Mass Balance of PCDD/F in a Dry Cleaning Machine

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Abstract

A mass balance was conducted for PCDD/F in the dry cleaning process. PCDD/F in the textiles were shown to be the dominant input into the dry cleaning machine. More than 80% of the PCDD/F in the textiles were removed during the dry cleaning process. This amount is concentrated in the residues from the solvent redistillation. Other pathways out of the dry cleaning machine such as air emissions, condensate or textile fluff were found to be negligible.

Introduction

The residues of solvent redistillation in the dry cleaning process are known to contain considerable amounts of PCDD/F (Ref.[2,3]). It was shown that dry cleaning with petrol and other chlorine free solvents as well as variation of the process parameters did not lower the PCDD/F content of the residues (Ref.[1,4]). The authors concluded that the PCDD/F load in the residues can not be attributed to PCDD/F synthesis from chlorinated solvents. A significant input of PCDD/F through solvents or additives was also excluded. Finally, these studies identified soiled textiles as the source of PCDD/F detected in the destillation residues.
In the present work PCDD/F fluxes into a dry cleaning machine were calculated on the basis of PCDD/F levels measured in soiled clothing before and after dry cleaning. In addition, samples were taken from an open loop dry cleaning machine to quantify other possible PCDD/F pathways out of the dry cleaning machine such as air emission, condensate and fluff from the fluff filter.

Experimental

Textile Samples: To estimate the PCDD/F input from textiles we separately analyzed the PCDD/F concentrations in different kinds of dirty textiles before and after dry cleaning. Street clothes (cotton, wool, polyester, polyamide and silk) as well as work clothes (cotton/polyester) were analyzed. The different

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textiles were dry cleaned 10-times under controlled conditions in precleaned machines at the Hohensteiner Institute. The samples were analyzed for PCDD/F using a previously published method (Ref.[4]).

Emissions from the dry cleaning machine: Samples were taken from a dry cleaning machine (Fa. BOEWE-PASSAT, Type 470) operated with perchloroethylene (PER). After the washing procedure the textiles are dried by pumping heated air in a closed loop through a condenser and back to the textiles. This loop includes a filter which removes the fluff from the air. Prior to every opening of the machine this type of dry cleaning machine is ventilated with indoor air at a flow rate of about 800 m^3/h for about 5 min to remove the remaining solvent from the textiles. During this "open loop" phase the air also passes through the filter and condensor before entering the exhaust system of the plant. During a period of 36 days of operation in which about 10 tons of textiles were cleaned we continuously measured the PCDD/F concentrations of gas and particulates in the indoor air supplied to the machine and, during the "open loop phase, in the exhaust line of the machine. Sampling and analytical procedures were according to Ref.[5] using a sampler head modified to obtain isokinetic conditions for the sampling in the exhaust pipe. In addition, representative samples of the fluff and the condensed water were taken. The quantity and composition of the textiles washed and the amount of condensate and fluff generated during this period of time were recorded.

Calculation of the mass balance

1. Input by textiles was calculated by relating the concentrations of PCDD/F in different types of dirty textiles to the mass and composition of the textiles cleaned in the machine during the period in which the air, fluff and condensate samples were collected.

2. Input of airborne PCDD/F was calculated by relating the indoor air concentrations to the amount of air which was supplied into the cleaner during the "open loop" periods.

3. Output of PCDD/F through textiles was calculated as in Ref.[1] above, using the concentrations measured in the same textiles after they had been cleaned.

4. Output of PCDD/F through condensate and fluff was calculated by relating the concentrations measured in these matrices to the total amount generated during the experiment.

5. Output of airborne PCDD/F was calculated by relating the concentrations measured in the exhaust of the dry cleaning machine to the total air volume supplied during the "open loop" periods.

6. Output through redistillation residues was calculated from the difference of (1+2) and (3+4+5).

Results and discussion

Figure 1 shows the results of the mass balance calculations described above. The following assumptions were made:

1. No input of PCDD/F by solvents or additives as reported in Ref.[1,4].
2. No PCDD/F formation during the process as reported in Ref.[1,4].
3. No PCDD/F output from the solvent filter. Prior to redistillation the used solvent is passed through a filter of siliceous earth to remove solid impurities. Due to the continuous extraction of the filter an accumulation of PCDD/F in the filter material does not seem very likely.

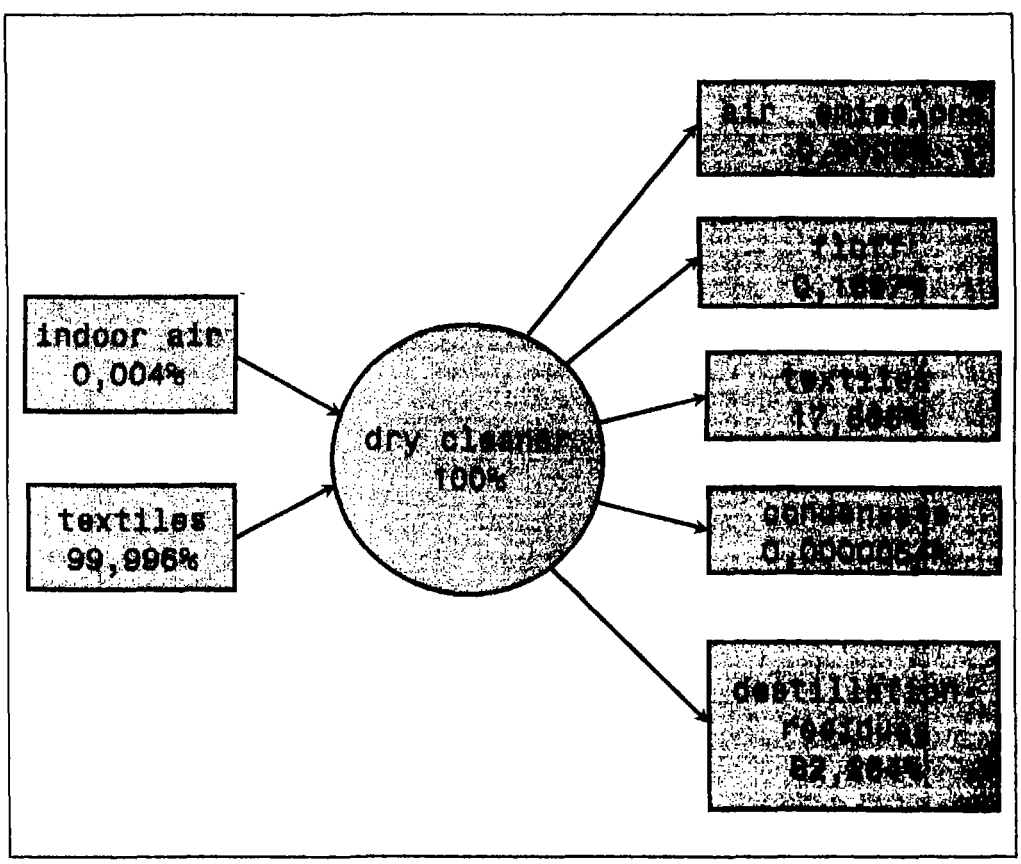

Figure 1: mass balance of PCDD/F (based on I-TEQ) in a open loop dry cleaning machine

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The mass balance, performed using international toxicity eqivalents (I-TEQ) shows clearly that the distillation residues are the only significant output pathway of PCDD/F removed from the textiles. They account for more than 80% of the total output. Almost all of the remainder is accounted for by the PCDD/F that was not removed from the textiles. It could be that the relative output attributed to the textiles is higher when the textiles are only cleaned once. Other outputs via air emission, condensate or fluff are negligible. Interestingly, the PCDD/F levels in the air emissions are significantly lower than in the inlet air. We attribute this to the fact that before leaving the machine the air has to pass through the textiles, the loaded fluff filter and the condenser, all of which act as traps for gaseous as well as for particle bound PCDD/F.

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