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ÉBAUCHE

CANADIAN ENVIRONMENTAL PROTECTION ACT

PRIORITY SUBSTANCES LIST

SUPPORTING DOCUMENT

DI-*n*-OCTYL PHTHALATE

Government of Canada
Environment Canada

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Unedited supporting documentation pertaining to environmental health aspects of di-n-octyl phthalate is available from Health Canada at the address cited above.

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1.0 IDENTITY OF SUBSTANCE

1.1 Name of Substance

Di-*n*-octyl phthalate, a phthalic acid ester, has the CAS (Chemical Abstracts Service) Registry Number 117-84-0, the molecular formula $C_{24}H_{38}O_4$, and a molecular weight of 390.6. Synonyms include: DnOP and 1,2-benzenedicarboxylic acid, dioctyl ester.

For simplicity, this report will use the term "DnOP" when referring to di-*n*-octyl phthalate. The structure of DnOP is shown in Figure 1.

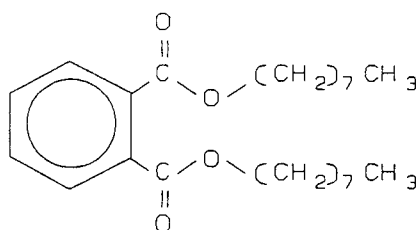


Figure 1. Structure of di-*n*-octyl phthalate.

1.2 Analytical Methodology

The most sensitive and selective analytical method for the determination of phthalic acid esters, including DnOP, in environmental media is gas chromatography with electron capture detection (Kohli et al., 1989). Thin layer chromatography may be used to separate phthalates from other solvent-extracted organic compounds. The U.S. Environmental Protection Agency has standardized the sample preparation and analysis for gas chromatography (GC) (method 606, detection limit 3.0 $\mu\text{g/L}$) and gas chromatography/mass spectrometry (GC/MS) (method 625, detection limit 2.5 $\mu\text{g/L}$) (U.S. EPA, 1982).

Two problems have plagued the chemical analysis and the reporting of concentrations of DnOP. The first problem, applicable to phthalic acid esters as a group, is that these chemicals frequently occur as plasticizers in analytical equipment and as contaminants in laboratory air and solvents. Di-*n*-octyl phthalate was specifically identified by Bauman et al. (1967) as a contaminant in lipid and soil samples collected in plastic-lined bags. Therefore, a great deal of care is needed to

prevent contamination during the collection, storage and analysis of environmental samples (Hites and Budde, 1991; Kohli et al., 1989; Mathur, 1974a; U.S. EPA, 1982). Many studies conducted prior to 1980 reporting environmental concentrations have not accounted for this problem (Pierce et al., 1980). Steps taken to avoid contamination are rarely described in the published reports and consequently the reliability of the data cannot be assessed. The second problem, specific to DnOP, is that the terminology is not consistent in the technical literature, where the substance is sometimes referred to as "dioctyl phthalate". This has led to confusion with the branched-chain isomer, bis(2-ethylhexyl) phthalate (DEHP), which is also sometimes referred to as "dioctyl phthalate" or "DOP". As a consequence, the occurrence of DnOP in the environment may have been overestimated, since reports of environmental concentrations of "dioctyl phthalate" could pertain to DEHP, which has been used in much higher quantities than DnOP.

2.0 PHYSICAL AND CHEMICAL PROPERTIES

Di-n-octyl phthalate is a clear, viscous liquid, with a reported vapour pressure of 0.02 Pa @ 25°C (Mabey et al., 1982) and a Henry's Law Constant of 1.7 Pa·m³/mol (Mabey et al., 1982). The range of octanol/water partition coefficient values reported in the literature, expressed as log K_{ow}, is between 4.96 and 9.9 (CMA, 1984; DeFoe et al., 1990; Mabey et al., 1982; Veith et al., 1984). Reported water solubilities ranged from 20 (DeFoe et al., 1990) to 3000 µg/L (Wolfe et al., 1980). The determination of the water solubility of phthalic acid esters is complicated since these compounds easily form colloidal dispersions in water (Klöpfer et al., 1982) and are subjected to the phenomenon referred to as "molecular folding" (Callahan et al., 1979). Additional chemical and physical properties of DnOP are presented in Table 1.

3.0 SOURCES AND RELEASES TO THE ENVIRONMENT

3.1 Production and Use

There are no Canadian producers of DnOP at the present time (Law, Sigurdson & Associates, 1993; SRI International, 1991). On the basis of confidential business information provided to Environment Canada, it is estimated that approximately one tonne of the substance is used annually in Canada (C. Fortin, personal communication, 1993). Di-n-octyl phthalate is not currently available on a commercial basis in North America and is made only on special order (Law, Sigurdson & Associates, 1993; Camford Information Services Inc., 1992). Available data are insufficient to estimate the amounts of DnOP imported in mixtures with other plasticizers or in finished plastic products.

Di-n-octyl phthalate is used as a plasticizer to impart flexibility to polymers, particularly polyvinyl chloride (PVC) used to make products such as gloves, flooring, flexible sheets, etc. (Law, Sigurdson & Associates, 1993).

3.2 Releases to the Environment

The occurrence of naturally-produced phthalates in biological and geochemical samples has been suggested, but in most cases the possibility of contamination during sampling or analysis could not be ruled out (Mathur, 1974a). However, it is unlikely that the amounts of phthalates produced naturally would be significant compared with those from anthropogenic sources (IPCS, 1992).

Worldwide, the release of phthalates directly to the atmosphere is believed to be the most important means of entry to the environment. The sources of such releases include emissions during the manufacturing and use of the substances and through the incomplete combustion of plastic material (IPCS, 1992). This is poorly quantified, however, and recent data on releases of phthalates in Canada have not been identified. Leah (1977) estimated that 2 to 4.5% of the total Canadian supply of phthalates is lost to the environment during production and processing, with about 95% of this loss resulting from processing. Peakall (1975) estimated that articles containing phthalate-plasticized material may lose about 1%/year of their phthalate content when in contact with liquids and 0.1%/year when in contact with air.

Recent information specifically related to the release of DnOP to the Canadian environment is limited to that reported by the Ontario Ministry of the Environment under the Municipal/Industrial Strategy for Abatement (MISA) program. Between February 1990 and January 1991, the mean concentration of DnOP in effluents being discharged into Lake Ontario from one organic chemical plant located in Whitby, Ontario, was 2.3 $\mu\text{g/L}$ (loading value of 0.001 kg/day) (OME, 1992). In the early 1980's, DnOP was detected at concentrations within the range of 1 to 10 $\mu\text{g/L}$ in effluents from Canadian chemical plants discharging into the St. Lawrence River at Cornwall, Ontario, and into the St. Clair River at Sarnia, Ontario, (CCREM, 1987; Munro et al., 1985).

A large amount of phthalic acid esters is often volatilized to the air in processing plants, condenses, and is washed into municipal wastewater systems or is released in effluents from plant mist eliminators (Zenon, 1982). Phthalates also enter municipal wastewater systems from contaminated cooling water from processing plants, from domestic use or disposal of products containing these esters, and from the release of scrubber wastewater from incinerators. Di-n-octyl phthalate was detected

in 9 of 15 Canadian municipal sludges sampled between 1980 and 1985, with concentrations ranging up to 115 mg/kg (dw) and a median concentration of 7 mg/kg (Webber and Lesage, 1989).

"Di-octyl phthalate" was detected, but not quantified, in extracts of municipal incinerator fly ash from Ontario, the Netherlands, and Japan (Eiceman et al., 1979). It was unclear whether this referred to DnOP or DEHP.

"Di-octyl phthalate" was reported at a concentration of 15 µg/L in the effluent of a kraft pulp and paper mill at Red Rock, Ontario, on Lake Superior (Brownlee and Strachan, 1977). The analytical method used in this study could not distinguish between DnOP and DEHP.

4.0 ENVIRONMENTAL FATE AND CONCENTRATIONS

4.1 Environmental Fate

The processes affecting the distribution and transformation of DnOP in the environment include atmospheric photooxidation, partitioning to soil, sediment and biota, and aerobic degradation (Callahan et al., 1979; Howard et al., 1991; Kohli et al., 1989; Pierce et al., 1980; Sanborn, 1975).

Howard et al. (1991), on the basis of scientific judgement, estimated a photooxidation half-life of DnOP in the atmosphere of less than 1.9 days.

Callahan et al (1979) reviewed the fate of DnOP in water and, by analogy with other phthalic acid esters, concluded that sorption onto particulate matter and biota was probably an important transport mechanism for the substance. The Niagara River Data Interpretation Group (1990) found that 38% of the DnOP loading at Fort Erie was in the water fraction and 62% in the suspended solids fraction. At Niagara-on-the-Lake the situation was reversed, with 65% of the DnOP in the water fraction and 35% in the solids fraction.

Di-*n*-octyl phthalate has been considered to be one of the less biodegradable phthalates (Mathur, 1974b), however a number of studies have shown that the substance can be biodegraded quite readily under aerobic conditions. Primary degradation amounted to 59.8% in 24 hours in the Semi-Continuous Activated Sludge (SCAS) test, while ultimate biodegradation to CO₂ amounted to 90.3% (half-life 5.3 days) in the Shake Flask test (CMA, 1984). Sanborn et al. (1975) found DnOP to be degraded and metabolized by a variety of aquatic organisms in a model ecosystem, with a degradation half-life of 5 days in the water column. Identified transformation products in this study included mono-*n*-octyl

phthalate and phthalic acid. Howard et al. (1991), on the basis of scientific judgement, estimated aerobic biodegradation half-lives for DnOP in soil and surface water to be 1 to 4 weeks. ✓

Di-n-octyl phthalate, like many other dialkyl phthalates, may form water soluble complexes with fulvic acids, found commonly in fresh water and soils. This may increase its mobilization and reactivity in soil and its solubility in water (Kohli et al., 1989). ✓

Bioconcentration factors for aquatic organisms are not available. In a laboratory model ecosystem with an exposure period of 33 days, algae accumulated the highest DnOP concentrations (1.8 mg/kg), *Daphnia* the least (0.16 mg/kg), while fish (0.59 mg/kg), snail (0.85 mg/kg) and mosquito larvae (0.59 mg/kg) accumulated intermediate concentrations of DnOP (Sanborn et al., 1975). Reliable bioconcentration factors could not be derived because the concentration of DnOP in the water continued to decrease throughout the study.

4.2 Environmental Concentrations

Concentrations of DnOP in various environmental compartments are given in Tables 2a and 2b. Very limited information is available concerning concentrations of DnOP in Canadian surface waters and sediments, and no reliable data on air, precipitation, soil or biota were identified.

Only a few recent studies were found reporting concentrations of DnOP in surface waters in Canada. Di-n-octyl phthalate was detected in one of 45 samples of raw surface water collected from Alberta between 1987 and 1992, at a concentration of 4 µg/L (detection limit, 1 µg/L) (Halina, 1993a). The Niagara River Data Interpretation Group (1990), using large-volume sampling techniques designed to lower the detection limit (0.15 ng/L), reported that the mean concentrations of DnOP in water samples collected from the Niagara River during 1988 and 1989 at Fort Erie and Niagara-on-the-Lake were 2.9 and 5.2 ng/L, respectively. Di-n-octyl phthalate was detected in 50 of 51 water samples from Fort Erie and in 38 of 44 water samples from Niagara-on-the-Lake. Germain and Langlois (1988), also using large-volume sampling methods (detection limit, 0.04 ng DnOP/L), reported a mean concentration for DnOP of 9 ng/L in the St. Lawrence River in the Montreal region in 1987. Di-n-octyl phthalate was not detected in 22 samples of raw drinking water supplies collected in 1992 from 11 municipalities in the Lac St-Jean and Charlevoix areas of Quebec (detection limit, 1.0 µg/L) (MENVIQ, 1993). ✓

Information contained in the NAQUADAT/ENVIRODAT database on concentrations of DnOP in surface waters are limited to approximately 80 records from Alberta and two records from

British Columbia dating from 1985 to 1988, with concentrations ranging from <1 to 7 $\mu\text{g/L}$ (NAQUADAT, 1993). Di-*n*-octyl phthalate concentrations between 1 and 10 $\mu\text{g/L}$ (actual values not specified) were reported in 4 of 24 samples of intake water for industrial chemical plants located on the St. Clair River in 1979-80 (Munro et al., 1985). ✓

In each of these sampling programmes cited above, the mean DnOP concentration was less than 1 $\mu\text{g/L}$. ✓

Brownlee and Strachan (1977) reported "dioctyl phthalate" at concentrations ranging from 0.1 to 55 $\mu\text{g/L}$ in Lake Superior near a kraft pulp and paper mill at Red Rock, Ontario, on Lake Superior. A concentration of 0.7 mg/kg dry weight was detected in the lake sediments, while only trace amounts were detected in suspended particles in the water column. The analytical method used in this study could not distinguish between DnOP and DEHP.

No data have been found pertaining to DnOP concentrations in Canadian ground water. Di-*n*-octyl phthalate concentrations in Alberta drinking water derived from ground water ranged from <1.0 to 1.8 $\mu\text{g/L}$ (average <1 $\mu\text{g/L}$) in 1985 and 1986 (Spink, 1986) and were less than 1.0 $\mu\text{g/L}$ from 1987 to 1992 (Halina, 1993b). ✓

Rogers and Hall (1987) reported DnOP concentrations of 94 $\mu\text{g/kg}$ and <15 $\mu\text{g/kg}$ dry weight in sediments 0.5 km and 1 km, respectively, downstream from a sewage outfall in the Fraser River estuary. Fallon and Horvath (1985) reported concentrations ranging from 90 to 260 $\mu\text{g DnOP/kg}$ in 3 sediment samples collected in 1982 from the south end of Grosse Ile in the Detroit River. The concentration of DnOP in St. Clair River sediments near Sarnia, Ontario, was reported to be 15 mg/kg (Environment Canada/OME, 1986).

In a study conducted under the Great Lakes Fish Monitoring Program, DnOP was scanned by GC/MS but not detected (detection limits were not estimated) in samples ($n = 1$ to 15) of fish from the Great Lakes (DeVault, 1985). In a study conducted by the Province of British Columbia (Swain and Walton, 1989), values of DnOP in muscle tissue in fish from the estuary area of the Fraser River were generally low. Concentrations were detected (detection limit = 0.01 $\mu\text{g/g}$) in only two of ten samples of muscle tissues (0.081 and 0.11 $\mu\text{g/g}$ wet-weight) analyzed by capillary gas chromatography with electron capture detection. These values, however, were not considered to be reliable by the authors due to possible sources of contamination in sampling and analysis. ✓

5.0 KINETICS AND METABOLISM

Stalling et al. (1973) reported that phthalate esters (DEHP and DBP) were metabolized in fish by enzymatic hydrolysis to monophthalates and other metabolites. Mathur and Rouatt (1975) tentatively identified ortho-phthalic acid as the major degradation product of DnOP produced by the bacterium *Serratia marcescens*. Sanborn et al. (1975) found that DnOP was metabolized quite quickly in model ecosystems. About one-half of the original concentration of DnOP in the water disappeared within five days. Mono-*n*-octyl phthalate (MnOP), phthalic acid, and several other unidentified metabolites, including a polar substance, were detected in *Physa* sp. snails, mosquito larvae (*Culex pipiens quinquefasciatus*), *Daphnia*, and mosquito fish (*Gambusia affinis*) after a three-day exposure to DnOP. The formation of MnOP by the mosquito larvae and by the salt marsh caterpillar larvae, *Estigmene acrea*, appeared to require both a mixed-function oxidase and an esterase. The metabolic pathway of DnOP with mosquito fish liver microsomes was non-oxidative ester cleavage.

6.0 EFFECTS ON THE ECOSYSTEM

The results of a number of toxicity studies are presented in Tables 3a (acute toxicity) and 3b (chronic toxicity). The results of studies indicating the most toxic effects of phthalate esters in various groups of organisms are summarized in the following sections. In many studies no adverse effects were found, even at the highest concentrations of DnOP tested. In other studies, adverse effects on aquatic organisms were found only at nominal concentrations in the upper portion of the range of water solubility reported for the substance.

6.1 Microorganisms

No information pertaining to adverse effects of DnOP on microorganisms was found in the literature.

6.2 Algae

No information pertaining to adverse effects of DnOP to algae was found in the literature.

6.3 Invertebrates

Tetra Tech Inc. (1986) studied effects of variations in Puget Sound sediment quality on benthic invertebrates. This study used several approaches to evaluate sediment toxicity, including the Apparent Effects Threshold. This approach involves comparison of data on the composition of sediments collected in contaminated areas to measures of biological effects associated

with these sediments. AETs were developed for three aquatic invertebrate effects indicators: amphipod (*Rhepoxynius abronius*) mortality, oyster (*Crassostrea gigas*) larvae abnormality, and depressions in total abundance of higher level (Polychaeta, Mollusca, Crustacea) benthic infauna. Estimated AET values for these indicators were >590 µg DnOP/kg for the amphipod, >420 µg DnOP/kg for the oyster, and >68,000 µg DnOP/kg for the higher level benthic fauna. Subsequent re-evaluation of the Tetra Tech data by Barrick et al. (1988) resulted in a lowering of the benthic infaunal community AET to >6,200 µg DnOP/kg and a raising of the amphipod AET to >2,100 µg DnOP/kg. As noted by U.S. EPA (1989), the AET approach is not recommended for the development of broadly applicable sediment quality criteria because of its site-specific nature and its inability to describe cause-and-effect relationships. ✓

Using equilibrium partitioning modelling, Tetra Tech Inc. (1986) calculated a sediment quality value of 130,000 mg DnOP/kg (dry weight) for sediment containing 1% organic carbon. Although use of equilibrium partitioning is becoming increasingly common in sediment quality assessment (Di Toro et al., 1991), this method assumes that nonionic organic chemicals such as DnOP are associated with sediment organic carbon and that partitioning of these chemicals between organic carbon and sediment pore water is at equilibrium (Chapman, 1989). Furthermore, the method has undergone only preliminary field validation (Chapman, 1989; Adams et al., 1992), and thus its use in a regulatory context is controversial.

The Phthalate Esters Program Panel of the Chemicals Manufacturing Association (CMA) generated data on the toxicity of 14 phthalic acid esters, including a mixture of di(*n*-hexyl, *n*-octyl and *n*-decyl) phthalate, to aquatic invertebrates (CMA, 1984). The results indicated that for the compounds with lateral chains of 6 carbons or more, no toxic effects were noted up to the water solubility. In the case of the mixture of di(*n*-hexyl, *n*-octyl and *n*-decyl) phthalate, the CMA reported a chronic MATC (Maximum Acceptable Toxicant Concentration) greater than 150 µg/L for *Daphnia magna*.

A 16-day lowest-observed-effect-level (LOEL) of 1,000 µg DnOP/L, based on a 75% reduction in the number of young produced per adult, was reported for *Daphnia magna* by McCarthy and Whitmore (1985). The reported no-observed-effect-level (NOEL) was 320 µg/L. The lowest DnOP concentration having a statistically significant effect on survival of adults in this study was 3,200 µg/L. ✓

Phthalates were found to be the least toxic of the chemical groups tested on the earthworm *Eisenia fetida* (Neuhauser et al., 1985, 1986). The LC50 value for DnOP was 3140 µg/cm² in a 2-day

contact test in which the chemical was applied to filter paper, with the toxic units referring to the amount of chemical per cm² of paper. Dimethyl phthalate was the most toxic phthalate tested, with a LC50 of 550 µg/m². By comparison, the most toxic of the 44 chemicals tested, 2,4-dinitrophenol, had a LC50 of 0.6 µg/m².

Di-n-octyl phthalate applied to female house flies topically or by injection at a concentration of 20 µg/fly (1000 µg/g) was not toxic, causing a mortality of less than 16% after 24 hours (Al-Badry and Knowles, 1980).

6.4 Fish

A 20-day LOEL of 10,000 µg DnOP/L has been reported for the fathead minnow, *Pimephales promelas*, based on a 75% reduction of the hatching rate (McCarthy and Whitmore, 1985).

6.5 Amphibians and Reptiles

No information pertaining to adverse effects of DnOP to amphibians or reptiles was found in the literature.

6.6 Plants

"Dioctyl phthalate" (isomer not specified) at concentrations of 0.1 and 1.0 mg/L did not inhibit *Impatiens sultanii* pollen germination or pollen tube growth (Bilderback, 1981).

6.7 Birds

There is very little avian toxicological information available for DnOP. Korhonen et al. (1983) studied the embryo toxicity of "dioctyl phthalate" (authors did not specify whether DnOP or DEHP) to white leghorn chicken eggs. On the third day of incubation, 5 µL of DOP in acetone were injected onto the inner shell membrane. Dioctyl phthalate did not have an embryotoxic effect over the acetone control at the highest dose tested (20 µmol or 7.8 mg). As DOP is a large, hydrophobic molecule, this lack of embryotoxicity is probably due to transport effects from its inability to penetrate the albumin-water layer and the vitelline membrane.

6.8 Mammals

No data were identified on the toxicity of DnOP to mammalian wildlife.

Environment Canada concluded that there were insufficient aquatic toxicity data available to derive a water quality guideline for the protection of freshwater or marine aquatic life (Environment Canada, 1992). The International Joint Commission and the governments of Manitoba and Ontario do not address DnOP specifically, but they have published water quality guidelines/objectives of 0.2 $\mu\text{g/L}$ for phthalates other than DEHP and DBP to protect aquatic life (Environment Canada, 1992).

The United States Environmental Protection Agency recently deleted DnOP from the list of toxic chemicals under section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 (U.S. EPA, 1993). The action was taken because the U.S. EPA did not believe that DnOP met the toxicity criteria for listing chemicals under the act. This means that DnOP is no longer included on the U.S. Toxic Release Inventory.

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Table 1. Chemical and physical properties of DnOP.

CAS Name:	1,2-Benzenedicarboxylic acid, dioctyl ester
CAS No.:	117-84-0
Synonyms:	DOP; phthalic acid, dioctyl ester; di-n-octyl phthalate
Empirical Formula:	$C_{24}H_{38}O_4$
Molecular Weight:	390.6
Appearance and Odour:	Clear, viscous liquid with a slight odour ⁽²⁾
Specific Gravity:	0.978 @ 20/4 C ⁽¹⁾
Melting Point:	-25 C ⁽¹⁾
Boiling Point:	220 C @ 101,300 Pa ⁽¹⁾
Henry's Law Constant:	1.53 X 10 ⁻⁷ Pa·m ³ /mol @ 25 C (calculated) ⁽²⁾ 1.7 Pa·m ³ /mol ⁽⁴⁾
Vapour Density:	13.52 (air = 1) @ 25 C ⁽²⁾
Vapour Pressure:	0.02 Pa @ 25 C ⁽⁴⁾ 0.0007 Pa @ 25 C ⁽⁷⁾
Water Solubility:	3.0 mg/L @ 25 C ⁽⁹⁾ (fresh water) 0.02 mg/L ⁽³⁾ 0.9 mg/L @ 25 C ⁽⁷⁾ (salt water) 0.001 mg/L @ 12 C ⁽⁵⁾
Solvent Solubility:	
Log K _{oc} :	8.99 ⁽²⁾ 9.56 ⁽⁴⁾
Log K _{ow} :	4.96 (calculated) ⁽⁷⁾ 7.06 ⁽⁸⁾ 8.06 (estimated) ⁽⁶⁾ 8.92 ⁽³⁾ 9.9 ⁽⁴⁾

⁽¹⁾ Data cited in Pierce et al. 1980.

⁽²⁾ Montgomery and Welkom 1990.

⁽³⁾ DeFoe et al. 1990.

⁽⁴⁾ Mabey et al. 1982.

⁽⁵⁾ Boese 1984.

⁽⁶⁾ McDuffie 1981.

⁽⁷⁾ CMA 1984, pertains to a mixture of di-n-hexyl-, di-n-octyl- and di-n-decyl phthalate.

⁽⁸⁾ Veith et al. 1984.

⁽⁹⁾ Wolfe et al. 1980.

Table 2a. Concentrations of DnOP in air, water, sediment, soil and biota in the Canadian and Great Lakes environment.

<u>Media</u>	<u>Concentration</u> mean (max. or range)	<u>Location</u>	<u>Reference</u>
Waste streams	(12-mo. ave. 2.3 µg/L)	Ontario organic chemical manufacturing plants	OME 1992
" "	(within 1-10 µg/L)	Effluents, St. Clair R. petrochemical plants	Munro et al. 1985
Sewage sludge	(0.7-15.0 mg/kg dw)	Winnipeg, Manitoba	Webber and Lesage 1989
" "	(trace-63.0 mg/kg dw)	Hamilton, Ont.	Webber and Lesage 1989
" "	7.0 mg/kg dw (median)	Other Canadian cities	Webber and Lesage 1989
" "	(trace-115.0 mg/kg dw)	" " "	Webber and Lesage 1989
Drinking water	<1.0 µg/L (<1.0-28 µg/L)	Alberta, Canada, drinking water derived from surface water	Spink 1986
" "	<1.0 µg/L (<1.0-11 µg/L)	Alberta, Canada, drinking water derived from surface water	Halina 1993b
" "	<1.0 µg/L (<1.0-1.8 µg/L)	Alberta, Canada, drinking water derived from ground water	Spink 1986
" "	(<1.0 µg/L)	Alberta, Canada, drinking water derived from ground water	Halina 1993b

Surface water	(within 1-10 $\mu\text{g/L}$)	St. Clair R.	Munro et al. 1985
"	(<1-7 $\mu\text{g/L}$)	Alberta, Canada	NAQUADAT 1993
"	<1.0 $\mu\text{g/L}$ (<1.0-4.0 $\mu\text{g/L}$)	Alberta, Canada	Halina 1993a
"	0.002879 $\mu\text{g/L}$ (water fraction)	Niagara R. at Fort Erie	Niagara River Data Interpretation Group 1990
"	0.004727 $\mu\text{g/L}$ (suspended solids fraction)	Niagara R. at Fort Erie	Niagara River Data Interpretation Group 1990
"	0.005197 $\mu\text{g/L}$ (Water fraction)	Niagara R. at Niagara-on-the-Lake	Niagara River Data Interpretation Group 1990
"	0.002768 $\mu\text{g/L}$ (water solids fraction)	Niagara R. at Niagara-on-the-Lake	Niagara River Data Interpretation Group 1990
"	0.009 $\mu\text{g/L}$ (water + suspended solids)	St. Lawrence R.	Germain and Langlois 1988
"	0.009 $\mu\text{g/L}$ (water fraction)	St. Lawrence R.	Germain and Langlois 1988
"	0.200 mg/kg (suspended solids fraction)	St. Lawrence R.	Germain and Langlois 1988
"	(<1 $\mu\text{g/L}$)	Raw water supplies from Quebec rural areas	MENVIQ 1993
"	(0.1-2.0 $\mu\text{g/L}$) ⁽¹⁾	L. Superior	Brownlee and Strachan 1977
"	(55 $\mu\text{g/L}$) ⁽¹⁾	L. Superior, edge of pulp & paper mill effluent plume	Brownlee and Strachan 1977

Sediment	(<0.1-0.26 mg/kg dw)	Detroit R.	Fallon and Horvath 1985
"	(0.7 mg/kg dw)	L. Superior	Brownlee and Strachan 1977
"	(15 mg/kg)	St. Clair R.	Environment Canada/OME 1986
Marine sediment	(0.094 mg/kg dw)	Fraser Estuary, B.C. (0.5 km below sewage outfall)	Rogers and Hall 1987

⁽¹⁾ Referred to as "dioctyl phthalate", isomer not stated.

Table 2b. Concentrations of DnOP in air, water, sediment, soil and biota in the non-Canadian, non-Great Lakes environment.

<u>Media</u>	<u>Concentration</u> mean (max. or range)	<u>Location</u>	<u>Reference</u>
Urban runoff	(<1.0-<2.0 µg/L)	Pima Co., Arizona	Wilson et al. 1990
Dry-well sediment	(0.3-4.2 mg/kg)	Pima Co., Arizona	Wilson et al. 1990
Sewage sludge	(<1.0-2,610 mg/kg dw)	Non-Canadian sludges	Webber and Lesage 1989
Phthalate ester plant discharge pond water	1.0 µg/L	Maryland, U.S.A.	Peterson and Freeman 1984
Phthalate ester plant discharge pond sediment	12.0 mg/kg	Chester R. system, Maryland, U.S.A.	Peterson and Freeman 1984
Sediment	(<0.005-0.062 ⁽¹⁾ mg/kg)	Chester R. system, Maryland, U.S.A.	Peterson and Freeman 1984
Marine sediment	(0.042-0.388 mg/kg dw)	Los Angeles, California	Swartz et al. 1985
Ground water	<10 µg/L	Pima Co., Arizona	Wilson et al. 1990

⁽¹⁾ Site located approximately 3 km below phthalate ester plant discharge pond.

Table 3a. Summary of acute toxicity values for DnOP.

Species	Study Type	End Point	Value	Reference
<u>Algae/Plants</u>				
Algae	Acute, static	96h EC50	>100 µg/L*	CMA 1984
<u>Invertebrates</u>				
<i>Daphnia magna</i>	Acute, static	48h LC50	>10,000 µg/L	McCarthy and Whitmore 1985
" "	Acute, static	48h EC50	>420 µg/L*	CMA 1984
Mysid shrimp	Acute, static	48h EC50	>520 µg/L*	CMA 1984
Midge	Acute, static	48h EC50	>240 µg/L*	CMA 1984
<u>Fish</u>				
Fathead minnow (<i>Pimephales promelas</i>)	Acute, flow-through	96h LC50	>45 µg/L	DeFoe et al. 1990
" "	Acute, static	96h LC50	>32,000 µg/L	McCarthy and Whitmore 1985
" "	Acute, static	96h LC50	>190 µg/L*	CMA 1984
" "	Acute, flow-through	96h LOEL (embryo survival)	>10,000 µg/L	McCarthy and Whitmore 1985
" "	Acute, flow-through	96h LC50	>250 µg/L*	CMA 1984
Bluegill (<i>Lepomis macrochirus</i>)	Acute, static	96h LC50	>180 µg/L	CMA 1984
Rainbow trout (<i>Oncorhynchus mykiss</i>)	Acute, flow-through	96h LC50	>240 µg/L*	CMA 1984

Sheepshead minnow Acute, flow-through 96h LC50 >370 µg/L* CMA 1984
(*Cyprinodon*
variegatus)

* Pertains to a mixture of di-*n*-hexyl-, di-*n*-octyl-, and di-*n*-decyl phthalate

Table 3b. Summary of chronic toxicity values for DnOP.

Species	Study Type	End Point	Value	Reference
<u>Invertebrates</u>				
Oyster	AET, Puget Sound	(increased abnormalities)	>420 µg/kg dw sediment	Tetra Tech Inc. 1986
<i>Crassostrea gigas</i>	Chronic	NOEL	100 µg/L*	CMA 1984
<i>Daphnia magna</i>	Chronic	LOEL	230 µg/L*	CMA 1984
" "	Chronic, static renewal	16d LOEL (survival)	3,200 µg/L	McCarthy and Whitmore 1985
" "	Chronic, static renewal	16d NOEL (survival)	1,000 µg/L	McCarthy and Whitmore 1985
" "	Chronic, static renewal	16d LOEL (reproduction)	1,000 µg/L	McCarthy and Whitmore 1985
" "	Chronic, static renewal	16d NOEL (reproduction)	320 µg/L	McCarthy and Whitmore 1985
" "	Chronic, static renewal	21d MATC (survival)	150 µg/L*	Springborn Bionomics 1984
Amphipod	AET, Puget Sound	(increased mortality)	>590 µg/kg dw sediment	Tetra Tech Inc. 1986
<i>Rhepoxynius abronius</i>	AET, Puget Sound	(increased mortality)	>2,100 µg/kg dw sediment	Barrick et al. 1988
<i>Rhepoxynius abronius</i>				
<u>Fish</u>				
Fathead minnow	Chronic, flow-through	20d LOEL (larval survival)	>10,000 µg/L	McCarthy and Whitmore 1985
(<i>Pimephales promelas</i>)	Chronic, flow-through	20d LOEL (hatching rate)	10,000 µg/L	McCarthy and Whitmore 1985
" "	Chronic, flow-through	20d NOEL (hatching rate)	3,200 µg/L	McCarthy and Whitmore 1985

* Pertains to a mixture of di-n-hexyl-, di-n-octyl-, and di-n-decyl phthalate