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*Canadian Environmental Protection Act*

Priority Substances List
Assessment Report

# Pentachlorobenzene

Government of Canada
Environment Canada
Health Canada

Aussi disponible en français sous le titre de :
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# Synopsis

Pentachlorobenzene is not produced in Canada and currently there is no domestic commercial demand for this substance. On the basis of limited data, the 2 most significant sources of entry of pentachlorobenzene into the Canadian environment result from spillage of dielectric fluids and from long-range transport and deposition. Pentachlorobenzene has been detected in samples of air, surface water, rain, sediment and biota collected at various locations in Canada. Pentachlorobenzene is removed from air and surface water by degradation processes, such as photo-oxidation and biodegradation, but can persist and accumulate under anaerobic conditions in buried sediments and soils.

The highest concentration of pentachlorobenzene detected in Canadian surface waters was over 10 000 times less than the effects threshold estimated for the most sensitive aquatic species identified. For wildlife, the dietary intake of pentachlorobenzene estimated for piscivorous mammals under worst-case conditions was more than 400 times less than the effects threshold estimated on the basis of studies in laboratory mammals. Although significant exposure of benthic organisms to pentachlorobenzene in sediments may be occurring in specific aquatic ecosystems in Canada, adequate data on the toxicological effects on these organisms were not identified. Therefore, it is not possible to determine whether concentrations of this substance in sediments could result in harmful effects to these biota.

Currently, the rates of release of pentachlorobenzene into the environment are low. Pentachlorobenzene is removed from the atmosphere by photo-oxidation and precipitation and, therefore, is present in low concentrations in air. As such, it is not expected to contribute significantly to global warming or to depletion of stratospheric ozone.

Based on limited available data on concentrations in ambient air, drinking water and food, the average total daily intakes of pentachlorobenzene for various age groups in the general population have been estimated. These average daily intakes are less (by approximately 250 to 1 000 times) than the tolerable daily intake derived on the basis of studies in laboratory animals. For breast-fed infants whose intakes are elevated for only a short period of their life-span, the estimated average total daily intake is 5 times less than the tolerable daily intake. The tolerable daily intake is the intake to which it is believed that a person can be exposed daily over a lifetime without deleterious effect.

**Based on these considerations, it has been determined that there is insufficient information to conclude whether pentachlorobenzene is entering the environment in quantities or under conditions that may be harmful to the environment.**
**It has been concluded, however, that pentachlorobenzene is not entering the environment in quantities or under conditions that may constitute a danger to the environment on which human life depends, or to human life or health.**

# 1.0 Introduction

The *Canadian Environmental Protection Act* (CEPA) requires the federal Ministers of the Environment and of Health to prepare and publish a Priority Substances List that identifies substances, including chemicals, groups of chemicals, effluents and wastes that may be harmful to the environment or constitute a danger to human health. The Act also requires both Ministers to assess these substances and determine whether they are "toxic" as defined in section 11 of the Act which states:

> "... a substance is toxic if it is entering or may enter the environment in a quantity or concentration or under conditions
>
> > (*a*) having or that may have an immediate or long-term harmful effect on the environment;
> >
> > (*b*) constituting or that may constitute a danger to the environment on which human life depends; or
> >
> > (*c*) constituting or that may constitute a danger in Canada to human life or health."

Substances assessed as "toxic" according to section 11 may be placed on Schedule I of the Act, and considered for possible development of regulations, guidelines or codes of practice to control any aspect of their life cycle, from the research and development stage through manufacture, use, storage, transport and ultimate disposal.

The assessment of whether pentachlorobenzene is "toxic", as defined under CEPA, was based on the determination of whether it **enters** or is likely to enter the Canadian environment in a concentration or quantities or under conditions that could lead to **exposure** of humans or other biota at levels that could cause adverse **effects**.

The assessment of whether pentachlorobenzene is "toxic" to human health under CEPA, is based principally on documentation prepared by staff of Health Canada for the International Programme on Chemical Safety (IPCS). Between 1984 and 1987, original data relevant to the assessment of risks to health associated with exposure to the chlorinated benzenes (excluding hexachlorobenzene) were reviewed by staff of Health Canada in the preparation of a draft IPCS Environmental Health Criteria Document (EHC). The current assessment has been updated and expanded to emphasize data most relevant to the assessment of the risks associated with exposure to pentachlorobenzene in the general environment in Canada.

In preparation of the IPCS document, a wide variety of scientific databases were searched to update information provided in earlier contractors' reports including an annotated bibliography on the chlorobenzenes (excluding hexachlorobenzene) by Peter Strahlendorf (1978) and a criteria document on chlorobenzenes (including hexachlorobenzene) by Michael Holliday and Associates (1984a; 1984b). Additional information was identified during peer review of the draft Environmental Health Criteria Document by IPCS focal points and a task group of experts which met in June 1990. More recently, in February 1991, a search was conducted of ENVIROLINE, Chemical Abstracts, Pollution Abstracts, Environmental Bibliography, IRIS, MEDLINE, and BIOSIS databases to identify recent data relevant to assessment in particular of the risks to the population of Canada. Data relevant to assessment of whether pentachlorobenzene is "toxic" to human health obtained after completion of these sections of this report (March 1992) were not considered for inclusion.

Information considered relevant to the assessment of whether pentachlorobenzene is "toxic" to the environment was identified from on-line searches completed in November 1990 of ASFA, BIOSIS, CAB Abstracts, Chemical Abstracts, CESARS, CIS, ENVIROLINE, Hazardous Substances, and IRPTC databases. A summary of information on the environmental toxicity, fate and levels of pentachlorobenzene in the Canadian environment, prepared under contract by Diane Koniecki (November 1991) was also consulted in the preparation of this report. Information received after March 1993 was not included in the environmental sections of this report.

Although review articles were consulted where considered appropriate, original studies that form the basis for the determination of "toxic" under CEPA were critically evaluated by staff of Health Canada (human exposure and effects on human health) and Environment Canada (entry and environmental exposure and effects). The following officials contributed to preparation of the report:

A.M. Bobra (Environment Canada)
D. Boersma (Environment Canada)
L. Brownlee (Environment Canada)
M. Giddings (Health Canada)
R. Gomes (Health Canada)
K.M. Lloyd (Environment Canada)
M.E. Meek (Health Canada)

B. Idris and R.G. Liteplo of Health Canada also contributed to the consolidation of the Assessment Report.

In this report, a synopsis that will appear in the *Canada Gazette* is presented. A summary of the technical information that is critical to the assessment, and which is presented in greater detail in unpublished Supporting Documentation, is presented in Section 2.0. The assessment of whether pentachlorobenzene is "toxic", as defined under CEPA, is presented in Section 3.0.

As part of the review and approvals process established by Environment Canada, the environmental sections of this Assessment Report were reviewed by the following: B. Oliver (Zenon Environmental Laboratories); M. Rankin (Dow Chemical Canada Inc.); and H. Rogers (Department of Fisheries and Oceans, Institute of Ocean Sciences). Sections related to the effects on human health were approved by the Standards and Guidelines Rulings Committee of the Bureau of Chemical Hazards of Health Canada. The entire Assessment Report was reviewed and approved by Environment Canada and Health Canada's CEPA Management Committee.

Copies of this Assessment Report and the unpublished Supporting Documentation are available upon request from the following:

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# 2.0 Summary of Information Critical to Assessment of "Toxic"

## 2.1 Identity, Properties, Production and Uses

Pentachlorobenzene (Chemical Abstract Service registry number 608-93-5) is a cyclic aromatic hydrocarbon with 5 chlorine atoms substituting for hydrogen atoms in the benzene ring. At room temperature, pentachlorobenzene is a white crystalline solid with a melting point of 86°C (Mackay and Shiu, 1981). Pentachlorobenzene (solid) has an estimated vapour pressure of 0.22 Pa at 25°C (Weast, 1972, 1973). The solubility of pentachlorobenzene in water at 25°C is 0.65 mg/L (Mackay *et al.*, 1992). The log octanol/water partition coefficient (log $K_{ow}$) for pentachlorobenzene is 5.0 (Mackay *et al.*, 1992). Pentachlorobenzene absorbs infrared radiation, including wavelengths in the 7 to 13 μm region (Sadtler Research Laboratories, 1982).

Pentachlorobenzene can be detected by gas chromatography with either flame ionization or electron capture detection, or by gas chromatography/mass spectrometry (Oliver and Nicol, 1984; Bosma *et al.*, 1988).

Pentachlorobenzene is not produced in Canada (Camford, 1991) and currently there is no domestic commercial demand for this substance. Less than 0.1 kg per year of pure pentachlorobenzene was imported into Canada from the United States for use as a laboratory reagent (Statistics Canada, 1991; Environment Canada, 1992a).

Formerly, pentachlorobenzene as well as trichlorobenzenes and tetrachlorobenzenes were used in combination with polychlorinated biphenyls (PCBs) in dielectric fluids. However, after regulations prohibiting new uses of PCB-containing dielectric fluids were introduced in 1980 (*Canada Gazette*, 1980), the amount of pentachlorobenzene used for this purpose declined considerably. Based on the results of a recent survey (Brien, 1992), small amounts of pentachlorobenzene (40 kg during the first 6 months of 1992) were still imported into Canada in dielectric fluids for use in the maintenance of transformers.

## 2.2 Entry into the Environment

There are no known natural sources of pentachlorobenzene and currently there is no commercial activity involving this compound in Canada. However, significant quantities of pentachlorobenzene remain in use in dielectric fluids. Based on recent estimates, up to approximately 200 000 kg of pentachlorobenzene are present in dielectric fluids currently in use and up to 1 000 kg of pentachlorobenzene are present in dielectric fluids in storage and destined for disposal by destruction (Environment Canada, 1991a). Since pentachlorobenzene may arise as a by-product or contaminant during the production of other chlorinated organic substances (including tetrachlorobenzenes, hexachlorobenzene, pentachloronitrobenzene, 1,1,1-trichloroethane, carbon tetrachloride, trichloroethylene, perchloroethylene and ethylene dichloride [US EPA, 1980]), it can enter the environment from releases of these compounds during their storage, use, transport or disposal. Approximately 17 kg per year of pentachlorobenzene may be released into the environment through the use of pentachloronitrobenzene in Canada (Brien, 1992). However, estimates of the amounts of pentachlorobenzene in other chlorinated compounds were not identified.

Pentachlorobenzene has also been identified in the waste streams from the following: pulp and paper mills; iron and steel mills; inorganic and organic chemical plants; petroleum refineries; and activated sludge waste water treatment plants (Rankin, 1993; OME, 1990a, 1990b, 1991a, 1991b, 1991c, 1992a, 1992b; Merriman, 1988; King and Sherbin, 1986; Oliver and Nicol, 1982). The concentrations of pentachlorobenzene ranged from non-detectable (detection limits ranged from 0.01 to 10 ng/L) to 5 400 ng/L; concentrations were highest in effluents from inorganic chemical plants and iron and steel mills. The sources of pentachloro- benzene in these waste streams have not been identified.

No readily available quantitative data on releases of pentachlorobenzene into the Canadian environment were identified. However, amounts released from the most likely sources were estimated and are summarized in Table 1. On the basis of limited data, the 2 most significant sources of entry result from spillage of dielectric fluids and from long-range transport and deposition.

## Table 1
## Estimated Major Releases of Pentachlorobenzene into the Canadian Environment

| Sources | Releases kg/year |
|---|---|
| Released Due to Dielectric Fluid Spills (after clean-up)[a] | 180 |
| Released from Dielectric Fluid Incineration[b] | 15 |
| Manufacture of Chlorinated Solvents[c] | |
| (before April 1992) | (24 to 70) |
| (after April 1992) | none expected |
| Use of Chlorinated Solvents[d] | 4 |
| From Other Chlorinated Compounds | unknown |
| Degradation and Metabolism of Other Chlorinated Compounds[e] | unknown |
| Long-range Transport and Deposition[f] | 286 |
| Effluents from Activated Sludge Waste Water Treatment Plants, Pulp and Paper Mills, Iron and Steel Mills, Inorganic and Organic Chemical Plants and Petroleum Refineries[g] | greater than 7 |
| Pesticide Use[i] | 17 |
| From Landfill Sites[h] | greater than 1 |

a. Based on $5.6 \times 10^3$ kg for a 10 year period and 67% removal from the initial spill due to recovery efforts (Menzies, 1992); thus, $1.8 \times 10^2$ kg/year would be released into the environment. These estimates do not include fugitive releases which can be substantial (Western Research, 1991).
b. The incineration release assumes a destruction efficiency of 99.99% (Dibbs, 1991); annual quantities are not known. Assumes 100% released in one year.
c. Before April 1992, approximately 24 to 70 kg were released annually from incineration of waste by-products (based on 1990 production figures [CPI, 1990a, 1990b, 1990c], emission factors by the US EPA (Brooks and Hunt, 1984), incineration efficiency of 99.99% (Environment Canada, 1991b; Jacoff *et al.*, 1986); since April of 1992, chlorinated solvents were no longer produced in Canada other than in one plant which manufactures carbon tetrachloride in Ontario. No pentachlorobenzene is expected to be released into the environment from this source (ICI, 1993).
d. Based on domestic demand in Canada (Camford, 1991) multiplied by an upper limit concentration of 1 mg/L, and assuming 10% release.
e. Pentachlorobenzene can be released into the environment, through the metabolism and degradation of other chlorinated compounds, such as lindane (Reed and Forgash, 1970; Karapally *et al.*, 1973; US EPA, 1980) and pentachloronitrobenzene (Kuchar *et al.*, 1969).
f. Transboundary entry from waste disposal sites (Oliver, 1984, 1985; Oliver and Kaiser, 1986) and in Canadian rainfall (Muir, 1993; Strachan, 1993) and snow (Welch *et al.*, 1991).
g. Loadings from Ontario iron and steel mills; for the other sectors, loadings are unknown (OME, 1990a, 1990b, 1991a, 1991b, 1991c, 1992a, 1992b). Historically, other sources released pentachlorobenzene into the environment, but due to changing technology, these sources have decreased drastically or been eliminated (Gilbertson, 1979; Alves and Chevalier, 1980).
h. Loading from only one site (a chemical company landfill in Sarnia, Ontario, used to dispose of chlorinated solvents still bottoms) [King and Sherbin, 1986].
i. Importation of pentachloronitrobenzene (Brien, 1992), assuming 100% release of pentachlorobenzene as a contaminant.

## 2.3 Exposure-related Information

### *2.3.1 Fate*

The fate of pentachlorobenzene in the environment is governed by transport processes such as volatilization and adsorption, and transformation processes such as photo-oxidation and aerobic biodegradation. Although pentachlorobenzene is removed from aerobic environments (e.g., air and surface water) by degradation processes, it can persist and accumulate under anaerobic conditions in buried sediments and soils.

Based on its physical and chemical properties, it is anticipated that pentachlorobenzene released into the atmosphere will eventually be distributed between air and water, with smaller amounts in soil and sediment (Mackay *et al.*, 1992). Washout from the atmosphere in rainwater also occurs (Muir, 1993; Strachan, 1993). Pentachlorobenzene can be photo-oxidized in the atmosphere, largely through reactions with hydroxyl (OH) radicals (Atkinson, 1987; Howard *et al.*, 1991). The estimated atmospheric half-life of pentachlorobenzene ranges from 45 to 467 days (1.28 years) [Howard *et al.*, 1991; Mackay *et al.*, 1992; Singleton, 1993]. This half-life is sufficient to permit long-range transport. The presence of pentachlorobenzene in air masses over the Pacific Ocean (Atlas and Schauffler, 1990) suggests that this substance may be transported over long distances.

Based on its physical and chemical properties, pentachlorobenzene released into water would be expected to adsorb to sediment and particulate matter (Kuntz and Warry, 1983; Oliver, 1987b, 1987c; Oliver and Nicol, 1984), with some volatilization to the atmosphere (Oliver, 1984; Oliver and Carey, 1986). The half-life for volatilization of pentachlorobenzene from river water (1 metre deep, flowing at 1 metre/second at 20°C and with a wind velocity of 3 metre/second), calculated according to the method described by Thomas (1982) for compounds of medium to high volatility, was estimated to be 6 hours. In water, biodegradation appears to be the only significant degradation process (Howard *et al.*, 1991). The half-life of pentachlorobenzene in surface water was estimated to range from 194 to 1 250 days (Howard *et al.*, 1991; Mackay *et al.*, 1992). The half-life for the anaerobic biodegradation of pentachlorobenzene in deeper waters ranged from 776 to 1 380 days (Howard *et al.*, 1991).

Pentachlorobenzene is expected to be persistent and immobile in soil. This substance has a $K_{oc}$ (organic carbon sorption coefficient) greater than 100 (Kenaga, 1980). Beck and Hansen (1974) calculated a half-life of 270 days for the degradation of pentachlorobenzene in soil, based on the results of a study in which soil was exposed to this substance (10 kg/ha) and stored in plastic covered containers. Half-lives ranging from 194 to 1 250 days have been estimated by Mackay *et al.* (1992).

Based on its physical and chemical properties, pentachlorobenzene is expected to be persistent in sediment (Mackay *et al.*, 1992). Although pentachlorobenzene strongly adsorbs to sediment, some can be removed by resuspension (Oliver, 1984, 1985; Oliver *et al.*, 1989), through biological activities such as bioturbation (Karickhoff and Morris, 1985) or through desorption into pore water and subsequent diffusion into overlying water (Charlton, 1983; Oliver and Charlton, 1984). The half-life for the biodegradation of pentachlorobenzene in sediment was estimated to range from 388 to 1 250 days (Howard *et al.*, 1991; Mackay *et al.*, 1992). On the basis of an analysis of core sediment samples from Lake Ontario and a lake near Kenora, Ontario, pentachlorobenzene has been released into the environment for more than 60 years (Oliver and Nicol, 1982; Oliver, 1984; Durham and Oliver, 1983; Oliver *et al.*, 1989; Muir, 1993) without significant anaerobic degradation in sediment (Oliver and Nicol, 1983).

Reported whole body bioaccumulation factors (BAFs) of pentachlorobenzene vary between 813 (mussel, *Mytilis edulis*) [Renberg *et al.*, 1986] and 20 000 (rainbow trout, *Oncorhynchus mykiss*) [Oliver and Niimi, 1983]. A BAF of pentachlorobenzene of 401 000 was reported for earthworms (*Eisenia andrei*) [Belfroid *et al.*, 1993]. Pentachlorobenzene from sediments can be available to benthic invertebrates. Concentrations of pentachlorobenzene in field populations of oligochaete worms and amphipods were related to levels in the sediments (Fox *et al.*, 1983). The accumulation of pentachlorobenzene by oligochaete worms from sediments in Lake Ontario in laboratory aquaria was demonstrated by Oliver (1987a). The extent of bioaccumulation from sediments appeared to be controlled by concentrations of pentachlorobenzene in the sediment pore water rather than from ingestion of contaminated sediment particles (Oliver, 1987a; Markwell *et al.*, 1989). Although pentachlorobenzene is a bioaccumulative compound, no aquatic food chain magnification has been reported (Thomann, 1989; Oliver and Niimi, 1988).

Air-plant (air-lichen) concentration factors for pentachlorobenzene from the upper Great Lakes region of Ontario ranged from $2.16 \times 10^7$ to $3.17 \times 10^7$ (Muir *et al.*, 1993). Though there is potential for the uptake of pentachlorobenzene by terrestrial plants through both roots and foliage, it is probably limited (Topp *et al.*, 1986; Trapp *et al.*, 1990).

### *2.3.2 Concentrations*

Pentachlorobenzene has been detected in samples of ambient air, surface water, drinking water, sediment and biota in Canada. Data on the concentrations of pentachlorobenzene in indoor air, estuarine or marine waters, or soil were not identified.

In a survey of ambient air at Windsor and Walpole Island, Ontario, mean concentrations in samples taken between August 1988 and October 1989 were 0.12 ng/m$^3$ in Windsor (detected in 31 of 32 samples) and 0.07 ng/m$^3$ for Walpole Island (detected in 27 of 30 samples), respectively (Environment Canada, 1990). Maximum concentrations at the 2 sites were 0.28 and 0.22 ng/m$^3$ at Windsor and Walpole Island, respectively (detection limit 0.03 ng/m$^3$). The sampling locations in Windsor were located approximately 6 km from a municipal waste incinerator plant in Detroit, Michigan, while Walpole Island is a rural location located 55 km from the same plant. The concentration of pentachlorobenzene in samples of air collected between February and April 1988 at Alert, Northwest Territories, ranged from 0.031 to 0.135 ng/m$^3$ (Patton *et al.*, 1991). Information on concentrations of pentachlorobenzene in indoor air in Canada, or elsewhere, were not identified, except in the vicinity of a limited number of contaminated sites.

The concentration of pentachlorobenzene in samples of rain collected from various locations across Canada between 1987 and 1991 ranged from < 0.01 to 0.09 ng/L; the mean concentration was 0.02 ng/L (Muir, 1993; Strachan, 1993).

The concentration of pentachlorobenzene in samples of water collected from various lakes and rivers in Canada between 1980 and 1991, ranged from non-detectable to 13 ng/L (detection limits ranged from 0.01 to 1 ng/L, depending upon the analytical technique used) [Oliver and Nicol, 1982, 1984; Fox *et al.*, 1983; Oliver, 1984; Chan *et al.*, 1986; Oliver and Kaiser, 1986; Fox and Carey, 1986; Chan and Kohli, 1987; Biberhofer and Stevens, 1987; Carey and Fox, 1987; Oliver and Niimi, 1988; Data Interpretation Group River Monitoring Committee, 1988, 1990; Stevens and Neilson, 1989; Muir, 1993]. All mean concentrations were less than 1.5 ng/L. The maximum concentrations were highest in samples of water obtained in the early 1980s from Lake Ontario at the mouth of the Niagara River (Fox and Carey, 1986; Oliver and Nicol, 1984) and St. Clair River (Oliver and Kaiser, 1986); however, concentrations have subsequently declined. The maximum concentration in samples of water collected from the Niagara River at Niagara-on-the-Lake during 1988 and 1989 was 0.24 ng/L (Data Interpretation Group River Monitoring Committee, 1990).

Information on concentrations of pentachlorobenzene in Canadian drinking water supplies is limited. Concentrations of pentachlorobenzene in the public water supplies of 3 cities in Ontario sampled in 1980, ranged from 0.03 ng/L to 0.05 ng/L with a mean value of 0.04 ng/L (the detection limit was approximately 0.01 ng/L) [Oliver and Nicol, 1982]. In a survey of drinking water from 139 locations in the 4 Atlantic provinces sampled between 1985 and 1988, pentachlorobenzene was not detected in 602 samples analyzed (detection limit = 0.002 µg/L) [Environment Canada, 1989a, 1989b, 1989c, 1989d].

The concentration of pentachlorobenzene in surficial sediments collected from various lakes and rivers in Canada between 1979 and 1991, ranged from non-detectable to 12 000 ng/g (dry weight) [detection limits ranged from 0.1 to 2 ng/g, depending upon the analytical technique] (Environment Canada, 1979; Oliver and Nicol, 1982; Fox *et al.*, 1983; Oliver and Charlton, 1984; Oliver and Bourbonniere, 1985; Oliver and Pugsley, 1986; Charlton and Oliver, 1986; Oliver, 1987b, 1987c; Merriman, 1987; Oliver and Niimi, 1988; Oliver *et al.*, 1989; Kaiser *et al.*, 1990; Welch *et al.*, 1991; OME, 1993). Concentrations were highest in samples obtained in 1985 from the St. Clair River near a waste disposal site at a chemical plant and an effluent outfall from an industrial area of Sarnia. The concentrations ranged from 0.4 to 12 000 ng/g in samples collected in 1985, while in samples obtained in 1990, the levels ranged from 35 to 2 800 ng/g (Oliver and Pugsley, 1986; OME, 1993). The mean concentrations were less than 10 ng/g (dry weight) with the exception of those obtained from Lake Ontario, the St. Clair River, and sites near point sources.

The level of pentachlorobenzene in suspended sediments collected from various locations in southern Ontario and Quebec between 1980 and 1989, ranged from non-detectable to 600 ng/g (dry weight) [detection limits ranged from 0.02 to 5 ng/g, depending upon the analytical technique] (Fox *et al.*, 1983; Kuntz and Warry, 1983; Oliver and Charlton, 1984; Chan *et al.*, 1986; Charlton and Oliver, 1986; Oliver and Kaiser, 1986; Sylvestre, 1987; Merriman, 1987, 1988; Oliver and Niimi, 1988; Data Interpretation Group River Monitoring Committee, 1988, 1990; Oliver *et al.*, 1989; Kaiser *et al.*, 1990). Concentrations of pentachlorobenzene were highest in samples obtained in 1985 from the St. Clair River near a waste disposal site at a chemical plant and an effluent outfall from an industrial area of Sarnia (Oliver and Kaiser, 1986).

The concentration of pentachlorobenzene in samples of biota collected from various lakes and rivers in Canada between 1980 and 1991 ranged from less than 0.01 ng/g to 93 ng/g (wet weight) [Oliver and Nicol, 1982; Oliver and Niimi, 1983, 1988; Fox *et al.*, 1983; Jaffe and Hites, 1986; Oliver, 1987a; Niimi and Oliver, 1989; Metcalfe and Charlton, 1990; Muir *et al.*, 1992; Muir, 1993]. The concentration of pentachlorobenzene in aquatic invertebrates obtained from Lake Ontario near the mouth of the Niagara River ranged from 0.3 to 93 ng/g (wet weight) [Fox *et al.*, 1983; Oliver and Niimi, 1988]. The levels of pentachlorobenzene in macrophytes obtained from the St. Clair River in the industrial area of Sarnia were in the low ng/g range (OME, 1987). Levels in lichens from Ontario were less than 1 ng/g (wet weight) [Muir *et al.*, 1993].

The concentration of pentachlorobenzene in various species of upper trophic level fish obtained in 1980 from Lakes Superior, Huron, Erie, and Ontario ranged from 0.6 to 16 ng/g (wet weight); the highest levels were in fish obtained from Lake Ontario near the Niagara River (Oliver and Nicol, 1982). The concentrations of pentachlorobenzene in various species of lake-dwelling fish collected in northwestern Ontario during 1990 and 1991, were relatively low (< 1 ng/g wet weight) [Muir, 1993].

Between 1980 and 1990, levels of pentachlorobenzene in herring gull eggs (*Larus argentatus*) collected from the Niagara and Detroit Rivers have declined approximately 15-fold, to 1 ng/g (i.e., the limit of detection) [Bishop *et al.*, 1992]. Pentachlorobenzene is included by Environment Canada in the routine monitoring of chlorinated organic compounds in wildlife, but is rarely detected at concentrations above 2 ng/g, with the detection limit ranging from 0.1 to 2.0 ng/g (Environment Canada, 1992b). Concentrations above the detection limit are usually observed in samples obtained from known contaminated areas such as the Niagara River. Levels of pentachlorobenzene in samples of narwhal blubber collected between 1982 and 1983 from Pond Inlet, Northwest Territories, ranged from 6.9 to 36.6 ng/g (wet weight) [Muir, 1993].

Information on concentrations of pentachlorobenzene in Canadian food supplies is limited. Pentachlorobenzene was not detected (detection limit = 0.00001 μg/g) in a limited study of fresh food composites from Ontario (Davies, 1988). Composites analyzed included leafy vegetables, fruits, root vegetables (including potatoes), egg/meat and 2% cows' milk which were prepared from samples obtained in 4 retail grocery stores. Pentachlorobenzene was occasionally detected in individual foods (16 samples each of 14 types of foodstuffs) in the U.S. Food and Drug Administration total diet study conducted between April 1982 and April 1986 (Gunderson, 1987). Mean concentrations ranged from not detected (detection limit not stated) to 0.0045 ppm (μg/g). Concentrations were highest in peanut butter and dry roasted peanuts (maximum value, 0.0090 ppm or [μg/g]) with pentachlorobenzene being detected in all 16 samples of each of these foodstuffs.

Pentachlorobenzene has been detected in breast milk. The mean concentration of pentachlorobenzene in the breast milk of Canadian women taken 3 to 4 weeks after parturition was < 1 ng/g (trace) with a maximum value of 1 ng/g. In this survey, the compound was detected in 97% of the 210 samples analyzed (detection limit and sampling period unspecified) [Mes *et al.*, 1986]. In the breast milk of women of the Canadian indigenous population, there were "trace" (< 1 ng/g) amounts of pentachlorobenzene in 17% of the 18 samples analyzed (detection limit not specified) [Davies and Mes, 1987].

## 2.4 Effects-related Information

### 2.4.1 *Experimental Animals and* In Vitro

$LD_{50}$s for pentachlorobenzene (gavage in peanut oil) are 940 to 1 125 mg/kg bw in adult and weanling rats and 1 175 and 1 370 mg/kg bw in Swiss Webster mice (Linder *et al.*, 1980). Decreased activity and tremors were observed in both species at sublethal doses; the kidneys, liver and adrenal glands of rats were also enlarged. In some rats, the gastric mucosa was hyperaemic, and a slight reddish fluorescence of the gastrointestinal tract was observed in both rats and mice under ultraviolet light, suggesting porphyria.

Identified information on the toxicity of pentachlorobenzene following short-term administration is restricted to 2 studies in rats (Chu *et al.*, 1983; NTP, 1991) and 1 in mice (NTP, 1991). In all of these investigations, pentachlorobenzene was administered in the diet. In Sprague-Dawley rats, hepatic enzymes were induced and there were dose-dependent mild histopathological changes in the liver, accumulation of pentachlorobenzene in the fat and liver, and a significant increase in liver weight at the highest dose following administration in the diet of 5, 50 or 500 ppm (mg/kg) [0.59 to 59 mg/kg bw/day] for 28 days. In an NTP study, F344 rats were administered 100, 330, 1 000, 3 300 or 10 000 ppm (mg/kg) [9 to 304 mg/kg bw/day for concentrations up to 3 300 ppm]. In the highest exposure group, all rats died. There was also depletion of thymic lymphocytes, hyperkeratosis of the forestomach, and forestomach acanthosis in females. At 3 300 ppm (mg/kg) body weights were reduced. There were increases in liver weights at concentrations as low as 100 ppm (mg/kg) in males and centrilobular hepatocellular hypertrophy at higher concentrations (as low as 330 ppm [mg/kg] in males). Increases in relative kidney weights and abnormal hyaline droplet formation in the renal cortical epithelium were observed at all concentrations in male rats (NTP, 1991). In $B6C3F_1$ mice exposed to the same dietary concentrations (5.2 to 410 mg/kg bw/day), all animals in the 2 highest dose groups (3 300 and 10 000 ppm (mg/kg) died by day 10, having clinical signs of toxicity prior to death. There was a significant increase in liver weights in both sexes at 330 and 1 000 ppm (mg/kg) and mild to moderate depletion of thymic lymphocytes, due to lymphocyte necrosis, in moribund animals or those that died early (NTP, 1991).

Sub-chronic studies in which analyses of body weight gain, survival, clinical signs of toxicity, clinical chemistry, haematology and histopathology of major organs and tissues have been examined in animals exposed to pentachlorobenzene, are restricted to 2 investigations in rats (Linder *et al.*, 1980; NTP, 1991) and 1 in mice (NTP, 1991). In all of these bioassays, pentachlorobenzene was administered in the diet. In female

Sherman rats ingesting diets containing 500 ppm (mg/kg) and greater (> 37.5 mg/kg bw/day*) pentachlorobenzene for 100 days, there was an increase in liver weight and hypertrophy of hepatic cells (Linder *et al.*, 1980). There was also an increase in kidney weights and renal hyaline droplet formation in males at 125 ppm (mg/kg) and above (> 8.3 mg/kg bw/day*). In addition, at 1 000 ppm (mg/kg) [males 81.1 mg/kg bw/day; females 78.7 mg/kg bw/day*], there was the following: an increase in adrenal weight and focal areas of renal tubular atrophy and interstitial lymphocytic infiltration in males; an increase in kidney weight in females; a decrease in haemoglobin and an increase in white blood cells in both sexes; and decreases in red blood cells and haematocrit in males. The no-observed-effect-level (NOEL) in female rats, derived on the basis of the results of this study, was 250 ppm (mg/kg) [18.2 mg/kg bw/day*]; the lowest-observed-effect-level (LOEL) in males was 125 ppm (mg/kg) [8.3 mg/kg bw/day*].

In a study conducted by the U.S. National Toxicology Program (NTP), F344 rats and $B6C3F_1$ mice (10 each sex/group) were administered pentachlorobenzene in the diet at concentrations of 0, 33, 100, 330, 1 000 or 2 000 ppm (mg/kg) for 13 weeks (2.2 to 164 mg/kg bw/day in rats; 5.2 to 410 mg/kg bw/day in mice) [NTP, 1991]. There were decreases in the mean body weights of male rats at 1 000 ppm [mg/kg] or more, and in females at all concentrations (33 ppm [mg/kg] and above). Absolute and relative liver weights were increased in both sexes at concentrations as low as 33 ppm [mg/kg] in males. At higher concentrations (as low as 330 ppm [mg/kg] for males), there was centrilobular hepatocellular hypertrophy and accumulation of an unidentified yellow-brown pigment in the hepatocytes, possibly containing porphyrins. In males, there were increases in kidney weights and renal histopathological effects at concentrations as low as 100 ppm (mg/kg), while nephrotoxic effects were observed only at higher concentrations in females (increases in kidney weights and histopathological effects at 1 000 ppm [mg/kg] or greater). The spectrum of renal lesions observed in male rats was characteristic of "hyaline droplet nephropathy", while exacerbation of spontaneous nephropathy characterized by renal tubular cell regeneration and homogenous intratubular protein casts was observed in rats of both sexes. The concentration of protein in the urine was increased in male and female rats exposed to dietary concentrations of pentachlorobenzene of 1 000 ppm (mg/kg) and above; this effect was especially prominent in males. Minimal thyroid follicular cell hypertrophy was also observed in male and female rats exposed to 1 000 and 2 000 ppm (mg/kg) pentachlorobenzene. Free thyroxin and total thyroxin concentrations were significantly decreased in exposed male and female rats indicating moderate hypothyroxinemia. At concentrations of 330 ppm (mg/kg) and above in females and 1 000 ppm (mg/kg) and greater in males, there were effects on haematological parameters including decreases

* Average daily intake derived from Figure 1 in Linder *et al.*, 1980.

in haematocrit values, haemoglobin concentrations, erythrocyte count (males), mean corpuscular haemoglobin and mean erythrocyte volume, and mean corpuscular haemoglobin concentration. These observations were consistent with mild to moderate anaemia. The incidence of abnormal sperm in males was also increased at both dietary concentrations at which it was examined (330 and 2 000 ppm [mg/kg]). On the basis of histopathological lesions, the authors considered the NOELs to be 33 ppm (mg/kg) in male rats and 330 ppm (mg/kg) in females (approximately 2.4 and 24 mg/kg bw/day, respectively).

In mice, there were compound-related clinical signs in both sexes including ventral swelling and ruffled fur, at the highest dietary concentration of pentachlorobenzene (2 000 ppm [mg/kg]). Kidney weights were increased at the highest concentrations (330 ppm [mg/kg] and above in males) and functional effects on the thyroid (decreases in total thyroxin concentrations) were observed at all concentrations in both sexes (33 ppm [mg/kg] and above). Liver weights were increased at lower concentrations (as low as 100 ppm [mg/kg] in males). The only exposure-related histological lesion in mice of either sex was centrilobular hepatocellular hypertrophy and minimal necrosis, observed at all concentrations in males and at 330 ppm (mg/kg) [68 mg/kg bw/day] or greater in females. On the basis of the histopathological lesions, the authors considered the NOEL in female mice to be 100 ppm (mg/kg) [approximately 22 mg/kg bw/day]. No NOEL in males could be established (LOEL = 33 ppm [mg/kg] or approximately 5.2 mg/kg bw/day).

Data on the chronic toxicity or carcinogenicity of pentachlorobenzene were not identified.

The results of available studies concerning the embryotoxicity, foetotoxicity and teratogenicity of pentachlorobenzene include one study in rats (Villeneuve and Khera, 1975) and one in mice exposed by gavage in corn oil (Courtney *et al.*, 1977). Although the results of the investigation in rats indicated that pentachlorobenzene is foetotoxic (increased incidence of extra ribs and sternal defects) at doses (50 mg/kg bw/day) below those which induced toxic effects in the mothers (Villeneuve and Khera, 1975), there were no embryotoxic, foetotoxic or teratogenic effects in the offspring of mice at doses which were maternally toxic (50 mg/kg bw/day and above) [Courtney *et al.*, 1977].

In the only identified study on the reproductive toxicity of pentachlorobenzene, Linder *et al.* (1980) reported maternal toxicity (lowest-observed-adverse-effect-level [LOAEL] = 37.5 mg/kg/day*), tremors in suckling pups (LOAEL = 18.2 mg/kg/day), decreases in pre-weaning growth rates and increases in pup mortality in rats at the higher doses.

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* Average daily intake derived from Figure 1 in Linder *et al.*, 1980.

Based on limited available data, mutagenicity in *S. typhimurium* with and without metabolic activation, effects on chromosomes in Chinese Hamster ovary cells *in vitro*, and micronuclei in peripheral blood smears in animals from the NTP sub-chronic study, pentachlorobenzene has not been genotoxic (Haworth *et al.*, 1983; NTP, 1991).

### *2.4.2 Humans*

Case reports of adverse effects in individuals, or epidemiological studies of populations exposed to pentachlorobenzene have not been identified.

### *2.4.3 Ecotoxicology*

The acute and chronic toxicity of pentachlorobenzene has been studied in several aquatic species. However, data were not identified concerning the toxicity of this compound to any other biota including sediment- and soil-dwelling organisms, terrestrial invertebrates, aquatic vascular plants, birds or wild mammals. For the water flea (*Daphnia magna*), immobilization was the most sensitive acute endpoint identified, with a 48-hour $EC_{50}$ of 122 µg/L (Hermens *et al.*, 1984). Based on the results of a 16-day $EC_{50}$ test, the most sensitive indicator of toxic stress in *Daphnia magna* was a reduction in productivity after exposure to 25 µg/L pentachlorobenzene (Hermens *et al.*, 1984).

The most sensitive endpoint following the acute exposure of fish to pentachlorobenzene, was an 96-hour $LC_{50}$ of 135 µg/L for the guppy (*Poecilia reticulata*) [van Hoogen and Opperhuizen, 1988]. Larval growth was the most sensitive indicator of toxic stress during early life stage toxicity tests on fish. van Leeuwen *et al.* (1990) reported a 28-day no-observed-effect-concentration (NOEC) [for survival, hatching and growth] of 34 µg/L for *Brachydanio rerio*.

Only one study on the toxicity of pentachlorobenzene in plants was identified. Based on the results of a study in which *Lactuca sativa* was grown on soil contaminated with pentachlorobenzene, Hesse *et al.* (1991) reported a 14-day $EC_{50}$ and NOEC (for growth) of 280 and 50 µg/g (dry weight), respectively, when normalized to a soil organic matter content of 10%.

# 3.0 Assessment of "Toxic" under CEPA

## 3.1 CEPA 11(*a*): Environment

Pentachlorobenzene is not produced in Canada and currently there is no domestic commercial demand for this substance. On the basis of limited information, the 2 most significant sources of entry of this substance into the Canadian environment result from spillage of dielectric fluids and from long-range transport and deposition. Pentachlorobenzene has been detected in air, surface water, rain, sediment and biota within Canada. It is removed from air and surface water by degradation processes but can persist and accumulate under anaerobic conditions in buried sediments and soils.

The lowest reported chronic effect level identified for freshwater organisms was 25 µg/L for *Daphnia magna* (16-day $EC_{50}$ for reduced reproduction). Dividing this value by a factor of 10 to account for interspecies sensitivity, to extrapolate laboratory results to field conditions, and to convert the chronic lowest effect level to a chronic no effect level, results in an estimated effects threshold of 2.5 µg/L. The highest concentration of pentachlorobenzene in surface waters in Canada (i.e., 13 ng/L in a sample obtained from Lake Ontario near the mouth of the Niagara River in 1982), is approximately 200 times less than the calculated effects threshold. Based on more recent data, the concentration of pentachlorobenzene in surface waters in Canada is approximately 10 000 times less than the calculated effects threshold.

Benthic organisms are exposed to pentachlorobenzene in sediments from: the Canadian Great Lakes and their connecting channels; the St. Lawrence River; Hawk and Far Lake, Northwest Territories; and Abercrombie Point, the Economy River, and Truro in Nova Scotia. However, no toxicological data were identified that would permit estimation of an effects threshold for these biota to determine the significance of this exposure. Similarly, because of the lack of information on concentrations and effects in soils (including those at sites where dielectric fluids have been spilled), it is not possible to determine whether soil-dwelling organisms are adversely affected by exposure to the levels of pentachlorobenzene present in Canada.

The potential for adverse effects to wildlife resulting from exposure to pentachlorobenzene has been evaluated based on a worst-case scenario involving the multimedia exposure of mink (*Mustela vison*), a terrestrial mammal having a diet consisting in part of aquatic prey. A daily intake of 126 ng/kg bw/day was estimated for mink living in the area near the mouth of the Niagara River where the levels of pentachlorobenzene in Canadian waters were the highest (Table 2). The uptake of pentachlorobenzene from air and water is negligible compared to that from food. In the absence of toxicological studies on wildlife species, the effects threshold for mink was estimated on the basis of

results of a sub-chronic ingestion study in mice. In this study, the LOEL was considered to be 5.2 mg/kg bw/day (NTP, 1991). Dividing this value by a factor of 100 (10 to account for interspecies differences and to extrapolate from the laboratory to the field, and 10 to extrapolate a chronic NOAEL from a sub-chronic LOEL), the effects threshold for wild mammals was estimated to be 52 µg/kg bw/day. Since the estimated intake of pentachlorobenzene by mink is more than 400 times less that the estimated effects threshold, exposure to pentachlorobenzene should have no adverse effect upon mammalian wildlife.

**Table 2**
**Estimated Worst-case Total Daily Exposure of a Piscivorous Mammal Around the Niagara Region, Ontario**

| Exposure Route | Environmental Levels[a] | Daily Rate of Consumption (per kg bw)[b] | Daily Intake (ng/kg bw/day) |
|---|---|---|---|
| Air | 0.22 ng/m$^3$ | 0.55 m$^3$/d | 0.12 |
| Surface water | 0.24 ng/L | 0.1 L/d | 0.024 |
| Biota (Fish) | 0.81 ng/g | 155.0 g/d | 126 |
| Total | – | – | 126 |

a. The level in air is the maximum level measured in a rural environment (Walpole Island, Ontario) in 1988-1989 (Environment Canada, 1990); the level in surface water is the maximum level measured in water samples from Niagara-on-the-Lake, 1988-1989 (Data Interpretation Group River Monitoring Committee, 1990); the level in fish is that predicted based on a log BAF of 3.53 for bluegill sunfish and the maximum concentration in surface water of 0.24 ng/L.
b. Inhalation rate from Stahl (1967); drinking rate from Calder and Braun (1983) and ingestion rate from Nagy (1987), assuming a diet of 75% fish.

**On the basis of available data, the concentrations of pentachlorobenzene present in Canadian surface waters are not expected to cause adverse effects in aquatic biota or wildlife. However, toxicological data on the effects of pentachlorobenzene on sediment- and soil-dwelling biota were considered insufficient to determine the significance of concentrations of this compound in these media in Canada. Therefore, the available information is insufficient to conclude whether pentachlorobenzene is entering the environment in quantities or under conditions that may be harmful to the environment.**

## 3.2 CEPA 11(*b*): Environment on Which Human Health Depends

Although pentachlorobenzene is present as a gas in the troposphere and absorbs infrared radiation in wavelengths ranging from 7 to 13 μm, its low rate of release and relatively rapid removal from the atmosphere by photo-oxidation (half-life ranges from 45 to 467 days) and precipitation, result in low concentrations in the atmosphere (< 0.01 $\mu g/m^3$). As such, pentachlorobenzene is not expected to contribute significantly to global warming or depletion of stratospheric ozone.

**On the basis of available data, it has been concluded that pentachlorobenzene is not entering the environment in quantities or under conditions that may constitute a danger to the environment on which human life depends.**

## 3.2 CEPA 11(*c*): Human Life or Health

***Population Exposure***

On the basis of the available data, it is likely that the general population in Canada is exposed to pentachlorobenzene principally in food (Table 3). Owing to the limited data available on concentrations in food in Canada (i.e., a small study of a limited number of food composites in which pentachlorobenzene was not detected [Davies, 1988]), intake from this source was calculated on the basis of the more extensive total diet study conducted in the U.S. (Gunderson, 1987). The total daily intake of pentachlorobenzene for age groups older than 6 months, is estimated to range from 0.0005 μg/kg bw/day to 0.002 μg/kg bw/day. Based on the concentrations determined in breast milk, total intake for suckling infants aged 0 to 6 months is estimated to be up to several orders of magnitude greater, from 0.01 μg/kg bw/day to 0.1 μg/kg bw/day.

**Table 3**
**Estimated Daily Intake (µg/kg) of Pentachlorobenzene by the General Population in Canada**

| | Estimated Intake µg/kg bw/day | | | | |
|---|---|---|---|---|---|
| Medium* | 0–6 mois[a] | 7 mois–4 yr[b] | 5–11 yr[c] | 12–19 yr[d] | 20+ yr[e] |
| Ambient Air[f] | 0.00002–0.00003 | 0.00002–0.00004 | 0.00003–0.00005 | 0.00002–0.00004 | 0.00002–0.00004 |
| Drinking Water[g] | – | 0.000002–< 0.0001 | 0.000001–< 0.00007 | 0.0000009–< 0.00005 | 0.0000009–< 0.00004 |
| Breast Milk[h] | 0.01–0.1 | – | – | – | – |
| Food[i] | – | 0.0022 | 0.0022 | 0.0011 | 0.00046 |
| Total Intake | 0.01 to 0.1 | 0.002 | 0.002 | 0.001 | 0.0005 |

a. Assumed to weigh 7 kg, breathe 2 $m^3$ of air per day and drink 750 ml of breast milk (as food) per day (Environmental Health Directorate, 1992).
b. Assumed to weigh 13 kg, breathe 5 $m^3$ of air per day and drink 0.8 litres of water per day (Environmental Health Directorate, 1992).
c. Assumed to weigh 27 kg, breathe 12 $m^3$ of air per day and drink 0.9 litres of water per day (Environmental Health Directorate, 1992).
d. Assumed to weigh 57 kg, breathe 21 $m^3$ of air per day and drink 1.3 litres of water per day (Environmental Health Directorate, 1992).
e. Assumed to weigh 70 kg, breathe 23 $m^3$ of air per day and drink 1.5 litres of water per day (Environmental Health Directorate, 1992).
f. Based on a range of mean atmospheric concentrations of pentachlorobenzene of 0.00007 µg/$m^3$ to 0.00012 µg/$m^3$ measured at Walpole Island, Ontario, and Windsor, Ontario (Environment Canada, 1990), assuming that concentrations in indoor air are similar to those in ambient air (Environmental Health Directorate, 1992).
g. Based on a range of mean concentrations of pentachlorobenzene in Canadian drinking water of 0.00004 µg/L (Oliver and Nicol, 1982) to < 0.002 µg/L (Environment Canada, 1989a, 1989b, 1989c, 1989d).
h. Based on a range of mean concentrations of pentachlorobenzene detected in breast milk (0.1 to 1.0 ng/g) from a Canadian National Survey and in the Canadian indigenous population (Davies and Mes, 1987), and assuming the density of breast milk is equal to 1.0 g/ml.
i. Estimated daily intake from food based on the levels of pentachlorobenzene in cheese, peanut butter, peanuts, french fries, margarine, vegetable oil, and candy (Gunderson, 1987) and the estimated intake by various age groups of the population of Canada (Environmental Health Directorate, 1992).

*, Data were insufficient to estimate intake from soil.

### *Effects*

Available data on the toxicity of pentachlorobenzene are limited. Epidemiological studies of exposed populations are not available and information on chronic toxicity or carcinogenicity in experimental animals has not been identified. Pentachlorobenzene has not been genotoxic in a small number of *in vitro* and *in vivo* studies of a limited range of genetic endpoints. Pentachlorobenzene has been classified, therefore, in Group V (inadequate data for evaluation) of the classification scheme for carcinogenicity developed for use in the derivation of the *Guidelines for Canadian Drinking Water Quality* (Environmental Health Directorate, 1989).

With the exception of a one-generation study designed to investigate specifically reproductive and developmental effects (Linder *et al.*, 1980), the longest-term studies of the effects of pentachlorobenzene are sub-chronic investigations. In the sub-chronic studies in which pentachlorobenzene was administered in the diet (the principal route of exposure of the general population) to rats (Linder *et al.*, 1980) and to rats and mice (NTP, 1991), the lowest dietary concentration (and associated dose on a body weight basis) at which compound-related effects were observed was that to which male mice were exposed (33 ppm [mg/kg] in the diet; 5.2 mg/kg bw/day) in the NTP bioassay (NTP, 1991). At this concentration, there was minimal to moderate centrilobular hepatocellular hypertrophy and occasional necrosis of hypertrophied hepatocytes (considered to be secondary to the hypertrophy) [NTP, 1991]. On the basis of this LOEL, a tolerable daily intake (TDI) is conservatively (owing to the paucity of available data) derived as follows:

$$\text{TDI} = \frac{5.2 \text{ mg/kg bw/day}}{10\,000}$$

$$= 0.0005 \text{ mg/kg bw/day } (0.5 \text{ µg/kg bw/day})$$

where:

- 5.2 mg/kg bw/day is the lowest no-observed-(adverse)-effect level (NO[A]EL) or LO(A)EL in sub-chronic studies conducted to date.
- 10 000 is the uncertainty factor (× 10 for intraspecies variation; × 10 for interspecies variation; × 10 for less than chronic study; × 10 for lack of data on carcinogenicity and chronic toxicity; additional factor of 10 for LOEL rather than NOAEL not incorporated since observed effects at the LOEL were minimal).

In developmental and reproductive studies conducted to date, pentachlorobenzene has not induced adverse effects at concentrations below that upon which the TDI derived above is based (Villeneuve and Khera, 1975; Courtney *et al.*, 1977; Linder *et al.*, 1980).

The total daily intake of pentachlorobenzene for various age groups in the Canadian population is estimated to range from 0.0005 to 0.1 µg/kg bw/day. These estimated average daily intakes are from 5- to 1 000-fold less than the TDI derived above. It should be noted, though, that with the exception of breast-fed infants, whose intakes are elevated for only a short period of their lifespan, the estimated average daily intakes are 250 to 1 000 times less than the TDI.

**On the basis of available data, therefore, it has been concluded that pentachlorobenzene is not entering the environment in quantities or under conditions that may constitute a danger in Canada to human life or health.**

## 3.4 Conclusion

**Based upon available data, there is insufficient information to conclude whether pentachlorobenzene is entering the environment in quantities or under conditions that may be harmful to the environment. It has been concluded that pentachlorobenzene is not entering the environment in quantities or under conditions that may constitute a danger to the environment on which human life depends, or to human life or health.**

# 4.0 Recommendations

To enable an assessment of the environmental effects of pentachlorobenzene, it is recommended that the following additional data be acquired on a high priority basis:

(i) concentrations of pentachlorobenzene in soil and sediment, particularly near point sources;

(ii) toxicity tests (chronic and acute) with benthic organisms representative of those in the Canadian environment, to determine the effects of pentachlorobenzene associated with sediment.

In addition, to permit a more complete assessment of the exposure of the general population in Canada to pentachlorobenzene, additional monitoring data are desirable, particularly for food and breast milk. Investigations of the chronic toxicity and carcinogenicity of pentachlorobenzene in experimental animals are also required to permit a more complete assessment of its toxicity. However, the priority for these studies is considered to be low.

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