds, the relationship between olfactory value and odor families, and the key offensive odorants identification are of great significance. The long term exposure to odorant pollutants, e.g., benzene, toluene, xylenes, benzene chloride, etc., may exert an adverse effect on human health (Davoli et al., 2010; Durmusoglu et al., 2010; Nadal et al., 2009), which might bring the non-carcinogenic or carcinogenic risk for the surrounding people, since ethylbenzene in odor nuisance has been reported to be the dominant health threat compound (Liu et al., 2016).

In this work, odorants from two typical working MSW disposal facilities in Shanghai (i.e., LF and CP, the detailed description was shown in Section 2.1), with the same MSW feedstock, were collected and identified to clarify the difference of odor components from MSW disposed under anaerobic and aerobic scenarios. The odor concentration and chemical levels of odor emissions from the dumping, transfer, disposal and post-treated process were analyzed using the triangle odor bag method and thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS), and the correlations between them were further discussed. Moreover, the priority odor pollutants were screened by fuzzy synthetic evaluation system, and their contributions for the occupational exposure were preliminarily estimated.

2. Materials and methods

2.1. Sampling sites description

The landfill (LF) in this study was located along the coast of East China Sea, some 60 km southeast from central Shanghai (31°03′N, 121°52′E) (Fig. 1(a)). The landfill site, with a daily disposal capacity of 7,600,000 kg, was divided into four phases and fifty-seven cell compartments according to time and spacial order, respectively. Odor emissions from one of the landfill compartments in IV phase (from 2010 to present, active working area) and the gas vent in III phase (from 2005 to 2010, soil covered area) were studied. The compost plant (CP) was situated in the southwest boundary of Shanghai, China (31°12′N, 121°04′E). It possessed a service area of 320 ha and disposal capacity of 500,000 kg per day. As illustrated in Fig. 1(b), after MSW was dumped, manual sorting combined with drum screen were adopted to eliminate the most of inorganic matters, e.g., papers, plastics, woods, metals, bricks etc. The oversize organic blocks continued to be crushed and re-sorted for obtaining the OFMSW. Dynamic aerobic compost technology, with regular pile-turning, was applied to treat the OFMSW. Some inorganic matters, e.g., papers, plastics and metals, were recycled and reused, while the rest was gathered and transferred to landfill. The MSW components of LF and CP were shown in Table S1.

Odorants were primarily released during the dumping, transfer, disposal and post-treated process of MSW treatment, and four sampling units were accordingly selected at the landfill and compost plant.

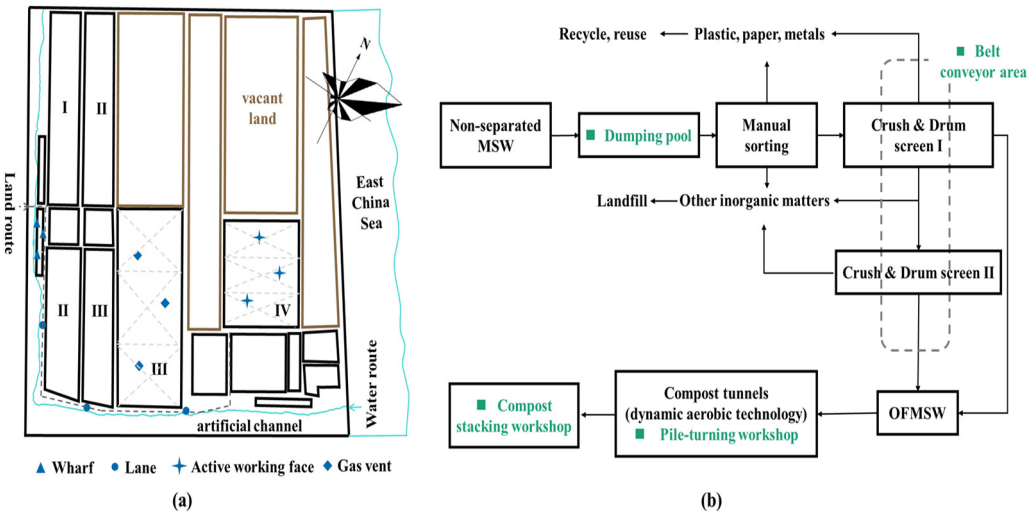

Fig. 1. The sampling units and technological process of landfill (a) and compost plant (b).