SUMMARY REPORT

CHEMICALS IN THE ENVIRONMENT

POLYCHLORINATED BIPHENYLS

Environnement Canada

Service de la protection de l'environnement

Canada

PACIFIC & YUKON REGION

DEPARTMENT OF THE ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC AND YUKON REGION

CHEMICALS IN THE ENVIRONMENT
PACIFIC AND YUKON REGION

III. POLYCHLORINATED BIPHENYLS (PCBs)

By

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February, 1985

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1. INTRODUCTION

This report is one in a series entitled "Chemicals in the Environment - Pacific and Yukon Region" prepared by the Environmental Protection Service. The objective of these reports is to provide the technical guidance necessary for: a) the interpretation of environmental quality data on specific chemicals, and b) the assessment of potential impacts resulting from the release of these chemicals into the environment.

The series will focus on both naturally occurring and man-made compounds whose release to the environment is of concern due to their persistence, toxicity and/or bioaccumulative abilities.

These reports discuss highlights of existing environmental quality data for B.C. and Yukon and provide information on environmental dynamics, potential impacts on the environment, and pertinent legislation and guidelines controlling both releases to the receiving environment and environmental quality.

This report is adapted from Garrett, C.L., "An Overview of PCBs and their Current Status in British Columbia", Environmental Protection Service, Pacific and Yukon Region, Regional Program Report 80-16 (1983). For additional information refer to this document.

2. USES AND SOURCES OF RELEASE

PCBs are a class of synthetic chlorinated hydrocarbons whose commercial formulations in North America are referred to by the trade name Aroclor. In the past PCBs were used extensively in such products as plastics, inks, carbonless copypaper, paints, pesticides, investment casting waxes and as dielectric, hydraulic, high temperature lubricating and heat transfer fluids. Due to increasing awareness of their environmental hazards, the manufacture of PCBs in North America was terminated in the early 1970's and the allowable uses have been severely restricted.

The greatest volume of PCB in use in British Columbia is in electrical equipment. Current PCB losses associated with electrical equipment may occur as a result of malfunctioning or damage; spillage during routine servicing; or as a result of improper disposal.

Very little information is available on PCB releases from industrial facilities in British Columbia. In 1977, sampling was conducted at specific B.C. oil refineries, mines, smelters, chemical manufacturing plants, pulp mills and a coal bulk loading facility. PCBs were not detectable in most discharges.

Sewage treatment plants have been identified as significant contributors of PCBs to the environment (1, 2, 3, 4). A survey of sewage treatment plants in British Columbia in 1976 revealed low PCB levels in discharges from all plants, with the highest levels occurring at plants which receive large amounts of industrial wastes (5). PCB concentrations in B.C. sewage treatment plant effluents were low in comparison to plants from more heavily industrialized areas of North America.

3. ENVIRONMENTAL DYNAMICS

Upon entering the environment, PCBs accumulate in various media at concentrations which are influenced by a variety of factors. Partitioning of PCBs between surface waters and bottom sediments depends upon such variables as salinity, amount of suspended matter, particle size, organic content and sediment characteristics.

PCBs have very low solubilities and receiving water concentrations are often below or near detection levels even in highly contaminated areas.

High levels of PCBs occasionally detected in surface waters are associated primarily with suspended solids. The transport of this material by tidal action and water currents can result in the spread of contamination to areas removed from the point of PCB entry. It is reported that suspended sediments contained PCBs at concentrations 4 to 10 times higher than did bottom sediments (6). This observation is probably associated with the fact that suspended sediments generally have a much smaller grain size than do bottom sediments.

Much of the particulate matter does eventually settle out of the water column and is deposited in the bottom sediments. Sediments in highly industrialized areas serve as a reservoir for PCBs. For this reason PCBs present a long term environmental hazard. Upon release to the environment PCBs can persist for many years or even decades (7).

The analysis of environmental samples shows a preponderance of isomers with five or more chlorine atoms (8). This is probably due, at least in part, to the greater resistance of the higher chlorinated biphenyls to bacterial degradation.

When not in contact with particulate matter or bottom sediments, chlorinated hydrocarbons (including PCBs) tend to concentrate at the air-water interface (9, 10, 11) and volatilization to the atmosphere may occur.

4. ENVIRONMENTAL LEVELS

4.1 Aquatic Systems

4.1.1 Water.

General

Due to the low solubilities of PCBs in water, seriously elevated concentrations in surface waters are rarely reported. PCBs preferentially adhere to particulate matter in the water column and the actual concentrations of dissolved PCB in aquatic systems are normally far below estimated saturation levels.

The solubilities of the individual PCB isomers vary with the position of the chlorine atoms and decrease with increasing chlorination. For this reason the lower chlorinated isomers are present in higher concentrations in the water column than are the higher chlorinated isomers (12, 13, 14, 15).

Leaching from heavily contaminated sediments can cause elevated water concentrations at the sediment/water interface, even when PCB discharges to the area have ceased (16, 17).

The United States Environmental Protection Agency (EPA) water quality objectives for the protection of marine and freshwater aquatic life are 0.030 ug/l and 0.014 ug/l PCB, respectively (18).

There are currently no national Canadian water quality guidelines for PCBs, however, some provinces have defined objectives for this group of chemicals.

British Columbia

No data were available for marine waters off British Columbia. PCBs have not been detected in the vast majority of the freshwater systems sampled (5).

In the few water systems where PCBs were detected, their presence was usually attributed to past spills or leaks from electrical equipment.

4.1.2 Sediments.

General

Concentrations in sediments depend on the composition of the sediments and their adsorbing capacity. Sediments and soils with high organic clay content have a high adsorbency potential for PCBs while sand does not (9). The degree of adsorption also increases with increasing chlorination of the PCB molecule and is, therefore, inversely related to the solubility of the PCB isomer. There is also some indication that adsorption of PCBs to sediments increases with increasing salinity (19).

High sediment levels have been detected in the vicinity of accidental spills and point source discharges from electrical equipment manufacturers, and industries utilizing such equipment; paper recycling plants; and municipal waste treatment facilities.

Sediments collected several years ago near two electrical equipment manufacturers in the eastern United States contained over 1000 mg/kg PCB (20, 21). Concentrations of up to 10 mg/kg have been detected in the bottom sediments near large municipal wastewater outfalls along coastal southern California (22).

Harbour areas often contain particularly high levels of PCBs. The continual discharges into these water systems, the water current patterns and the inadequate flushing of these sheltered areas tend to confine pollution to the low energy regions of harbours. PCB levels in Baltimore Harbour were between 1.0 and 2.0 mg/kg at most locations although a concentration of 84 mg/kg was detected in one sample (23).

British Columbia

High sediment concentrations, often exceeding 1.0 mg/kg dry weight, have been detected off certain industrial facilities in British Columbia (5). In many instances this contamination has probably resulted from leaks or spills from PCB-containing electrical or hydraulic equipment.

While there are no capacitor, transformer or hydraulic equipment manufacturing plants in British Columbia, PCB releases from such equipment may occur during routine use, servicing, malfunction, and as a result of inadequate disposal.

For example, leakage from equipment containing PCBs is thought to be the source of the moderately elevated PCB levels in the sediments adjacent to several pulp and paper mills in the province.

PULP MILL LOCATION	PCB CONCENTRATION (mg/kg dry weight)
Harmac	0.007 to 1.5
Port Alberni	0.01 to 5.5
Powell River	0.01 to 1.7
Woodfibre	0.01 to 4.5
False Creek	0.01 to 3.9

Very high levels of PCBs in the sediments of Porpoise Harbour near Prince Rupert were detected following the malfunction of a PCB filled transformer at a local pulp mill. A concentration of 75000 mg/kg was detected in sediments from the immediate spill site. Contaminated sediments were capped to prevent contact with aquatic organisms.

Many plants have recently taken preventative measures to eliminate or reduce releases to the environment and, in most instances, the faulty equipment responsible for these elevated environmental levels is no longer in use. For this reason, the contamination detected in the receiving environments of many of these industries may be a result of historical rather than current releases.

Elevated PCB concentrations have also been detected throughout Burrard Inlet with particularly high concentrations occurring in the vicinity of shipbuilding and ship repair facilities. For example, PCB concentrations of up to 16.8 mg/kg were detected in sediments off the Bayshore Inn in Coal Harbour. This contamination may be attributable to the past use of PCB-containing marine paints and/or leaks and spills from electrical and hydraulic equipment at shipyards located in this general vicinity.

The sources of PCBs in other areas of Burrard Inlet have not been identified but this water system receives sewer wastes, atmospheric fall-out, effluent discharges and runoff from numerous industries as well as extensive marine traffic. Concentrations of up to 3.6 mg/kg PCB have also been detected in the bottom sediments of Victoria's Inner Harbour. Although no point sources have yet been identified, Victoria Harbour receives inputs similar to those described for Vancouver Harbour (Burrard Inlet), but on a smaller scale.

In 1976, a paper recycling plant in Burnaby was identified as a significant source of PCB release to the Fraser River (24). Levels of up to 1 mg/kg dry weight were identified in the sediments immediately adjacent the plant. At this time it was expected that, as old supplies of PCB-containing paper were used up in the recycling process, PCB releases and environmental levels would decrease. However, subsequent monitoring by EPS in 1979 indicated that both effluent releases and sediment concentrations were of a greater magnitude than indicated by the 1976 sampling. Sediments adjacent to the outfall contained 1.5 mg/kg.

Improved pollution control measures at the plant have now reduced PCB releases substantially to meet allowable limits.

4.1.3 Aquatic Organisms.

General

4.1.3.1 Uptake. Aquatic organisms can accumulate PCBs directly from the water and sediments or via the food chain.

The relative contribution of food to PCB body burdens in fish varies significantly between water systems and is dependent on the PCB concentrations in food sources (25, 26, 27).

The potential for the uptake of PCBs into local biota exists even in aquatic systems where PCB inputs are low. Detectable levels of PCB in tissues of aquatic organisms have been reported in systems far removed from obvious sources of PCB release and in areas where ambient water concentrations are close to, or below, the limits of detection. Aquatic organisms can rapidly accumulate tissue residue levels many thousands of times higher than water concentrations.

Amphipods and other invertebrates accumulate particularly high concentrations of lower chlorinated compounds (tri- and tetra- isomers). In studies with fish, however, the highly chlorinated PCB compounds (penta- and hexa- isomers) were often accumulated more readily and eliminated much more slowly than were the lower chlorinated isomers (28, 29, 30).

The half life of PCB in rainbow trout increases with the chlorination of the compound (31). It has been estimated that PCBs may persist in fish tissues for approximately 3 months after removal from contaminated environments (32). As a result of studies on PCB uptake and elimination in fish, it has been concluded that the capability of fish to metabolize PCB was low in comparison to mammals (33).

4.1.3.2 Levels. PCB levels in tissues of aquatic organisms are influenced by such factors as species, age, feeding habits and specific behavioural patterns as well as the concentration and exposure time (34) and temperature (35). In general, older individuals, as well as bottom and detritus feeders, tend to accumulate higher levels of PCBs (36).

The highest levels of PCB and other lipophilic compounds are found in the livers and adipose tissue due to the high lipid content of these tissues (31, 36, 37). Studies on the uptake of PCBs by fish showed the greatest retention in the liver followed by the gills, heart, brain and muscle (38). High concentrations have also been found in the hepatopancreas of shrimp (39) and lobster (40) from contaminated areas.

British Columbia

Information on current levels of PCB in fish and aquatic invertebrates in British Columbia is limited (5).

Two major sampling programs, one in 1973 and the other in 1980, have provided data on PCB concentrations in numerous fish species from several areas of the Fraser River. Mean PCB levels in fish species sampled in the Fraser River were well below the Health and Welfare guideline of 2 ppm. The highest levels were generally present in the North Arm which is the most industrialized region of the Fraser River. This finding indicated that industrial development and urbanization in the Greater Vancouver area has contributed PCBs to the Fraser River.

In 1980 PCB residues in muscle tissue of fish from the North Arm ranged from less than 0.1 to 0.8 mg/kg. PCB levels were below the limits of detection in all species collected from other areas of the Fraser River.

Preliminary sampling in the Fraser River estuary region indicates that PCB levels in bottom fish and crab were higher in Sturgeon Bank than in Roberts Bank.

Sampling in the Sturgeon Bank area revealed that PCB levels in crabs decrease with increasing distance from the Iona Island sewage treatment plant outfall. Additional monitoring is required to determine the extent to which PCB levels in Sturgeon Bank biota are influenced by discharges from the nearby sewage treatment plant. From the limited data available, however, the PCB concentrations in biota collected near the plant outfall appear to be lower than the levels detected in biota near sewage outfalls in southern California.

Information on PCB levels in aquatic invertebrates from other areas of British Columbia is very limited, but the available data indicate that levels are well below the 2 mg/kg guideline (5).

4.1.3.3 Toxicity. Acute toxicities of PCBs to aquatic organisms appear to be related to their solubilities and hence are indirectly proportional to the relative chlorine content of the mixture. Due to the insoluble nature of the highly chlorinated isomers, even toxicity tests using Aroclors comprised largely of highly chlorinated isomers may reflect the toxicity of the more soluble lower chlorinated components (41). The toxicities of commercial PCB formulations may also vary according to the presence of chlorinated dibenzofurans or other toxic impurities.

Many freshwater and estuarine organisms, particularly invertebrates, exhibit extreme sensitivity to PCBs as indicated by the seven day LC_{50} tests for the following species: grass shrimp, 3 ug/l; crayfish, 30 to 100 ug/l; and dragonfly, 800 to 1000 ug/l (42). Freshwater crustaceans are very sensitive to low concentrations of PCBs. Exposure to 1.0 ug/l or more Aroclor 1254 decreased populations of arthropods, amphipods, bryozoans, crabs and molluscs.

The exposure of aquatic organisms to PCBs experimentally has resulted in reproductive impairments and productivity and hatchability failures in: Daphnia, Gammarus and Tanytarsus at water concentrations of less than 1 ug/l (43); Atlantic salmon eggs containing 0.4 to 1.9 ug/l (44); in striped bass eggs containing concentrations of up to 1.8 ug/l (45); and in fathead minnows at water concentrations of 0.9 ug/l (42). PCB inhibits growth in marine diatoms at concentrations as low as 10 to 25 ug/l, and in fathead minnows and flagfish at 2.2 ug/l (46). Oyster shell growth was inhibited by 59% at a concentration of 10 ug/l Aroclor 1254 (24). PCBs have also been shown to affect liver enzyme responses (47) and to interfere with predator/prey interactions (48) and limb regeneration (49).

Significant amounts of PCBs are transferred from female fish to their eggs. In contaminated areas this could be important in influencing egg and fry survival (50).

A mortality rate of 10-28% was observed in rainbow trout eggs containing 0.39 ug/kg Aroclor 1254 (51). The threshold concentration for salmon egg mortality is approximately 0.5 ug/kg, which is equivalent to a whole fish concentration of approximately 2.5 to 5.0 ug/kg (52). Studies with Baltic flounder indicate that PCB concentrations above 120 ug/l in eggs can result in decreased survival of developing eggs and larvae (53).

4.2 Terrestrial Systems

4.2.1 Atmosphere.

General

Disposal in municipal dumps and attempts at destruction in conventional incinerators may result in vaporization of PCBs and subsequent emission into the atmosphere. Wind currents would carry these aerosols considerable distances, contaminating areas many miles from the source in amounts partially dependent upon regional rainfall (54, 55). The presence of PCBs in open ocean and arctic ecosystems has been attributed mainly to atmospheric transport.

Data collected from eastern Canada confirm suspicions that municipal incinerators release measureable amounts of PCBs into the atmosphere. The majority of PCB was found to be in gaseous form rather than associated with particulate matter, and total PCB concentrations were 1.32 ng/m^3 in a research community, 0.82 to 2.88 ng/m^3 in a heavily urban-industrialized area, and 1.85 to 9.30 ng/m^3 downwind from a municipal incinerator (56).

It has been shown that approximately 80-100% of the PCBs in the atmosphere are in the vapour phase (57). PCBs associated with atmospheric particulates are usually adsorbed to submicrometer size particles (58).

PCB concentrations of 0.4 to 3.0 ng/m^3 and 10 to 150 ng/l were detected in the air and the precipitation, respectively, from the Great Lakes area (59).

Studies indicate that atmospheric deposition is the main source of PCB input to the upper Great Lakes (Lake Superior and Lake Michigan) and a significant source to the other lakes. It has been estimated that atmospheric PCB inputs to Lake Superior and Lake Michigan are 6300 to 8000 kg/year and 5000 to 6000 kg/year, respectively (59).

British Columbia

No information was available on PCB levels in the air and precipitation of British Columbia. However, in 1983 it was reported that emissions from the incinerator at Royal Jubilee Hospital in Victoria released approximately 26 mg PCB/hr. (60).

4.2.2 Soil and Vegetation.

General

PCBs do not occur naturally in the environment and detectable levels in soils occur as a result of spills, industrial releases, atmospheric transport or application of sewage.

Monitoring throughout the United States indicates that soils from agricultural areas rarely contain detectable levels of PCB. Although PCBs were frequently detected in soils from urban areas, concentrations were usually less than 1 mg/kg (61).

In general PCBs are stable in soils and are not readily leached. However, their mobility in soil and availability for uptake into vegetation is influenced by various soil characteristics including organic matter content, total clay content, pH, temperature, water content, and particle size distribution. Leaching and mobility of PCBs is encouraged by low organic matter and clay content, high water content, elevated temperature and large particle size. An increase in pH in organic soil may increase PCB mobilization by solubilizing humic materials and releasing associated PCBs (62).

The lower chlorinated PCB isomers are more water soluble and less tightly adsorbed to soil particles than the higher chlorinated forms. For these reasons they are also more mobile in soil (62).

PCBs may be lost from soil by both volatilization and microbial degradation, with losses from these routes being more pronounced for lower chlorinated compounds (63).

PCB uptake into terrestrial vegetation occurs through the root system and through transport across the epidermal layers of the foliage and stems.

Uptake by plants is determined by both PCB concentration and mobility in soils. Levels in plants tend to increase with increasing soil concentrations. The fact that the lower chlorinated isomers are more mobile in soil make them more accessible for uptake into vegetation.

Significant differences between uptake into various plant species have been noted. Carrots are particularly efficient at accumulating lipophilic compounds such as PCBs. Plant roots, in general, tend to accumulate higher levels of PCB than do plant tops, however, it is possible that this may be due to PCB adsorption to the root surface rather than to absorption (62).

British Columbia

The only available information on PCB levels in soils from B.C. was obtained from spill sites, where samples were highly contaminated, often containing over 1000 mg/kg. No information was available to indicate typical levels of PCB in soils and vegetation from agricultural or urban areas of the province.

4.2.3 Wildlife.

General

Certain wildlife species, particularly fish-eating birds and aquatic mammals, accumulate high levels of PCBs in their tissues (64, 65, 66).

White-tailed eagles from Stockholm, Sweden contained 240 mg/kg and 17000 mg/kg PCB in pectoral muscle and fat, respectively (67). Gull eggs from Lake Ontario and Lake Michigan in the 1970's contained 134 mg/kg and 249 mg/kg PCB, respectively (68). In 1983, PCB concentrations of up to 7 mg/kg were detected in the eggs of Norwegian seabirds with the highest levels occurring in Herring gull (69). Herring gulls collected on Lake Michigan in the late 1970's also contained higher levels of PCBs than did other species of waterbirds. Concentrations of up to 160 mg/kg were detected in the eggs of this species (70). The ban on the manufacture and most uses of PCBs in many countries has contributed to declining PCB levels in many waterbird populations (71).

Measurable levels of PCB have been detected in mammals from most areas of the world. Polar bears, arctic fox, and wild sheep from Greenland contained 21, 2.8 and 1.2 mg/kg PCB, respectively (72). Significant PCB levels have been detected in marine mammals, particularly in the fat/blubber, liver, and kidney (73, 74, 75, 76).

British Columbia

Most of the information on PCB levels in birds was collected in the 1960's and 70's. Elevated PCB levels were detected in a wide range of fish-eating birds including those listed in Table 1 (22).

Owls, hawks, Passerines and Galliformes from B.C. all contained very low or undetectable levels of PCBs.

Similarly, PCB levels were below the detection limit in almost all tissue samples obtained from ungulates from the Cache Creek area of B.C. No information was available for PCB levels in fish-eating mammals (24).

4.2.3.1 Toxicity.

Birds

Although LD_{50} values for most avian species are quite high (usually several hundred ppm), PCBs may contribute to reproductive impairment in birds through reduced hatchability (77), behavioural modifications (78, 79, 80, 81), decreased egg production (82) and embryo abnormalities (77, 82). Abnormalities associated with unhatched embryos include; edema, unabsorbed yolk (77), the inability of chicks to break the shell and emerge (78, 82) and leg, toe and neck deformities (82).

Most of the toxic effects of PCBs have been observed in laboratory situations. Very little information is available on the effects of PCBs on wild populations. It is very difficult to isolate the toxic effects of each contaminant, due to the fact that wild birds are usually exposed to, and accumulate, multiple contaminants. High levels of PCBs and

TABLE 1 ELEVATED PCB CONCENTRATIONS IN B.C. BIRDS

SPECIES	LOCATION	DATE	TISSUE	MEAN PCB CONTENT[1]
Fork-tailed Petrel	Skedans Island	1970	Egg	15.2
Common Murre	Danger Reef	1972	Fat	26.55
Pelagic Cormorant	Mittlenatch Is.	1970	Egg	5.36
Brandt's Cormorant	Ganges Harbour	1972	Fat	43.45
Double-crested Cormorant	Mandarte Island	1970	Egg	14.0
Western Grebe	Duck Lake	1969	Fat	46.5
Western Grebe	Captain Passage	1972	Fat	44.65
Great Blue Heron	Kootenay River	1969	Egg	12.97
Great Blue Heron	Victoria	1972	Liver	13.28
Great Blue Heron	Coquitlam	1977	Egg	14.9
Great Blue Heron	UBC Endowment Lands	1978	Egg	21.4
Merlin[2]	Lower Mainland	--	Egg	8.64
Peregrine Falcon	Langara Island	1968	Egg	7.03
		1969	Chick	3.24
Bald-headed Eagle	Port Hardy	1974	Subcut. Fat	9.64
		1975	Visceral Fat	4.80
Bald-headed Eagle	Saanich	1972	Subcut. Fat	22.84
			Visceral Fat	59.67

[1]mg/kg wet weight

[2]expressed in mg/kg dry weight

DDE, for instance, often occur in the same bird colonies. Whereas population declines, when identified, are more commonly attributed to the eggshell thinning effects of DDE (83), PCBs are sometimes suspected of contributing to reproductive abnormalities. For instance, researchers have speculated that the severe reproductive impairment in herring gulls from the Great Lakes was due to the high levels of PCBs, DDE and other toxic contaminants. Eggs from these colonies contained PCB levels higher than those shown to be toxic to poultry (10-15 mg/kg dry weight in the whole egg) (83).

The level of PCB exposure causing toxic effects varies significantly depending on species sensitivities and the length of exposure, but several effects have been noted in birds fed 10-50 mg/kg PCB for several weeks.

Some researchers have shown a positive correlation between death and PCB levels of over 300 mg/kg in certain species of birds (81, 84, 85, 86).

Chlorinated dibenzofurans, which are present as impurities in commercial PCB formulations, are highly toxic and may be responsible, at least in part, for some of the toxic effects of PCBs (87).

Mammals

PCBs generally have a low acute toxicity to most mammalian species, however, some species (such as mink) exhibit an extreme sensitivity to low levels in the diet. A decline in the reproductive success of commercially reared mink was ultimately attributed to the high PCB concentrations in the Great Lakes coho salmon which comprised approximately 30% of their diet (88, 89). Experiments on the dietary effects of PCBs on mink demonstrated that 10-30 ppm Aroclor 1254 in the diet was fatal, while 5-10 ppm inhibited reproduction and 1 ppm significantly reduced reproductive success (90).

Toxic symptoms observed in poisoned mink included anorexia, liver and kidney damage, and internal hemorrhaging (88).

Organochlorine pesticides and PCBs are also suspected of contributing to the decreased reproductive success of California sea lions (91) and ringed seals from the Baltic Sea (92). Premature births and unusually high organochlorine pesticide and PCB residues were observed in California sea lions from San Miguel Island. In Baltic ringed seals only 27% of an expected 80-90% of the reproductively mature females were pregnant at the time of inspection. Elevated DDT and PCB levels were detected in non-pregnant female ringed seals as were uterine abnormalities. The findings were indicative of fetal resorption or abortion. It is possible that these effects are due to exposure to a combination of contaminants which may act synergistically. Simultaneous exposure to DDT or dieldrin intensifies the toxic effects of PCB to mink (93).

The most commonly reported effect of dietary exposure to PCBs is liver damage. Some of the other toxic effects observed in experimental animals include; decreased mating (94), increased offspring mortality (94), pulmonary congestion (95), internal hemmorhaging (95), porphyria (96, 97), atrophy of thymus and spleen (98, 99), increased susceptability to disease (98, 99), and the formation of neoplastic and pre-neoplastic lesions (94, 100, 101).

5. REGULATIONS AND GUIDELINES

The current regulations and guidelines pertaining to PCBs in the aquatic environment are as follows:

5.1 Water Quality

At present there are no Canadian water quality criteria or guidelines for acceptable concentrations of PCBs in surface waters.

The U.S. Environmental Protection Agency water quality objectives for the protection of aquatic life are 0.014 ug/l for freshwater systems and 0.030 ug/l for marine systems (18).

5.2 Human Health

Health and Welfare Canada has established a guideline of 2 mg/kg (wet weight) as an acceptable level of PCBs in fish and shellfish intended for human consumption.

5.3 Ocean Disposal

Acceptable levels of PCBs in materials destined for ocean disposal have been established under the Ocean Dumping Control Act. PCBs are listed under Schedule 1 of the Act which states that the maximum quantity or concentration of PCBs (or other organohalogen compounds) in materials to be ocean disposed must not exceed "0.01 parts of the concentration shown to be toxic to marine animal and plant sensitive organisms in a bioassay sample and test carried out in accordance with procedures established or approved by the Minister".

5.4 Industrial Effluents and Emissions

Regulations governing the use of PCBs in Canada have been developed under the Environmental Contaminants Act and are designed to control PCB release by industrial facilities. Chlorobiphenyl Regulation No. 1 (introduced in 1977 and amended in 1980) prohibits most non-electrical uses of PCBs. This regulation is meant to stop all new entry of PCB equipment into the marketplace; ban the use of PCB-filled electromagnets over food or animal feed; restrict existing uses to totally enclosed electrical equipment which, under normal operation conditions, does not present a threat to human health or environmental quality; and eliminate existing stocks of make-up or bulk dielectric fluids to minimize occupational exposure and spills of PCBs during maintenance or servicing activities.

Chlorobiphenyl Regulations No. 2 and No. 3 became effective August 1, 1985. These regulations were developed to control the release of PCBs to the environment and to restrict the sale of existing equipment containing PCBs.

The release of deleterious substances into waters frequented by fish is prohibited by Section 33(2) of the federal Fisheries Act. In a 1977 precedent setting case PCBs were proved to be a deleterious substance as described by the Act and a B.C. pulp mill was charged and convicted under Section 33(2). This was the first time the Fisheries Act had been used in Canada to prosecute a release of PCBs into the environment.

The level of PCBs in specific industrial effluents and atmospheric emissions can also be controlled under provisions contained in the British Columbia Waste Management Act.

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