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Emissions from simulated deep-seated fires in domestic waste

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Abstract

The emissions from deep-seated fires in domestic waste have been investigated. The gas phase yields of PAH, PCDD/F, PCB, HCB, particles, and metals associated to the particulate matter were analysed during a series of simulated deep-seated fires. The method of extinguishment was varied and in cases where water was used for extinguishment, the runoff water was analysed for PAH, PCDD/F, PCB, hexachlorobenzene, and metals. In total six tests were performed. In four of the tests, samples of the fire residue were analysed for PCDD/F, PCBs, and chlorobenzenes.

Keywords: Waste; fire; PAH; PCDD/F; PCB; Extinguishing water

1. Introduction

During recent years a large number of fires in landfills have occurred. The fires have attracted much attention since some of them have extended over a long period of time and have been difficult to extinguish. These fires can also result in significant emissions, both from a local and a national perspective. Bergström and Björner (1992) estimated, from an inquiry on landfill fires during the years 1989–1990, the total emissions of polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/F) from fires in 25000 tons of waste to be 36 g (toxic equivalents, Nordic). These PCDD/F emissions were 3–4 times as large as the total emissions of PCDD/F from combustion of waste in incineration plants in Sweden at that time (10 g toxic equivalents, Bergström and Björner, 1992). The emissions to air from controlled combustion of waste have since then decreased to 1.1 g/yr (in 2004) (SNV, 2005) which makes the difference even larger. During an investigation it was found that 7000 tons of waste were consumed in fires in 2002 (RVF, 2003). This is a lower value than the one mentioned above (from the late 1980s). Since the total amount of waste consumed in fires can be influenced even by a small number of very large fires, the total amount varies from year to year. However, even if the amount from 2002 would be representative, the emissions to air from these fires would still be higher than the total PCDD/F emissions to air from incinerators.

The main cause of the fires during 2002 was assumed to be auto-ignition (including help by glass, sun, and dry material). In the earlier study (1989–1990), arson was given as the main cause of the fires.

It has been shown that the emissions from surface fires are larger than those from deep-seated fires, both measured in absolute concentrations and as per ton of waste (Pettersson et al., 1996). One reason for the lower emissions from a deep-seated fire could be the long distance from the seat of the fire to the surface and the consequent cooling of the gases. This means that the heavier species could condense on their way to the surface. However, the total amount emitted from a deep-seated fire could be larger than from a surface fire due to the difficulty in extinguishment and its, normally, prolonged duration.

As part of a national survey of sources of unintentionally produced species, the Swedish Rescue Service Agency

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(SRV) needed to investigate the emissions of PCDD/F, polycyclic aromatic compounds (PAHs), polychlorinated biphenyls (PCBs), and hexachlorobenzene (HCB) from fires in landfills with domestic waste. They also needed to study the effect of the method of extinguishment with a focus on deep-seated fires. There existed data from previous investigation on emissions from fires in waste (Öhrström, 1989; Ruokojärvi et al., 1995a,b; Pettersson et al., 1996; Lemieux, 1997; Martens et al., 1998; Lemieux et al., 2000, 2003; Gullett et al., 2001; Nammari et al., 2004). However, these studies either did not include all the species identified as part of this study, did not give quantitative results or were not representative for the type of fire of interest. Therefore, it was decided to perform a new test series with simulated deep-seated fires in domestic waste.

2. Test samples of waste and relating characteristics

The aim of the work was to perform tests with waste that was representative for stored domestic waste. The waste material should also be practical to handle. The waste material selected for the test series was compressed and baled actual domestic waste. The waste bales were transported by truck to SP. The bulk density of the compressed waste was approximately 615 kg m^{-3}. The district in Sweden from which the waste was taken had recently performed a thorough analysis of the contents of their waste. The result from this analysis is presented in Table 1.

Table 1
Results from analysis of the waste[a] in the district from where the waste for the tests was taken

Type of waste	Mass (kg)	Fraction (%)	Minimum (%)	Maximum (%)
Newspapers	503	14.1	1.1	36.1
Paper packages	352	9.9	5.2	23.1
Compostable	1177	33.0	15.5	50.4
Other biofuel	334	9.4	2.0	22.8
Sum biofuel		*66.4*	*51.7*	*84.9*
Plastic packages, hard	111	3.1	0.4	9.5
Plastic packages, soft	306	8.6	3.9	15.2
Diapers	232	6.5	0.0	33.5
Other fossil fuels	112	3.1	0.4	11.4
Sum fossil fuels		*21.30*	*8.6*	*44.2*
Glass packages	85.8	2.4	0.0	8.9
Metal packages	80.0	2.2	0.40	5.2
Other non-combustion	250	7.0	0.8	21.7
Sum non-combustion		*11.6*	*2.9*	*25.7*
Dangerous waste	22.6	0.6	0.0	3.2
Total	*3566*	*100*		

[a] In total 250 waste sacks (3566 kg) from 25 truck loads were analysed. The minimum and maximum values are based on analysis of five sacks from a truck load.

Table 2
Moisture contents in the different bales with waste

Bale 1 (test 1a)	Bale 2 (test 2a)	Bale 3 (test 2b)	Bale 4 (test 3a)
52.4	47.8	51.9	54.8

Samples were taken in connection with the different tests given within parentheses (wt%).

For the fire tests the plastic sheathing around the bales was removed and the waste was placed in a 1 m^3 cubic steel container. The unwrapping of the bales resulted in decompression of the material and a decrease in the bulk density to 220–260 kg m^{-3}. Analyses of the moisture content of the waste in the bales were made. One representative sample was taken from each bale used. The results from these analyses are given in Table 2. For the sample taken from bale 1, a more detailed fuel analysis was performed. The results of the fuel analysis are given in Table 3.

3. Experimental set-up

The waste was placed in a 1 m^3 cubic container with an open top, prepared with thermocouples to study the temperature development and distribution in the waste material. The temperature was measured in 13 positions (see Fig. 1). For safety reasons (the waste could include spray cans) a metal grating was placed over the open top of the container. The container was placed on load cells to register the mass loss. Further, the container was placed under a hood connected to an exhaust duct which collected the produced fire gases. Ignition of the waste material was obtained using an electric charcoal lighter giving an effect of 950 W. The lighter was placed centrally in the waste bulk (position I in Fig. 1). The spread of pyrolysis was rather slow in some tests and therefore an additional lighter was used in the two last tests. This ignition method gave a more stable burning. The second lighter was placed in position II (see Fig. 1).

Table 3
Fuel analysis of the waste from bale 1 (values given for dry sample)

Analysis	Test 1a (dry sample)
Sulphur, S (wt%)	0.15
Carbon, C (wt%)	46.2
Hydrogen, H (wt%)	6.3
Nitrogen, N (wt%)	0.84
Chlorine, Cl (wt%)	0.70
Oxygen, O (wt%)	30.8[a]
Ash (wt%)	15
Calorimetric heat of combustion at constant volume (MJ kg^{-1})	19.73
Calorimetric heat of combustion at constant pressure (MJ kg^{-1})	18.38

[a] Not analysed, but estimated by difference.