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Chemosphere 59 (2005) 1465–1474

CHEMOSPHERE

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Evaluation of PCDD/Fs patterns emitted from incinerator via direct ambient sampling and indirect serum levels assessment of Taiwanese

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Received 17 March 2004; received in revised form 7 October 2004; accepted 15 December 2004

Abstract

The aim of this study was to evaluate the PCDD/Fs patterns in ambient air based on data information emitted from incinerator generated from ambient air measurements and those in serum. Four circular zones, namely A, B, C, and D, were identified based on simulated ambient annual average PCDD/Fs concentrations, from a selected municipal waste incinerator. Sixteen ambient samples were taken from the 4 circular zones across 4-seasons. Eighty-nine volunteers were recruited according to the demographic distribution within each zone. PCDD/Fs profiles were documented both for air and serum samples collected. Comparing to the congener patterns from ambient air and serum samples, we found that OCDD, OCDF, 1,2,3,4,6,7,8-HpCDD, and 1,2,3,4,6,7,8-HpCDF were the predominant groups among 17 congeners from both the ambient air and serum sample. And, factor analysis showed the distribution patterns of PCDD/Fs from ambient air and serum samples are almost identical across different zones, except for congener patterns of serum samples from residents in zone C. In addition, the average PCDD/Fs level significantly reduced for about 10 folds than those of the other three seasons when the incinerator was shut down in one of sampling periods. We might conclude that ambient air exposure was the most important contributor to PCDD/Fs levels in ambient air but not the single in serum. Therefore, another or more powerful source, such as occupational exposure, dietary intake or the consumption of local food, should be further investigated at the same time.

Keywords: PCDD/Fs; Dioxin; Incinerator; Atmospheric; Serum

1. Introduction

Polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) are toxic substances generated unintentionally as by-products from human activities such as combustion, manufacturing of organic chloride pesticides, using chloride chemicals in paper mills, wool-treating factories, or other plants (Fiedler et al., 1997; Patandin et al., 1999). PCDDs consist of 75 mono- to octa-chlorinated congeners, and PCDFs include 135 congeners. To this date, due to the toxicity and tendency to bio-accumulate in plants and animals, most

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0045-6535/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.chemosphere.2004.12.075

researchers have focused their efforts on the seventeen 2,3,7,8-substituted PCDD and PCDF congeners.

Most PCDDs and PCDFs (dioxins like compounds) are also well known to resist to environmental and biological degradation and to disperse into various parts of the environments through the atmosphere, water, soil, sediments, and food (Czuczwa and Hites, 1986; Tong et al., 1991; Zook and Rappe, 1994; Coutinho et al., 1998; Lorber et al., 1998; Abad et al., 2000). Lorber et al. (1998) showed that a similar "incinerator signature" profile was manifest in stack-gas emission of ash and in air and soil matrices around incinerators, and it was also found that soil concentration of dioxins declined with distance from outside of fence line to urban area which far away several kilometers from incinerator. And, Domingo et al. found that PCDD/Fs levels increased in soil and vegetation in the vicinity of an old municipal waste incinerator (Domingo et al., 1999). The above results all suggest that dioxins are emitted into ambient air and deposited in the soil, and then accumulated in the environment. Therefore, we further concerned about whether PCDD/Fs emission of incinerator could be transported from stack to soil, food, and finally via food intake and inhalation into the human body.

To the date, the varied pattern between the ambient air and serum analysis was shown in the previous studies. Many investigations have found that the fraction of PCDFs to TEQ was higher than PCDDs to TEQ in ambient air evaluation (Kurokawa et al., 1996; Oh et al., 1999; Kim et al., 2001). However, one study (Gonzalez et al., 1998) reported that PCDDs represented the 95% of total PCDD/Fs, and an earlier study (Jimenez et al., 1996) reported that PCDDs represented the 88.5% of total PCDD/Fs in Spain population. Gonzalez et al. also showed that the most important isomers for TEQ accumulation were hexa-CDD, penta-CDD and penta-CDF in serum analysis as well as Jimenez et al. reported for serum PCDD/Fs accumulation.

One recent study (Evans et al., 2000) determined whether the lipid-adjusted serum-TCDD levels increased or not in a population living in the vicinity of hazardous waste incinerator burning materials contaminated with 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). The results showed that TCDD levels decreased from preincineration to 4 months after incineration had begun, and further decreased at the end of the incineration period. Deml et al. (1996) also reported no increasing body burden of PCDD/Fs in a non-occupationally exposed group living in the vicinity of an incinerator when compared to background levels in the general populations. Another study (Gonzalez et al., 1998) reported no significant difference in serum PCDD/Fs concentrations between potentially exposed groups living in districts less than 1 km from an incinerator and unexposed groups living in districts about 4 km away. Though most published studies showed that the incinerators emission unlikely to be related to serum PCDD/Fs levels in subjects living nearby, most of them have loosely defined "ambient exposure", so it is difficult to suggest that incineration emission did not result in any measurable PCDD/Fs exposure to the population surrounding the incinerator. However, the serum distribution levels of people were also not in relation to the definitely predicted ambient levels in our previous report (Chen et al., 2004).

The current study therefore aimed to measure the PCDD/Fs patterns emitted based on data information generated from ambient air measurements and serum samples of the neighbor residents from the incinerator. In addition, seasonal ambient PCDD/Fs levels were able to evaluate some temporal variability over a year. PCDD/Fs profiles were documented and the variation between ambient air and serum samples was also examined in this study.

2. Materials and methods

2.1. Sampling

2.1.1. Atmospheric dispersion model and atmospheric sampling

An incinerator has been operating for 7 years in a typical metropolitan city of northern Taiwan was selected. To simulate the ambient PCDD/Fs exposure of participants in the vicinity of the incinerator, we applied the atmospheric dispersion model (Industrial Sources Complex Short Term, version 3.0, ISCST3), using an emission inventory of dioxin, to estimate the ambient dioxin concentrations (Chang and Lee, 1998). The performance of ISCST3 has been evaluated to be good with accuracy about 68% (Sivacoumar et al., 2001). Data included the PCDD/Fs concentrations emitted from the stack, height and diameter of the stack, emission capacity of exhaustion per hour, and 3 years real time meteorological data (1997, 1999, 2000) such as wind speed, wind direction and mixing layer height were input in ISC3 model for atmospheric dispersion simulation. The ISCST3 model was used to generate Gaussian atmospheric dispersion of emitted PCDD/Fs (Coutinho et al., 1998; Rosenbaum et al., 1999). SURFER software (version 6.02) was used to draw the equal annual concentration plots afterwards, and four geographical areas were defined according to the levels of estimated air pollution. The area with the highest average pollution level was zone A, and zone B was second, C third, and D fourth. We collected 2 atmospheric samples from area A and B together, 1 sample from area C, and another from area D in each season. Totally, there were 16 air samples collected during a year.

2.1.2. Subjects selection

Ninety-five volunteers were recruited, however, only 89 peoples (45 males, 44 females) completed all evalua-