ORGANIC POLLUTANTS IN STACK GASES COMPARED TO SOLID EMISSIONS OF MUNICIPAL SOLID WASTE INCINERATORS

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1 Introduction

Within the scope of fundamental investigations, the Bavarian State Office for Environmental Protection performs emissions measurements at thermal waste treatment plants to optimize operation and to accompany and support development of new technologies of waste gas cleaning. Since the late 80ies dirty gas measurements before or between the components for waste gas cleaning are performed to study gas composition and pollutant content in dependence on the operating conditions of the plants, and to assess the efficiency of the installed systems in detail.
The results of investigations at 5 Bavarian municipal solid waste incinerators (MSWI) with grate firing, carried out from October 1995 to March 1997, are summarized and discussed in comparison to formerly published data [1,2] concerning solid emissions sampled in the course of the same measuring campaigns.

2 Materials and Methods

2.1 Sampling

A description of the waste gas cleaning units at the examined MSWI including measuring locations is given in table 1. Dirty gas was generally sampled after the waste heat boiler or after the first waste gas cleaning unit (dust removal); clean gas just before the stack. Each campaign included three suctions of about 8 h each, carried out simultaneously in the dirty as well as the clean gas.

Table 1: Characteristics of MSWI and the installed waste gas cleaning units

Plant	Waste Input [Mg/h]	Sequence of Waste Gas Cleaning Units	Measuring Location dirty/clean gas	Solid Residues
A	7.6	ESP (**1**) - 3-stage scrubber (**2**) - wet ESP (**3**) - SCR (**4**) - fabric filter (**5**)	after **1**/ after **5**	bottom ash - boiler ash - ESP dust
B	16.8	ESP (**1**) - 3-stage scrubber (**2**) - SCR (**3**) - fabric filter (**4**)	after **1**/ after **4**	bottom ash - grate screenings - boiler ash - ESP dust - fabric filter dust
C	6.5	spray absorber (**1**) - fabric filter (**2**) - 2-stage scrubber (**3**) - wet ESP (**4**)	before **1**/ after **4**	bottom ash - grate screenings - boiler ash - fabric filter dust
D	12.7	spray absorber (**1**) - fabric filter (**2**) - SCR (**3**)	before **1**/ after **2**	bottom ash - grate screenings - boiler ash - fabric filter dust
E	9.6	waste gas cooler (**1**) - cyclone (**2**) - evaporation cooler (**3**) - fabric filter (**4**) - SCR (**5**)	after **1**/ after **5**	bottom ash - grate screenings - fabric filter dust

ESP: electrostatic precipitator SCR: selective catalytic reduction

The solid emissions (bottom ash, grate screenings, boiler ash, electrostatic precipitator dust, fabric filter dust) investigated in [1] are also presented in table 1.

2.2 Analytical

All samples were investigated for their content on PAH, PCDD/F and PCB. For PAH 24 components in the gas and 16 components (acc. to EPA 610) in the solids, for PCDD/F 17 congeners (acc. to 17. BImSchV) and for PCB 6 congeners (acc. to AbfKlärV) were determined. PAH and PCB were analyzed by HRGC/MS (SIM mode); PCDD/F by HRGC/HRMS. Clean-up, fractionation and final separation were carried out by standard methods described in [3,4].

3 Results and discussion

Concentrations of PAH, PCDD/F and PCB in the MSWI dirty and clean gas are shown in table 2.

				Median		34	2.5

Table 2: Concentrations in the dirty and clean gas: PAH, PCDD/F and PCB

			Dirty Gas	Clean Gas
PAH	Mean	ng/m^3	201	42.4
	Min		26	25
	Max		1110	67
	Median		134	37.7
PCDD/ PCDF	Mean	ng I-TEQ/m^3	3.59	0.008
	Min		1.20	0.001
	Max		5.90	0.030
	Median		4.10	0.004
PCB	Mean	ng/m^3	33.1	10.7
	Min		1.2	0.1
	Max		82	43

Regarding the examined organic pollutants, waste gas cleaning is most efficient for PCDD/F. More than 99 % are separated from the dirty gas, e.g. by active carbon sorption at fabric filters which are esp. designed and optimized for separation of volatile heavy metals and PCDD/F. For PAH and PCB separation is less effective; concentrations are reduced to about a quarter of the dirty gas values.

The ranges of concentration of PAH, PCDD/F and PCB in the solid residues [1] are given in table 3.

Table 3: Concentrations in the solid residues [1]: PAH, PCDD/F and PCB

			Bottom Ash		Grate Screenings	Boiler Ash	ESP Dust	Fabric Filter Dust
			0 - 8 mm	8 - 32 mm				
PAH	Mean	µg/kg	746	329	2034	142	89.1	546
	Min		83.4	29.2	191	2.3	28.6	6.9
	Max		2150	1900	14100	1430	273	4010
	Median		631	127	860	21.0	43.0	122
PCDD/ PCDF	Mean	ng I-TEQ/kg	14.8	5.3	9.0	289	518	1368
	Min		3.6	0.7	2.5	87.4	311	290
	Max		30.9	11.7	24.7	1125	1010	3706
	Median		14.0	5.2	5.8	253	455	1210
PCB	Mean	µg/kg	21.7	34.1	8.8	13.3	13.9	15.8
	Min		1.4	0.4	1.0	0.3	1.3	0.5
	Max		52.8	102	34.0	36.0	62.6	41.8
	Median		24.3	15.7	3.9	3.4	1.5	15.3

It is evident that in most cases PAH are enriched in the solid combustion residues (bottom ash, esp. grate screenings), whereas chlorinated compounds (PCDD/F, PCB) are mainly found in the residues of the waste gas cleaning units, essentially in the fabric filter dust.

The similarity of PCDD/F congener patterns found in the dirty and clean gas samples as well as in the solid residues of the waste gas cleaning process is illustrated in figure 1.

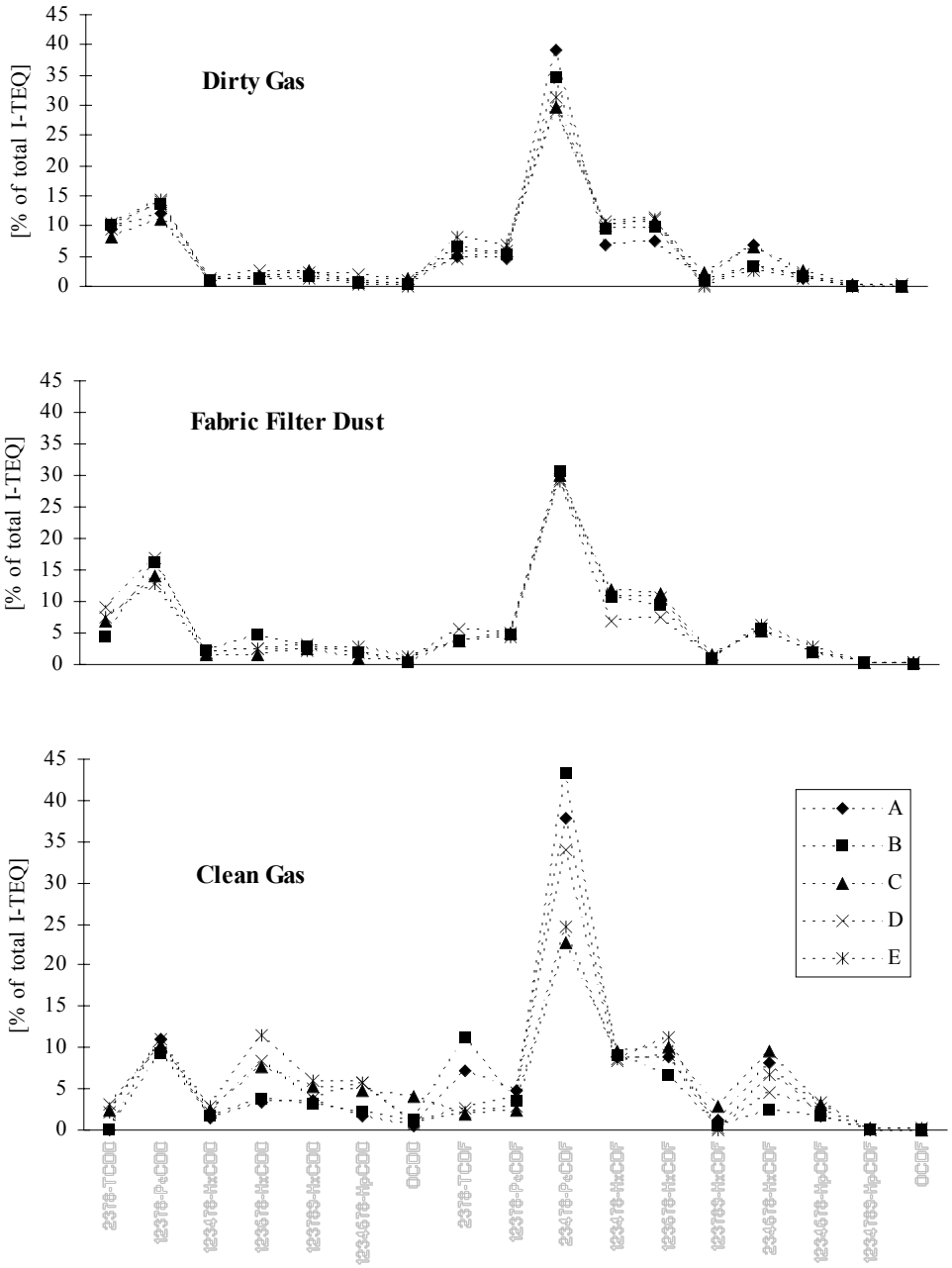

Figure 1: PCDD/F patterns of dirty gas, fabric filter dust and clean gas

Comparing the congener patterns it has to be considered that gas sampling was carried out at temperatures of 190 to 230 °C (dirty gas) respectively 80 to 170 °C (clean gas); according to [5] the temperature range for *de-novo*-synthesis of PCDD/F lies between 200 and 500 °C. While the patterns of dirty gas samples and the residues of fabric filters were found to be almost identical, a relative depletion of 2,3,7,8-TCDD and a corresponding enrichment of 1,2,3,6,7,8-HxCDD with respect to the contribution to the total I-TEQ was observed in case of the clean gas. The more pronounced spread of measured values observed for the clean gas compared to the other samples can either be attributed to sampling and analytical effects (lower concentrations, partly at the detection limit) or to the influence of different multistage technologies used for waste gas cleaning. Generally the results demonstrate that regional differences concerning the waste input material of the 5 MSWI are of minor significance for PCDD/F content and distribution.
In the case of the analyzed PCB congeners the extensive scattering of measured values didn't allow a general interpretation.
For PAH the relatively volatile components, such as naphthalene and phenanthrene, are the main compounds in the examined output fluxes; nonvolatile PAH were found to a much lower extent.
The measured data as well as the practical experience gained lay the basis for further investigations of exhaust emissions cleaning systems in cooperation with public and private operators.

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5 References
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