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VOCs released from municipal solid waste at the initial decomposition stage: Emission characteristics and an odor impact assessment

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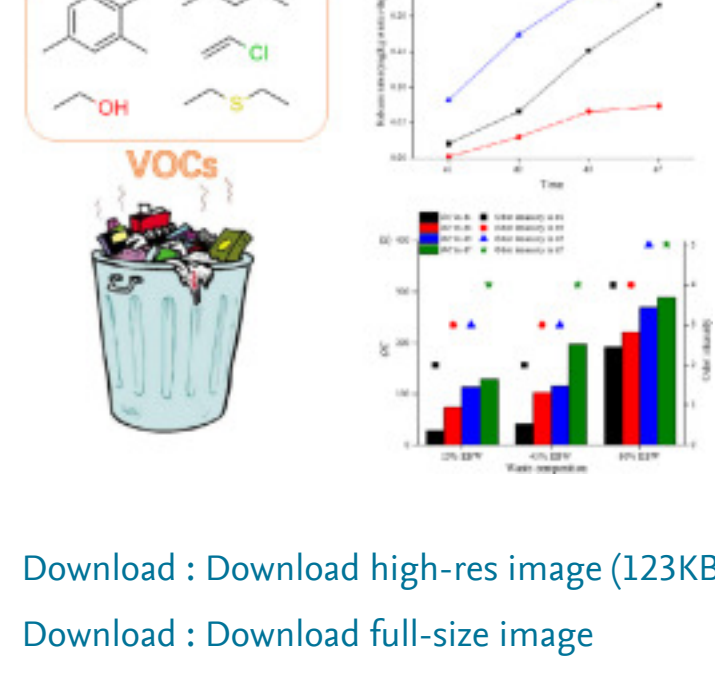
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Abstract

The nuisance from odor caused by municipal solid waste (MSW) is resulting in a growing number of public complaints and concerns. Odor pollution occurs in the initial decomposition stage of MSW, including waste collection, transportation and early pre-treatment. Furthermore, decomposition takes place in waste facilities that are often close to living areas, which can result in odor impacts on local inhabitants. However, this aspect of odor impact from MSW has not been well studied. In the current study, lab-scale waste cells were designed to simulate MSW storage conditions in the early stage. The characteristics of VOCs emissions with different waste compositions were analyzed. The odor concentration (C_0 , non-dimensional) method and odor intensity were used for the assessment of odor. Ethanol was the substance with highest emission rate. The release rate of VOCs increased with the growth easily biodegradable waste (EBW). VOCs emissions was reduced by 25% when the proportion of EBW decreased from 60% to 45%. Methyl sulfide, ethanol, dimethyl disulfide and ethyl acetate were identified as typical odorants. The EBW proportion in waste is the main factor significantly influencing odor pollution. The C_0 was 244.51 for the 60% EBW condition, which was only 61.46 for 15% EBW condition. These study results provide important information for the implementation of a garbage sorting policy and the monitoring of odor pollution from waste management.

Graphical abstract



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Introduction

Odor is ranked No. 2 among the 7 biggest environmental threats. Nuisance complaints during the municipal solid waste (MSW) management process have long been a public issue of concern (Nie et al., 2018). Organic compositions are mainly related to the emissions of odorants from MSW (Liu et al., 2018). Due to economic conditions and living habits, easily biodegradable organic compounds are the major composition in most developing Asian countries, particularly in China (He, 2010a; Yue et al., 2014). For example, 215 million tons of MSW were cleaned in China in 2018 (National Bureau of Statistics, 2019) and over 60% of the wet base was food wastes (Dong et al., 2010). As a result, large amounts of odorants are released from MSW. Although waste-sorting is becoming compulsory in several big cities in China (China GOSC, 2017), odor pollution is the current and future constraint on the development of solid waste disposal facilities.

Recently, volatile organic compounds (VOCs) from MSW management facilities have been widely studied (Chang et al., 2019b; Cheng et al., 2019). Over 140 species of VOCs have been detected from landfills (Allen et al., 1997). The landfill working face is considered the greatest source of VOCs emissions (Duan et al., 2014; Liu et al., 2016; Liu et al., 2015). In addition, VOCs, especially volatile sulfur compounds, are the main causes of odor pollution at landfill sites (Kim et al., 2009; Liu et al., 2018; Wu et al., 2018). In a recent study, oxygenated compounds were identified as the dominant component from an MSW transport station (Zhao et al., 2015). Above all, most studies mainly focused on MSW management facilities. However, before arriving at landfill sites or other facilities where they are properly treated, MSW are generated and stored in households and communities. The easily biodegradable organic fractions in MSW are degraded and result in by-products, such as VOCs, which are released from the time the waste is generated. This stage of the process is most closely related to where people live, but few studies have investigated the release of VOCs during the initial decomposition process of MSW (Statheropoulos et al., 2005).

In the initial decomposition stage (including waste collection, transportation and early pretreatment), MSW are naturally piled in open or partially sealed waste containers. VOCs are mainly released through direct volatilization from waste, aerobic bio-degradation and anaerobic bio-degradation (Wu et al., 2010). Hence, the waste composition and optional conditions are major impact factors on fugitive emissions of VOCs. Tan et al. (2017) investigated the emission characteristics of VOCs in the first 24 h after waste generation, and ethanol was detected as the dominant compound. Wu et al., 2020 identified ethanol, methyl mercaptan and hydrogen sulfide were as the key pollutants in waste storage stage. In large cities, MSW can be transported to waste management plants within 24 h of generation. Nevertheless, in less developed cities and rural areas, it is not possible to implement daily waste cleaning, and wastes are usually held in containers for a few days before being transported. Moreover, odor impacts in the initial decomposition stage have not been well studied.

For odor impact assessments, the olfactory test and theoretical threshold test are two principle methods that are used (Liu et al., 2018). The olfactory test is a subjective sensory assay method used to measure olfactory ability. In this test, the panelists' sensitivity determines the results and the odor pollution of each chemical compound cannot be analyzed (Blank, 2002; Oleszkiewicz et al., 2018). The theoretical threshold test is calculated based on an odor threshold value and provides results as an odor concentration (C_0) (Feilberg et al., 2010). The C_0 is a measure of importance of a specific compound to the odor of a sample. Compared with the olfactory test, the theoretical threshold test provides an option to combine the chemical concentration of a substance with its odor concentration (Feilberg et al., 2010; Wu et al., 2017). In addition, the theoretical threshold test could also help to identify the odor contribution of each substance.

The objective of this study was to reveal odor pollution in the initial decomposition stage of MSW in China. Lab-scale waste cells were designed to simulate MSW storage conditions in the early stage. Then, the characteristics of the emissions of VOCs during the process were analyzed, and the impacts of waste composition on VOCs emissions were investigated. An odor impact assessment was also conducted based on the theoretical threshold test. The typical odorant and odor intensity were identified during the initial decomposition stage of MSW. The results of the current study could provide further understanding of the emission characteristics of VOCs in the initial decomposition stage of MSW. In addition, with the implementation of a garbage sorting policy in China, the results could provide more information for monitoring odor pollution from waste management.

Section snippets

Experimental laboratory apparatus

Lab-scale waste cells were designed for the simulation of the MSW initial decomposition condition. These were chosen instead of full-scale dustbins or a landfill site as they permitted a more controlled system and improved the possibility of drawing findings more easily regarding the relationship between VOCs emissions and waste fractions. As shown in Fig. 1, the cells were cylindrical and made from polymethyl methacrylate, 3 reactors were operated for each condition at the same time.

Each...

Characteristics of VOCs emissions during the initial decomposition stage of MSW

A total of 43 VOC species were identified in the experimental batches, which can be classified into 5 categories, namely, sulfur compounds, aromatics, halogenated compounds, hydrocarbons, and oxygenated compounds. The qualitative and quantitative results across all tested batches are summarized in Table 2. Overall, the category and number of VOCs detected were similar for all the tested batches, but the concentrations of VOCs varied significantly during the process. These variations might be...

Conclusions

The characteristics of VOCs emissions and their odor impacts at the initial decomposition stage of MSW were studied. Oxygenated compounds had the highest concentration, and ethanol was the dominant compound. Methyl sulfide, ethanol, dimethyl disulfide and ethyl acetate were identified as typical odorants ($C_0 > 1$). The release rate of VOCs was mainly influenced by the proportion of EBW in the waste. The average release rate at the initial decomposition stage was 0.19 mg/kg waste/day (60% EBW)...

Declaration Competing of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper....

Acknowledgment

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- [Underestimated contribution of fugitive emission to VOCs in pharmaceutical industry based on pollution characteristics, odororous activity and health risk assessment](#)
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...Furthermore, with increasing in demand for medicine, the expansion on scale and amount of pharmaceutical factory in China would lead to the augment on VOC emission in the future. Previous studied have confirmed that VOCs from pharmaceutical industry were potent odorants (Liang et al., 2021; Liao et al., 2021; Zhang et al., 2020; Hu et al., 2020; Liu et al., 2020) or posing health risk on the population (Cheng et al., 2021; Liu et al., 2017). Characterization of VOC source and chemical composition was a key step to improve their odor abatement and reduce corresponding health risk in pharmaceutical industry....
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- [Emission of odor pollutants and variation in microbial community during the initial decomposition stage of municipal biowaste](#)
2023, *Science of the Total Environment*
Citation Excerpt :
...Municipal biowaste, including restaurant food waste (FW) and household kitchen waste (HKW), is principally recognised as being related to odorants nuisance complaints due to its high organic portion as well as high moisture, which could provide favourable conditions for the emission of odorants during the decomposing stage (He et al., 2020; Liu et al., 2020)...
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- [Degradation of biogas in a simulated landfill cover soil at laboratory scale: Compositional changes of main components and volatile organic compounds](#)
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...The contents of O-substituted compounds (i.e., esters, ketones, aldehydes, and alcohols) increased during the first 6 days and then fluctuated until the end of the experiment (Fig. 5a). O-substituted compounds are typical food flavouring components (Panakkal et al., 2021) and have been detected during initial anaerobic decomposition of easily biodegradable wastes (Liu et al., 2020) and in composting facilities (Mustafa et al., 2017). The relatively low concentrations detected for O-substituted compounds in the biogas samples (Fig. 5a) may have been related to both (i) low content in the investigated FW substrate and (ii) consumption during AD since they are recognised as intermediate metabolites in the process (Duan et al., 2014; Wiecek et al., 2011; Wikandari et al., 2015)...
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- [Characteristics, secondary transformation and odor activity evaluation of VOCs emitted from municipal solid waste incineration power plant](#)
2023, *Journal of Environmental Management*
Citation Excerpt :
...MSW is an odor pollution source (Zhao et al., 2015; Zhang et al., 2021; Piccardo et al., 2022), the annoying odors emitted from MSWIPP showed a negative effect on the quality of life and brought potential health hazard to the nearby residents. Odor pollution from MSW landfill sites raised attention during the last decade (Liu et al., 2020; Zhang et al., 2021; Wang et al., 2021). However, the odor from MSWIPP had not been studied yet....
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