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PRC Engineering
Suite 600
303 East Wacker Drive
Chicago, IL 60601
312 938-0300
TWX 910-2215112
Cable CONTOWENG

prc
Planning Research Corporation

NEW BEDFORD HARBOR ENDANGERMENT ASSESSMENT

TASK 2.1

DETERMINING THE DERMAL ABSORPTION RATE OF PCBs

DRAFT LETTER REPORT

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Waste Programs Enforcement
Washington, D.C. 20460

Work Assignment No.	:	560
EPA Region	:	1 (C)
Site No.	:	TGB811443
Date Prepared	:	November 26, 1986
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PRC No.	:	15-5600-78
Prepared By	:	Alliance Technologies Corporation
Telephone No.	:	(617) 275-5444
EPA Primary Contact	:	Frank Ciavattieri
Telephone No.	:	(617) 223-1951

PRC Engineering
Suite 600
303 East Wacker Drive
Chicago, IL 60601
312-938-0300
TWX 910-2215112
Cable CONTOWENG

prc
Planning Research Corporation

November 26, 1986

Mr. Frank Ciavettieri
U.S. EPA Region 1
JFK Federal Building
Boston, MA 02203

Dear Mr. Ciavattieri:

PRC Environmental Management, Inc. and its subcontractor, Alliance Technologies Corporation (formerly GCA Corporation, Technology Division) are pleased to submit two reports entitled, "New Bedford Harbor Endangerment Assessment, Task 2.1 - Determining the Dermal Absorption Rate of PCBs - Draft Letter Report" and "New Bedford Harbor Endangerment Assessment, Task 2.2 - Determining Dose-Response Reference Levels - (DRRLs) - Draft Letter Report."

Should you have any questions or wish to discuss these reports or the work assignment in general with me directly, please feel free to do so.

Thank you for your assistance and cooperation.

Sincerely,

PRC Environmental Management, Inc.

Eric S. Morton

Eric S. Morton
Public Health Scientist

ESM/klb

Enclosure

cc: Nancy Deck
Bruce Bakaysa (letter only)
Barb Myatt, Alliance Technologies Corp.

INTRODUCTION

Under Task 2.1 of the revised workplan dated 20 August 1986, GCA was tasked to develop dermal absorption estimates for PCBs. These absorption estimates are to be used for assessing the risks associated with direct contact with contaminated sediments. To develop dermal absorption percentages for PCBs, GCA was tasked to research both the bioavailability of PCBs adsorbed onto sediments and the dermal absorption potential of the structurally similar compound 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD). A complete review of the articles pertaining to the bioavailability of PCBs has not been conducted and meetings with Dr. Renate Kimbrough (Center for Disease Control) have not been arranged. Upon completion of these two tasks, GCA will meet with Dr. Kimbrough to discuss the proposed absorption percentages for PCBs to be used in the Endangerment Assessment.

This report is organized as follows. The first section outlines GCAs activities conducted to identify information pertaining to the bioavailability of PCBs adsorbed onto soils or sediments. The second section discusses the chemical, physical and structural similarities between PCBs and TCDD. Of the six subtasks identified under this task, GCA has completed two (approximately 25% of the work required).

BIOAVAILABILITY OF PCBs

Based on comments received to GCA's Draft Workplan (March, 1986) it was GCA's original intention that information concerning the bioavailability of PCBs in New Bedford Harbor sediments would be received from U.S. EPA Region I (Barbara Beck). It was thought that these bioassay studies could provide an indication of how readily PCBs desorb from sediments rendering them bioavailable for dermal uptake. However, after conversations with Barbara Beck (U.S. EPA), it was determined that the bioassay studies being conducted on New Bedford Harbor sediments were not applicable to the types of dermal contact expected in the New Bedford Harbor area. Instead, these bioassay studies examined the bioavailability of PCBs after ingestion of contaminated soils. The physical processes which govern the bioavailability of PCBs after ingestion are different than those which govern the bioavailability of PCBs after direct dermal contact.

To determine if other applicable studies have been performed, GCA conducted a literature search and obtained articles relating to the behavior of PCBs or TCDDs in soils or sediments. It appears that more information is available for TCDD than for PCBs suggesting that extrapolation from the TCDD studies to the PCB studies may be necessary. Some of the pertinent articles include:

Bioavailability of TCDD in Missouri Soil. E.E. McConnell. Crisp Data Base, National Institute of Health. CRISP/86/ES21064-03.

The Use of Dermal Absorption Data in Developing Biological Monitoring Standards. T. Pierce. Ann. Am. Conf. Gov. Ind. Hzg. Vol. 12 ISS Int. Symp. Occup. Exposure Limits, 1985 (331-7).

Dioxin Transport from Contaminated Sites to Exposure Locations: A methodology for Calculating Conversion Factors. G.W. Dawson et al. Govt. Reports Announcements and Index, Issue 20, 1985.

Risk Analysis of TCDD Contaminated Soil. J. Schaum. EPA Report EPA/600/8-84/031 1984.

Dioxin in Soil: Bioavailability After ingestion by Rats and Guinea Pigs. E.E. McConnell et al. Science. March 9, 1984, (1077-1079).

A Critical Examination of Assessments of the Health Risks Associated with 2,3,7,8-TCDD in Soil. D.J. Paustenbach and F.J. Murry. Chemosphere. February 1986.

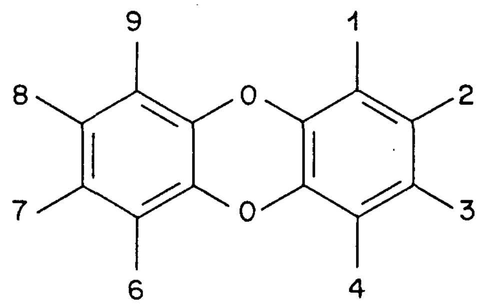
The review of these articles and the data base (DERMAL) has not been completed to date. GCA believes that more time is needed to effectively review these articles than was allotted under the original work schedule. Because of the status of this task, GCA did not meet with Dr. Renate Kimbrough, as a meeting with Dr. Kimbrough would not be productive until such time as the bioavailability evaluation is completed.

STRUCTURAL SIMILARITIES BETWEEN PCBs AND TCDD

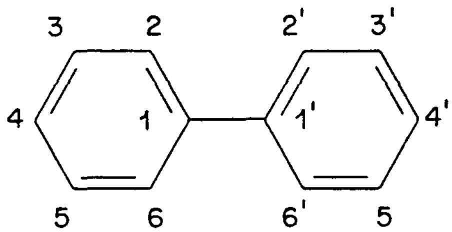
To determine if the dermal absorption rates developed for TCDD could be extrapolated for use in estimating the dermal absorption potential of PCBs, GCA reviewed the structural, chemical and physical properties of these two classes of compounds. A comparison of these properties for PCBs and TCDDs Is presented below.

TCDD belongs to the dibenzo-p-dioxin class of compounds which is characterized by two aromatic rings joined by two oxygen atoms that form a third, bridging ring. The basic structure and numbering convention of the dioxin class are shown in Figure 1. Each of the numbered carbon atoms can hold one substituent, which for purposes of this evaluation will be considered to be a hydrogen or chlorine atom. The dioxin molecular weight will be a minimum of 184 amu, if all positions are filled with hydrogen atoms. The maximum molecular weight of 468 amu could be realized if all eight positions are chlorinated (octachloro-dibenzo-p-dioxin). TCDD is the tetrachlorodibenzo-p-dioxin, wherein four of the substituent and positions hold chlorines and the other four positions hold hydrogens. The molecular weight of TCDD is 318 amu. The 2,3,7,8-TCDD isomer is of greatest toxicological concern, and therefore dermal absorption data are generally more available for this isomer.

PCBs, or polychlorinated biphenyls, are a class of compounds characterized by two aromatic rings joined together by a single bond between a carbon atom from each ring. The structure and numbering convention for PCBs are shown in Figure 1. Each of the numbered carbon atoms can hold one substituent which for purposes of this study will be considered to be either a hydrogen or chlorine atom. The minimum molecular weight of 154 amu corresponds to the nonchlorinated biphenyl compound, and the maximum molecular weight of 400 amu corresponds to decachlorinated biphenyl. PCBs and dioxins are structurally similar in that each consists of two aromatic rings bonded together by some type of bridge. While the aromatic rings of PCBs are directly bonded together by a single carbon-carbon bond, the aromatic rings of dioxin are connected by two oxygen bridges that link adjacent carbon atoms on one ring to corresponding carbon atoms on the other ring. The oxygen bridge results in unsubstituted dioxin being a slightly larger molecule than unsubstituted biphenyl. However, the range of molecular weight for PCBs



DIOXINS



PCBs

Figure 1. Structure and ring numbering convention for Dioxins and PCBs.

overlaps that of dioxins, indicating that the ranges of molecular size will also overlap. Because permeation through a membrane, such as skin, is partially dependent on molecular size, this analysis suggests that compounds in the PCB and dioxin classes will exhibit comparable permeation through a membrane.

Additional factors which are considered in assessing dermal absorption of chemical compounds include lipophilicity, aqueous solubility, and chemical composition (i.e. reactivity). Both PCBs and chlorinated dioxins have high lipophilicity, low aqueous solubility, and low chemical reactivity (both are highly stable). Although the oxygen bridges in dioxin were considered to be potentially reactive sites, degradation and reaction of dioxins seems to occur more readily as substitution of ring substituents (Esposito, et.al., 1980).

Because direct correlations have not been made for physical/chemical properties and dermal absorption rates (McLaughlin, 1984), an alternative approach was used to further substantiate that PCB and TCDD dermal absorption rates are similar. A method was developed by Hawley (1985) to convert dermal absorption rates empirically obtained for a compound applied in a solvent matrix to dermal absorption rates for a compound applied in a soil matrix. Using data obtained by Poiger and Schlatter (1980), Hawley calculated a ratio for the dermal absorption rate of TCDD on soil relative to that of TCDD in solvent. His estimate, which was verified by GCA, was that the rate of TCDD absorption from soil was approximately 15 percent of the rate of TCDD absorption in a solvent carrier. If a dermal absorption rate has been determined for a compound in solvent, one can apply the 15 percent factor to obtain a dermal absorption rate of the compound from soil. The accuracy of this estimate is, of course, contingent on soil adsorption properties of the compound being similar to those of TCDD. This aspect of the demonstration is discussed as a separate issue.

Dermal absorption rates for a monochlorobiphenyl and a hexachlorobiphenyl were available from the literature (Shah, et al, 1981, as reported in McLaughlin, 1984). These indicate that 1.2 percent of a hexachlorobiphenyl applied to skin in an acetone matrix is absorbed and recovered in the liver and that 8.0 percent of an applied monochlorobiphenyl was recovered in the liver. Application of the 15 percent ratio for soil/solvent absorption rate calculated for TCDD, results in estimated absorption rates of these PCBs from soil, as follows:

hexachlorobiphenyl	-	0.2 percent
monochlorobiphenyl	-	1.2 percent

These values are comparable to the TCDD dermal absorption percentages being used by GCA (i.e., 0.3 to 3 percent).

Demonstrating that the rate of dermal absorption of PCBs from soil is similar to that of TCDD, requires that similar soil adsorption tendencies be exhibited for each compound class. The literature indicates that PCBs (Haque and Schmedding, 1976; Haque, et al, 1974) and dioxins (Esposito, et al, 1980) are strongly bound to soils containing high levels of organic matter and that adsorption decreases with decreasing organic matter content. Sandy soils permit greater desorption of PCBs via volatilization at elevated (60°c) temperatures (Haque, et al, 1974) and dioxins via aqueous leaching (Esposito, et al, 1980).

Major indicator parameters for adsorption to soil organic matter include aqueous solubility and the octanol/water partition coefficient. The aqueous solubility of 2,3,7,8-TCDD is reported as 0.000317 mg/l (Schroy, 1984), while those for PCBs range from 0.0070 mg/l for octachloro-biphenyl to 5.9 mg/l for monochlorobiphenyl (Hutzinger, et al, 1974). These solubilities show that PCBs have somewhat greater aqueous solubility than TCDD and may be less strongly adsorbed to soil organic matter. The octanol/water partition coefficient for 2,3,7,8-TCDD is 1.4×10^6, while those for PCBs are in the 10^4 to 10^6 range. Thus, the octanol/water partition coefficients indicate that these two compound classes should have very similar tendencies to adsorb to soil organic matter.

CONCLUSION

The comparsion of the structural, physical and chemical properties of PCBs to TCDDs show similarities between these two classes of compounds suggesting that PCBs may be dermally absorbed at rates similar to those estimated for TCDD. To determine if these absorption estimate can be extrapolated for use in assessing the dermal absorption of PCBs from New Bedford Harbor sediments a more detail review of the bioavailability of PCBs from New Bedford Harbor sediments must be performed. A review of these articles has not been conducted at this time. GCA does not recommend developing dermal absorption estimates for PCBs until such a review occurs and until discussions with Dr. Kimbrough can be arranged.

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