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Dioxin Emissions from Wood Combustion

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Introduction

Combustions are a major source of the emissions of polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) into the environment. While many investigations have been performed to study the emissions of PCDD and PCDF from municipal waste incinerators as well as hazardous waste incinerators, there are only few reports on dioxin emissions from wood combustions[1-5].

Under the guidance of the Swiss Federal Office of the Environment (BUWAL), the dioxin emissions of different kind of furnaces (6 to 1800 kW) burning different kind of wood (natural wood, chipboards, waste wood) were investigated. Additionally, the dioxin emissions from a household stove, grilling meat over charcoal and burning household waste were measured.

Experimental

Combustion furnaces: a) household stove, open or closed (6 kW), b) stove for pieces of wood (35 kW), c) automatic wood chip furnaces (110 to 1800 kW).

Combustibles: 1) natural beech wood stored for 2 years, 12% humidity, 2) mixed natural wood chips, 40-60% humidity, 3) chipboards, 4) waste wood chips from demolition of buildings, 10-25% humidity, 5) charcoal used for grilling meat, 6) combustible part of household wastes sampled for 2 weeks in 12 households, consisting of 2/3 paper and carton and 1/3 plastics.

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Sampling: The flue gases were sampled according to the German guideline VDI-3499, part 3 (draft)[6]. The sampling train consisted of a water cooled quartz probe, a condensation flask at 4°C, and 2 impingers with methoxyethanol at -30°C. 10 ng of ^{13}C-1,2,3,4-TCDD placed into the condensation flask was used as the sampling spike. Sampling time was 4-6 h, resulting in a sampling volume of 7-13 m³.

Analysis: Sample preparation was done according to the German guideline VDI-3499, part 3 (draft) with minor modifications. The condensate was spiked with all 2,3,7,8-substituted PCDDs/PCDFs as ^{13}C-labeled compounds (10 ng each for tetra- to heptaCDD/CDF, 20 ng each for OCDD/OCDF). The silica probe, the condensate and the impinger liquids were extracted with toluene. The combined toluene extract was cleaned up by a two step column chromatography using basic alumina and a mixed column with silica/NaOH, silica and silica/H_2SO_4. 5 ng of ^{37}Cl-2,3,7,8-TCDD were added to the final extract as an injection standard. Separation and quantitation were done by high resolution gas chromatography coupled to electron impact high resolution mass spectrometry (VG Autospec Q, Fison Instruments) following EPA method 1613[7].

Results and Discussion

The results are summarized in Table 1. Some combustions were performed using favourable and unfavourable combustion conditions characterized by the different CO content in the flue gases listed in Table 1.

The PCDD/PCDF emissions from combustion of natural wood were low. The values between 0.019 and 0.214 ng TE/Nm³ were below or slightly above the limit for waste incinerators of 0.1 ng TE/Nm³ valid in Germany, Austria, Netherlands and Sweden. The emissions under unfavourable combustion conditions with higher CO concentrations were higher by a factor of about two.

The dioxin emissions from chipboard combustions were comparable with the results of the natural wood combustion.

Much higher emissions, between 2.7 and 14.42 ng TE/Nm³, were observed when waste wood was incinerated. These values are comparable with the emissions from old municipal waste incinerators.

The grilling of meat over charcoal may theoretically result in the formation of PCDD/PCDF due to the salty meat juice dripping onto the hot charcoal. However the measured dioxin concentration in the flue gas (0.028 ng TE/Nm³) was very low.

In Switzerland, most of the households pay a waste disposal fee proportional to the amount of waste produced. Therefore it is possible to assume that people dispose of their waste by incinerating it in their own household stoves. Our result of 114.4 ng TE/Nm³ shows that this may result in very high emissions of dioxins.

Table 1: PCDD/PCDF concentrations in the flue gases of wood combustions.

Combustion Furnace	Nominal Power kW	Combustibles	CO mg/Nm³	PCDD/PCDF ng TE/Nm³
household stove, open	6	natural beech wood	6300	0.064
household stove, closed	6	natural beech wood	3700	0.104
stove for pieces of wood	35	natural beech wood	560	0.019
stove for pieces of wood	35	natural beech wood	10200	0.034
wood chip furnace	110	natural wood chips	1300	0.214
wood chip furnace	150	natural wood chips	340	0.066
wood chip furnace	150	natural wood chips	3300	0.173
wood chip furnace	150	chipboard chips	60	0.076
wood chip furnace	150	chipboard chips	3000	0.024
wood chip furnace	150	waste wood chips	250	14.20
wood chip furnace	410	waste wood chips	345	14.42
wood chip furnace	850	waste wood chips	70	2.70*
wood chip furnace	1800	waste wood chips	510	9.57*
household stove, closed	6	charcoal/grill	19300	0.028
household stove, closed	6	household waste	6000	114.40

TE were calculated using the NATO I-TEF's

* related to 11 vol% oxygen, all other TE values related to 13 vol% oxygen

Conclusions

This study shows that

- combustions of natural wood and chipboards result in low dioxin emissions although they may be above the limit of 0.1 ng TE/Nm³,

- combustion of waste wood produces high emissions of PCDD/PCDF, presumably due to the content of chlorinated wood treating agents like pentachlorophenol or other dioxin precursors,
- combustion of household waste yielded in very high dioxin emissions which may result in local high immisions,
- the results are generally comparable with the results of other investigations[1-5].

References

1 Blessing R, Frenkler W, Wissmann G. Dioxin-Emissionen aus Feuerungsanlagen. *Umwelt* 1991; 21:E43-E48.
2 Aittola JP, Viinikainen S, Roivainen J. The Emissions of PCDD/PCDF's and Related Compounds from Co-Combustion of RDF with Peat and Wood Chips. *Chemosphere* 1989; 19:353-359.
3 Bröker G, Geueke KJ, Hiester E, Niesenhaus H. Emission polychlorierter Dibenzo-p-dioxine und -furane aus Hausbrandfeuerungen. *LIS-Bericht* 1992; Nr.103. Essen: Landesanstalt für Immissionsschutz Nordrhein-Westphalen.
4 Brunner W, Pröll M. Der Wamsler Thermo Prozessor: Ein zukunftssicherer Weg zur schadstoffarmen Verbrennung. *VDI-Berichte 922* 1991; 247-257.
5 Wurst F, Pey Th, Boos R, Scheidl K. Untersuchungen zur PCDD/F-Emission bei der Holzverbrennung. *Organohalogen Compounds* 1991;7:197-199.
6 VDI-Richtlinie 3499, Bl.3 (Vorentwurf). *Messen von Emissionen:* Messen von polychlorierten Dibenzo-p-dioxinen und Dibenzofuranen an industriellen Anlagen. Düsseldorf: Verein Deutscher Ingenieure, 1990.
7 EPA. *Method 1613:* Tetra-through Octa- Chlorinated Dioxins and Furans by Isotope Dilution. Washington, DC: United States Environmental Protection Agency, 1989.