Air Quality impact of the shut-down of a Hospital Waste Incinerator in the Oporto Region

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1. Introduction

Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) are injected into the atmosphere by various combustion processes and dispersed throughout the environment by atmospheric transport. These combustion processes include the incineration of municipal solid wastes (MSW). The construction of a MSW incinerator in the Portuguese region of Oporto in 1998 led to the development of an external air quality monitoring program[1,2]. Since that year, the collection of a total of 89 samples has provided a characterization of PCDD/PCDF levels in the Oporto region.

To trace any source of contamination, a comparison of the PCDD/PCDF homologue profiles in environmental samples is made by a simple direct comparison and by cluster analysis. The determination of characteristic homologue profiles in representative environmental samples is essential to evaluate the relationship between sources and impacted areas. This information helps to understand the impact of the surrounding industries on the environment and public health, having in mind that the Oporto region is one of the major industrial and densely inhabited areas of Portugal. The present paper focuses on PCDD/PCDF ambient air data obtained in this region since June 1998 until February 2004.

2. Materials and methods

2.1 Sampling sites

An ambient air monitoring program for the MSW incinerator in the Oporto region was designed with the main objective of accompanying and evaluating the effects on the surrounding area. In 1998, a set of two monitoring sites were selected in the suburbs of Oporto, in a radius of a few kilometres from the MSW complex, followed by another two in 1999. In August 1999, sampling ceased at the closest site (NW) to the facility, the same happening to one of the sites located downtown Oporto in February 2000.

2.2 Sample collection and analysis

Sampling apparatus for PCDDs/PCDFs in ambient air was carried out according to German guideline VDI 3498 Part 2, 2002. The sampling apparatus consisted basically of a filter system, a mast, a suction pump, a gas volumeter and timer. Particulate matter (PM) in the air was collected on a glass fiber filter. Filter-passing matter was collected on a polyurethane foam. To monitor the effectiveness of sampling, a second polyurethane foam was connected downstream. The reference volume is the volume of air that is drawn through the sampling device and measured with a gas volumeter during the sampling period (72 hours).

The PCDDs/PCDFs which were deposited on the glass fibre filter and absorbed in the PU foam were extracted and cleaned up from interfering components in a multistage separation process. They were quantified by gas chromatography/mass spectrometry, according to German guideline VDI 3498 Part 1, 2002.

3. Results and discussion

Ambient air sampling of PCDDs/PCDFs in the Oporto region began Summer 1998, with atmospheric PCDD/PCDF characterization of 89 samples until February 2004.

In the computation of the total I-TEQ, for those congeners below the detection limit the actual concentration was assumed to be half the detection limit.

3.1 PCDD/PCDF seasonal variation

Another ambient air monitoring program, developed in the vicinity of a similar MSW facility in the Lisbon region, with a total of 42 PCDD/PCDF samples collected between February 1999 and January 2004, revealed a range of concentrations from 7,5 to 152 fg I-TEQ.m^{-3}. For all these samples and the ones collected in the Oporto region, Fig. 2 illustrates several statistical parameters.

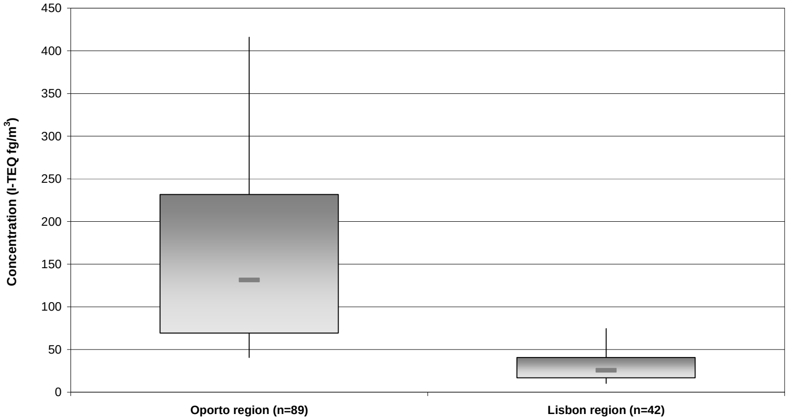

Fig. 2 – PCDD/PCDF statistical parameters: mean, percentile 10, 25, 75 and 90 determined for ambient air samples collected in the Oporto and Lisbon region.

Fig. 2 shows that percentile 25 for the Oporto region (69,0 fg I-TEQ.m^{-3}) is higher than percentil 75 for the Lisbon region (40,6 fg I-TEQ.m^{-3}).

The difference between the group of samples from Oporto and the one from Lisbon can not be explained by any natural characteristic of any of these regions. Both monitoring programs include territory with suburban characteristics belonging to the Oporto and Lisbon metropolitan areas. Concentrations measured in Lisbon are comparable to those found in rural and non contaminated urban areas[5]: 83% of PCDD/PCDF concentrations in this region range from 10 to 100 fg I-TEQ.m^{-3}. On the other hand, in Oporto, 77% of samples collected are in the 40 to 400 fg I-TEQ.m^{-3} range, approximately 4 times higher than the Lisbon region levels.

For determining the seasonal behaviour of PCDDs/PCDFs, two periods were considered, Spring/Summer (April-September) and Autumn/Winter (October-March), referred to as Summer and Winter in all figures presented in this paper. Fig. 1 shows several statistical parameters, expressed in I-TEQ, calculated for all PCDDs/PCDFs concentrations and considering the Spring/Summer and Autumn/Winter periods. The mean value (37 fg I-TEQ.m^{-3}) and concentration range (13-42 fg I-TEQ.m^{-3}) for Summer 2002 are the lowest, followed by Summer 2003 (mean: 50 fg I-TEQ.m^{-3}, range: 9,8-172 fg I-TEQ.m^{-3}). Differences between these two periods, as well as the last two winter periods, are related to different number of samples collected.

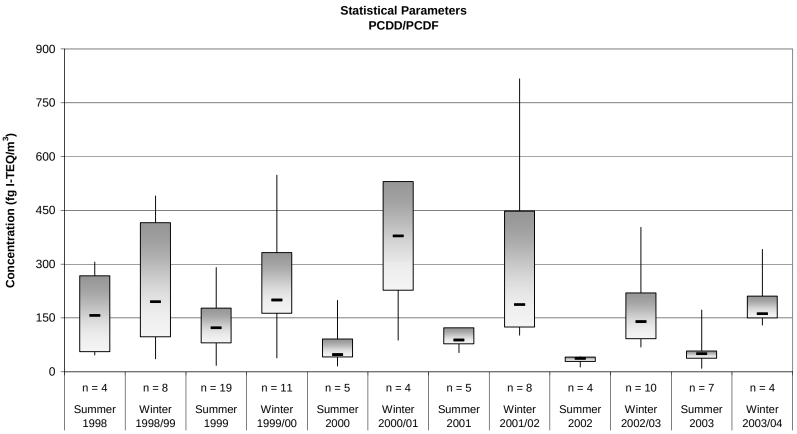

Fig. 1 – PCDD/PCDF statistical parameters: mean, percentile 10, 25, 75 and 90 determined for ambient air samples collected in the Oporto region.

Winter levels are approximately 3 to 4 times higher then summer levels, while it is possible to observe a gradual decrease of mean concentrations of atmospheric PCDDs/PCDFs over time. The seasonal variation of concentrations is noteworthy and consistent with previous findings in other airsheds[4]. The major seasonal pollution source of atmospheric PCDD/PCDF levels in the region may be household wood burning for heating in winter. Burning woods at low temperature with low burning efficiency, plus burning of chlorinated phenol added (as antiseptic) woods may increase PCDD/PCDF emission[3].

3.2 Homologue profiles

Homologue profiles were analysed in order to derive some further indications on the possible dioxin sources. Just as with PCDD/PCDF concentrations, seasonal behaviour is evident over PCDD/PCDF homologues (Fig. 3). The hepta- and octa-CDD and tetra-CDF have accounted for at least half of the total concentrations over the last years. Since Winter 2000/01 there has been an increased contribution of about 50% from the tetra-CDF species (4F), and a decrease to approximately one third of the hexa-CDD.

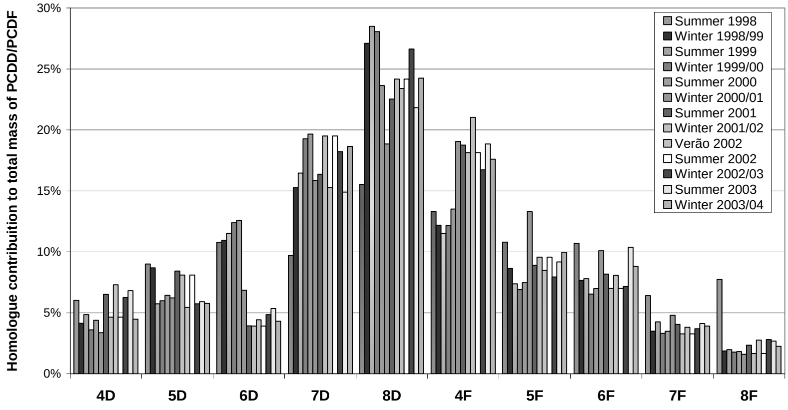

Fig. 3 – Homologue profiles of ambient air samples collected in the Oporto region.

For a more global approach, hierarchical cluster analysis was performed considering all seasonal periods since the beginning of PCDD/PCDF ambient air sampling in the Oporto region. All data were normalized such that [PCDD] + [PCDF] = 1 and average homologue contributions from each season, expressed as I-TEQ.m^{-3}, were used as inputs to the cluster analysis. Cluster analysis provided information on one of the sources responsible for PCDD/PCDF levels and profiles determined until Summer 2000 (Fig. 4).

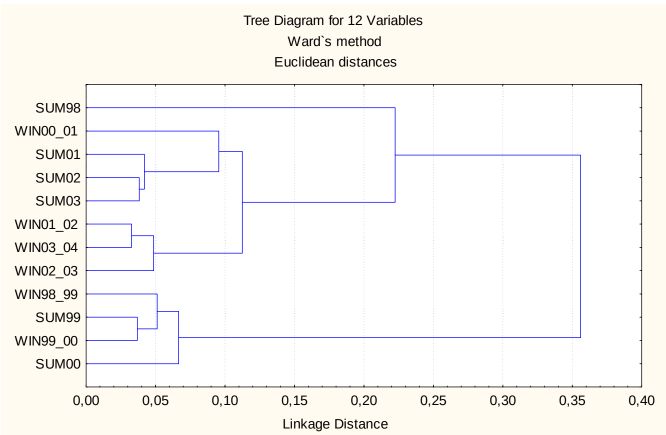

Fig. 4 – Hierarchical tree plot of cluster analysis of ambient air samples collected in the Oporto region.

Apart from no relation with the PCDD/PCDF emissions from the MSW incinerator in the Oporto region in Summer 1998, because of its inexistence at that time, cluster analysis evidenced that PCDD/PCDF levels in the environmental samples collected until Winter 2000/01 were more related with the Hospital Waste Incinerator of the S. João Hospital. Shut down of the Hospital Waste incinerator during the beginning of 2001 resulted in a redistribution of homologue fractions, with an apparent increase in tetra-CDF species. This relative increase helped to better visualize the contribution of one of the main sources of these congeners: the siderurgy industry operating in the region.

Closing down of an important emission source like a hospital waste incinerator surely had great effect, not only on regional levels of PCDD/PCDF but also on PCDD/PCDF homologue profiles of the samples collected, just as illustrated in Fig. 4.

4. Acknowledgement

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5. References

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