A STUDY OF DRY CLEANING SOLVENTS AND CLOTHING: SOURCE OF DIOXIN EXPOSURE?

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Introduction

Both the government and private researchers around the world have used dioxin contaminations in the air, water, soil and foods for assessing the amount of daily dioxin exposure to human beings. However, not many of the dioxin studies focused on clothes or other fabrics as a possible source for dioxin contamination and exposure. However, the data presented in this paper indicate that fabrics should be considered as one of sources of dioxin exposure. A study by the University of Bayreuth, Germany, showed that the sludge residues of the dry-cleaning solvent distillation were contaminated with dioxins.¹ CWWI and ISWC began to research on possible dioxin contaminants in the dry-cleaning related industries since 1997. CWWI and ISWC contacted and requested the analysis of dioxin amount in sample materials at several qualified dioxin-measurement/research institutes², designated by Japanese government. This paper is about the findings resulted from the analysis.

Methods and Materials

<u>Methods</u>: Gas chromatograph method was applied for fabric dioxin analysis. The analysis was applied according to the Dioxin Analysis Manual for Residues presented by Ministry of Environment Japan (Water Pollution and Prevention Division, July 1998). PCDDs and PCDFs were measured for fabric dioxin analysis, but Coplanar PCBs were not, because Coplanar PCBs were not officially considered as dioxins in Japan until July 1999. International Toxicity Equivalency Factor (I-TEF) and World Health Organization Toxicity Equivalency Factor 1997 (WHO-TEF) were used for calculating Toxicity Equivalency Quantity (TEQ) in the sample materials.

<u>Materials</u>: CWWI purchased the brand-new clothes samples from various stores in Japan between the years 1997 and 2000 and sent the clothes to the institutes for analysis. As for the dry-cleaned clothes samples, CWWI purchased brand-new clothes and brought them to several dry cleaners to be dry-cleaned. CWWI pick them up after the dry-cleaning and sent them to the institutes for analysis. For the dry-cleaning solvent samples, ISWC mixed together dry-cleaning solvents and CWWI sent them to the institutes. (At the dry cleaners, several types of dry-cleaning solvents are normally mixed together for better results.)

Results and Discussion

Results

<u>Dry-cleaning solvents Samples</u>: 3 types of brand-new solvents and 1 type of petrol-based solvent that is currently in use were analyzed. The brand-new perc-based solvent³ measured 7.8 pg WHO-TEQ/l of dioxin concentration. The brand-new petrol-based solvent⁴ measured 7.3 pg WHO-TEQ/l **ORGANOHALOGEN COMPOUNDS**

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of dioxin concentration. The brand-new stain-remover (spot cleaning) solvent measured 76 pg-TEQ/l of dioxin concentration. The currently in use petrol-based solvent measured 780.0 pg-TEQ/l of dioxin concentration⁵. (Table1)

Table 1 Analysis of dioxins in dry-cleaning solvents

		Types of dry-cleaning solvents						
CDD/PCDF/ Coplanar PCBs	unit	Perc-based solvent (new)	Petrol-based solvent (new)	Spot cleaning solvent (new)	Parc-based solvent (used)			
PCDDs	ng/liter	1.4	1.3	2.0	20			
PCDFs	ng/liter	2.8	3.4	3.8	55			
PCDDs+PCDFs	ng/liter	4.2	4.7	5.8	75			
PCDDs/DFs TEQ	pg TEQ/I	7.2	6.8	75	270			
Coplaner PCB TEQ	pg TEQ/I	0.55	0.47	1.3	510			
Total TEQ	pg TEQ/l	7.8	7.3	76	780			
TEF: WHO-TEF (WH	O/IPCS 1998)	TEQ: 2,3,7	,8 TeCDD (pg-TE	Q/liter)				

Table 2: Brand-new Fabrics; Actual value of dioxin concentration and TEQ (pg I-TEQ/g)

	PCDDs/PCDFs						
Samples	PCDDs	PCDFs	PCDDs+PCDFs	I-TEQ			
Suit 1 (Black)	164.4	120.6	285	4.4			
Suit 2 (Black)	268	154.8	420	8.5			
Suit 3 (Black)	281.2	179	460	9.3			
Suit 4 (Black)	141.6	514	660	13 *			
Suit 5 (Black)	250	450	700	19 *			
Suit 6 (Blue)	171.5	50.7	220	2.0			
Suit 7 (Blue)	45.4	95	140	3.1			
Suit 8 (Grey)	65.2	57.2	120	1.8			
Suit 9 (Red)	42.6	34.7	77	0.82			
Windbreaker	50.2	49.2	99	1.5			
(Grey)							
Underwear 1 (Black)	26.96	31.1	58	1.4			
Underwcar 2 (Black)	164	60.7	220	2.8			
Jersey knit (Black)	166.1	474	640	20			
Kimono (Black)	23.73	5.69	29	0.28			
Futon (Blue)	15.9	12.14	28	0.38			
Jeans (Blue)	2.93	8.42	11	0.36			
Uniform (Blue)	17.4	75.7	93	1.0			
Sports wear (Blue)	3.82	15.2	19	0.11			
Curtain (Blue)	7.18	5.24	12	0.073			
Sweater (Purple)	4.08	2.98	7.1	0.034			
Skirt (Purple)	60.5	19.2	80	0.85			
Pants (Grey)	12.59	8.77	21	0.13			
Blanket (Beige)	1.28	1.28	2.6	0.0055			
Smock (White)	2.82	2.86	5.7	0.020			
Shcet (White)	4.156	0.68	4.8	0.0075			

TEF: International-TEF

TEQ: 2,3,7,8 TeCDD (pg-TEQ/g)

* : includes Coplanar PCBs TEQ

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<u>The Brand-new Clothes Samples</u>: 25 samples of new clothes and other new fabrics were analyzed. Some clothes were additionally analyzed for Coplanar PCBs TEQ as exceptions. The results shows that all the samples were contaminated with dioxins. The actual value of dioxin concentration ranged from 2.56 pg/g to 700 pg/g. (Table 2) Toxicity Equivalency Quantities were calculated ranging from 0.055 pg I-TEQ/g to 20 pg I-TEQ/g (Table 2).

<u>The Dry-cleaned Clothes Samples</u>: 9 brand-new clothes were dry-cleaned by different dry-cleaners and were measured dioxins. Dioxin concentration ranged from 0.0330pg I-TEQ/g to 3.4 pg I-TEQ. CWWI compared the actual value of concentration of dioxin and TEQ in/on the fabric samples before and after dry-cleaning. (Table 3)

Table 3: Comparison of actual value of dioxins concentration and I-TEQ concentration in the clothes samples before and after the dry-cleaning (Petrol-based solvent and Perc-based solvent)

Petrol-based	Samples							
solvent		Blanket		Pants ⁶	Uniform	Mout	on Rug	
Before cleaning	2.6	(0.0055)	21	(0.13)	93 (1.0)	Not me	asured	
After cleaning	7.0	(0.01)	28	(0.30)	180 (1.2)	520	(3.4)	

Parc-based	Samples									
solvent		Blanket	Pa	ints 1 ⁶	Pa	nts 2 ⁶	Pa	ints 36		Futon
Before cleaning	2.6	(0.0055)	2.6	(0.13)	2.6	(0.13)	2.6	(0.13)	28	(0.38)
After cleaning	15	(0.033)	34	(0.14)	35	(0.16)	34	-(0.37)	97	(0.39)

Actual value of dioxin: pg/g International TEQ: (pg TEQ/g)

<u>Wastewater from a Dye Factory</u>: A sample of wastewater from a dye factory in Nagano Prefecture was analyzed for dioxin and measured to have 2.1 pg I-TEQ/l of dioxin concentration.

Table 4: Dioxin analy	sis in wastewater from	a Dye Factory		TEF: International TEF			
Sample	PCDD/PCDF						
	PCDDs	PCDFs	PCDDs+DFs	I-TEQ			
Wastewater	103 pg/liter	74 pg/liter	180 pg/liter	2.1 pg I-TEQ/liter			

Discussion

<u>The Dry-cleaning Solvents Samples</u>: The data shows that brand-new dry-cleaning solvents were contaminated with dioxins. The study by the university of Bayreuth, Germany concluded that the dioxins in the residues are extracted from the dioxins of the clothes, but this analysis indicates that dry-cleaning solvents are also a source of dry-cleaning related dioxin contamination.

<u>The Brand-new Clothes Samples</u>: The data shows that all the new clothes samples were contaminated with dioxins. Because of new, and not yet dry-cleaned fabrics were contaminated with dioxins, a textile-making-process could be a source of dioxins. In the analysis, there is a tendency that the dark colored fabrics contain more dioxins than light colored ones. There is a possibility that the fabric dyeing process produces dioxins as by-products. The possibility is supported by the results of analysis of dioxins in the wastewater from a dye factory.

The Dry-cleaned Clothes Samples: The comparison of dioxin concentration shows that dry-cleaned fabrics contain more dioxins than the same fabrics before being dry-cleaned. It can be concluded

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that the dry-cleaning process adds dioxins on clothes.

Conclusion and Perspective

Dry-cleaning solvents and brand-new as well as dry-cleaned clothes are contaminated with dioxins. The dry-cleaning solvents that CWWI analyzed, could be the sources of dry-cleaning related dioxin contamination. Dye factory could be a source of fabric dioxin contamination. It is possible that fabrics are contaminated with dioxins first in the process of dyeing and then with additional dioxins in the dry-cleaning process. Dry-cleaning solvents are distilled, and the distillation extracts dioxins in the solvents. There are filters in the dry-cleaning machine, but fabrics could play the role of filters and catch dioxins. (The clothes are cleaned in a dry-cleaning washer which has 200liter solvent that contains, we calculate, appropriately 156,000 pg I-TEQ dioxins.)

This study can be important for the dioxin inventory, because we could conclude that the dioxin emission from the wastewater of dye industry is more than the emission of aluminum industry. The assessment of total daily exposure of dioxins needs to consider the exposure from clothes and other fabrics both brand-new and dry-cleaned. In addition, the assessment needs further studies for dioxin absorption through skins.

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References

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- ² Japan Quality Assurance Organization, Tokyo/ Joetsu Environmental Science Center, Niigata/ The Chiba Pharmaceutical Association Research Center, Chiba/ Shizuoka Industrial Environment Center, Shizuoka/ Shimazu Techno Research, Nagoya/ Nippon Total Science, Hiroshima/ Field Science, Sapporo/ Environmental Research Institute, Tokyo/ Maxxam Analytics Inc., Canada/ Seika Corp., Tokyo/ Chugai Technos, Environmental Tech Center/ Gesellschaft fur Arbeitsplatz unt Umweltanalytik mbH, Germany
- ³ Combination of Perchloroethylene, dry-cleaning soap and sizing (P-480)
- ⁴ Combination of Trichlorotrifluoroethane, dry-cleaning soap and sizing (TBF-N)
- ⁵ Only petrol-based solvent was analyzed as used solvent.
- ⁶ The same pants are dry washed at different cleaners.

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