INVESTIGATIONS OF THE ORIGIN OF PCDD/F IN MUNICIPAL SEWAGE SLUDGE

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Abstract

The contributions of surface runoff and houshold wastewater to the PCDD/F levels in sewage sludge were investigated. The PCDD/F homologue pattern in household wastewater was very similar to that in sewage sludge, whereas the patterns in runoff and sewage sludge were different. A crude mass balance indicated that 3-5 times more of the Cl_8DD in sewage sludge originates from households than from runoff. These results suggest that the importance of household wastewater as a PCDD/F source has been underestimated.

Introduction

PCDD/F is present in sewage sludge at concentrations of 30-100 ng TE/kg DW, even in the absence of industrial sources[1]. This creates problems for the disposal of sewage sludge. It has often been applied as agricultural fertilizer, but it was recently demonstrated that this practice leads to PCDD/F accumulation in soils and, when applied excessively, to accumulation of PCDD/F in the agricultural food chain.[2]

It is to date unclear where the PCDD/F in the sewage sludge originate. A literature study of this subject came to the conclusion that a large fraction of the contamination cannot be explained with our current knowledge of PCDD/F sources.[3] At last years conference we presented the results of investigations of the contribution of surface runoff.[4] The concentrations in sludge were not significantly different between periods of dry and wet weather, which suggested that atmospheric deposition and surface runoff were not the primary PCDD/F source.

In the last year we have shifted our attention to other potential sources, focussing on household wastewater.

Experimental

Household wastewater was sampled on two different days at an appartment building in Bayreuth (FRG) with approximate 750 inhabitants. The samples were collected with a ladle at 5 minute

intervals over an hour as the water fell over a weir, a method which ensured a sample representative of the flux leaving the building. The water flow was also monitored.

The aqueous and particulate phases of the waste water were separated by filtration. The filtrate was extracted with toluene in a separatory funnel. This toluene was then used for soxhlet extraction of the solid residue. The cleanup and analysis methodology has been described elsewhere[4].

Results and Discussion

Figures 1-4 show four typical PCDD/F homologue patterns from Bayreuth: one sewage sludge sample (Fig. 1), one sample from household wastewater (Fig. 2) and two runoff-sediment samples (Fig. 3 and 4).

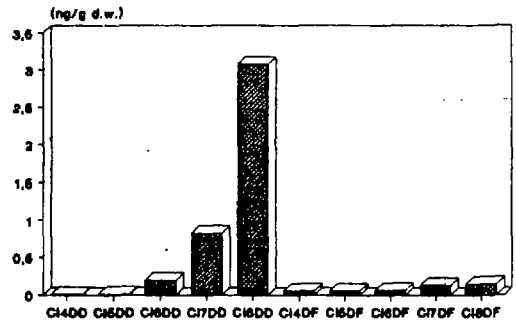

Fig.1: PCDD/F in Primary sludge (Bayreuth; 7.6.91)

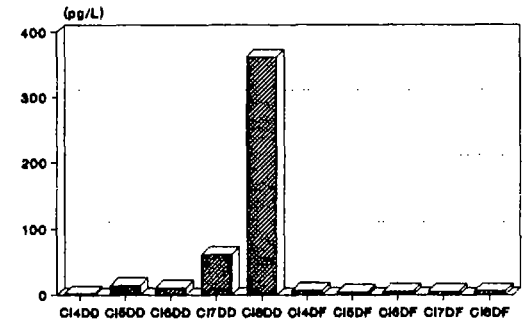

Fig.2: PCDD/F in Household Wastewater (Bayreuth, October 1991)

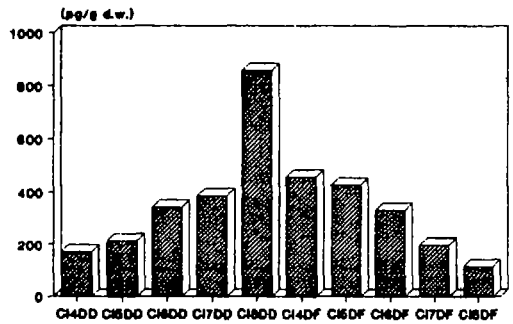

Fig.3: PCDD/F in Runnoff-Sediment 1 (Bayreuth, September 1991)

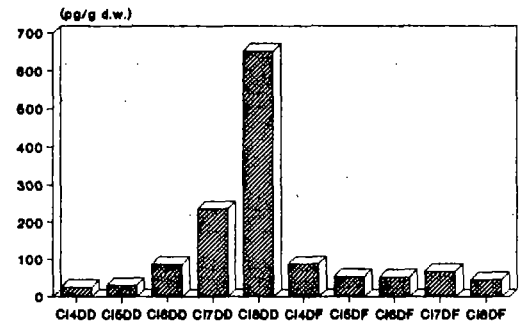

Fig.4: PCDD/F in Runnoff-Sediment 2 (Bayreuth, September 1991)

Significant differences are perceptible between the sludge and the waste water samples on the one hand and the sediment samples on the other hand. The PCDD/F-homologue patterns of sewage sludge and household wastewater agree very well with each other.

The Cl_8DD-fluxes in household wastewater are plotted on a per inhabitant bases for two different days in Figures 5 and 6:

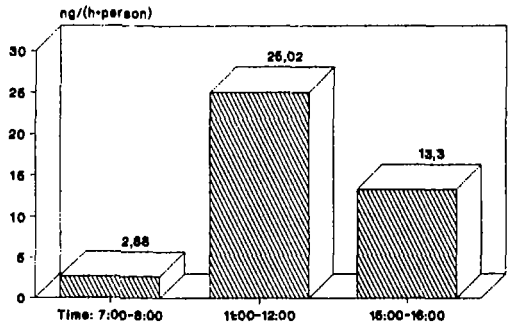

Fig.5: Cl8DD-Quantity in Household Wastewater (October 1991)

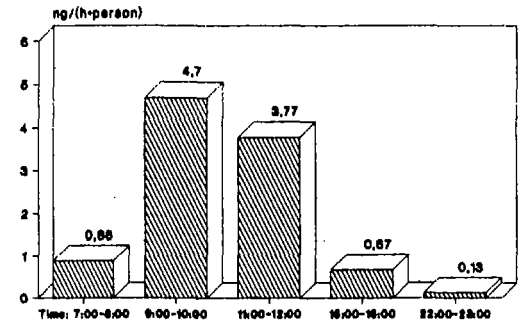

Fig.6: Cl8DD-Quantity in Household Wastewater (March 1992)

There is a distinct daily variation with low fluxes in the morning and evening and high fluxes around noon. The magnitude of the fluxes is significantly different for the two days, differing by a factor of 5.

An attempt at a crude mass balance of Cl_8DD in the sewage sludge was made using these data. The results are illustrated in Figures 7 and 8:

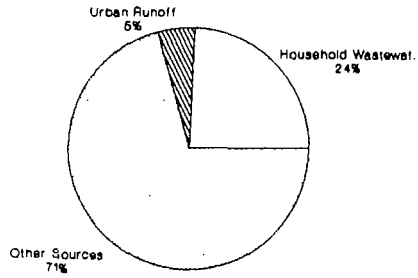

Fig.7: Pathways of Cl8DD into Primary Sludge (Worste Case)

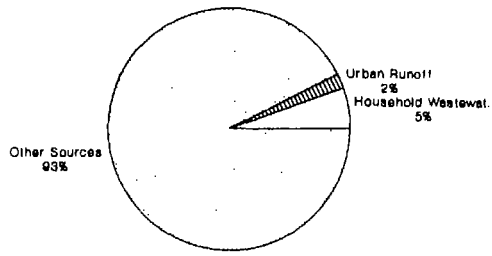

Fig.8: Pathways of Cl8DD into Primary Sludge

Figure 7 illustrates a mass balance calculated with 'worst case' Cl_8DD-concentrations of urban runoff and the household wastewater data from Figure 5. The contribution from household wastewater is nearly 5 times higher than the contribution from urban runoff. Figure 8 is based on average runoff concentrations and the lower household wastewater values of Figure 6.

Two ratios characteristic for PCDD/F in sewage sludge (1,2,3,6,7,8-Cl_6DD/1,2,3,4,7,8-Cl_6DD; $Cl_8DD/\Sigma Cl_4DF$) are plotted against each other in Figure 9.

Whereas the surface runoff samples are all in the lower left corner, the sludge and household wastewater samples occupy the upper right portion of the plot. The agreement between sludge samples and household wastewater indicates a possible connection between these media. Urban runoff differs clearly from sludge samples.

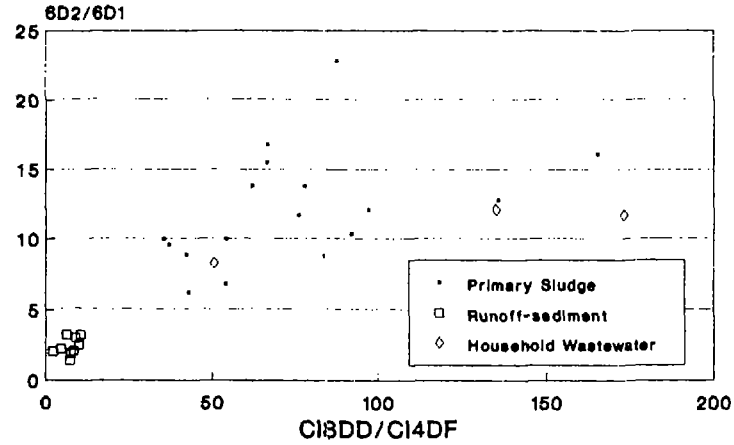

Fig.9: 6D2/6D1-ratio plotted against the Cl8DD/Cl4DF-ratio

Conclusions

- The PCDD/F homologue patterns from sludge samples and household wastewater are very similar.

- Significant quantities of PCDD/F are present in household wastewater.

- The contibution of C_8DD from household wastewater is estimated to be 3-5 times higher than the contribution from urban runoff.

References

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2) McLachlan,M.S.; Hinkel,M.; Reissinger,M.; Kaupp,H.; Hippelein,M.; Hutzinger,O.: Eintrag von chlorierten Kohlenwasserstoffen (PCDD, PCDF und PCB) in die Nahrungskette durch Klärschlammdüngung; *Materialienbände des STMLU, Bayrisches Umweltministerium*, **1992** in press

3) Ghir,R.; Klöpffer,W.; Rippen,G.; Partscht,H.; Stoll,U.; Müller;J.: Die Herkunft von polychlorierten Dibenzo-p-dioxinen (PCDD) und Dibenzofuranen (PCDF) bei der Grundbelastung von kommunalen Klärschlämmen; *Korrespondenz Abwasser* 6/1991, 38, 802-805

4) Horstmann,M; Kaune,A.; McLachlan,M.S.; Reissinger,M.; Hutzinger,O.: Temporal Variability of PCDD/F concentrations in sewage sludge; *Chemosphere*, **1992** in press