

## VII.

### **HEALTH RISK AND NEEDS ASSESSMENT FOR THE AIRBORNE TOXIC CONTROL MEASURE FOR PARA-DICHLOROBENZENE SOLID AIR FRESHENERS AND TOILET/URINAL CARE PRODUCTS**

#### **A. INTRODUCTION**

Para-dichlorobenzene (PDCB) is a chlorinated benzene compound designated by the International Agency for Research on Cancer to be possibly carcinogenic to humans (Group 2B). It is also a California Toxic Air Contaminant (TAC) and a federal Hazardous Air Pollutant. Humans are substantially exposed to this compound by breathing indoor air. The compound is widely used primarily as the air freshener in toilet and urinal deodorant blocks and also as the main ingredient in mothballs. Breath, blood, urine and even breast milk samples and adipose tissue from most persons in the United States show measurable levels of PDCB, which is indicative of its widespread use (see Subsection H.5. Body Burden). The U.S. Consumer Product Safety Commission and the U.S. EPA recommend that where possible, PDCB, and items to be protected against moths, should be placed in trunks or other containers that can be stored in areas that are separately ventilated from the home, such as attics and detached garages (CPSC-U.S. EPA, 2004).

The Air Resources Board has followed the use of PDCB in air fresheners since 1991. At the time, PDCB toilet/urinal blocks were essentially the only urinal deodorizer available. While we recognized at the time that PDCB was a possible human carcinogen, little in the way of viable alternatives existed. Staff decided at the time to provide an exemption for PDCB air fresheners that were at least 98 percent pure, with the intention of following the health effects literature and watching for the availability of alternatives.

Since that time, a number of viable non-toxic, biodegradable toilet/urinal deodorizers and solid air fresheners have become available and are widely accepted by consumers. These products are used in the same capacity as a traditional PDCB product. They are placed in urinals contained within a screen, and hung from toilet bowl rims or are in the form of a solid air freshener and can be placed anywhere in a room. Not only do the toilet/urinal care product alternatives provide a pleasing aroma, but they may also clean the urinals and toilets, which the PDCB products do not do. Given the availability of good alternative products, and the potential carcinogenicity of PDCB, staff believe it is now appropriate to ban PDCB use in solid air fresheners and toilet/urinal care products.

Under this proposal, effective December 31, 2006, no person shall sell, supply, offer for sale, or manufacture for use in California any solid air fresheners or toilet/urinal care products that contain PDCB. Solid air fresheners or toilet/urinal care products that contain PDCB that were manufactured before December 31, 2006, may be sold, supplied, or offered for sale until December 31, 2007, so long as the product clearly

displays the date on which the product was manufactured, or a code indicating such date. A one year sell through is provided, rather than a longer timeframe in order to reduce public exposure to PDCB as soon as possible. The proposed Airborne Toxic Control Measure (ATCM) for Para-dichlorobenzene Solid Air Fresheners and Toilet/Urinal Care Products is contained in Appendix A - Consumer Products Regulation, section 94509 in the proposed new subsection (o).

Such a prohibition will contribute to the reduction of both indoor and near source outdoor air concentrations of PDCB. The use of toilet/urinal blocks leads to the ubiquitous presence of PDCB in sewage waters. Wastewater treatment plants aerate sewage in order to promote biodegradation as well as to strip toxic compounds. In so doing, the majority of PDCB entering wastewater treatment plants is transferred to the air, and may affect communities in the vicinity of the treatment plant. The primary source of PDCB in the wastewater is the toilet/urinal blocks.

Staff is not proposing to ban PDCB use in mothballs. The Department of Pesticide Regulation (DPR), a part of the California Environmental Protection Agency, registers PDCB use as a pesticide for control of clothes moths. ARB does not have regulatory authority, under Health and Safety Code sections 39650-39675, to control registered pesticides in their pesticidal use and therefore, we are not addressing this use of PDCB in moth balls.

In this Chapter we do the following:

- Describe the TACs program, and provide the regulatory authority behind this rulemaking.
- Present the outreach efforts on the part of the Air Resources Board (ARB or Board) staff to encourage input from the public and affected industry.
- Provide the physical and chemical characteristics of PDCB, its manufacturing and use.
- Present data on concentrations of PDCB in ambient and indoor air, drinking and sewage water, and human body fluids. The presence of PDCB in these mediums is linked to its use as a solid air freshener and in toilet/urinal care products.
- Lay out the health risks associated with exposure to PDCB, including its acute and chronic toxicity as well as its cancer risk.
- Calculate the increased cancer health risk due to exposure to PDCB.
- Estimate the decreased cancer health risk as a result of this regulation.

Chapter VI of this report will quantify the volatile organic compound (VOC) emission reduction benefits gained by eliminating PDCB use in solid air fresheners and

in toilet/urinal care products. Viable alternatives widely used today are discussed, as are issues brought up by concerned parties.

## **B. BACKGROUND**

The compound PDCB is used extensively in solid air fresheners (room deodorants), toilet/urinal care products, and in moth balls. The ARB has identified this compound as a TAC under California's Toxic Air Contaminant Identification and Control Program.

The California Toxic Air Contaminant Identification and Control Program (program), established under California law by Assembly Bill 1807 (Stats. 1983, Ch. 1047) and set forth in Health and Safety Code (HSC) section 39650-39675, requires the ARB to identify and control TACs in California.

The HSC specifies two approaches for the identification of a substance as a TAC. HSC section 39657(a) requires the State Board to identify TAC's using a process that includes a review by the Scientific Review Panel on Toxic Air Contaminants. Under this approach, the listing in a regulation that a substance is a TAC must contain a threshold determination. If the State Board has found there to be no threshold exposure level below which no significant adverse health effects are anticipated from exposure to the identified substance, a determination of "no threshold" is specified. If the Board has found that there is not sufficient available scientific evidence to support the identification of a threshold level, the "Threshold" column specifies "None identified." To date the 20 substances that have been identified under HSC section 39657(a) have had potential carcinogenic effects and have been listed with a threshold determination of "None identified." (See title 17, CCR, section 93000)

The second way a substance is identified as a TAC is through HSC section 39657(b). In this section, the State Board is required, by regulation, to designate any substance that is listed as a HAP pursuant to subsection (b) of Section 112 of the federal Clean Air Act (42 U.S.C. Section 7412(b)) as a TAC. Under this second approach the federal HAPs are listed in regulation without a specified threshold determination. Para-dichlorobenzene was identified as a TAC by the Board under HSC section 39657(b) in 1993. (See title 17, CCR, section 93001)

Following the identification of a substance as a TAC, HSC section 39665 requires ARB, with participation of the air pollution control and air quality management districts and in consultation with affected sources and interested parties, to prepare a report on the need and appropriate degree of regulation for that substance. HSC section 39665(b) requires that this "needs assessment" address, among other things, the technological feasibility of proposed ATCMs and the availability, suitability, and relative efficacy of substitute products or processes of a less hazardous nature.

Once ARB has evaluated the need and appropriate degree of regulation for a TAC, HSC section 39658(b)(4) authorizes ARB to adopt an ATCM for that substance.

Depending on the threshold determination the design of the ATCM is different. HSC section 39666(b) specifies that for TACs for which the ARB has determined that there is a threshold exposure level below which no significant adverse health effects are anticipated, the ATCM shall be designed to reduce emissions sufficiently so that the source will not result in, or contribute to, ambient levels at or in excess of the threshold.

For TACs for which the ARB has not specified a threshold, the ATCM must be designed to reduce emissions to the lowest level achievable through application of best available control technology (BACT), or a more effective method, unless the ARB has determined, based on an assessment of risk, that an alternative level of emission reduction is adequate or necessary to prevent an endangerment of public health.

PDCB was identified as a TAC and no threshold was specified. Therefore, the applicable level of control should be to the lowest level achievable through application of BACT, or a more effective method, since the ARB has not determined (based on the risk assessment set forth in the document) that an alternative level of risk reduction is adequate or necessary. In addition, all of the substances having potential carcinogenic effects that have been listed in regulation under HSC section 39657(a) (title 17, CCR, section 93000) have been listed with a threshold determination of "None identified." Staff believes, therefore, the law requires and a precedent has been set for the level of control necessary for TACs with no specified threshold designation.

### **C. PURPOSE**

Para-dicholorobenzene is a California TAC and a federal HAP with potential carcinogenic and non-cancer health effects. The proposed ATCM will ban the use of PDCB in toilet/urinal care product and solid air fresheners. (See Appendix A- Consumer Products Regulation, section 94509 (o). A number of viable alternatives to PDCB toilet/urinal blocks are available. There are also complying solid air fresheners available that do not contain PDCB. The proposed ATCM will also result in significant VOC emission reductions, (see Chapter VI, Subsection J., Toilet/Urinal Care Products and Solid/Gel Air Fresheners).

The Phase I Consumer Products Regulation excluded products comprised of 98 percent or more PDCB from being subject to the Solid Air Freshener VOC standard of 3 percent by weight (Consumer Products Regulation; section 94521, title 17, CCR). This action allowed manufacturers to continue using PDCB in toilet blocks without needing to reformulate to meet the VOC standard for Solid Air Fresheners in the Consumer Products Regulation.

PDCB toilet blocks were provided the exclusion because the compound is the product. Since PDCB is considered a VOC, there was no reformulation option whereby these products could meet the 3 percent VOC standard. In theory these products were already maximally efficient in that the entire product is fragrance so no VOC's are emitted that do not contribute to the air freshening function of the product. Also, at the time of the exclusion, there were few alternative products available.

Since that time, a number of viable alternatives to PDCB toilet/urinal blocks and solid air fresheners have been brought to market. In addition, troubling data has emerged on atmospheric, water, waste water effluent, and physiologic fluid concentrations of this compound. Because of these concerns, its carcinogenic potential and the availability of alternatives, the ARB is proposing this ATCM.

#### **D. REGULATORY AUTHORITY**

Several sections of the HSC provide the ARB with authority to adopt the proposed ATCM. HSC section 39600 (General Powers) and 39601 (Standards, Definitions, Rules, and Measures) confer to the ARB, the general authority and obligation to adopt rules and regulations as necessary to execute the Board's powers and duties imposed by State law. More specifically, the California's Toxic Air Contaminant Identification and Control Program (Program) established under California law by Assembly Bill 1807 (Chapter 1047, Statutes of 1983) and set forth in HSC sections 39650 through 39675, mandates the identification and control of air toxics in California.

#### **E. REGULATORY ACTIVITIES**

##### **1. Airborne Toxic Control Measures**

Once the ARB has evaluated the need and appropriate degree of regulation for a TAC, State law (HSC section 39666) requires the ARB to adopt regulations to reduce emissions of the TAC in consideration of cost, risk and other factors specified in HSC section 39665. To date, the ARB has developed 19 ATCMs (See Chapter II, of the Technical Support Document for more detail).

##### **2. National Emission Standards for Hazardous Air Pollutants (NESHAPs)**

In the federal Clean Air Act Amendments of 1990, the United States Environmental Protection Agency (U.S. EPA) identified PDCB as a hazardous air pollutant (HAP) because evidence indicated the substance may have adverse effects on human health or the environment. As of the writing of this report, the U.S. EPA had not promulgated a comparable NESHAPs control measure specifically for PDCB from solid air fresheners and toilet/urinal care products. The U.S. EPA has adopted the following NESHAPs standards which control emissions of PDCB, as one of multiple HAPs, from manufacturing and industrial facilities:

- National Emission Standards for Hazardous Air Pollutants for Source Categories; Organic Hazardous Air Pollutants from the Synthetic Organic Chemical Manufacturing Industry and Other Processes Subject to the Negotiated Regulation for Equipment Leaks. (U.S. EPA NESHAP, 1994)
- National Emission Standards for Hazardous Air Pollutants: Miscellaneous Organic Chemical Manufacturing; Final Rule. (U.S. EPA NESHAP, 2003b)

- National Emission Standards for Hazardous Air Pollutants: Off-Site Waste and Recovery Operations; Final Rule. (U.S. EPA NESHAP, 1996)
- National Emission Standards for Pharmaceuticals Production. (U.S. EPA NESHAP, 2001)
- National Emission Standards for Hazardous Air Pollutants for Source Categories: Pharmaceuticals Production; Final Rule. (U.S. EPA NESHAP, 1998)
- National Emission Standards for Hazardous Air Pollutants: Site Remediation; Final Rule. (U.S. EPA NESHAP, 2003a)
- National Emission Standards for Hazardous Air Pollutants: Rubber Tire Manufacturing; Final Rule. (U.S. EPA NESHAP, 2002)
- National Emission Standards for Hazardous Air Pollutants: Final Standards for Hazardous Air Pollutant Emissions From Wood Furniture Manufacturing Operations. (U.S. EPA NESHAP, 1995 & 1998)

### 3. Consumer Products

The Board not only has the authority to develop control measures to reduce emissions of TACs, it also has the authority to develop regulations to reduce VOC emissions. Section 41712 of the HSC requires ARB to adopt regulations to achieve the maximum feasible reduction in VOC emissions from consumer products. As part of the regulatory process, ARB must determine that adequate data exist for it to adopt the regulations. ARB must also determine that the regulations are technologically and commercially feasible, and necessary to carry out the Board's responsibilities under Division 26 of the HSC. In addition, HSC section 41712(c) provides that no regulation shall be adopted which requires the elimination of a product form. For a detailed discussion of regulatory activities relating to the consumer products program see Appendix B, of the Technical Support Document.

## **F. OUTREACH EFFORTS**

Outreach and public participation are important components of ARB's efforts to develop regulations. Manufacturers of solid air fresheners, marketers, distributors and private labelers, operators of publicly owned treatment works, as well as industry representatives, have participated and been kept apprised of our concerns regarding both the large emissions from PDCB toilet blocks, the market availability of low emitting counterparts and our intentions to potentially take regulatory action for these products. For more detail on public outreach see Chapter II.

As provided in HSC 39665(c), relevant comments on the ATCM received by ARB on the proposed ATCM have been included in the administrative record. They are listed

as a reference at the end of this Chapter (ATCM Comments) and are available from ARB staff upon request for public review and comment.

## **G. SOURCES, EMISSIONS, AND CHEMICAL AND PHYSICAL CHARACTERISTICS OF PDCB**

The following sections describe the sources, emissions, and chemical and physical characteristics of PDCB.

### **1. Sources**

PDCB is a synthetic VOC compound widely used as an air freshener and moth repellent. It is not known to occur in nature. The general population is primarily exposed to PDCB through its use in solid room air fresheners, toilet/urinal blocks and mothballs. These products typically consist of over 99 percent PDCB, which is the active ingredient. The majority of the PDCB in these products is emitted to the air, although some portion of the toilet and urinal blocks do enter the wastewater stream. As will be described shortly, the majority of PDCB in wastewater is transferred back to the air in wastewater treatment plants. PDCB is also used extensively as an intermediate in the production of the plastic polyphenylene sulfide, used in electronics, and in the production of trichlorobenzene. Emissions to the air or water from these processes are minimal in California as it is neither manufactured nor processed here, and industrial releases are minimal. Minor uses of PDCB are as a soil fumigant, and insecticide for fruit borers and ants, a chemical intermediate in the manufacturing of dyes, pharmaceuticals, resin-bonded abrasives and as a pesticide and mildewicide (Tenth Annual Report on Carcinogens, 2004). The use percentages of PDCB as presented in the Chemical Market Reporter 1999 are as follows:

Polyphenylene Sulfide Resin: 50 percent  
Room deodorants: 25 percent  
Moth control: 15 percent  
Miscellaneous, including dye and pesticide intermediates: 10 percent

Total US demand (consumption) is listed below for 1999, and for 2003, as reported in the Chemical Market Reporter, April 2004.

Demand 1999:	93 million pounds
Demand 2003:	68 million pounds

PDCB is manufactured by chlorination of benzene or chlorobenzene in the presence of a catalyst such as ferric oxide. It is produced in the United States by Solutia (formerly Monsanto Company), PPG Industries, and Metachem (formerly Standard Chloride of Delaware). No production is done in California. The table below, adapted from the Agency for Toxic Substances and Disease Review (ATSDR), December 1998, list the facilities that process or manufacture PDCB. Also listed are the

uses for PDCB. This data was derived from the Toxics Release Inventory, of which only certain types of facilities actually report.

**Table VII-1  
Facilities that Manufacture or Process PDCB**

<u>Facility</u>	<u>Location</u>	<u>Activities and Uses</u>
Bay State Sterling	North Manchester, IN	Manufacturing Aid
Bay State Sterling	Westborough, MA	Manufacturing Aid
Carolina Solite Corp	Norwood, NC	Ancillary/Other Use
Coughlan Prods. Corp	Clifton, NJ	Formulation Component
Coughlan Prods. Corp	Wayne, NJ	Formulation Component
Coughlan Prods. Corp	Paterson, NJ	Formulation Component
Crest Prods., Inc.	Oldsmar, FL	Formulation Component
Dow Chemical Co.	Plaquemine, LA	Produce, Impurity
Fortron Ind.	Wilmington, NC	Reactant
Fresh Prods., Inc.	Toledo, OH	Import, Sale/Dist, Repack
Fuller Brush Co.	Great Bend, KS	Formulation Component
Heartland Cement Co.	Independence, KS	Ancillary/Other Use
Hospital Specialty Co.	Cleveland, OH	Article Component
I. Schneid Inc.	Atlanta, GA	Article Component, Repack
Monsanto	Sauget, IL	Produce, Sale/Distribution
NIPA Hardwicke Inc.	Elgin, SC	Reactant
Phillips Chemical Co.	Borger, TX	Reactant
Phillips Research Center	Bartlesville, OK	Reactant
PPG IND., Inc.	New Martinsville, WV	Produce, sale/Distribution
Standard Chlorine of DE	Delaware City, DE	Produce, On-site use/Processing
Willert Home Prods	St Louis, MO	Article Component

Adapted from ATSDR, 1998.

## **2. PDCB Emissions from Solid Air Fresheners and Toilet/Urinal Care Products**

PDCB emissions from solid air fresheners not used in toilet/urinal care, are 0.624 tons per day (tpd) in 2006. PDCB emissions from toilet/urinal care products in 2006 are 2.716 tpd. Total PDCB emissions from air fresheners and toilet/urinal care products are about 3.3 tpd or 1,219 tons per year in 2006.

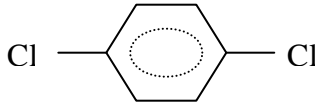
The ATCM prohibits the use of PDCB in solid air fresheners and toilet/urinal care products. All of the emissions will be eliminated as the result of implementing the ATCM. See Chapter VI, Subsection J. for more detail.

## **3. Chemical and Physical Characteristics**

PDCB, or 1, 4-dichlorobenzene, occurs as colorless or white crystals. These crystals readily sublime at room temperature, a characteristic that, along with its fragrance, make the compound suitable for use both as a room air freshener as well as

for moth control. PDCB is poorly soluble in water, hence it has found extensive use in toilet and urinal deodorant blocks. PDCB is soluble in organic solvents such as ether, benzene, alcohol and acetone. Table VII-2 below, adapted from ATSDR 1998, lists chemical information for PDCB.

**Table VII-2  
Chemical Information for PDCB**

<b>Characteristic</b>	<b>Reference</b>	
Chemical Name	1,4-Dichlorobenzene	Lide 1994
Synonyms	p-Dichlorobenzene Para-dichlorobenzene p-chlorophenyl chloride PDCB p-dichlorobenzol	HSBD 1996
Trade Names	Paracide; Paradow Santachlor; Paramoth	Farm Chemicals 1983 Merck, 1989
Chemical Formula	C6H4Cl2	Howard 1990
Chemical Structure		
Identification Numbers:		
CAS Number	106-46-7	Merck 1989
NIOSH RTECS	CZ4550000	HSDB 1996
EPA Hazardous Waste	U072	HSDB 1996
OHM/TADS	No data	
DOT/UN/NA/IMCO Shipping	UN 1592, IMO 6.1	HSDB 1996
HSDB	5523	HSDB 1996
NCI	C54955	HSDB 1996

CAS = Chemical Abstracts Service

NIOSH = National Institute for Occupational Safety and Health

TRECS = Registry of Toxic Effects of Chemical Substances

EPA = Environmental Protection Agency

OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System;

DOT/UN/NA/IMCO = Department of Transportation/United Nations/North

America/International Maritime Dangerous Goods Code

HSDB = Hazardous Substances Data Bank

NCI = National Cancer Institute.  
Adapted from ATSDR, 1998.

Physical properties of para-dichlorobenzene are listed below in Table VII-3, also adapted from ATSDR, 1998.

**Table VII-3  
Physical Properties of PDCB**

<b>Physical Property</b>	<b>Value</b>	<b>Reference</b>
Molecular Wt	147.01	Lide 1994
Color	White or colorless	Verschueren 1983
Physical State	Solid	Verschueren 1983
Melting Point	53.1°C	Lide 1994
Boiling Point	174.55°C	Lide 1994
Density at 20 °C	1.2475 g/ml	Lide 1994
Odor	Aromatic	Verschueren 1983
Odor Threshold:		
Water	0.011 mg/L	Amoore and Hautala 1983
Air	0.18 ppm (1.1 mg/m <sup>3</sup> )	
Solubility Water	Practically insoluble	Merck 1989
	79 mg/L at 25 °C	Verschueren 1983
Organic Solvents	Soluble in alcohol, ether, Acetone and benzene	Lide 1994
Partition Coefficients:		
Log octanol/water	3.52	Howard 1990
Log Koc	2.44	Chiou et al. 1983
Partition Coefficient in water/air	10	
Vapor Pressure	0.6 mmHg at 20°C	Verschueren 1983
Henry's Law Constant	0.0015 atm-m <sup>3</sup> /mol	Howard 1990
Flashpoint	66 °C	NFPA 1994
Conversion factors	1 ppm = 6.01 mg/m <sup>3</sup>	Verschueren 1983
	1 mg/m <sup>3</sup> = 0.166 ppm	

Adapted from ATSDR 1998.

## **H. EXPOSURE TO PDCB**

### **1. Wastewater Concentrations**

PDCB enters the water primarily through its use as toilet and urinal deodorant blocks. While poorly soluble in water, its widespread use in this capacity leads to measurable amounts of PDCB in sewage streams, surface and ground waters.

Toilet blocks dissolve into the sewage stream, which is processed in wastewater treatment plants. Parker et al. (1993) studied the fate of VOC's in municipal activated sludge plants. In a pilot plant operated in Ontario, Canada, the team found that halogenated hydrocarbons are much less readily biodegraded and more readily stripped to the atmosphere than their non-chlorinated counterparts. Of the measured VOC's, PDCB was the most recalcitrant to biodegradation (about 20 percent), and among the most heavily stripped at 68 percent. Average effluent concentration measured 1.8 µg/L. Approximately 10 percent of the PDCB remained in the sludge, with about 1 percent remaining in the water and released to surface waters following treatment. When applied to full scale plants, average removal of PDCB from the waste stream falls to about 74 percent in plants with aeration basins. These percentages vary according to the sewage treatment process, ranging from 19 percent to 94 percent during treatment depending on the clarification process, filtering and aeration processes. Almost all PDCB removed from waste water is released to the air by aeration processes.

The County Sanitation Districts of Los Angeles County operate a confederation of 11 wastewater treatment plants serving approximately 5 million people in Los Angeles County. The Districts monitor influent and effluent waters for PDCB as well as other compounds. Between approximately 1990 and 2000, 410 influent and 464 effluent samples were tested for PDCB. Median influent concentrations entering most plants is 2 to 5 µg/L with a maximum concentration of 83 µg/L. Median effluent concentrations are generally less than 1 µg/L. Effluent concentrations as high as 7 µg/L have been detected. Levels above 5 µg/L are troubling in that plants producing recycled water must meet the California Maximum Contaminant Level for drinking water of 5 µg/L limit. Two plants have had exceedances, with one plant exceeding the limit on 3 occasions during 2000. (CSDLAC, 2000)

The Sanitation Districts have evaluated the sources of PDCB extensively. Industrial facilities that may release PDCB into District sewage waters were identified and their releases quantified. The total PDCB attributed to industrial sources is only 0.074 pounds per day. Using average wastewater concentrations in the 2 to 5 µg/L range and calculating total treatment plant influent, average daily PDCB in influent is at least 20 pounds per day. Based on the fairly uniform influent concentrations, District personnel feel that the sources of PDCB in wastewater must be population based rather than a few industrial facilities that would release PDCB only in a few wastewater streams. Their investigation of industrial PDCB releases confirms this. They conclude that the vast majority of PDCB in wastewater is from toilet and urinal deodorant blocks. (CSDLAC, 2000) Interestingly, using 20 pounds per day influent with the Districts serving 5 million people and extrapolating for over 30 million people in California, over 90 percent of the PDCB from toilet urinal blocks evaporates rather than enters the wastewater treatment plants.

Wastewater measurements in other areas yield similar concentrations of PDCB. Influent to the North Regional Wastewater treatment plant in Broward County, Florida had PDCB concentrations of approximately 6 - 7 µg/L and effluent concentrations of 1.2 µg/L (Tansel and Eyma, 1999). Bell et al. (1993) measured the stripping of VOC's at

two plants in Ontario, Canada. The study showed average wastewater concentrations of 1.6 µg/L, with maximum off-gas concentrations of 92 µg/m<sup>3</sup> and 222 µg/m<sup>3</sup>. Concentrations within the plant ranged from 1.2 to 4.5 µg/L. The study found that high airflow rates led to greater VOC emissions from Publicly Owned Treatment Work's (POTW), and suggested that increasing the biomass and hence biodegradation within the aeration areas may decrease VOC emissions.

While stripping removes VOC's from the water, it effectively simply transfers them to the air. As PDCB is poorly biodegraded, increases in biomass, while increasing the biodegradation of PDCB, are still not likely to control emissions significantly. With current wastewater treatment technology, the only way to effectively avoid transferring wastewater PDCB back to the air is to remove it from the waste stream. This ATCM will accomplish this.

## 2. Drinking Water Concentrations

PDCB is occasionally found in drinking water. Knox and Canter (1996) listed PDCB among the top 58 most frequently occurring contaminants in drinking water. Data presented by ATSDR, 1998, typically show PDCB in just a few percent of drinking water samples and at concentrations well below 1 parts per billion, well below drinking water standards.

**Table VII-4  
Drinking Water Standards in Select Areas**

	Standard	Reference
World Health Organization	Guideline value 300 µg/L	ATSDR, 1998
United States	Drinking Water = 75 µg/L	U.SEPA, 1991
United States	DW HAL (child) draft 1 day = 10 mg/L	
	Longer term (10-day) 10 mg/L	ATSDR, 1998
California	Drinking Water Standard 5 ug/L	FSTRAC, 1999

## 3. Outdoor Air

Outdoor air concentrations of PDCB range from non-detectable (Shah and Heyerdahl, 1988) in rural areas away from sources to measureable levels outside of homes or in urban areas where air freshener products are used. Grosjean et al. listed concentrations in Los Angeles during 1993 ranging from nondetectable to 0.349 ppb and in 8 locations around the U.S. with a range of 0.020 to 0.290 ppb. Fraser et al. (1998) measured atmospheric concentrations of 86 VOC's during a severe Los Angeles smog episode in September, 1993. These measurements were undertaken during the worst smog event of that year, and were done to validate predictive models on ozone generation. PDCB concentrations averaged 0.1 ppb (0.0 – 0.35 ppb). Hartwell et al, 1992, reported a similar average of 0.12 ppb while measuring PDCB in 50 different Los Angeles locations during 1987. PDCB was detected at 84 percent of the sites.

Per the Children's Environmental Health Protection Act (Escutia, Senate Bill 25, 1999), the ARB was directed, in part, to evaluate the adequacy of the statewide air quality monitoring network to gather data necessary to determine childhood exposure to toxic air contaminants and criteria pollutants. The ARB recently completed monitoring studies in Wilmington, Long Beach and Los Angeles, California as part of this evaluation, all industrialized areas. The November, 2003 report (CAQM-SS, 2003) documents 24 hour average PDCB levels of 0.15 ppb in Los Angeles, 0.16 ppb in North Long Beach, and 0.18 ppb in Wilmington. Many samples were below the level of detection at the Wilmington School.

While California has no ambient air quality standard, seven states, including Arizona, Massachusetts, Oklahoma, South Carolina, Texas, Virginia and Washington have established average acceptable ambient air concentrations. These range from 24 hour averages of 11 to 1,500 ppb. Atmospheric concentrations of PDCB obviously tend to be significantly below these values.

#### **4. Indoor Air**

Indoor air concentrations of PDCB tend to be significantly higher than ambient air concentrations. Because its major uses are for indoor air freshening and as an insect repellent, PDCB is found almost ubiquitously in indoor air. Wallace, 1991, studied over 1,000 homes in the U.S., Germany and the Netherlands. Indoor air concentrations in 347 homes in the U.S. averaged  $25 \mu\text{g}/\text{m}^3$  with a maximum concentration of  $1,600 \mu\text{g}/\text{m}^3$ . In 500 homes in Germany, concentrations were similar with a mean of  $14 \mu\text{g}/\text{m}^3$  and a maximum of  $1260 \mu\text{g}/\text{m}^3$ . Concentrations in 319 homes in the Netherlands were slightly lower with a mean of  $1 \mu\text{g}/\text{m}^3$  and a maximum of  $299 \mu\text{g}/\text{m}^3$ . The Canadian Priority Substances List Assessment Report for PDCB reported PDCB concentrations in Canadian homes averaging  $15 \mu\text{g}/\text{m}^3$  (CEPA, 1993). Morita and Ohi (1975), in studies of Tokyo air during the 1970's, found that indoor air concentrations ranged from  $105 \mu\text{g}/\text{m}^3$  in a bedroom to as high as  $1700 \mu\text{g}/\text{m}^3$  in a wardrobe. Wallace et al., 1989, studied common activities of daily living to quantify exposure to VOC's based on activity. In a home with a single toilet deodorant block, indoor air concentrations ranged from  $100 \mu\text{g}/\text{m}^3$  to  $600 \mu\text{g}/\text{m}^3$ . Breath samples from the inhabitants ranged from  $40 - 50 \mu\text{g}/\text{m}^3$  during a 48 hour occupancy period. Occupant breath levels were remarkably stable after discontinuing the block, testament to the long half-life of PDCB in the human body.

The U.S. EPA Total Exposure Assessment Methodology (TEAM) study (Hill et al., 1995b) reported that 80 percent of U.S. homes contain detectable levels of PDCB. There are substantial seasonal variations in indoor concentrations as would be expected given the wide variations in internal ventilation with the seasons. In a nationwide Canadian study during 1991, Fellin and Otson, 1994, monitored indoor air concentrations of 26 VOC in 754 homes across Canada during 1991. They attempted to correlate indoor air concentrations with outdoor temperature and humidity. As might be expected, PDCB levels in the home correlated best with household product use such as moth balls rather than outdoor climate conditions. Indoor concentrations did follow a

seasonal variation, though, with mean indoor air concentrations in winter, spring, summer and fall of 35.75, 15.00, 10.54 and 15.00  $\mu\text{g}/\text{m}^3$ . Seasonal variations of 60 common indoor air VOC's were studied by Seiffert et al, 1989, in 12 homes in Berlin over a one year period. Similar to Fellin and Otson, their studies demonstrated a distinct increase in total indoor VOC concentrations during winter months when windows tend to be closed.

Concentrations of PDCB in a bathroom with one deodorizer block measured by Scuderi, 1986, ranged from 470 to 760  $\mu\text{g}/\text{m}^3$ . A bathroom with one urinal deodorizer block and one toilet deodorizer block measured 700 to 1,300  $\mu\text{g}/\text{m}^3$ .

Kostiainen, 1995, studied concentrations of 48 VOC's in the indoor air of 50 normal houses and 38 "sick" houses. "Sick" houses are dwellings in which occupants complained about the odor or they had symptoms resembling those seen in Sick Building Syndrome. PDCB averaged 0.65  $\mu\text{g}/\text{m}^3$ , with no significant difference between the sick houses and normal houses. PDCB was detected in all homes studied.

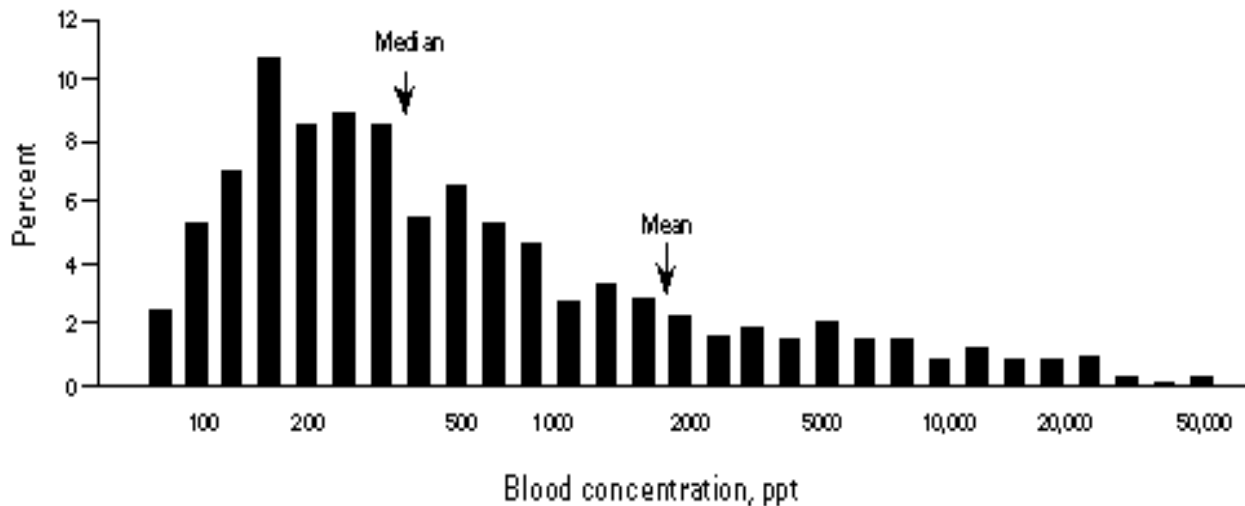
## **5. Body Burden**

The U.S. EPA Total Exposure Assessment Methodology (TEAM) Study, Southern California results, were published by Hartwell et al. (1992). The study measured PDCB concentrations in breath, personal air, kitchen air and outdoor air samples for 50 individuals collected in the Los Angeles area during 1987. PDCB concentrations were measured in 56.3 percent of breath samples (range 0.76 to 1.08  $\mu\text{g}/\text{m}^3$ ), personal air 95.3 percent (median 2.38  $\mu\text{g}/\text{m}^3$ ), kitchen air 97.6 percent (median 1.39  $\mu\text{g}/\text{m}^3$ ) and 84.4 percent of outdoor air samples (median 0.72  $\mu\text{g}/\text{m}^3$ ). It is interesting to note that the breath and personal air samples had higher PDCB concentrations than the room air samples. PDCB has a long half life in the body (est. 20 – 30 hrs by Wallace et al., 1989), so the breath, and to a lesser extent personal air samples, would reflect integrated exposure over the course of a day, rather than simply moment to moment exposure. Hence, higher than room air concentrations of PDCB in the breath imply that exposure from non-measured rooms, i.e. bathrooms with PDCB toilet blocks or closets/bedrooms with PDCB moth balls was occurring. In addition, body burden may be added to by drinking water, although given the drinking water standards this would be expected to be minimal.

Hill et al. (1995a) analyzed urine samples collected as part of the National Health and Nutrition Examination Survey III (NHANES III). Samples for approximately 1,000 individuals ranging in age from 20 to 59 were analyzed, reflecting a broad spectrum of the U.S. population in terms of age, sex and race/ethnicities, urban and rural residence, as well as region of the country. Urine was analyzed for 12 pesticide analytes, one of which is 2,5-dichlorophenol (2,5-DCP), the primary metabolite of PDCB. The metabolite 2,5-DCP was detected in 98 percent of samples, with a mean concentration in urine of 200  $\mu\text{g}/\text{liter}$  and a high of 8,700  $\mu\text{g}/\text{liter}$ . 2,5-DCP was the most frequently encountered metabolite and was present in the highest concentration. This reflects near ubiquitous exposure to PDCB of the general population.

In a similar study, Ashley et al. (1996) measured blood concentrations of a number of VOCs including PDCB. PDCB was measured in blood from 1,037 individual participants in the NHANES III study. These are individuals that were not occupationally exposed to PDCB. Blood concentrations are presented in the graph below. PDCB was detected in 96 percent of individuals, which reinforces the findings of Hill et al., mentioned above. The mean concentration of PDCB was 1,900 ppt (1.9  $\mu\text{g/L}$ ), and 75 percent of the population has blood levels less than 1.0  $\mu\text{g/L}$ .

**Figure VII-1 Blood Concentrations**



Adapted from Ashley et al., 1996.

Hill et al. (1995b) analyzed the population groups above and found a very strong correlation between the urine 2,5-DCP and blood concentrations of PDCB when the urine is corrected for dilution. Such a correlation is expected as the urine represents a major route of excretion for PDCB from the body. Urinary 2,5-DCP had a median concentration of 30  $\mu\text{g/L}$ , a mean of 200  $\mu\text{g/L}$ , a 90th percentile of 460  $\mu\text{g/L}$  and a 95th of 790  $\mu\text{g/L}$ . Blood concentrations, presented in the above graph, had a median level of 0.33  $\mu\text{g/L}$ , a mean of 2.1  $\mu\text{g/L}$ , a 90th percentile of 4.8  $\mu\text{g/L}$  and a 95th of 11  $\mu\text{g/L}$ . It is interesting that Pagnotto and Walkley (1965) reported that among exposed workers, PDCB in air at a concentration of 33 ppm correlate with urine concentrations of 2,5-DCP in the 90 – 100  $\text{mg/L}$ . This would imply that since the mean urinary concentration among the U.S. population is about 200  $\mu\text{g/L}$ , the population is exposed to a weighted average of over 33 ppm. The weakness of this correlation is that the concentrating effects of the kidneys are not accounted for. Given that airborne concentrations ranging from 17 – 500 ppm cause eye irritation among workers (Dow 1978), one would expect that a substantial portion of the U.S. population are exposed at a potentially irritant level. Once again, this correlation is weak in that the concentrating effects of the kidneys are ignored.

Urine samples from 96 percent of 197 Arkansas children were positive for the direct metabolite of PDCB (Hill et al, 1995 a and b).

Mes et al. (1986) analyzed breast milk from 210 Canadian women for chlorinated hydrocarbons. PDCB was detected in 86 percent of the samples. From 5 regions across the country, PDCB levels in breast milk averaged between 4 and 7 ng/g of breast milk. The overall average was 6 ng/g milk. The consistency in the measured levels across the country are indicative of the ubiquitous nature of exposure to PDCB. Milk samples collected from 46 lactating women in five locations in the eastern U.S. had PDCB ranging in concentration from 0.04 to 68 µg/ml (mean 9.15 µg/ml) (U.S. EPA 1986).

Morita and Ohi, 1975, studied concentrations of PDCB in human adipose tissue. They analyzed fat samples derived from 34 patients in Tokyo hospitals. Average PDCB concentrations in adipose tissue measured 2.3 µg per gram of fat, and all fat samples had measurable levels of PDCB. Given the lipid solubility of PDCB, fat concentrations provide a more time-integrated picture of exposure. The National Human Adipose Tissue Survey (NHATS) conducted in 1982, estimating exposure of the general population to organic chemicals, found PDCB in 100 percent of 46 human adipose tissue specimens (EPA 1989d from ATSDR, 1998). While the half-life estimated by Wallace et al., 1989, was between 20 – 30 hours, persons who accidentally ingested rice oil contaminated with PDCB still had trace levels in their sputum two years later (Morita and Ohi, 1975). Whether this represented a slow release from fat stores or is simply reflective of ongoing exposure is uncertain.

## **6. Summary**

The data in the preceding sections implicate indoor air PDCB, derived urinal and toilet blocks and to a lesser extent mothballs, as the primary means by which humans are exposed. The fairly constant levels in all sewage streams, including from states in which little PDCB is used industrially, implicate a population based source, which in this case is toilet/urinal blocks, solid air fresheners, and moth balls. Constant levels in breast milk across widely different geographic regions, once again implicate a population based source. PDCB is not present in most ground water supplies, and foods rarely have measureable levels (ATSDR, 1998). It is clear from the data presented that PDCB in toilet/urinal blocks, and solid air fresheners, along with moth balls are a major source of human exposure.

### **I. STABILITY, PERSISTENCE, TRANSFORMATION PRODUCTS, AND DISPERSION POTENTIAL**

Paradichlorobenzene enters the air primarily through its use in consumer products. Paradichlorobenzene is a fragrant, subliming solid, and its use in air fresheners leads to direct atmospheric emissions as these products volatilize. Its use in toilet/urinal deodorant blocks also ultimately leads to atmospheric emissions as PDCB

entrained in the waste stream either volatilizes directly from the stream or is stripped as discussed previously in POTW's.

Sublimation rates from consumer products range from  $1.6 \times 10^{-3}$  to  $4.6 \times 10^{-3}$  g/min at 21 to 24°C (Scuderi, 1986). This claim is consistent with manufacturers labels that advertise a 30 day life for a 4 ounce urinal block. PDCB entrained in sewage water is expected to volatilize rapidly, with half-lives in a model river of 4.3 hours (ATSDR, 1998). Once in the air, atmospheric PDCB is degraded by the hydroxyl radical, and only minimally by other reactions (Atkinson et al., 1985). Using the reported reaction rate with the hydroxyl radical of  $3 \times 10^{-13}$  cm<sup>3</sup>/mol-sec, Atkinson et al., 1985 and Sigh et al., 1981 estimate the atmospheric half-life to be 39 days. This relatively slow degradation rate may lead to its wide dispersion, but it is not likely to accumulate in the air (ATSDR, 1998). Reactions with the hydroxyl radical initiate the reactions which, in smog chamber tests, produce dichloronitrophenol, dichloronitrobenzene and dichlorophenol (Howard, 1989 from ATSDR, 1998). From sediment and soil, PDCB is much more likely to sublime and enter the air than undergo transformation. Transformation by photolysis, hydrolysis, biodegradation and oxidation are expected to be relatively minor processes (EPA 1985 from ATSDR, 1998).

## **J. POTENTIAL HEALTH EFFECTS OF PDCB**

Exposure to PDCB (1,4-dichlorobenzene; 1,4-DCB) may result in both cancer and non-cancer health effects. The health effects information presented in this Subsection was prepared by the Office of Environmental Health Hazard Assessment (OEHHA) (OEHHA, 2004).

### **1. Cancer effects**

Animal studies have shown that PDCB causes cancer at several sites in rats (kidney tumors in male rats) and mice (liver tumors). There are also a few reports of possible effects in humans, but these are only isolated case reports which do not conclusively demonstrate a carcinogenic effect; however, they do underscore the significance of the animal data. There has been scientific debate as to the mechanisms by which PDCB causes cancer in rodents, and it is generally considered that the applicability of PDCB-induced male rat kidney tumor data to human cancer hazard evaluation is probably inconclusive. However, the PDCB-induced liver tumors in mice do indicate a potential for human carcinogenicity. IARC has PDCB as *possibly carcinogenic to humans (Group 2B)*. The State of California listed PDCB under Proposition 65 as a substance known to cause cancer on January 1, 1989.

A National Toxicology Program (NTP) study provided evidence of liver carcinogenicity in both male and female mice. Based on this study, the OEHHA calculated an oral cancer potency of  $5.4 \times 10^{-3}$  (mg/kg-day)<sup>-1</sup> for PDCB, and a Public Health Goal of 0.006 mg/L (6 ppb) for PDCB in drinking water (OEHHA, 1997). The Air Toxics Hot Spots guidelines list a cancer unit risk value for PDCB of  $1.1 \times 10^{-5}$  (µg/m<sup>3</sup>)<sup>-1</sup>, and an inhalation potency (slope factor) of  $4.0 \times 10^{-2}$  (mg/kg-day)<sup>-1</sup> (OEHHA, 2002).

## **2. Non-Cancer Effects - Acute**

The median lethal dose (LD50) of PDCB to rats and mice has been estimated between 1 and 5 g/kg body weight, either by oral, inhalation, subcutaneous or intraperitoneal routes. Therefore, PDCB is not a potent acute toxin. Death resulted from respiratory paralysis following the appearance of symptoms including tearing and salivation, excitement, then ataxia (loss of muscular coordination) and dyspnea (difficulty in breathing). Post-mortem examination revealed effects on the liver [enlargement, necrosis (killing of cells within the tissue)], kidney (necrosis), lungs [edema (fluid leakage), hemorrhage (bleeding)] and the eyes and nose (irritation).

## **3. Non-Cancer Effects - Chronic**

Following long-term exposures of rats to PDCB by inhalation, reductions in body weights and food consumption were observed. Effects on the central nervous system (tremors) of these rats were also noted. There were also respiratory and dermal effects (nasal and ocular discharge), and effects on the liver and kidney (increased organ weight). OEHHA developed a Chronic Reference Exposure Level (cREL) of 800  $\mu\text{g}/\text{m}^3$  (100 ppb) for PDCB, based on these effects in rats in a study by the Chlorobenzene Producers Association (OEHHA, 2001). U.S. EPA used this same study as a basis for derivation of their Reference Dose for Chronic Oral Exposure (RfC), which is numerically the same as the cREL, as described in their IRIS database.

In addition to these chronic effects on adult rodents, studies looking for effects on development and reproduction in rodents have been described. Significant decreases in live births, pup weights, and pup survival were noted at high dose levels and increases in skeletal variability in rat pups (extra ribs) were noted at comparatively high doses.

No systematic studies of effects in humans chronically exposed to PDCB have been reported, but there are sporadic case reports of human illness associated with such exposures. A variety of symptoms were described, some of which are consistent with nervous system, liver and respiratory effects described in rodents.

## **K. RISK ANALYSIS**

To assess the potential health risks due to PDCB exposure, Staff modeled the only significant outdoor source in California, wastewater treatment plants. Because PDCB is primarily an indoor air contaminant, we also estimated the risk based on average indoor exposure using information from the TEAM studies.

## 1. Wastewater Treatment Facility Modeling

### Methodology

This section presents the methodology used to estimate the potential cancer and chronic noncancer health risks from exposure to PDCB emissions from wastewater treatment plant (WTP) operations. The assumptions used to determine the potential health risks are not based on operations at a specific location, rather a generic (i.e. example) operating scenario was developed based on a range of possible operating scenarios. The estimated risks provide an approximate range of potential health risks due to emissions of PDCB from wastewater treatment operations.

The methodology used in this risk assessment is consistent with the Tier-1 analysis presented in the OEHHA Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA, 2003). The OEHHA guidelines and this assessment utilize health and exposure assessment information that is contained in the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors (OEHHA, 2002) and Part IV, Technical Support Document for Exposure Analysis and Stochastic Analysis (OEHHA 2000).

The cancer health risk estimates provide a “qualitative” assessment of the potential impacts due to emissions of PDCB from wastewater operations. The cancer and chronic noncancer health risk estimates will depend on actual site specific parameters, including wastewater throughput, PDCB concentration in wastewater, equipment operation methods, and site meteorology. Risk will also vary depending on the distance a receptor is from the sources of emissions, the duration of exposure, type of receptor (worker or residential), and the inhalation rate.

### Source Description

PDCB is widely used primarily as the air freshener in toilet and urinal blocks and becomes part of the sewage and wastewater flow to wastewater treatment plants. As part of wastewater treatment operations, the water and sewage is agitated and aerated to the ambient air to promote biodegradation. During this process, volatile compounds in the wastewater can be released to the air. Other treatment processes are open to the ambient air, transferring volatiles, including PDCB, to the air. Emissions of PDCB are expected from the following five process areas (in order of highest annual emissions); the aerator tanks, dechlorination tanks, secondary clarifiers, chlorination tanks, and effluent filters. To estimate potential health impacts of PDCB emissions, these process areas were characterized as elevated area sources rather than ground level emission sources because the processes occur from tanks and equipment that stand 15 to 20 feet above the ground. PDCB emissions from these sources are expected to be close to ambient temperatures with no upward velocity. Operation of the wastewater treatment plant and emissions of PDCB are assumed to occur 24 hours per

day and 7 days per week. Table VII-5 shows the source parameters used for this assessment.

**Table VII-5  
Emission Source Parameters**

Source Type	area
Height of Emissions	5 meters
Aeration Source Area	14,319 meters squared
Aeration PDCB Emission Rate	$1.58 \times 10^{-3}$ grams/second
Dechlorination Source Area	256 meters squared
Dechlorination PDCB Emission Rate	$7.05 \times 10^{-4}$ gram/second
Secondary Clarifiers Source Area	9,985 meters squared
Secondary Clarifiers PDCB Emission Rate	$6.91 \times 10^{-5}$ gram/second
Chlorination Source Area	94 meters squared
Chlorination PDCB Emission Rate	$9.65 \times 10^{-6}$ gram/second
Effluent Filters Source Area	2,500 meters squared
Effluent Filters PDCB Emission Rate	$1.32 \times 10^{-6}$ gram/second

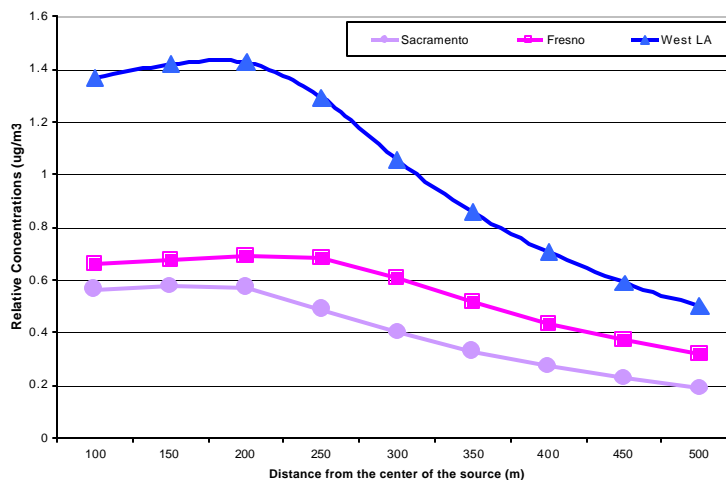
#### Dispersion Modeling Methods

The airborne concentrations of PDCB due to emissions from wastewater operations were estimated using the United States Environmental Protection Agency (EPA) ISCST3 version 02035 dispersion model. ISCST3 uses EPA-approved algorithms to estimate potential ambient annual average concentrations of PDCB as a result of PDCB emissions from area sources.

Meteorological data from West Los Angeles were selected to evaluate meteorological conditions with lower wind speeds and more persistent wind directions, which result in less pollutant dispersion and higher estimated ambient concentrations. To address the range of meteorological conditions expected in California and the diversity of results due to different meteorological conditions, dispersion modeling was also done using meteorological data for Sacramento and Fresno. Figure 1 shows the relative concentration impacts for these meteorological data sets when compared to conditions at the West Los Angeles location.

A 50-meter spacing receptor grid was used to find the locations of the highest PDCB concentrations due to emission sources that are part of wastewater treatment operations. Receptors were placed 20 meters from the perimeter of the area source with the largest contribution to maximum concentrations. To further characterize impacts from PDCB emissions, polar coordinate receptors were also placed at 50-meter incremental spacing 50 meters to 450 meters from the center of this area.

**Figure VII-2  
Comparison of Relative Pollutant Concentrations Found Using Sacramento,  
Fresno, and West Los Angeles Meteorological Data**



### Health Risk Assessment Methods

Maximum ground level concentrations were used to estimate potential cancer and chronic noncancer health risks from inhaling emissions of PDCB. PDCB is not a multipathway pollutant, and the inhalation pathway is the method of exposure to the cancer and noncancer impacts of this pollutant. Under current OEHHA recommended risk assessment methodology, to estimate potential cancer risks, the estimated maximum annual ground level concentrations, in micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ), is converted to a pollutant dose. To do this, the average daily inhalation dose over 70 years, in milligrams per kilogram of body weight per day ( $\text{mg}/\text{kg}\text{-d}$ ), is multiplied by the inhalation cancer potency factor developed by OEHHA. The result is an estimate of the potential cancer risk due to inhalation.

Unit risk factors (URF), in the units of inverse concentration,  $(\mu\text{g}/\text{m}^3)^{-1}$ , used in previous assessments, can be used for assessing cancer inhalation risk directly from air concentrations. However breathing rates, expressed in units of liters per kilogram of body weight-day can be coupled with the air concentrations to estimate dose in  $\text{mg}/\text{kg}\text{-d}$ . This is the approach recommended by OEHHA for assessing cancer risks. The cancer inhalation potency factor used in this assessment for PDCB is  $0.04 (\text{mg}/\text{kg}\text{-d})^{-1}$ . These values assume a residential exposure of 70 years. Other exposure parameters in OEHHA risk assessment guidelines (OEHHA, 2000 and OEHHA, 2003), including the current breathing rate values, are used in the calculation of risk assessment results.

Potential chronic noncancer health impacts due to exposure to ambient PDCB are expressed as a hazard quotient. To estimate potential chronic noncancer risks, the estimated maximum annual ground level concentrations are divided by its

corresponding chronic inhalation reference exposure level (REL). The OEHHA-approved chronic REL for PDCB is 800 µg/m<sup>3</sup>.

### Health Risk Assessment Results

Risk assessment at a generic facility finds that the maximum health impacts are due to the two sources that generally have the largest mass of PDCB emissions, the dechlorination process and the aeration process. The maximum ground level concentrations are usually found downwind from the dechlorination process because the mass emissions per unit of surface area is higher than the aeration process. To estimate health impacts from PDCB emissions, this assessment uses the maximum cumulative ground level concentrations from all processes or sources of PDCB at a wastewater treatment plant. The highest cancer impact of approximately 9 per million was found 20 meters downwind from the perimeter of the dechlorination process area.

Maximum concentrations were also determined at specific distances from the center of the dechlorination process source area. Table VII-6 presents the estimated potential cancer health risks at these distances and ground level concentrations, using the 95<sup>th</sup> percentile breathing rates from OEHHA and ISCST3 version 02035 dispersion model.

**Table VII-6  
Potential Cancer Health Risks Due to PDCB Emissions  
from Processes as Part of Wastewater Operations**

Potential Cancer Health Risks due to PDCB Emissions from Processes as part of Wastewater Operations									
Distance (meters)*	50	100	150	200	250	300	350	400	500
Risk per Million	7	6	5	4	2	1	<1	<1	<1

- This is the distance from the center of the area source with the highest nearby impacts
- Risk values are based on OEHHA's 95<sup>th</sup> percentile breathing rates

Chronic noncancer impacts were also estimated with the maximum chronic noncancer health risk (as a hazard index) of 0.00085. This hazard quotient value is well below the threshold of significance (HQ > or = 1.0).

The Community Air Quality Monitoring by the ARB described previously has found similar outdoor risk due to PDCB. This study in part evaluates the cancer risk to children by exposure to toxic air contaminants. At levels previously discussed in Downtown Los Angeles, North Long Beach and Wilmington, PDCB cancer risk estimates were 10, 11 and 12 in one million, respectively, very similar to the outdoor risks posed by the POTW PDCB emissions. PDCB ranked fifth among the nine toxic air contaminants studied in terms of cancer risk, higher than methylene chloride, perchloroethylene, and acetaldehyde.

## **2. Indoor Air Exposure**

Indoor air concentrations of PDCB are significantly higher than outdoor concentrations, and humans spend the majority of their time indoors. The TEAM study, analyzing the 24 hour exposure of 750 persons in six urban areas, measured an arithmetic mean 24 hour exposure of 22 ug/m<sup>3</sup>, while outdoor air averaged only 0.6 ug/m<sup>3</sup> (Wallace, 1991). These studies analyzed exposure in over 1000 persons in communities across the United States, including in heavily industrialized cities such as Los Angeles.

To calculate the increased cancer risk due to this exposure, the unit risk factor is utilized. A unit risk factor (URF) is defined as the estimated upper-confidence (usually 95%) probability of a person contracting cancer as a result of constant exposure to a concentration of 1 ug/m<sup>3</sup> over a 70-year lifetime. The Air Toxics Hot Spots guidelines list a unit risk value for PDCB of  $1.1 \times 10^{-5} (\mu\text{g}/\text{m}^3)^{-1}$ . By multiplying the URF by the average 24 hour exposure of 22 ug/m<sup>3</sup>, an increased excess cancer risk of 242 in a million is calculated. This represents, as mentioned, an upper-confidence limit. Worth mentioning is that the average exposure numbers from the TEAM study reflect only about one-third of homes actually using PDCB. Hence, in those homes where the total daily exposure is much higher, the cancer risk would be much greater.

PDCB from solid air fresheners and toilet/urinal blocks accounts for, on average, about 60 percent of the total indoor air PDCB based on information from the Chemical Market Reporter, 1999, and ARB surveys. Removing PDCB from solid air fresheners and toilet/urinal blocks products would be expected to result in a 60 percent reduction in this cancer risk or 145 excess cancer risk in a million.

### **L. AVAILABILITY AND TECHNOLOGICAL FEASIBILITY OF THE ATCM**

The proposed ATCM prohibits the use of PDCB in solid air fresheners and toilet/urinal care products. Compliance with the proposal will not be difficult. Numerous non-PDCB toilet/urinal care products are already available and well accepted by consumers. Product formulation strategies exist today and are described in Chapter VI, Subsection J.

As with the toilet/urinal care products, there are many non-PDCB air fresheners available. The traditional room air fresheners that are available are metered-dose products, gels, fragrance pearls, and potpourri. There are also solid/gel room air fresheners available at stores for general consumers and for janitorial supplies. See Chapter VI, Subsection J. for more detail.

### **M. COST OF THE ATCM**

The PDCB blocks generally cost less than their non-PDCB counterparts, as little as half as much, but substantial overlap in price was seen, especially when the blocks were sold contained within a urinal screen. A review of online retailers reveal a typical

PDCB 12 pack of four ounce blocks, each which will last for approximately 30 days, with prices in the \$5 to \$8 range. Comparable prices for the non-PDCB block, albeit with screen included, average \$17 for a 12 pack with each individual block also lasting for about 30 days.

Rim hanging blocks showed similar prices differentials, with a PDCB 12 pack selling for about \$9 and a non-PDCB 12 pack selling for about \$18. The price for non-PDCB blocks, though, is not always higher, with some manufacturers selling PDCB blocks saturated with an alternate fragrance such as cherry and contained within a screen in the \$20 range for a 12 pack. Enzyme-containing non-PDCB blocks tend to be the most expensive, with prices running in the \$25 range for a 12 pack.

We estimate the per unit production cost of solid air fresheners as a result of this regulation to be 5 cents. The Toilet/Urinal Care Products per unit production cost is estimated to be 3 cents. The cost effectiveness for solid air fresheners is \$3.20 per pound VOC reduced. The cost effectiveness for the Toilet/Urinal Care Products is 69 cents per pound VOC reduced.

For a detailed discussion of cost and economic impacts see Chapter VIII and Appendix E.

## **N. ENVIRONMENTAL IMPACTS**

See Chapter IX and Subsection K. of this Chapter for a detailed discussion of environmental impacts.

## **O. ACTIONS TAKEN OR BEING CONSIDERED BY OTHER STATES, AGENCIES, OR MUNICIPALITIES**

Many municipalities have a policy against the purchase or use of PDCB products in their facilities. Examples include the City of Seattle, Washington; City of Gotenborg, Sweden; Erie County, New York; the New York Department of Corrections; and the Fire Department of New York City. In addition, the New York State legislature is currently considering a statewide ban on the sale or use of PDCB products in any location open to access by the public. Finally, the state of Vermont has banned the state agencies from purchasing PDCB products.

The Fire Department of New York did air quality studies in the fire house of Engine Company 279 in response to complaints by fire fighters. The firehouse was using PDCB air fresheners in their restrooms. Air sampling was done for a number of VOCs and toxic air pollutants, among them PDCB, at the initial evaluation in March 7-8, 2003, and followed up on March 15, 2003 after instituting recommendations, including removal of the PDCB air freshener. Results before and after are as follows:

## Para-dichlorobenzene levels (ppb)

Location in Firehouse:	March 7-8	March 15
Roof:	ND	44.9
Locker Room:	214	ND
Kitchen:	141	123
Bunk:	379	6.11
Restroom:	1,278	ND
Basement Weight Room	30	24.5

ND = Not detected

As the data demonstrates, removal of the PDCB air freshener from the restroom reduced levels of PDCB to non-detectable levels, which would be expected given that the source was removed. Of note, the elevated level in the kitchen was from an unidentified source, thought possibly to be due to an exterminator or fumigation product. (FDNY, 2003)

### **P. RATIONALE FOR REDUCING EXPOSURE TO PDCB**

This document demonstrates both the ubiquitous exposure to PDCB and the potential health and cancer effects associated with this exposure. Given the availability and consumer acceptance of alternatives to PDCB solid air fresheners and toilet/urinal blocks and the potential health benefit from reducing exposure to this compound, staff believe that the prohibition of PDCB represents BACT and will protect public health.

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