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Determination and Reduction of PCDD/F Emissions From Wood Burning Facilities

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1. Objectives

PCDD/F are known to be generated in many thermal processes like e.g. waste incineration or metallurgical processes. Analyses of chimney soot from different heating systems[1] showed wood combustion to be a possible generation process, too. Within the research and development project of the German Federal Environmental Agency (Umweltbundesamt) "Determination and Reduction of Halogenated Dioxin and Furan Emissions from Thermal Processes", in 1992/93 various wood burning facilities were monitored with regard to their PCDD/F production and release potential.

2. Approach and methods

For the intended survey, seven wood burning plants were selected for clean gas analyses under the following aspects: capacity (50 kW to > 5 MW), feeding (manual, mechanical) and furnace type (chute, fixed or moving grate, fuel injection, pre-firing system) and input material (woodblocks, saw dust, bark, treated and untreated plywood residues). Table 1 compiles the respective data of the analyzed plants including flue dust removal systems.
At two plants, burning material was varied in order to clarify the influence of the input material (block, briquet, chops, dust), of special organic compounds (PVC-coating) and the inorganic hardener (ammonium sulphate, ammonium chloride) of plywood on PCDD/F emission. Input material was analyzed for under others the presence of organic and inorganic chlorine. Clean gas was analyzed for PCDD/F, dust, HCl, SO_3 (all discontinuously) and O_2, SO_2, NOx, CO, CO_2, and TOC (all continuously).

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Table 1: Investigated wood burning plants, burning material and air dust filter type

#	Plant Type	Burning Material	Dust Filter
1	Hand fed chute incinerator 48 kW	wood blocks, coated and uncoated plywood, wood residues	none
2	Pre firing system 211 kW	briquets of chopped wood	multi cyclone
3	Fuel injection incinerator 9.6 MW	1 mix of untreated wood and 2 wood-based product residues 3 untreated pine wood 4 untreated pine wood 5 plywood, hardened with ammo- 6 nium sulphate 7 plywood, hardened with ammo- 8 nium sulphate, coated with PVC	electro filter
4	Moving grate incinerator about 39 MW	wood pieces, coated and uncoated plywood, wood, bark, saw dust	electro filter
5	Stoker incinerator 234 kW	1 mix of untreated wood and resi- 2 dues of wood-based products 3 plywood, hardened with ammo- 4 nium sulphate 5 plywood, hardened with ammo- 6 nium sulphate, coated with PVC 7 plywood, hardened with ammo- 8 nium chloride 9 untreated pine wood 10 untreated pine wood	cyclone
6	Stoker incinerator 3.5 MW	coated and uncoated plywood, hardened with ammonium sulphate	electro filter
7	Stoker incinerator 117 kW	briquets of chopped wood	none

PCDD/F analysis: Sample collection followed VDI[2] (condensation method). Samples are spiked with a mixture of a $^{13}C_{12}$-labelled PCDD- and PCDF-standard per degree of chlorination and then extracted with toluene. Clean-up of the raw extract and fractioning by adsorption chromatography on silicagel- and aluminum oxide columns follow. The PCDD/F containing fraction is concentrated and a defined aliquot of the final volume is injected into a GC/MS. Screening analysis and detection of higher chlorinated congeners is performed with a non-polar DB-5 capillary column, isomer specific detection uses a polar capillary column (CP Sil 88), the MS performing in MID-mode (multiple ion detection). Quantification is based on standard addition, with a recovery rate of the internal standard of at least 70 %.

3. Results

Emission concentrations ranged from 0.004 to 9.820 ng I-TEQ/Nm³, with the majority of values > 0.1 ng I-TEQ/Nm³. Figure 1 shows the distribution of the results.

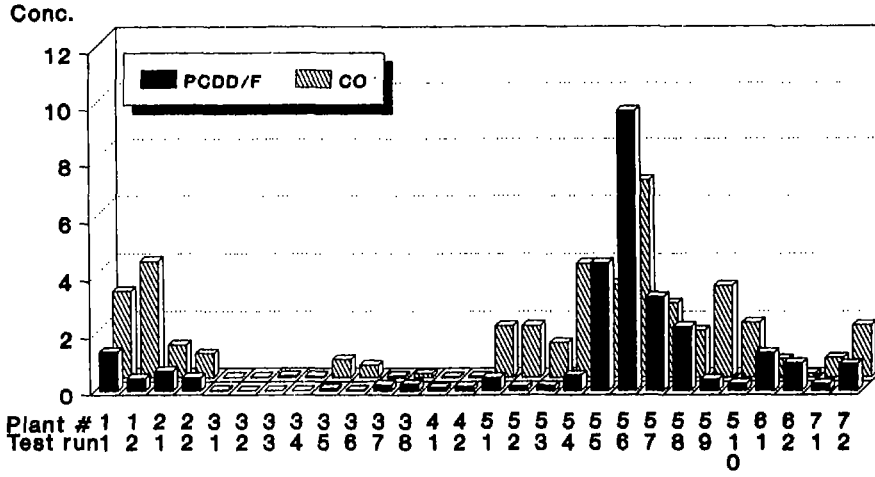

Figure 1: PCDD/F (in ng I-TEQ/Nm³) and CO (in g/Nm³) at different test runs.
1, 2, 4, 6, 7: x1 and x2 are double measurements.
3, 5: sample enumeration see table 1.
1, 2, 5, 7: emission concentration related to 13 Vol.-% O_2
3, 4, 6: emission concentration related 11 Vol.-% O_2

4. Conclusions

Even the use of natural input materials (untreated wood) produced emissions above 0.1 ng I-TEQ/Nm³, the emission limit for waste incineration plants (17. BImSchV) considering facilities with insufficient combustion conditions (high emissions of CO). Highest dioxin concentrations occured after addition of halogenated materials

(ammonium chloride hardened plywood or PVC coated plywood) to the input, but a statistically significant correlation cannot be derived. However, very clear relationships were determined between CO and PCDD/F concentrations in the emissions. This was especially true for production specific wood wastes and when halogenated input materials were added. Therefore, it can be concluded that the addition of halogenated input materials produced a worser combustion quality at the monitored facilities. The dominant influence of combustion quality on PCDD/F emission concentrations can be seen from the increasing CO concentrations and simultaneously decreasing flue gas temperatures.

Two of the three large facilities (> 1 MW) have lower PCDD/F emission concentrations than the plants with smaller thermal capacity. Thus, the facility size tends to have an influence on PCDD/F concentration due to more accurately managed combustion conditions. With the addition of input materials containing large halogen quantities at these large facilities, a significant increase in emission concentration could also be measured in the emissions. However, these concentrations remained below those determined at small facilities using natural woods.

As raw gas analyses have not been performed, the influence of dust removal on PCDD/F emission concentrations cannot be quantified. An optimized particle removal system can play a positive role in emission reduction. But more effective measures seem to be the optimization of the combustion process to improve combustion quality, and the substitution of halogenated materials in the wood working industry for decreasing the input of halogens into the incineration process.

Facilities with smaller thermal capacity (< 1 MW) using the typical input materials generally showed emission less than 0.5 μg I-TEQ/h. Comparable loads in the large facilities could only be determined at the one which had lowest PCDD/F concentrations using typical input materials. With the addition of atypical input materials at this as well as at the other two large facilities, emission loads of up to 7.2 μg I-TEQ/h were determined. Based on these data, an annual load of 1 to 50 mg I-TEQ/a per plant could be estimated. For a less populated and industrialized region such a plant can contribute up to 15 % of the total PCDD/F emission.

An emission standard of 0.1 ng I-TEQ/Nm^3 could be considered as a goal for advanced wood burning facilities using these reduction techniques.

5. References

1. Thoma H. PCDD/F concentrations in chimney soot from house heating systems. *Chemosphere* 1988;17:1369-79

2. Draft, VDI guideline 3499, page 2, Condensation Method. Society of German Engineers, Düsseldorf, Germany