CONGENER SPECIFIC ANALYSIS OF DIOXINS AND FURANS IN BOTTOM ASH OF MEDICAL WASTE INCINERATORS

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Introduction

Polychlorinated dibenzo-*p*-dioxins (PCDD) and dibenzofurans (PCDF) can be formed in a variety of combustion processes, including incineration of municipal solid waste, medical waste and hazardous chemical waste. Since these have been received a lot of importance as a source of these toxic chemicals, many laboratory studies have been carried out[1]. As with modern incinerators, hazardous waste burning facilities with state-of-the-art air pollution control devices can have very low PCDD/F emissions (e.g., 0.01ng TEQ/m^3)[2]. But the annual releases into the atmosphere of PCDD/F from hazardous waste incineration in the United States have been estimated between 15 g and 79 g TEQ per year. Laboratory studies of hazardous waste incineration and PCDD/F formation have focused on the role of chlorine, metal chlorides, and process parameters[3-7]. The role of particles and deposits has rarely been explored. Work by Naikwadi et al. was done with bag house filter ash and bottom ash from an industrial waste incinerator, using ^{13}C-pentachlorophenol as reactant at 300°C for 60 min in air. Both ashes produced 830–950 ng PCDD/100g ^{13}C-pentachlorophenol[8,9]. We used ash samples collected from the secondary combustor of incinerators burning medical waste and studied its PCDD/F concentration.

Materials and Methods

Ash was obtained from the secondary combustion chambers from five facilities in India burning medical waste. Details on temperature and residence time at the sampling location, date of collection, and sampling method were not available to us. PCDD/Fs were determined according to a protocol from the Ministry of Health and Welfare, Japan[10]. The samples were well homogenized, weighed out 10.2–13.4 g, and extracted with toluene in a Soxhlet apparatus. Clean-up was performed according to the methods described elsewhere[10]. The crude extracts were transferred to hexane and spiked with $^{13}C_{12}$-labeled PCDD/Fs (Cambridge Isotope Laboratories Inc., Andover, MA, USA). Then the samples were treated with sulfuric acid and further clean-up procedure was made using silica gel, alumina, and silica-mixed active carbon columns. PCDD/Fs were determined by a high-resolution gas chromatograph (HP5890 Series II, Hewlett Packard, USA) connected to a mass spectrometer (SX102A, JEOL, Japan) with selected ion monitoring at resolution 10 000. A SP-2331 column (Supelco, USA, 60 m) was used in the gas chromatograph.

Results and Discussion

The concentrations of PCDD/Fs in the extracts are shown in Table 1 which ranges from 3.699 to 8.371ng/Kg. Relatively high concentration was observed in the bottom ash samples from all 5 medical waste incinerators. The number of non-detects for each congener at each site is also presented (a value of zero indicates that the congener was present in every sample at the site). The method used for data reporting (where if a congener was below the detection limit, it was assumed to be present at half the detection limit) could have a significant influence on the congener profiles. Due to the varying detection limits, both by sample and by congener, the profiles may be skewed towards congeners with higher detection limits.

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Ash1 shows that the tetra chlorinated dioxin group, 2,3,7,8-Tetrachloro dibenzo dioxins and furans and penta chlorinated dibenzo dioxins and furans dominates the profile. Sample 2 exhibited the similar trend as observed at sample1. Here also the tetra chlorinated dioxin group, 2,3,7,8-Tetrachloro dibenzo dioxins and furans and penta chlorinated dibenzo dioxins and furans dominates the profile. The profiles for the measurement of dioxins and furans in ash sample 3 shows that the octa chlorinated dioxin group, 2,3,7,8-Tetrachloro dibenzo dioxins and furans, penta chlorinated dibenzo dioxins and furans, hexa and octa chlorinated furans dominates the profile. Bottom ash sample 4 shows that the hepta, octa chlorinated dioxin groups, 2,3,7,8-Tetrachloro dibenzo dioxins and furans and penta chlorinated dibenzo dioxins and furans dominates the profile. Bottom ash sample 4 (which has been collected from a common incineration facility where medical waste collected from various hospitals are incinerated) shows trace level of these toxic chemicals. However, while the tetra chlorinated dioxin group dominates the profile, it is a lower proportion of the total dioxin profile than at the other four sites, with the contribution from the chlorinated furan groups being higher. Analytical result of bottom ash sample 5 shows that the 2,3,7,8-Tetrachlorinated and hexachlorinated dibenzofuran dominates the profile.

Table 1 DIOXINS AND FURANS IN BOTTOM ASH COLLECTED FROM VARIOUS MEDICAL WASTE INCINERATORS IN INDIA
(All values are given in µg/Kg)

COMPOUND NAME	Ash1	Ash2	Ash3	Ash4	Ash5
Dioxin Congeners					
2,3,7,8-TCDD	1.38	1.5	0.95	0.62	1.07
1,2,3,7,8-PeCDD	0.062	0.07	0.044	0.07	0.021
1,2,3,4,7,8-HxCDD	0.028	0.018	0.057	0.08	0.035
1,2,3,6,7,8-HxCDD	0.047	0.027	0.054	0.085	0.035
1,2,3,7,8,9-HxCDD	0.033	0.025	0.02	0.075	0.035
1,2,3,4,6,7,8-HpCDD	0.013	0	0.023	0.025	0.035
1,2,3,4,6,7,8,9-OCDD	0.014	0.016	0.06	0.073	0.098
Furan Congeners					
2,3,7,8-TCDF	3.6	3.65	6.8	2.5	6.5
1,2,3,7,8-PeCDF	0.024	0.014	0.064	0.024	0
2,3,4,7,8-PeCDF	0.026	0.016	0.06	0.03	0
1,2,3,4,7,8-HxCDF	0.014	0.02	0.029	0.019	0.062
1,2,3,6,7,8-HxCDF	0.013	0.011	0.029	0.017	0.062
2,3,4,6,7,8-HxCDF	0.01	0.021	0.057	0	0
1,2,3,7,8,9-HxCDF	0.012	0.015	0.045	0.013	0.062
1,2,3,4,6,7,8-HpCDF	0.028	0.045	0.018	0.054	0.078
1,2,3,4,7,8,9-HpCDF	0.026	0.013	0.05	0	0.017
1,2,3,4,6,7,8,9-OCDF	0.045	0.023	0.011	0.014	0.05

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