Congener-Specific Monitoring of PCB and Hexachlorobenzene in Hazardous Waste Incineration Workers

Anders S. Seldén[1], Håkan B. Westberg[1], Annika Hanberg[2], and Yvonne Nygren[3], [1]Department of Occupational and Environmental Medicine, Örebro Medical Centre Hospital, SE-701 85 Örebro, Sweden, [2]Institute of Environmental Medicine, Karolinska Institute, SE-171 77 Stockholm, Sweden, and [3]Department of NBC Defence, National Defence Research Establishment, SE-901 82 Umeå, Sweden.

Abstract

Exposure to PCB and hexachlorobenzene (HCB) at a hazardous waste incineration plant was well below the corresponding threshold limit value (TLV), and the overall plasma PCB level in exposed workers was equivalent to matched controls. Some covariation was observed, however, between the PCB congener pattern of exposed workers' plasma and parallel air samples, indicating that congener-specific biomonitoring of PCB could be a useful complement to technical surveillance of the work environment. HCB biomonitoring also seemed to be of value in this respect. A trend analysis based on historical plasma samples, obtained from a subgroup of exposed workers prior to first exposure, showed decreasing levels of several (but not all) of the PCB congeners monitored, whereas the trend for HCB was slightly increasing.

Introduction

Hazardous waste incineration workers are exposed to a plethora of chemicals and some of them are organochlorine compounds (OCC). Many OCC of variable human toxicity are biologically stable and they are therefore often candidates for biological monitoring. To assess the exposure to persistent OCC at a hazardous waste incineration plant, air sampling of selected compounds was supplemented with analysis of blood samples from active workers. Blood samples collected from workers before entering into production (waste incineration) were also analysed for trends.

Material and Methods

Air samples from various locations within the plant were collected by two independent groups using slightly different sampling techniques and different analytical laboratories. Group A used glass fibre filters coupled with polyurethane foam plugs for sampling and gas chromatography with electron capture detection for PCB, whereas HCB was sampled on a Tenax sorbent and analysed by gas chromatography-mass spectrometry[1)]. Group B used glass fibre filters coupled with an XAD-2 sorbent for sampling and gas

chromatography-low resolution mass spectrometry for analysis[2]. Both groups, however, analysed the same PCB congeners (IUPAC #28, 52, 101, 118, 153, 138 and 180).

With approval from the local human research ethics committee and informed consent by the subjects involved, plasma samples from 29 male workers (mean age 42 years; range 26-63 years) occupationally exposed to OCC as well as other types of hazardous waste and 60 controls matched for sex, age, residency and social status (blue collar workers) were analysed for the same seven PCB-congeners included in the technical samples and for HCB. Historical plasma samples, obtained prior to the start of employment at this particular workplace and kept frozen in a blood bank at minus 70 ^{0}C until analysis 6-12 years later, were available for 20 of the exposed subjects, and these samples were analysed for assessment of temporal trends.

The OCC of interest in the plasma samples were analysed by gas chromatography-high resolution mass spectrometry. The results were corrected for recovery as determined with $^{13}C_{12}$-labelled standards and adjusted for the lipid content. However, the lipid content of the historical plasma samples was much lower than in the fresh samples, probably secondary to lipolysis, and the trend assessment was based on the OCC values prior to lipid adjustment. The coefficient of variation for the PCB-analyses was approximately 20%.

Results and Discussion

There was no difference in the plasma level of the sum of seven PCB congeners between exposed workers and controls (Table 1) but the interindividual variation was substantial. The overall PCB content in the historical samples from the subgroup of exposed workers was slightly higher than in the fresh samples (4.0 ng/g plasma *vs* 3.8 ng/g), but the difference was within random variation.

Table 1. Congener-specific and summary levels of PCB in plasma (ng/g lipid) of hazardous waste incineration workers and matched controls.

	Exposed (n=29)			Controls (n=60)		
PCB, IUPAC #	Mean	SD	Range	Mean	SD	Range
28	62*	139	4.0-724	3.3	5.2	0.7-29
52	2.5**	2.4	0.5-13	1.3	1.6	0.5-12
101	3.9	2.2	1.9-12	3.5	3.9	1.4-32
118	34	20	9.2-75	42	58	5.1-349
153	240	131	88-626	265	225	92-1739
138	188	95	66-494	205	198	67-1571
180	152	67	65-353	160	114	59-846
Σ PCB	682	325	241-1576	680	543	234-4523

* $p<0.05$; ** $p<0.01$ (t-test for unpaired observations /exposed *vs* controls/ after log transformation)

In the congener-specific analysis, slightly different results emerged (Table 1). The level of PCB #28 as well as #52 were significantly higher in the exposed workers than in the controls, and these results were quite concordant with the congener profile of the air monitoring analyses, where the lower chlorinated PCB #28 and #52 dominated (Table 2). The estimated total PCB levels in the air samples as well as the ambient air levels of HCB were well contained within the corresponding TLV (10 000 ng/m^3 for PCB[3)] and 25 000 ng/m^3 for HCB[3)]).

Table 2. PCB and HCB in air (ng/m^3) from various locations at a hazardous waste incineration plant.

Organochlorine compound	Drum storage[A]	Drum preparation[B]	Incinerator[B]	Reference[A]
PCB, IUPAC #				
28	28	31	1.3	0.020
52	8.4	5.0	0.50	0.020
101	4.8	0.65	0.37	0.018
118	1.7	0.20	0.11	0.0043
153	3.3	0.16	0.18	0.013
138	2.9	0.15	0.15	0.015
180	0.68	0.050	0.052	0.010
Σ PCB	50	37	2.7	0.10
Total PCB[a]	260	190	14	0.51
HCB	0.066	11	0.57	0.019

[A] Measurement by Group A; [B] Measurement by Group B; [a] Estimate

The plasma level of HCB was significantly higher in exposed workers than in controls (63 ng/g lipid *vs* 35 ng/g; p=0.01 after log transformation). In the intraindividual comparison of HCB, somewhat higher levels were recorded in the fresh plasma samples compared to the historical samples obtained before the start of employment (0.40 ng/g plasma vs 0.27 ng/g; p=0.05 after log transformation; t-test for paired observations).

The congener-specific analysis of PCB in the historical plasma samples from the waste incineration workers showed statistically significant reductions over time ($p<0.05$; t-test for paired observations) for PCB #52, 101, 138 and 180, as opposed to the levels in the fresh plasma samples, whereas PCB #28 was increased about two-fold. Still, this increase was not significant due to a large variation.

The estimated exposure to PCB as well as to HCB in the handling of hazardous waste at this particular incineration plant proved to be well below current TLV. The overall plasma PCB level of exposed waste incineration workers was not different from matched controls, but a covariation of some lower chlorinated PCB congeners in the air samples from the plant and in the plasma samples was observed, indicating some influence of the occupational exposure on the overall PCB load. The results also suggested that the occupational exposure to HCB was sufficient to discriminate, on the group level, between exposure/non-exposure in the plasma samples as well as to indicate an accumulation of HCB over time. A previous biomonitoring study of chlorinated dioxins and dibensofurans in this population showed no significant differences with historical controls[5)], and in the

overall risk assessment for exposed workers, biologically persistent OCC were not considered a specific health problem.

Acknowledgements

Blood samples were collected by nurses Ewa Herminge, Christina Holmqvist and Eva-Lotta Ardermark. Research assistant Ing-Liss Bryngelsson and statistician Lennart Bodin participated in the data management and analysis. Drs Gunnar Ahlborg jr and Kjell Andersson were initiators of the blood bank.

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