Soil Monitoring in the Vicinity of an Old Municipal Solid Waste Incinerator: PCDD/F Concentrations

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Introduction

Although incineration reduces the volume of waste by approximately 90% and allows for recovery of much of the energy bound in the waste, the emissions of metals and polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), as well as their impact on public health are issues of great concern (1-3).

Humans in the vicinity of MSW incinerators can be exposed to PCDD/Fs via various direct and indirect pathways, which include inhalation, the terrestrial and aquatic food chain, and ingestion of soil and water impacted by the emissions (4). Since PCDD/Fs have a low vapor pressure and are semivolatile and lipophilic compounds, they accumulate in media rich in organic carbon such as soils and sediments (5,6). Consequently, PCDD/F contaminated soils may cause a transfer to the food chain (7,8).

In order to determine the temporal variation in the levels of metals and PCDDs and PCDFs in soils in the vicinity of an old municipal solid waste incinerator (Montcada, Barcelona, Spain), in 1997 we collected soil and vegetation samples at the same sampling points in which samples were taken one year before. The levels of PCDD/Fs in soils are here reported and compared with those previously obtained (9).

Materials and Methods

In October 1997, 24 soil samples were collected in the surroundings of the MSWI (Montcada, Barcelona, Spain) in the same points in which samples had been also taken in the 1996 survey (9). Duplicate soil samples were taken at 100, 250, 500, 750, 1000, 1500, 2000 and 3000 m from the stack in each of the three main directions of the wind rose in the area (S, NW, NE). The sample amounts consisted of a minimum of 500 g. Soil samples were sieved through a 2 mm mesh screen to obtain a more homogenous grain distribution. Determination of dry matter content was achieved by drying subsamples (1-3 g) at 130°C overnight (9).

The extraction and clean-up procedures, as well as the analytical determination of PCDD/Fs were carried out as recently reported (9). For the determination of groups of PCDD/F congeners with the same degree of chlorination and for the hepta- and octa-PCDD/F congeners substituted at the 2,3,7,8-positions, a Hewlett Packard 5890 series II gas chromatograph provided with an on-column injector was applied in combination with a Hewlett Packard 5972 low resolution mass spectrometer. For the determination of the tetra- to hexa-PCDD/F congeners substituted at the 2,3,7,8-positions, a Varian 3300 gas chromatograph provided with a septum-equipped programmable injector was applied in combination with a Finnigan MAT 95 high resolution mass spectrometer.

For I-TEQ calculations, in the case of values under the detection limit, the congener was assumed to be present at half of the detection limit (0.05 ng/kg dry matter). Principal Component Analysis (PCA) was applied to compare the distribution of PCDD/F patterns and profiles found in the samples collected in the same sampling points in both studies.

Results and Discussion

PCDD/F concentrations ranged from 0.15 to 29.27 ng TEQ/kg (dry matter), with a median value of 2.56 and a mean value of 4.47 ng TEQ/kg. In the 1996 survey, PCDD/F levels ranged from 0.30 to 44.26 ng TEQ/kg (dry matter), with median and mean values of 3.52 ng TEQ/kg and 6.91 ng TEQ/kg. PCDD/F levels decreased in 14 of the 24 samples, while the remaining 10 samples showed increases of different orders. Most tetra- to octa-PCDD/Fs could be detected in all soil samples, whereas OCDD was the predominant congener and contributor to I-TEQ, followed by 1,2,3,4,6,7,8-HpCDD. This is a typical profile of PCDD/Fs in soil samples collected in the vicinity of MSW incinerators (5,9,10).

Figure 1 shows calculated total I-TEQs according to the three main wind directions for the 1996 and 1997 surveys. When the Kruskal-Wallis test was applied to these directions, no statistically significant differences in PCDD/F levels were seen. In turn, PCDD/F levels in soil samples collected at different distances from the stack for the 1996 and the 1997 studies are depicted in Fig. 2. In both surveys, the highest PCDD/F concentrations were found at 750 m from the stack to the south direction: 44.26 ng TEQ/kg (9) and 29.27 ng TEQ/kg (this study).

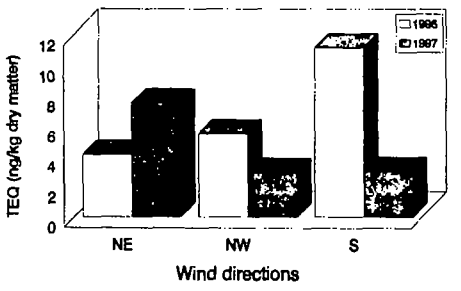

Fig. 1. PCCD/F levels in soils collected in the vicinity of an old MSWI according to the main wind directions in the area

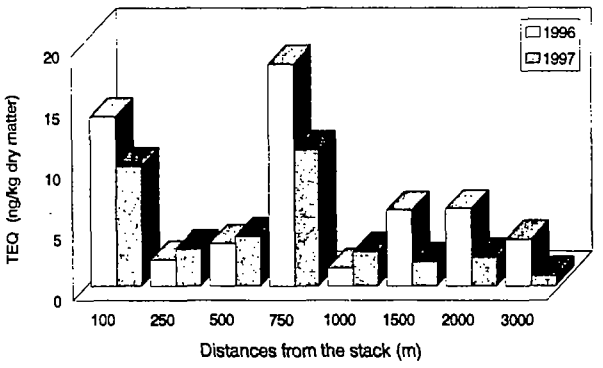

Fig. 2. PCDD/F levels in soils collected at different distances from an old MSWI

To correlate the analytical data for the 1996 and 1997 surveys, as well as to evaluate potential changes in the isomer distribution (for example, as a result of chemical reactions, volatilization, or dechlorination), PCA was applied to the 48 soil samples corresponding to both studies. PCA provided a single two-dimensional model which would explain 92.7 % of the variance in the data (Fig. 3). The first main PC (which would explain 62.6 % of the variance) is highly and positively correlated with the lower substituted PCDD/Fs, while the second PC (30.1% of the variance) is positively correlated with the higher substituted PCDD/Fs (1,2,3,4,7,8-HxCDD, HpCDD, OCDD and OCDF).

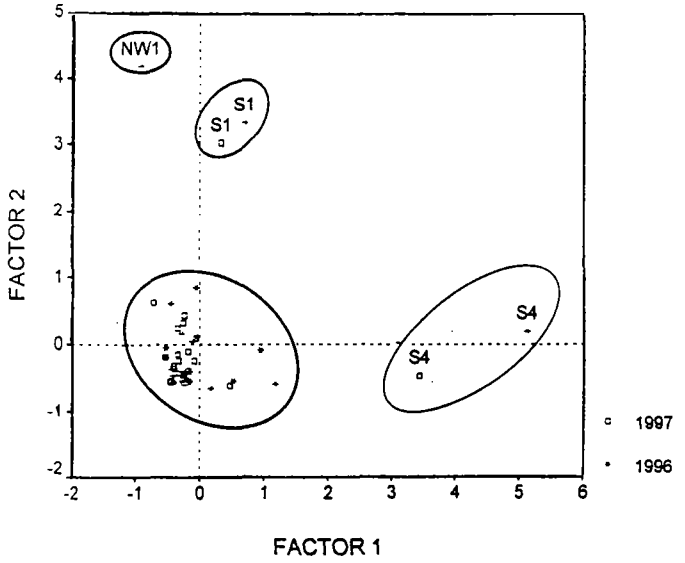

Fig. 3. Principal component analysis: plot for soil samples collected in the vicinity of an old MSWI in 1996 and again in 1997

The results of the current study show that, in general terms, PCDD/F concentrations in soils collected in the vicinity of an old MSWI decreased slightly during the last months. Since the operation conditions of the plant were basically unchanged, this decrease could be explained taking into account external processes such as PCDD/F volatilization, degradation, or other mechanisms that are controlled by the characteristics of the congeners and the environment. Also, the continuous general effort to reduce PCDD/F emissions from a number of different sources could be another explanatory factor for the current decreases.

Acknowledgements

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