An Investigation of PCDD/F in a Composting Operation

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Abstract

The levels of PCDD/F were investigated in compost from a commercial composting operation that processes household vegetable waste. An annual cycle in the I-TE levels in the compost was observed, with peak concentrations in summer that were 2.5 times higher than in winter. This increase in the I-TEs was due to increases in the levels of Cl_7DD and Cl_8DD, whereas the concentrations of the Cl_4-Cl_6 congeners varied little over the year. A rough mass balance of the composting process suggested that Cl_7DD and Cl_8DD might be formed during composting.

Introduction

As part of their waste reduction strategies numerous municipalities in Germany have begun to separately collect and compost organic waste. The resulting compost is a valuable resource that can be used for soil improvement in home gardens and in agriculture. However, considerable levels of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F) have been found in compost[1]. This has generated concerns about the suitability of compost as a fertilizer.

The purpose of this study was to more closely investigate PCDD/Fs in a small composting operation. The variation in the concentrations of PCDD/F in compost were measured over the period of a year. Two rough mass balances were conducted for PCDD/F in the composting process.

Experimental

The composting operation studied was supplied with the vegetable waste (no ash or cinders) of a small town (pop. 3368) in northeastern Bavaria. The waste originated from both private households and small businesses such as hotels, bakeries, grocery stores and a flower shop. Only 27% of the households

participated in the composting as the majority composted privately in their yards. For this reason relatively little garden waste was present in the material collected.

The composting was conducted on the concrete floor of a large shed. One part filler (garden waste from another source) was added to every three parts of municipal waste to improve the porosity of the starting material. The starting material was piled in a windrow about 80 cm high and 160 cm wide. The windrow was mechanically mixed every 3 days. The temperature within the windrow climbed to ca. 70°C, generally within a week, and remained there for several weeks. The biological decomposition stopped after ca. 7 weeks when the water was used up.

Two samples of finished compost were collected every two months between November 1991 and September 1992. In March and September two samples of the starting material (vegetable waste plus filler) for the respective composts were taken.

All samples were analysed for PCDD/F using a modified version of the method specified in the German Sewage Sludge Regulation. The HRGC/HRMS measurements were conducted on a VG Autospec Ultima at a resolution of 10,000.

The samples of starting material and finished compost for the mass balances in March and September were analysed for cadmium, copper and lead. These metals served as conservative tracers to determine the mass loss during the composting process. Five metal measurements were conducted for each sample using AAS.

Results

The concentrations of 2,3,7,8-Cl_4DD toxicity equivalents (TEs) in the compost samples are plotted in Figure 1. The difference between the two samples for a particular month was, with one exception, less than 10% (Note that only one sample was analysed in March). An annual cycle in the PCDD/F levels is apparent, with the lowest concentrations in winter and 2.5 times higher values in summer.

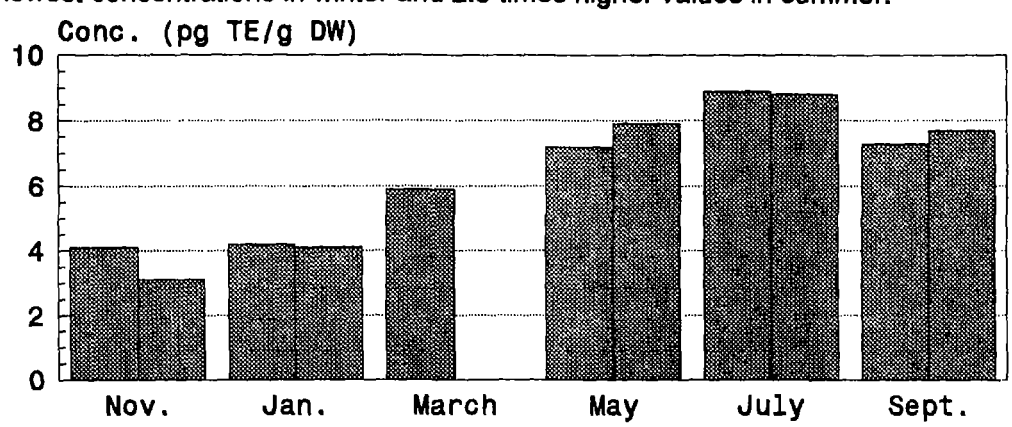

Figure 1: Concentrations of PCDD/F in Compost Sampled over 1 Year

A closer examination of the data showed that the increase in TEs was due to increases in the levels of Cl_7DD and Cl_8DD. The Cl_8DD concentrations were 8.4 times higher in July than in November and the 1,2,3,4,6,7,8-Cl_7DD levels were 5.9 times higher. A smaller increase was observed for 1,2,3,6,7,8-Cl_6DD and Cl_8DF, whereas the concentrations in the Cl_4-Cl_6DD/F congeners remained relatively constant throughout the year (see Figure 2).

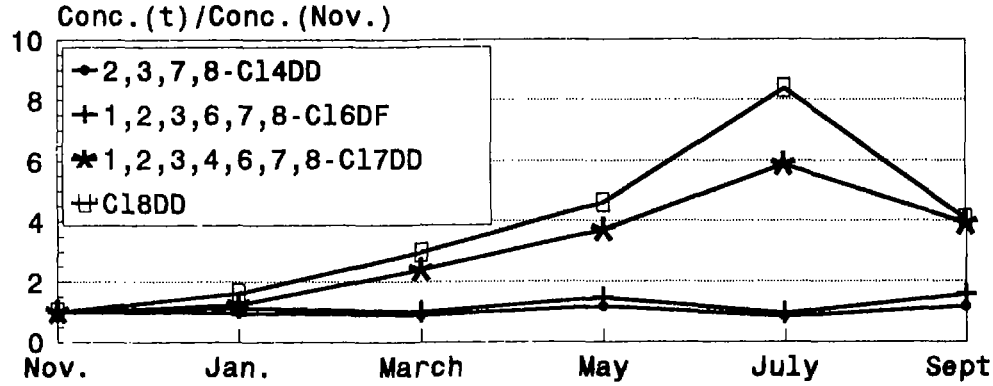

Figure 2: Concentrations of Various PCDD/F Congeners in Compost Sampled over 1 Year normalized with respect to the Concentrations in the November Sample

The heavy metal analyses indicated that ca. 50% of the dry mass was lost during the composting process. The accumulation factor, the quotient of the concentration in the finished compost and the concentration in the starting material, was corrected for this loss and plotted (see Figure 3). For the March compost a large number of the furans had values close to one, but the concentration factors for the dioxins and higher chlorinated furans lay considerably lower, indicating losses during composting. These results are uncertain though, as the concentrations of the PCDD/F in the two samples of starting material differred by up to a factor of 2. The concentration factors in the September compost lie a little below 1 for most congeners, somewhat higher for the Cl_6DD and Cl_8DF, and around 3 for Cl_7DD and Cl_8DD, indicating production of these compounds. In this case the differences between the parallel samples were <10% for almost all congeners.

Discussion

The dramatic increase in the concentrations of Cl_7DD and Cl_8DD in summer was puzzling. No seasonal source was apparent that would supply large amounts of these two congeners. Measurements of the organic fraction of household waste in Germany revealed higher levels of PCDD/F in winter than in summer[2].

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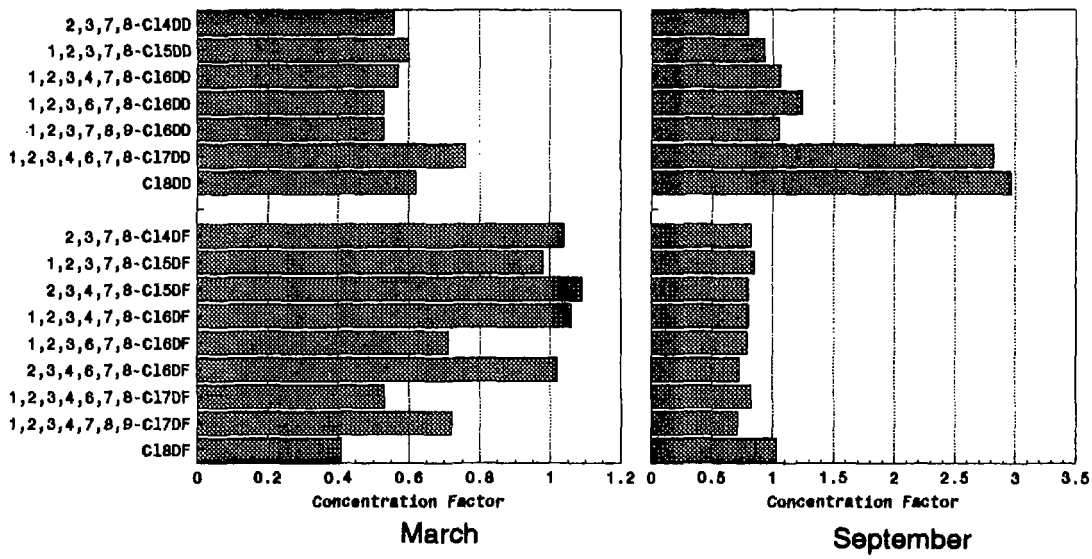

Figure 3: Accumulation Factors for the 2,3,7,8-substituted PCDD/F for 2 Composts

The results of the September mass balance suggest that these compounds could be produced during the composting process. The concentration factors were elevated for the same compounds that had higher concentrations in summer (and in the September compost). This hypothesis is very tentative however. The starting material was heterogeneous, so that it is possible that the two samples did not contain representative levels of the PCDD/F. The discrepancies between the two samples of starting material for the March compost illustrate this problem.

The levels of PCDD/F in the compost lay below the guideline of the German Health Office (BGA) for unrestricted use of agricultural soil (5 pg TE/g DW) in winter and somewhat above this level in summer. If the source of the summer contamination could be identified and eliminated, the concentrations in the compost would likely always be below this guideline.

References

1 Krauß P, Hagenmaier H, Benz T, Hohl J, Hummler M, Korherr U, Kummer V, Mayer J, Weberruß U. Organische Schadstoffe im Kompost. Paper presented at the 59th Abfalltechnischen Kolloquium in Stuttgart, March 15, 1991.
2 Wilken M, Cornelsen B, Zeschmar-Lahl B, Jager J. Verteilung von PCDD/PCDF und anderen Organochlorverbindungen in verschiedenen Fraktionen des Hausmülls. *Organohalogen Compounds* 1991:7;347-358.