

POLYCHLORINATED BIPHENYL, POLYCHLORINATED DIBENZO-P-DIOXIN, AND
POLYCHLORINATED DIBENZOFURAN CONTAMINATION IN PCB DISPOSAL FACILITIES

Charles J. Bryant*, Richard W. Hartle, Michael S. Crandall, and Paul Roper

Division of Surveillance, Hazard Evaluations, and Field Studies
National Institute for Occupational Safety and Health
Cincinnati, Ohio 45226

ABSTRACT

The National Institute for Occupational Safety and Health recently completed industrial hygiene surveys in three PCB disposal facilities. Contamination levels of PCBs (surface and airborne) and PCDDs/PCDFs (surface) were characterized during normal operations. Ninety-five out of ninety-six air samples collected for PCBs exceeded the NIOSH Recommended Exposure Limit of 1.0 ug/m^3 . Seventy-four percent (86/117) of the PCB surface samples were above our contamination guideline of 100 ug/m^2 . Twelve surface samples were collected for the determination of the tetra- through octa-chlorinated PCDD and PCDF homologs and the 2,3,7,8-substituted isomers. Eleven (92%) of the samples were above our contamination guideline of 1.0 ng/m^2 (2,3,7,8-TCDD equivalents). The 2,3,7,8-TCDD isomer was found in one facility.

INTRODUCTION

PCB disposal has been a major area of concern since the restriction of PCB use in the United States and other countries. Large quantities of PCB-containing products such as transformer oils and capacitors are being removed from service and must be disposed of properly. While PCB regulations and disposal requirements differ from country to country, there is a common analytical interest in determining their presence in the environment and in potential sources to the environment (1).

During January through June 1987, the National Institute for Occupational Safety and Health (NIOSH) measured contamination levels in three PCB disposal facilities. These evaluations were at the request of the Environmental Protection Agency (EPA).

The objective of the study was to determine the air and surface concentrations of PCBs as well as surface levels of PCDDs/PCDFs (2,3,7,8- substituted isomers, and total tetra- through octa-chlorinated homologs) in three PCB disposal facilities. Sampling and analytical methods were identical in each plant, although the sampling strategies varied dependent upon plant size and methods of PCB handling and disposal.

METHODS

Surface Sampling: PCBs, PCDDs and PCDFs

The surface samples were collected using 3" x 3" soxhlet extracted cotton gauze pads wetted with 8-ml of pesticide grade hexane. The sampling procedure consisted of marking off a surface into a 0.25 m² area using a metal tape measure. Each 0.25 m² area was wiped, with a gauze pad held with a gloved-hand, in two directions; the second direction was performed at a 90 degree angle to the first direction. The gauze pad sample was then placed in a glass sample container equipped with a Teflon-lined lid. Each PCDD/PCDF sample was a composite of four 0.25 m² samples for a total area of 1.0 m², whereas the PCB samples consisted of a single sample from an area of 0.25 m². The samples were extracted, purified by column chromatography and analyzed for PCDDs/PCDFs using high resolution capillary column gas chromatography and selected ion monitoring mass spectrometry (2). The samples were extracted and analyzed for PCBs using capillary column gas chromatography electron capture detection (3).

Air Samples: PCBs

Air samples for PCBs were collected by drawing air through a glass tube containing 150 mg of florisil adsorbent (100 mg front and 50 mg back sections) at a flowrate of 1.0 liters per minute using calibrated, battery-operated sampling pumps. The samples were analyzed using the procedures previously referenced (4).

Evaluation Criteria

NIOSH recommends that airborne exposure to PCBs in the work place be limited to, or below, the minimum reliable detectable concentration of 1 ug/m³ (using the recommended sampling methods) determined as a TWA for up to a 10-hr workday, 40-hr workweek. The NIOSH recommended exposure limit was based upon the findings of adverse reproductive effects in experimental animals, on the conclusion that PCBs are carcinogenic in rats and mice and, therefore, potential human carcinogens in the work place, and on the conclusion that human and animal studies have not demonstrated a level of exposure to PCBs that will not subject workers to possible liver injury (5).

The Environmental Protection Agency's spill cleanup policy (April 2, 1987 - 52 FR 10688) includes discussions of industrial surfaces contaminated from PCB spills occurring after May 1987. EPA states that the estimated level of oncogenic risk associated with dermal exposures of 50 ug/m^2 of PCBs on hard, indoor, high-contact surfaces is between 1×10^{-5} and 1×10^{-6} . NIOSH continues to promote the lowest feasible level concept for exposure to potential carcinogens. Therefore, based upon background studies conducted by NIOSH, this (background level) appears to be 50 to 100 ug/m^2 (6,7).

In July of 1985, an advisory panel was convened to provide guideline recommendations for air and surface cleanup for PCBs, PCDDs, and PCDFs for the State Highway Department Building in Santa Fe, New Mexico (8). Both NIOSH and the EPA were represented on this panel. The advisory panel also considered the potential risk of cancer resulting from exposure to PCDDs and PCDFs. The guideline for PCDDs and PCDFs is intended to maintain this risk below one in one million for a person spending his/her working lifetime (30 years) in the building. Animal studies on the carcinogenicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) were used to estimate the potential cancer risks. NIOSH recommends that 2,3,7,8-TCDD be regarded as a potential occupational carcinogen, that occupational exposure to 2,3,7,8-TCDD be controlled to the lowest feasible level, and that decontamination measures be used for 2,3,7,8-TCDD-contaminated work environments. This recommendation is based on a number of reliable studies demonstrating carcinogenicity in rats and mice (9).

The surface guideline recommended by the advisory panel is 1 ng/m^2 of 2,3,7,8-TCDD equivalents. 2,3,7,8-TCDD equivalents are defined as the concentration of 2,3,7,8-TCDD which by itself would be believed to exhibit the same biological potency as the mixture of structurally-related compounds, PCDDs/PCDFs, actually present in a sample. The structurally-related PCDDs and PCDFs which could be observed include the tetra- through octa-chlorinated homologs and 2,3,7,8- substituted isomers.

This procedure, developed by the New York State Department of Health, estimates the amount of 2,3,7,8-TCDD that would have to be present to exhibit a similar toxicity as the measured quantity of all of the various other PCDDs and PCDFs that are present (10). The procedure assumes certain weighting factors (ratios of toxicities) between 2,3,7,8-TCDD and the other PCDDs and PCDFs. The weighting factors that are used in this report are those currently proposed by the U.S. Environmental Protection Agency (Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Dibenzo-p-Dioxins and Dibenzofurans (CDDs and CDFs), Risk Assessment Forum, EPA 625/3-87/012, 1987).

Table I
 Surface Concentrations of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (2,3,7,8-TCDD) Equivalents
 Surface and Airborne Concentrations of Polychlorinated Biphenyls (PCBs)

Plant A

Location	2,3,7,8-TCDD Equivalents (ng/m ²)	PCB Air Levels (ug/m ³)		PCB Surface Levels (ug/m ²)	
		Mean*	Range	Mean*	Range
Receiving	0.95	3.3	2.0 - 6.7	1413	81 - 1.8 x 10 ⁴
Oil Transfer/Storage	2.2	4.3	2.9 - 5.4	5118	656 - 2.6 x 10 ⁴
Transformer Load/Unload	1.7	5.9	3.9 - 7.8	21455	11280 - 7.2 x 10 ⁴
Drain/Flush	191**	5.9	3.9 - 7.8	84374	2316 - 1.6 x 10 ⁵
Maintenance	---	3.6	2.6 - 6.2	1228	148 - 3.7 x 10 ³
Offices/Laboratory	---	---	-----	36	4 - 532
Lunchrooms	---	2.4	-----	159	39 - 980

*Geometric Mean

**Contained 1.56 ng of 2,3,7,8-TCDD

Table II
 Surface Concentrations of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (2,3,7,8-TCDD) Equivalents
 Surface and Airborne Concentrations of Polychlorinated Biphenyls (PCBs)

Location	2,3,7,8-TCDD Equivalents (ng/m ²)	PCB Air Levels (ug/m ³)		PCB Surface Levels (ug/m ²)	
		Mean*	Range	Mean*	Range
Old PCB Warehouse	39.7	4.8	4.1 - 5.8	98590	54000 - 1.8 x 10 ⁵
New PCB Warehouse	8.3	10.8	9.9 - 12.0	30000	-----
North Warehouse	4.8	4.3	-----	24800	-----
Kiln Dock/Shredder	25.1	24.3	19 - 40	160000	-----
Kiln Area/Ash Drag Tndr	40.5	23.0	22 - 24	27000	-----
Offices/Lunchrooms	-----	1.3	0.85 - 2.1	124	11 - 1200
Maintenance	-----	---	-----	23470	19000 - 2.9 x 10 ⁴
Shower Room	-----	---	-----	729	200 - 4800

*Geometric Mean

Table III
 Surface Concentrations of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (2,3,7,8-TCDD) Equivalents
 Surface and Airborne Concentrations of Polychlorinated Biphenyls (PCBs)

Plant C

Location	2,3,7,8-TCDD Equivalents (ng/m ²)	PCB Air Levels (ug/m ³)		PCB Surface Levels (ug/m ²)	
		Mean*	Range	Mean*	Range
Drain/Decontamination	13	19.2	11.8-30.5	9122	960-13960
Disassembly	--	19.3	12.6-29.1	-----	-----
Stripper	16	14.9	10.8-24.7	71760	-----
Other**	3	4.2	1.8-6.8	201	10-2880

*Geometric Mean

**All areas outside containment

RESULTS

Ninety-six air samples were collected for analysis of PCBs. Thirty-three of the samples were taken at Plant A (Table I), forty-one at Plant B (Table II), and twenty-two at Plant C (Table III). All of the samples showed detectable levels of PCBs ranging from 0.85 to 30.5 $\mu\text{g}/\text{m}^3$. Ninety-five (99%) of the samples exceeded the NIOSH recommended exposure limit of 1.0 $\mu\text{g}/\text{m}^3$.

The PCB analyses of 117 samples collected on various surfaces are summarized in Tables I-III. Forty-two samples were taken in Plant A, fifty-six in Plant B, and nineteen in Plant C. The surface concentrations of PCBs measured in the plants ranged from 4 to 1.56 $\times 10^6 \mu\text{g}/\text{m}^2$. Eighty-six (74%) of the samples were above the surface criterion of 100 $\mu\text{g}/\text{m}^2$.

Twelve surface samples (Plant A/4 samples, Plant B/5 samples, Plant C/3 samples) were collected for tetra- through octa-chlorinated PCDD and PCDF homologs and the 2,3,7,8-substituted isomers, and are summarized in Tables I-III. The calculated concentrations of TCDD-equivalents ranged from 0.95 to 191 ng/m^2 . Eleven (92%) of the samples were above the 1.0 ng/m^2 evaluation criteria proposed by the Governor of New Mexico Expert Advisory Panel. Of particular concern was the presence of 2,3,7,8-TCDD isomer in the Drain/Flush sample (Plant A/Table I) at a concentration of 1.56 ng/m^2 .

CONCLUSIONS

A study was conducted to determine the concentrations of airborne and surface PCBs, and surface levels of PCDDs/PCDFs (converted to 2,3,7,8-TCDD equivalents) in three PCB disposal facilities. The environmental data from these surveys indicate a consistent presence of PCBs and PCDDs/PCDFs above the evaluation criteria. The 2,3,7,8-TCDD isomer was found in at least one facility. These studies suggest that other, similar facilities should be investigated, and that higher levels of employee protection are warranted.

ACKNOWLEDGEMENTS

The authors are grateful to John Kominsky, NIOSH; for his technical guidance in preparation of this manuscript. Chemical analysis of samples for PCDDs/PCDFs by Triangle Laboratories, Inc. and PCBs by DataChem, Inc.

REFERENCES

1. M.D. Erickson. "Introduction," in Analytical Chemistry of PCBs, (Boston: Butterworth Publishers, 1986), p. 3.
2. Triangle Laboratories, Inc. Analytical Reports: Determination of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans in Surface Wipe Samples. Triangle Laboratories, Inc. Research Triangle Park, North Carolina.

3. DataChem, Inc. Analytical Reports: Determination of PCBs in Air and Surface Wipe Samples. DataChem, Inc., Salt Lake City, Utah.
4. NIOSH Manual of Analytical Methods, 3rd ed., Vol. 2., Method 5503, U.S. Department of Health and Human Services, Publ. (NIOSH) 84-100 (1984).
5. National Institute for Occupational Safety and Health. Criteria for a Recommended Standard. Occupational Exposure to Polychlorinated Biphenyls. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW, Publication No. (NIOSH) 77-225).
6. J.R. Kominsky, W.T. Slade and R. Mooring. Background Concentrations of Polychlorinated Biphenyls, Polychlorinated Dibenzo-p-Dioxins, and Polychlorinated Dibenzofurans in Three Office Buildings in Santa Fe, New Mexico. Paper presented at the American Industrial Hygiene Conference, Montreal, Canada, June 1-5, 1987.
7. J.R. Kominsky and C.D. Kwoka. Background Concentrations of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans In Office Buildings In Boston Massachusetts. Paper presented at the Dioxin '87 Symposium, Las Vegas, Nevada, October 4-9, 1987.
8. J.R. Kominsky and J.M. Melius, Final Certification Report: New Mexico State Highway Department's General Office Building and Annex, 1120 Cerillos Road, Santa Fe, New Mexico. HETA Report No. 85-414-1805. National Institute for Occupational Safety and Health, Cincinnati, Ohio. September, 1986.
9. National Institute for Occupational Safety and Health. Current Intelligence Bulletin No. 40: 2,3,7,8-Tetrachlorodibenzo-p-dioxin. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1984. (DHHS (NIOSH) Publication No. 84-104).
10. G. Eadon, K. Aldous and G. Frenkel, et al. 1982. Comparisons of Chemical and Biological Data on Soot Samples from the Binghamton State Office Building. Albany, N.Y.: Center for Laboratories and Research, New York State Department of Health. March, 1982.