PCDD/F-Emissions from Domestic Heating with Wood, Coal and Coke

Wolfgang Moche, Gerhard Thanner

Federal Environment Agency, Spittelauer Laende 5, 1090-Vienna, Austria

Introduction

In 1994 the Federal Environment Agency presented the Austrian Air Emission Inventory[1].
In this study the PCDD/F emissions from non-industrial combustion plants are estimated as 16 g I-TEQ/year representing 58% of the total PCDD/F emissions in Austria.
The majority of the furnaces used for residential heating are fuelled with wood. In urban areas coal and coke is still used in considerable amounts. The annual consumption of coal and coke in Austrian flats on the basis of data from 1992 was approximately 300 000 t [2].
There are only few data available for domestic coal combustion in the international literature.
Due to this lack of data in 1997 the Federal Environment Agency startet a measuring programe on emissions of PCDD/F from the combustion of coal, coke and wood in small household stoves.
The first results of that study[3] had been presented at DIOXIN '98, showing unexpected high concentrations of PCDD/F in the emissions from a small household stove fuelled with coal.
The recalculation of the Austrian Air Emission Inventory based on these data would have increased the estimated PCDD/F emissions from the non-industrial combustion plants significantly.

In 1999 the Federal Environment Agency continued the study with different types of household stoves to gain a wider databasis and to confirm the previously published data.

Experimental

In the present study three different household stoves were used. The stoves were operated on the first floor of a residential building with the sampling site situated in the attic, approximately 12 m above. Each of the three stoves was fuelled with wood, coal and coke. The sampling comprised the whole burning cycle, including the start phase of burning and refuelling phases. After each experiment the chimney had been sweeped, to avoid cross contamination.

Furnaces: a) household stove, Co. Thorma, Type „Kassel", 6 kW, new
b) household stove, Co. Meller, 6 kW, more than 10 years in use

c) household stove, Co. Morsø, 5 kW, Type 1410, 5 years in use

Fuel: The fuels (wood, coal and coke) used for the experiments were purchased from a local dealer.

Sampling: The used sampling train consisted of a water-cooled quartz probe with a titanium-nozzle attached, a condensation flask, three impingers each of them containing 750 ml ethyleneglycol at -10°C, a glas cartridge filled with glass wool of different density, a glasfibre-filter and three PU-foam plugs (Ø 4cm, h 5cm). The first impinger was spiked with ^{13}C-1,2,3,4-TCDD as sampling spike. The sampling was done isokinetically with simultaneous monitoring of CO/CO_2- and O_2-concentration. The sampling volumes comprised 4 to 6 m³ with sampling periods of 3 to 6 hours.

Analysis: The condensate and the ethyleneglycol were pressure filtrated over 0.45 µm nylon filters. The filtrated impinger/condensate-fractions, the combined nylon filter, glasswool plug and glasfibre filters and the PU-foam plugs were spiked with a ^{13}C-recovery standard solution containing all 2,3,7,8-substituted PCDD/F-congeners and extracted with toluene separately. The clean-up of the separate extracts comprised a four-stage column chromatography. The analysis and quantitation was carried out by HRGC/HRMS.

Sampling and analysis as described above are in compliance with the recently released CEN-1948[4]. Results

The results of the emission measurements and the derived emission factors are presented in the tables below.

Furnace	Experiment	% O_2	ng I-TEQ/Nm³ (0% O_2)	Emission Factor ng I-TEQ/kg coal (0% O_2)
household stove „Thorma“				
	#1 wood	17,2	0,28	5,7
	#2 wood	17,9	0,09	1,6
	#3 wood	17,8	1,96	70,1
	#4 coal	17,9	34,56	1704
	#5 coal	18,4	38,68	2140
	#6 coal	18,2	30,05	2541
	#7 coal	18,0	22,91	2294
	#8 coke	19,1	3,58	472
	#9 coke	18,2	4,40	423

Furnace	Experiment	% O_2	ng I-TEQ/Nm³ (0% O_2)	Emission Factor ng I-TEQ/kg coal (0% O_2)
household stove „Meller“				
	#1 wood	16,9	0,38	6,3
	#2 wood	16,6	1,49	19,4
	#3 wood	14,7	1,17	32,6
	#4 coal	17,1	17,52	631
	#5 coal	17,1	7,92	548
	#6 coal	17,1	20,03	1299
	#8 coke	18,2	2,72	333
	#9 coke	16,6	0,89	116

Furnace	Experiment	% O_2	ng I-TEQ/Nm³ (0% O_2)	Emission Factor ng I-TEQ/kg coal (0% O_2)
household stove „Morsø“				
	#1 wood	16,3	1,12	37,9
	#2 wood	16,1	0,58	17,9
	#3 coal	17,4	7,46	527

The above listed concentrations and emission factors from coal burning confirm the results of the 1997 study.

The concentrations of PCDD/F in emissions from coke burning are by a factor of ten lower than those from coal burning. The lowest concentrations resulted from wood burning, ranging from 0.09 to 1.96 ng I-TEQ/Nm³ (0% O_2).
The results of the present study show that coal burning in small residential stoves is an important PCDD/F source which seems to be underestimated in emission inventories.

References

1. König K, Radunsky K, Ritter M; Austrian Air Emission Inventory 1994; *Umweltbundesamt-Wien*, Reports R-140 **1997**.
2. ÖSTAT; Energieverbrauch der Haushalte im Jahre 1992; *Beiträge zur österreichischen Statistik*, Heft Nr. 1.169, **1995**.
3. Moche W., Thanner G.; PCDD/F-Emissions from Coal Combustion in Small Residential Plants; *Organohalogen Compounds*, Vol. 36, 329-332, **1998.**
4. Stationary source emissions – Determination of the mass concentration of PCDD/PCDFs; *CEN* 1948, **1997**.