PCDD/PCDF levels in flue gases during combustion of refuse derived fuel in three different boilers and during combustion of four different fuel mixtures in same boiler

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1. Introduction

Waste incineration has been reported to be a source of organic chlorinated compound emissions. Fuel material, it's chlorine and metal content has an influence on the formation of organic chlorinated compounds as PCDD/Fs [1-2]. Also other parameters of the combustion process like oxygen concentrations, turbulence and temperature can involve the toxic compound emissions. In this paper two different investigation series have been presented. In the first series refuse derived fuel pellet (RDFP) was combusted in three different boilers. The purpose of this investigation was to compare PCDD/F concentrations in flue gases when RDFP was combusted. Combustion tests were performed in 2 MW and 1 MW circulating fluidized bed pilot plants and in 32 kW fixed bed laboratory pilot plant. In all tests the combustion conditions were adjusted as optimal as possible. In the second series four different fuel mixtures were combusted in a 1 MW fluidized bed pilot plant keeping combustion conditions equal in all tests. In this investigation the purpose was to compare PCDD/F concentrations in flue gases when different fuel materials were co-combusted in the same boiler.

2. Experimental

Flue gas samples of fluidized bed plants were sampled in the same temperature range (240-270 °C). In the fixed bed laboratory pilot the combustion efficiency was low and the temperatures of flue gases were lower (in the sampling point about 120-150 °C) than in the fluidized bed boilers. In all tests sampling were performed before flue gas cleaning. The methods of sampling and analysis were comparable in all tests and the methods are reported elsewhere[2]. Combustion conditions in fluidized pilot plant tests were similar except of longer retention times in 2 MW boiler than in 1 MW boiler. Retention times were about 3 s in the laboratory pilot, 7 s in the 1 MW pilot and 8 s in the 2 MW pilot boiler.

3. Results and discussion

PCDD/F concentrations in flue gases when RDFP were burned in different boilers are present in Figures 1-3. Values are arithmetic means of three to five tests.

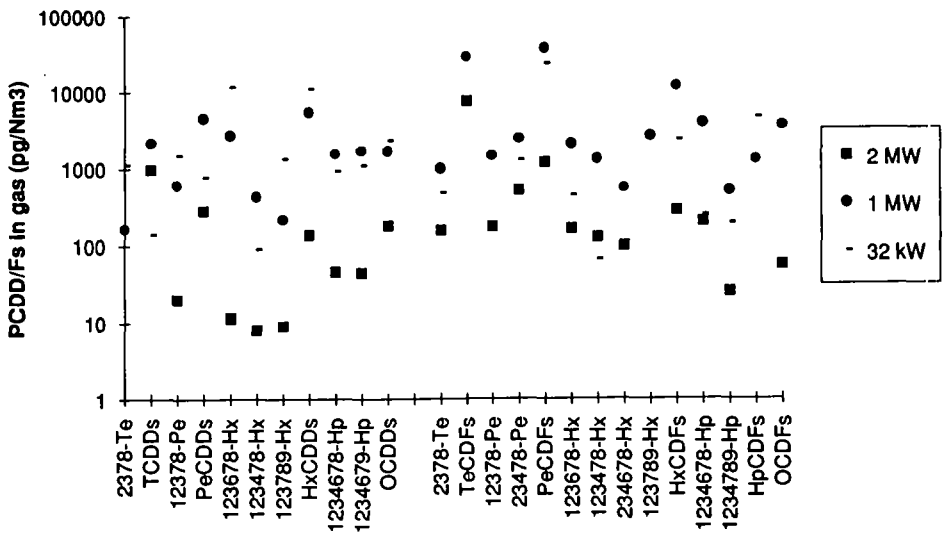

Figure 1. PCDD/F concentrations in gas phase (adsorbed in XAD-2). Same fuel, different boilers.

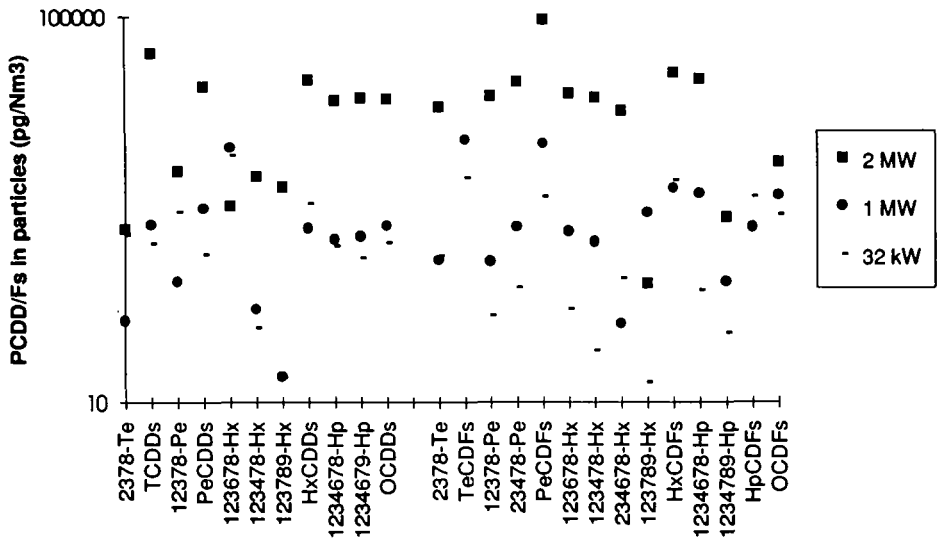

Figure 2. PCDD/Fs in particles sampled by glass fiber filter (pg/Nm^3). Same fuel, different boilers.

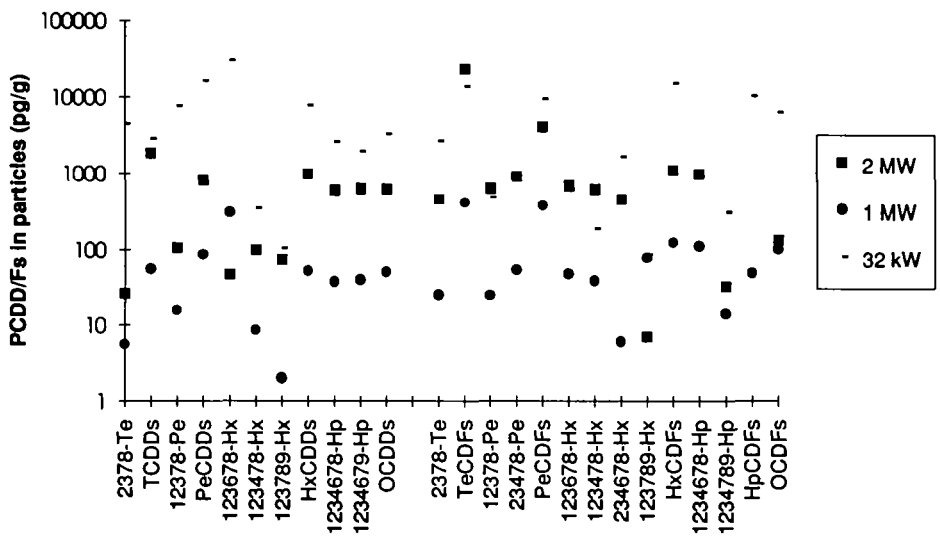

Figure 3. PCDD/Fs in particles calculated pg/g (flue gas samplings). Compare Figures 2 and 3.

The Figures 1-3 shows that in the laboratory pilot the concentrations of PCDD/Fs in gas phase and in particles (pg/g) were high compared to bigger boilers. On the contrary PCDD/F concentrations in particles (calculated by pg/Nm^3) were high in 1 MW and 2 MW boilers because of high particle concentrations before cleaning systems. This can be the consequence of high particle concentrations, longer retention times and possible de-novo synthesis reactions on particle surfaces in the high capacity boilers. When PCDD/F concentrations in particles were calculated by pg/g, the highest amounts of PCDD/Fs were observed in the laboratory pilot tests. High PCDD/F levels in gas phase in the laboratory pilot may be a consequence of rapid gas phase reactions. Rapid reactions could be present because of the short retention time before sampling and low particle amounts in flue gases. In the laboratory pilot gas phase reactions with PCDD/F precursors and other hydrocarbons may involve PCDD/F formation reactions. The isomeric distribution was quite similar in all tests when same fuel material were incinerated. This means that the isomeric distribution is based on fuel material and the concentration levels of PCDD/Fs depend on combustion conditions and boiler construction. The results of four different fuel material burning tests in the same 1 MW boiler (three to five samplings) are presented in Figures 4 and 5.

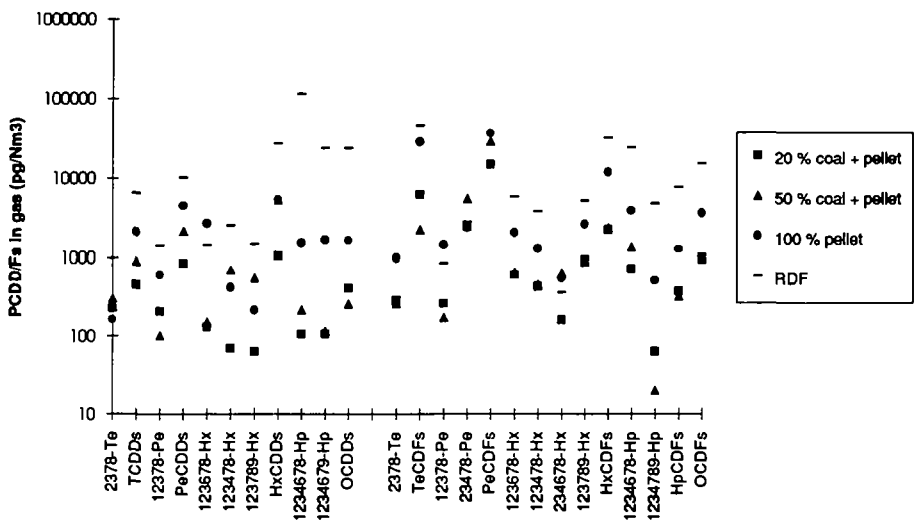

Figure 4. PCDD/Fs in flue gas phase.

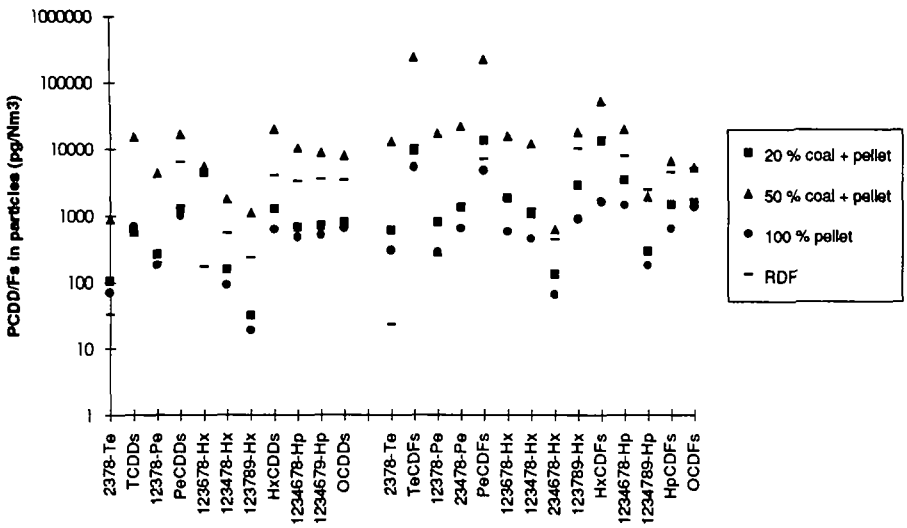

Figure 5. PCDD/Fs in flue gas particles.

In the gas phase highest PCDD/F concentrations were observed in RDF combustion. RDF also consisted of high amounts of metals, like copper. It is possible that in RDF combustion tests rapid gas phase reactions were promoted by metals more effectively than slow de-novo particle reactions. The finding that there was no significant differency in PCDD/F concentrations in particle phase in flue gases when different fuel material were combusted support this hypothesis (Fig.5). RDF fuel consists also of more heterogenous material than pellet and in RDF combustion flue gases have higher CO and hydrocarbon concentrations than in other fuel combustion tests. The combustion technique, boiler capacity and fuel material have effects on formation rates of PCDD/Fs. Different boiler and fuel material are specially effecting on the concentrations of PCCD/Fs, but the isomeric distribution between the different tests was similar. The results in this paper are collected from different combustion tests. All the tests were the basic test runs, when optimum combustion conditions were the purpose to reached. On the basis of that the results of these investigations are giving interesting information about the behaviour of the boilers and fuels.

5. References

1) Stieglitz, L., Zwick, G., Beck, J., Roth, W. and Vogg, H., On the de-novo synthesis of PCDD/PCDF on fly ash of municipal waste incinerators. Chemosphere, 18, 1219-1226, 1989.

2) Halonen, I., Tarhanen, J., Kopsa, T., Palonen, J., Vilokki, H. and Ruuskanen, J., Formation of polychlorinated dioxins and dibenzofurans in incineration of refuse derived fuel and biosludge. Chemosphere, 26, 1869-1880, 1993.