ehp ENVIRONMENTAL HEALTH PERSPECTIVES

ehponline.org

Soil Contamination from PCB-containing Buildings

Robert F. Herrick, Daniel J. Lefkowitz, George A. Weymouth

doi:10.1289/ehp.9646 (available at http://dx.doi.org/)
Online 6 November 2006

NIEHS
National Institute of Environmental Health Sciences

National Institutes of Health
U.S. Department of Health and Human Services

Soil Contamination from PCB-containing Buildings

Robert F. Herrick[1], Daniel J. Lefkowitz[2], George A. Weymouth[3]

[1] Department of Environmental Health, Harvard School of Public Health, 665 Huntington Ave., Boston MA 02115

[2]Pcbinschools.org, Yorktown, NY

[3] International Union of Bricklayers and Allied Craft Workers, Local 3, Retired

Corresponding author: Robert F. Herrick, Department of Environmental Health, Landmark Center, 401 Park Drive, Room 404E, Boston MA 02215, phone 617.384.8803, fax 617.384.8849, email herrick@hohp.harvard.edu

Running header: Soil Contamination from PCB-containing Buildings

Keywords: caulk, environmental exposure, leachability, PCB, public buildings, schools, soil

Acknowledgements: This investigation was supported in part by the National Institute for Occupational Safety and Health through the Harvard Education and Research Center for Occupational Safety and Health, Grant number T42 008416-02. The authors declare that they have no competing financial interests.

Abbreviations

EPA	Environmental Protection Agency
ng/m^3	nanograms per cubic meter of air
PCB	polychlorinated biphenyls
ppm	parts per million by mass
TCLP	Toxicity Characteristic Leaching Procedure

Outline of Section Headers

ABSTRACT

Background: Polychlorinated biphenyl (PCB) in construction materials such as caulking used around windows and expansion joints may constitute a source of PCB contamination in the building interiors, and surrounding soil. Several studies of soil contamination have been conducted around buildings where the caulking has been removed by grinding or scraping. The PCB in soil may have been generated in the process of removing the caulking, but natural weathering and deterioration of the caulking may have also been a source.

Objectives: The objectives of this study were to measure PCB levels in soil surrounding buildings where PCB-containing caulk was still in place, and to evaluate the mobility of the PCB from caulking by the Toxicity Characteristic Leaching Procedure (EPA Method 1311).

Discussion: We found soil PCB contamination ranging from 3.3 to 34 mg/kg around buildings where undisturbed caulking with PCB contents ranging from 10,000 to 36,200 mg/kg was present. The results of the Toxicity Characteristic Leaching Procedure (leachate concentrations 76-288 mg PCB/L) suggest that PCB in caulking can be mobilized, apparently as complexes with dissolved organic matter that also leached off the caulking material.

Conclusions and Recommendations: While these new findings are based upon a small sample size, they demonstrate the need for a national survey of PCB in building materials, and in soil surrounding these buildings. As the buildings constructed during the time the PCB caulking was in use (1960s and 70s) include

schools, hospitals, and apartment buildings, the potential for exposure of children is a particular concern. The practice of disposing of old PCB caulking removed during building renovations in conventional landfills should be reconsidered, given the apparent mobility of PCBs from the caulking material. Disposal of some caulking material in non-hazardous waste landfills might lead to high PCB levels in landfill leachate.

BACKGROUND

In June 2004, we reported the results of a study that found elevated PCB levels in building caulking materials used around windows and in expansion joints in masonry buildings (Herrick et al. 2004). Our investigation of 24 buildings in the Greater Boston Area revealed that one-third (8 of 24) contained caulking materials with PCB content exceeding 50 parts per million (mg/kg) by weight. The U.S. EPA considers materials exceeding PCB content of 50 ppm that were not specifically authorized for use by U.S. EPA to be "unauthorized-use" nonliquid PCB products that require removal and decontamination (U.S. EPA 1998a). PCB bulk product waste is defined in 40CFR761.3 as " waste derived from manufactured products containing PCBs in a non-liquid state, at any concentration where the concentration at the time of designation for disposal was ≥ 50 ppm PCBs. . . .PCB bulk product waste includes, but is not limited to: Non-liquid bulk wastes or debris from the demolition of buildings and other man-made structures manufactured, coated, or serviced with PCBs." (U.S. EPA 1998a).

Results similar to those found in Boston have been reported by investigators examining buildings in Germany, Finland, and Sweden (Balfanz et al. 1993; Burkhardt et al. 1990; Corner et al. 2002; Coghlan et al. 2002, Fromme et al. 1996; Pyy and Lyly 1998). In Switzerland, a national survey focused on concrete (masonry) buildings found that almost half of all such buildings erected between 1955 and 1975 (1348 buildings sampled) contained joint sealants (caulking) with PCB concentrations between 20 and 550,000 mg/kg (Zennegg et al. 2004).

Priha et al. (2005) sampled soil around 11 buildings from which PCB-containing caulking had been removed. He reported total PCB concentrations in soil ranging from 0.11 mg/kg to 26.9 mg/kg. Highest PCB concentrations were in areas closest to the buildings, and they declined as the distance increased. Average concentration in samples taken within 2 m of the buildings was 6.83 mg PCB/kg and in the distance of 3–10 m from the walls it was 0.52 mg/kg. Highest soil concentrations were found on the southern side of the buildings (average concentrations 16.6 mg/kg south, 2.00 mg/kg west, 2.39 mg/kg east, and 3.96 mg/kg north). Priha concluded that "The area south of these buildings is more contaminated than those in other directions, and, therefore, the weathering of sealants is probably an important mechanism in the spread of PCBs to the surroundings.", however the old caulking had been abated in these buildings. Grinding of the old caulking material to remove it from the building masonry joints could also have contributed to the finding of soil contamination.

At a New York State elementary school constructed in 1969, PCB-containing caulking (60,000 mg/kg) had been removed during window replacement in 2003 (Whitaker 2005). Wipe samples were taken inside and outside the school. Indoor sampling locations included classroom floors, walls, and windows as well as inside the ventilation system. Outdoor sampling locations consisted mainly of windows but also included the surrounding soil to determine the contamination into the surrounding environment. Surface concentrations on the outside of the

building measured via wipe samples ranged from 0.92 µg/100 cm^2 (alcove above boiler room) to 34 µg/100 cm^2 (outdoor window sill). The U.S. EPA considers a surface to be contaminated if concentrations exceed 10 µg/100 cm^2 (U.S.EPA 1998a). Indoor wipe samples yielded levels ranging from 0.22 µg/100 cm^2 (classroom) - 2.3 µg/100 cm^2 (plenum of exhaust system). Soil contamination ranging from 0.96-40.0 mg/kg PCB (8 samples) was found. The caulking material in other parts of the building has not been replaced, although it is visibly deteriorated (Figure 1). As in the case of the Finnish buildings studied by Priha, the soil contamination could have been caused by weathering of the caulking, but the generation of PCB-containing particles during scraping and grinding to remove the old caulking material could not be ruled out as a source.

Our objectives of the study reported here were to measure PCB levels in soil surrounding buildings where PCB-containing caulk was still in place, and to evaluate the mobility of the PCB from caulking by the Toxicity Characteristic Leaching Procedure (EPA Method 1311, U.S. EPA 1992).

METHODS

We identified three buildings (designated A, B, and C) where PCB-containing caulk appeared to be present. In the opinion of an experienced bricklayer (G.W.) who examined these buildings, the PCB-containing caulking had not been disturbed or removed from these buildings. All three of these buildings were typical of masonry buildings of the type constructed in the 1960s and 70s. One

was a university family housing unit, and the other two were schools. We sampled the caulking, and at each building we also sampled surface soil at a distance of approximately 30 cm from the building foundation. PCB content in both the caulking and soil samples was determined in accordance with EPA Method SW846 8082A (U.S. EPA 1998b).

In order to assess the mobility of PCB from samples of caulking material, we utilized the TCLP (EPA method 1311, U.S. EPA 1992). Of the 3 buildings where we had collected paired caulking and soil samples, we only had the recommended amount of caulking material (100 g) from Building A to conduct the procedure, so we selected 2 other caulking samples from the original set of 24 we tested in 2004 for analysis by the TCLP. This test was designed to simulate leachate generation from a material if it were co-disposed with municipal solid waste in a non-hazardous waste landfill (U.S. EPA 1998a). The extraction liquid simulates municipal solid waste leachate. While these are not the conditions to which intact caulking would be subjected during natural weathering in a building, this test does determine the mobility of analytes in liquid, solid and multiphasic waste. It is used to determine whether PCB bulk product waste can be disposed of in non-hazardous waste landfills, and we postulated that the finding of PCB in the caulking leachate would suggest a possible pathway between PCB in caulking material and soil. Each of these 3 caulking samples had PCB content exceeding 5000 mg/kg in the bulk material.

RESULTS

The analysis of the bulk caulking material from the three buildings yielded the following results: Building A, 36,200 mg/kg; Building B, 10,000 mg/kg; Building C, 14,800 mg/kg. Soil analysis for PCB in the soil surrounding these buildings found 34 mg/kg at Building A; 3.3 mg/kg at Building B; and 3.4 mg/kg at Building C.

Caulking samples from the three buildings subjected to the TCLP contained 36, 200 mg/kg (Building 1, which was the same as Building A), 5,010 mg/kg (Building 2), and 5,970 (Building 3). Analysis of the extract from the three samples analyzed by the TCLP found 76 mg PCB/L (Building 1), 137 mg PCB/L (Building 2), and 288 mg PCB/L (Building 3). These levels exceed by a factor of at least 7,600 the 10 µg/L limit for the result of leachate tests that allows PCB bulk product waste to be disposed of in non-hazardous waste landfills (U.S. EPA 1998a).

DISCUSSION

In 2004, we found that 8 of 24 buildings sampled in the Greater Boston Area contained caulking material with more than 50 ppm PCB, with the highest level of 36,200 ppm. The findings from studies in Finland (Priha et al. 2005) and the investigation at the PCB-containing school in New York strongly suggest that this caulking material can be a source of soil contamination around the outside perimeter of these buildings. In these cases, however, the caulking had been

removed from the buildings prior to testing for soil contamination. As the process of removing the caulking includes scraping, grinding, and other steps that may aerosolize the PCB-containing material, the source of the soil contamination could not be established. Natural weathering and deterioration of the caulking over the almost 30 years it was in the building walls may have contributed, but soil contamination from the removal process could not be ruled out.

In this study, we selected buildings where the caulking had apparently never been disturbed. We found PCB soil contamination around these buildings where the caulking was undisturbed, and the results of the TCLP demonstrate that PCB appear to be readily mobilized from the caulking. The TCLP results should be interpreted with caution, as the procedure is designed to simulate conditions in municipal solid waste landfills, and not natural weathering. As the concentrations of PCB in the extracts from the TCLP far exceed the aqueous solubility of PCB (generally around 0.1 - 10 µg/L depending on the congener), we believe that the PCB apparently exist as complexes with dissolved organic matter that also leached off the caulking material.

While the quantity of PCB in the bulk caulking samples appeared to be a reasonable predictor of the amount of PCB found in soil around the buildings that contained the caulking, the amount of PCB released by the TCLP extraction procedure was not related to the PCB content of the bulk material. This may be a result of the small number of samples we examined. Given that the caulking

material is at least 30 years old, it may be degraded to the point that the PCBs, which were plasticizers in the original polysulfide polymer formulations, can be mobilized into solution. In some cases, the caulking has clearly lost its elasticity (Figure 1) and the extent of degradation in any caulking material sample may be a better predictor of the amount of PCB that can be mobilized than the bulk PCB content of the caulk.

CONCLUSIONS

Our findings suggest that the most likely cause of the soil contamination found around these PCB-containing buildings is natural weathering. PCBs appear to be mobilized from the caulking as part of a complex with dissolved organic material. The practice of disposing of old PCB caulking removed during building renovations in conventional landfills should be reconsidered, given the apparent mobility of PCBs from the caulking material. Disposal of this caulking material in non-hazardous waste landfills could lead to high PCB levels in landfill leachate. In 2004, we recommended a random probability-based survey of schools, hospitals, and other masonry buildings constructed or renovated during the time when PCB-containing caulking was in use, to assess the extent to which this material is still in place. While the size of our study is small, these new findings suggest that this survey should include measurement of PCB in soil surrounding buildings where PCB caulking is present and an assessment of the risk that this material may pose, especially to children in schools and other buildings where soil contamination is found.

REFERENCES

Balfanz E, Fuchs J, Kieper H. 1993. Sampling and analysis of polychlorinated biphenyls (PCB) in indoor air due to permanently elastic sealants. Chemosphere (26) 5: 871-880.

Burkhardt U, Bork M, Balfanz E, Leidel J. 1990. Indoor air pollution by polychlorinated biphenyl compounds in permanently elastic sealants. Offentl Gesundheitweis. 52,10: 567-574.

Coghlan KM, Chang, MP, Jessup, DS, Fragala, MA, McCrillis, K, Lockhart, TM. 2002. Characterization of polychlorinated biphenyls in building materials and exposures in the indoor environment. In: Indoor Air 2002, Proceedings: 9th International Conference on Indoor Air Quality and Climate, June 30 – July 5 2002, Monterey, California. 2002; 4, 147-152.

Corner R, Sundahl M, Ek-Olausson B, Tysklind M. 2002. PCB in Indoor Air and Dust in Buildings in Stockholm. In: Indoor Air 2002, Proceedings: 9th International Conference on Indoor Air Quality and Climate, June 30 – July 5 2002; Monterey, California 4:141-146.

Fromme H, Baldauf AM, Klautke O, Piloty M, Bohrer L. 1996. Polychlorinated biphenyls (PCB) in caulking compounds of buildings- assessment of current status in Berlin and new indoor air sources. Gesundheitswesen 58(12): 666-672.

Herrick RF, McClean MD, Meeker JD, Baxter LK, Weymouth, GA. 2004. An unrecognized source of PCB contamination in schools and other buildings. Environ Health Perspect. 112:1051-1053.

Priha E, Hellman S, Sorvari J. 2005. PCB contamination from polysulphide sealants in residential areas – exposure and risk assessment. Chemosphere 59:527-543.

Pyy V, Lyly O. 1998. PCB in jointing materials in prefabricated houses and in the soil of yards (10/98), Helsinki, Finland: City of Helsinki Environment Centre.

U.S. EPA (Environmental Protection Agency). 1992. METHOD 1311 TOXICITY CHARACTERISTIC LEACHING PROCEDURE. Available http://www.epa.gov/epaoswer/hazwaste/test/pdfs/1311/pdf [accessed 25 July 2006]

U.S. EPA. 1998a. Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions.40CFR761. Washington, DC:U.S. Environmental Protection Agency.

U.S. EPA. 1998b. Test Methods for Evaluating Solid Waste,

Physical/Chemical Methods. EPA publication SW-846, Washington, DC:U.S. Environmental Protection Agency.

Whitaker, B. 2005. Tainted soil to be removed next to Westchester school. New York Times (New York NY) 4July. New York/Region p1.

Zennegg M, Kohler M, Tremp J, Seiler C, Minder-Kohler S, Beck M, Lienemann P, Wegmann L, Schmid P. 2004. Joint sealants, an overlooked diffuse source of polychlorinated biphenyls (PCB) - results of a nationwide study in Switzerland. ORGANOHALOGEN COMPOUNDS 2004 Volume 66: 899-904.

Figure 1 – Deteriorated PCB caulking in a building expansion joint