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GASEOUS ORGANIC EMISSIONS FROM VARIOUS TYPES OF HOUSEHOLD WASTE*

Ken Wilkins

National Institute of Occupational Health, Copenhagen, Denmark

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Abstract: Plans to recycle most of the household waste in Denmark resulted in the introduction of sorting into different fractions. Thus household waste was divided into glass, paper and cardboard, biodegradable waste (mainly from the kitchen), and miscellaneous waste (mainly packaging materials). Since it had been reported that spoiled food generated high concentrations of organic volatiles and it was anticipated that microbial growth might be faster in the biodegradable fraction compared to mixed waste, samples of emissions of these two waste types were analyzed using standard air pollution methods. Samples of garden waste emission were also analyzed because of complaints from collection personnel. Several hundred compounds were indentified and quantified with gas chromatography/ mass spectroscopy (GC/MS). Most of these occurred at concentrations much lower than their TLVs (threshold limit values). The toxic organosulfur derivatives dimethyl sulfide and dimethyl disulfide could be accumulated in relatively airtight containers at concentrations greater than their TLVs and thus could be a contributing factor in the complaints from collection personnel of nausea and airway irritation.

Address for correspondence: Ken Wilkins, National Institute of Occupational Health, Lersø Parkallé 105, DK-2100 Copenhagen Ø, Denmark. E- mail: ckw@ami.dk

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INTRODUCTION

There has been little interest in organic emissions from household waste since the most dangerous pollutants originate from industrial waste. Two investigations of emissions from domestic waste landfills are available [2, 11].

Plans to recycle most of the household waste in Denmark resulted in the introduction of sorting of waste into different fractions. Thus, household waste is to be divided into glass, paper and cardboard, biodegradable waste (mainly from the kitchen), and miscellaneous waste fractions. An alarming prevalence of work related illness at a central sorting facility [4, 5] raised questions about new health problems which might arise as a result of handling the new waste fractions.

Since the new biodegradable fraction consists primarily of food residues, and anaerobic spoilage of various foods for 2-3 weeks had been reported to generate 100-1000 ppm of hydrogen sulfide (TLV 10 ppm [1]), methyl mercaptan (TLV 0.5 ppm [1]) and dimethyl disulfide [3], it is possible that organosulfur compounds contribute to the bioaerosol exposure of waste handling personnel. Samples of garden waste emission were also investigated in response to a report of symptoms in some collection personnel. Emissions from these three waste types were analyzed using standard methods [7, 8, 9].

METHODS

After normal waste collection, waste headspace volatiles were sampled through a hole in the top of the storage section of waste collection trucks [7, 8, 9].

In laboratory experiments, kitchen waste (n = 3) and garden waste (n = 4) was stored in loosely covered plastic containers and headspace samples collected at weekly intervals for 4 weeks [10].

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Table 1. Dominant VOCs in collection truck headspace of household waste according to retention time identified by GC/MS (M = mixed waste, B = biodegradable waste, G = garden waste).

COMPOUND	M	B	G
pentane	+		
dimethyl sulfide			+
ethanol	+	+	+
acetone	+		+
dichloromethane	+		
methyl acetate	+	+	
2-propanol	+		
2-methylhexane	+		
3-methylhexane	+		
1-propanol	+		
ethyl acetate	+	+	+
2-butanone		+	+
1,1,1-trichloroethane	+		
methylcyclohexane	+		
heptane	+		
2-butanol		+	+
2-methyl-1-propanol	+	+	+
2-pentanone	+	+	
1-butanol	+	+	
dimethylcyclohexanes	+		
acetic acid	+	+	
octane	+		
dimethyl disulfide		+	
dimethylheptanes	+		
C_2-cyclohexanes	+		
toluene	+	+	+
C_3-cyclohexanes	+		
3-methyl-1-butanol		+	
2-methyl-1-butanol		+	
3-hydroxy-2-butanone	+	+	+
butyl acetate	+		
m,p-xylene	+		
ethylbenzene	+		
dimethylheptanes	+		
α-pinene	+	+	+
methyloctanes	+		
o-xylene	+		
styrene	+		+
nonane	+		
camphene	+		+
ß-pinene	+	+	+
ß-myrcene	+		+
methylnonanes	+		
Δ3-carene	+	+	+
trimethylbenzenes	+		
decane	+		
limonene	+	+	+
ß-phellandrene			+
undecane	+		
benzaldehyde		+	
γ-terpinene			+
dodecane	+		
thujone			+

Table 2. Total sulfur-organic VOC concentration in garden waste (mg/m^3, nd = not detected).

truck headspace (n = 3)	container headspace (n = 4)	nylon bag headspace (n = 3)
nd - 0.025	nd - 4.7	0.68 - 8.1

Solid samples were placed in a nylon 66 foil bags and a headspace sample was taken after a 24 hour equilibration period.

All gas samples were concentrated on Tenax TA and stored at 4°C before standard thermal desorption GC/MS analysis [7, 8, 9].

RESULTS AND CONCLUSIONS

About 300 volatile organic compounds (VOCs) were indentified [7-10]. Table 1 is a list of the dominant compounds from the three waste types.

Mixed waste, which consisted primarily of packaging materials including food containers, yielded primarily aliphatic and aromatic hydrocarbons, and some esters and alcohols, all of which probably were derived from packaging materials or their labels (printing inks etc.). Food residues probably contribute to the biological volatiles: alcohols, esters, acetic acid, ketones and terpenes.

The major VOCs from biodegradable waste were alcohols, esters, acetic acid, ketones, dimethyl disulfide and monoterpene hydrocarbons, all of which could be derived from food and its spoilage by microorganisms.

Garden waste headspace was also dominated by alcohols, esters, ketones, dimethyl sulfide, and monoterpene hydrocarbons. Esters and carboxylic acids were less prominent in some samples while terpenes were more prominent than in biodegradable waste. Most characteristic for garden waste was the presence of the highest concentrations of organosulfur derivatives and especially the formation of oxygenated and highly odoriferous monoterpenes (thujone, myrtenal, verbenone, linalool oxides, menthone, menthol, fenchone). These oxygenated monoterpenes could well represent oxidative microbial bioconversion of the ubiquitous pinenes and Δ3-carene, the dominant monoterpenes.

The standard indoor air analysis procedure used for this study was not suitable for analysis of hydrogen sulfide or methanethiol so concentrations of the organosulfur compounds here in Table 1 must be considered as indications of the relative risk for physiological effects. Although there is no TLV for dimethyl disulfide, one of the major compounds found here, investigations of toxicity of organosulfur derivatives showed that its toxicity is at the same level as that of methanethiol (TLV 0.5 ppM) [6]. Total organosulfur VOC concentrations measured for garden waste, the samples which gave the highest concentrations, are summarized in Table 2. While

concentrations in the collection truck headspace were low, those measured in waste containers and in plastic bags were quite variable and could reach 5-10 ppm. If waste handling personnel is exposed to sulfurous gases in these concentrations, albeit during short periods when containers (bags) are opened, it is quite probable that sulfurous gases will contribute to upper airway irritation and nausea.

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REFERENCES

1. Arbejdstilsynet: *Grænseværdier for Stoffer og Materialer Atanvisning Nr. 3.1.0.2*. Arbejdstilsynet, Copenhagen 1994 (in Danish).

2. Brookes BI, Young PJ: The development of sampling and gas chromatography-mass spectrometry analytical procedures to identify and determine the minor organic components of landfill gas. *Tantala* 1983, **30**, 665-676.

3. Kamiya A, Ose Y: Study of odorous compounds produced by putrefaction of foods. V. Fatty acids, sulfur compounds and amines. *J Chromatogr* 1984, **292**, 383-391.

4. Sigsgaard T, Malmros P, Nersting L, Petersen C: Respiratory disorders and atopy in Danish refuse workers. *Am J Resp Crit Care Med* 1992, **149**, 1407-1412.

5. Sigsgaard T, Abel A, Donbeak L, Malmros P: Lung function changes among recycling workers exposed to organic dust. *Am J Ind Med* 1994, **25**, 69-72.

6. Tansy MF, Kendall FM, Fantasia J, Landin WE, Oberly R: Acute and subchronic toxicity studies of rats exposed to vapors of methyl mercaptan and other reduced sulfur compounds. *J Toxicol Environ Health* 1981, **8**,71-88.

7. Wilkins K: Volatile organic compounds from household waste. *Chemosphere* 1994, **29**, 47-53.

8. Wilkins K, Larsen K: Identification of (micro)biological volatiles by HRGC/MS. *J High Resol Chromatogr* 1995, **18**, 373-377.

9. Wilkins K, Larsen K: Volatile compounds from garden waste. *Chemosphere* 1996, **32**, 2049-2055.

10. Wilkins K, Breum NO, Nielsen M: *Occupational Safety and Health in Waste Collection and Recycling. Report No. 10. Bioaerosols and Volatile Organic Chemicals from Garden Waste (in Danish with an English summary).* National Institute of Occupational Health, Copenhagen 1996.

11. Young PJ, Parker A: The identification and possible environmental impact of trace gases and vapours in landfill gas. *Waste Manag Res* 1983, **1**, 213-226.