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Waste Management Paper No

Polychlorinated Biphenyl (PCB) Wastes

A Technical Memorandum on Reclamation, Treatment and Disposal including a Code of Practice

London Her Majesty's Stationery Office

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FOREWORD

This is a technical memorandum which deals with the possible sources and the disposal of polychlorinated biphenyl (PCB) wastes arising in, or imported into the UK. It applies, in addition, to analogous substances such as alkylated chlorobiphenyls and polychlorinated ter– and higher phenyls, which have as yet only restricted uses in the UK.

The memorandum has been prepared by the Department's Wastes Division. It is based largely on the informal report of a Sub-Group of the Department of the Environment's Working Group on Waste Disposal Legislation. The membership of the Sub-Group was as follows:

Chairman

Mr I Prest, Central Unit on Environmental Pollution
Department of the Environment
at present Director, Royal Society for the Protection of Birds

Secretary

Mr J P Gibrow, Central Unit on Environmental Pollution
Department of the Environment

Members

Dr H A Vaddan Monsanto Chemicals Ltd
Dr D Davies Marketing Director, Redland/Purle Ltd
Mr H Pullen also of Redland/Purle (attended on one occasion)
Mr R L Stanley Director, BEAMA Transmission and Distribution Association
Mr Christopher attended in Mr Stanley's place on one occasion
Mr A W Davies Chief Pollution Officer, Glamorgan River Authority
Mr G Davies also of Glamorgan River Authority filled this position on Mr A W Davies's appointment to a regional water authority
Mr M Stansfield Department of Industry
Mr A W Kenny, Mr R G D Osmond and Mr J Bentley of the Department of the Environment also participated.

The final chapter comprises a Code of Practice prepared in a form suitable for those requiring direct answers about disposal of PCB wastes.

1 BACKGROUND

1.1 PCBs are a range of substances consisting of a biphenyl molecule wi or without alkyl or aryl substituents in which more than one chlorine atom is substituted in the biphenyl nucleus. As manufactured today they are mixtures of compounds chlorinated to varying degrees according to the intended use and may also contain low levels of such highly toxic impurit chlorobenzothioxins and polychlorodibenzofurans.

1.2 It is believed that PCBs do not occur naturally. They are very resistant chemical and biochemical degradation, their stability increasing with the degree of chlorination and therefore they persist in the environment. They are soluble in fats and oils and, since they are only metabolized and excrete slowly, they accumulate in the fatty tissues of living organisms.

1.3 The pattern of their environmental behaviour and distribution is revea by present environmental levels consequent on the previous uncontrolled and disposal. They are widely distributed with high levels occurring in industrial areas (up to several hundred ppm in sediments near some industri outfalls in the USA having been recorded) and very low levels elsew typically 0·00001 ppm * in air and sea-water, less than 0·001 ppm in fresh water and less than 0·01 ppm in soil and submarine sediments.

1.4 However, aquatic organisms take up PCBs from water. The mean concentration in North Atlantic plankton is about 0·2 ppm. Levels up to 0·1 ppm in lobsters, 0·5 ppm in mussels and 2 ppm in herring have been reported. Predatory birds, particularly those feeding on aquatic organisms at the end of food chains, show the highest levels : 900 ppm has been reported in the liver of a UK heron.

1.5 Fortunately the end of this food chain is not of importance to man. In th great majority of his foods in the UK, the level is well below 0·05 ppm.

1.6 PCBs are sold under a variety of trade names which are given in Annex

*1 ppm is one part per million.

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1.6.1 Prior to 1973 they were used as dielectric fluids, hydraulic fluids, heat transfer fluids, lubricants and vacuum pump fluids and as plasticizers in adhesives, sealants, paints, plastics and carbonless copying paper.

1.6.2 In February 1973 the Council of the OECD agreed to confine their use to dielectric and hydraulic fluids, the latter application being limited to use in mining equipment for special duties. In the UK, the sole manufacturer has operated a more stringent voluntary control since 1971, restricting its sales to dielectric applications although providing samples for research purposes.

1.7 The general conclusion is that the use of PCBs should be restricted to applications where the employment of substitute products would present greater overall hazards and that their disposal should accord with the Code of Practice herein (section H).

1.8 The EEC will shortly be publishing two directives relating to PCBs; one dealing with the restrictions on marketing, and use which is closely aligned to OECD and UK production controls; and the other is concerned with the treatment and disposal of PCB waste.

2 NATURE OF WASTES AND ARISINGS

2.1 The wastes requiring disposal are:

2.1.1 those arising in the manufacture of PCBs, both solid and liquid

2.1.2 dielectric fluid removed from transformers because of degradation or contamination

2.1.3 dielectric fluid in scrapped transformers

2.1.4 dielectric of scrapped capacitors ex manufacture, and in redundant equipment

2.1.5 fluids replaced in 'historical' non-dispersive uses or in scrapped equipment ie pre 1971 for applications employing PCBs of UK origin and pre 1973 for those employing PCBs from OECD.

2.1.6 PCB contaminated material eg scrap capacitor windings, absorbent material used in cleaning equipment or spills

2.1.7 imported wastes.

2.2 In the manufacturing process, the commercial material is distilled from a mixed chlorination product leaving the higher boiling fractions and substances formed by polymerization. These still bottoms range from tars to glasses; they are highly chlorinated, stable and therefore very persistent in the environment but are relatively immobile. In addition there are unwanted liquid fractions and contaminated cloths, paper, sawdust, Fuller's Earth, etc used to mop up spills and leaks arising in transfer and use and to clean out equipment. There is only one manufacturer in the UK. Current manufacture waste arisings are about 400 tonnes of PCB pa of which one-third is liquid the demand for PCB is static and the arisings are not expected to increase

2.3 Because of their high boiling points, stability, non flammability and dielectric characteristics, PCBs have been used in transformers since the 1940s. Prior to 1971 only some units carried labels warning users of the for adequate disposal. Since 1971 new transformers have been so labelled and some manufacturers have contacted all their customers, even those purchased units in the 1940s, advising them of the need for adequate dis Some retrospective labelling identifying this need has been carried out c the older equipment still in use.

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2.4 There are ten major UK manufacturers of transformers whose combined use of the more highly chlorinated transformer PCB fluids is about 300 tonnes pa of which about two-thirds is for the home market; the demand is static since the growing demand for transformers in this area is being met by the development of large dry-dielectric types and of alternative dielectric fluids such as those based on silicones, though the changeover is slow due to their higher cost. PCB-filled transformers are principally used where the consequences of fire from ignition of the dielectric, due to arcing or from an external source, would be serious eg in ships, basements of buildings and (but not in the UK) mines. However the dense fumes which are evolved when PCBs are subjected to high temperatures makes them unacceptable in some situations eg underground public transport systems.

2.5 Transformer dielectric fluids may be adversely affected by entry of water and the equipment operators are therefore advised to sample and analyse the fluid periodically. (The manufacturer of PCB provides an analytical service.) It may be necessary to replace the fluid because of contamination or breakdown. Since the life of large transformers is about thirty years, the UK is just coming to the period of substantial replacement of PCB-filled units. At present a few are scrapped annually with an average dielectric charge per unit of 1 tonne. It is expected that about 130 tonnes of PCBs will arise for disposal in 1985 (from both sources; rejected dielectric and scrapped transformers) and about 250 tonnes in 2000.

2.6 Large capacitors are used to smooth out large (shock) load fluctuations on industrial power supply systems. Many large factories are equipped with banks of them. The four major manufacturers use about 600 tonnes pa of the lower chlorinated PCBs for this purpose. The average content per unit is about 3kg with a range over all units of 0·75 to 30kg.

2.7 These capacitors first went into service in the late 1950s and since their life is about twenty-five years, waste from them is not yet significant. However, it is estimated that by the 1980s 130 tonnes PCB pa and by 2000 400 tonnes pa will arise for disposal.

2.8 There is no parallel to the transformer case of occasional replacement of the fluid in large capacitors due to deterioration.

2.9 Small PCB-filled capacitors are fitted to the starter units of fluorescent lights and fractional horse-power motors of the type used in domestic and light-industrial electrical equipment. Typically they contain about 50 g of the lower chlorinated PCBs, mostly absorbed in the windings. They carry no label identifying the PCB content. There are upwards of 100 million fluorescent lights in use. The waste in these applications arises when the equipment is scrapped or (as rejects) during manufacture of the capacitors. Owing to the development of alternative capacitors and motor systems it is understood that the use is likely to decrease. At present the estimated use is 600 tonnes PCB in some 16 million units with a waste production of 250 tonnes pa which it is estimated, will peak at 600 tonnes in 1980, or possibly sooner, and then decrease to 100 tonnes by 1990.

2.10 The use of PCBs for purposes other than those detailed above was about 100 tonnes in 1972/73. It has not been possible to estimate the current waste production for the historical uses but a study of Deposit of Poisonous Waste Act notifications suggests that there is now little waste from this source.

2.11 In recent years up to 250 tonnes PCB pa wastes, both from manufacture and use, have been imported from mainland Europe because of insufficient adequate disposal capacity in this area.

2.12 The annual waste arisings, present and predicted are summarized in Annex 2.

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3 TOXICITY ASPECTS

3.1 As deduced from animal experiments, the acute oral toxicity of PCBs to man is low, being similar to DDT. The chronic toxicity is moderate. In an incident in Japan in which PCB contaminated rice oil was estimated to have been consumed by more than 15,000 people, of the 1,000 confirmed cases the average dose associated with significant clinical symptoms was 30 mg/day but effects were noticed in those who had taken in 3 mg/day over several months.

3.2 It is also known however that some aquatic organisms may be killed at very low levels, for example certain freshwater shrimps at 0·001 ppm or less in water, a consequence of the factors noted in 1.4 and it has been reported that no threshold level was found below which shrimps did not accumulate PCBs. The accumulation of PCBs in the livers of predatory birds feeding on aquatic organisms may interfere with the shell-forming process leading to thin-shelled eggs and a consequential high mortality amongst chicks.

3.3 There is some uncertainty in interpreting data on toxicity due to the presence in early commercial preparations of significant levels of impurities, notably chlorobenzodioxins and polychlorodibenzofurans. It is therefore difficult to set permissible levels for PCBs. The US Food and Drug Administration have set interim levels in food ranging from 0·2 ppm for special infant and junior foods to 5 ppm for poultry and the edible part of fish and shellfish. The US Environmental Protection Agency has recommended that discharge to surface waters should be controlled so that levels do not exceed 0·00001 ppm in the recipient waters.

3.4 Whilst the moderate toxicity of PCBs argues that the precautions need not be extreme but the concentration up the aquatic food chain and sparse knowledge of the chronic effects in man (as is not unusual with substances which do not occur naturally) argue for practical controls.

4 GENERAL DISCUSSION OF METHODS OF TREATMENT AND CURRENT DISPOSAL METH

4.1 Incineration

4.1.1 Most of the currently generated PCB wastes are destroyed by incir tion, this being done in units registered in the UK under the Alkali Acts as Chemical Incinerators. These units are fitted with wet gas scrubbing syst and are capable of achieving sustained temperatures of 1100°C. There ar at present four or possibly five such units in the UK.

The wastes disposed of in this way include :

a Liquid waste from the manufacturing process and from transformers large capacitors.

b Solid wastes from the manufacturing process, usually cast in drums.

c Miscellaneous solid wastes including waste from the manufacture of small capacitors and contaminated rags, sawdust, Fuller's Earth etc arising at manufacturing and handling plants.

4.1.2 Arising out of metal recovery operations some further but unknown quantities of PCB wastes are subjected to varying degrees of heat treatm These are principally associated with scrap, small capacitors which are recovered from domestic waste when it passes through a transfer depot o treatment plant and from industrial separation operations. Though the principal metal used in small capacitor construction is aluminium, the met separation process is not completely effective and some PCB associated non-ferrous components finds its way into ferrous scrap. It is likely that th PCB content of such scrap which undergoes processing in steel furnaces where temperatures reach 1600°C, is substantially destroyed, though som may escape to atmosphere with the reducing gases.

4.1.3 Little PCBs will be destroyed in the recovery of non-ferrous metals some will escape to the atmosphere but there will be substantial dilution i exhaust system and after release to the atmosphere. Some break-down b virtue of the material acting as a chlorine donor will probably occur.

4.1.4 Nowadays a major proportion of metal scrap is treated at fragmenta plants where items are fed in intact, and after cleaning, which may involve

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incineration, the ferrous scrap is separated magnetically. The capacitors would probably be shattered in the process and some PCBs would escape to the environment without destruction.

4.2 Landfill

4.2.1 A high proportion of the small capacitor scrap, arising from use in the starter circuits of fluorescent light fittings and fractional horse-power electric motor applications, is disposed of to landfill separately or in redundant appliances. One of the main routes is via domestic refuse which is taken direct to landfill, where domestic electrical equipment is not normally recovered for scrap and the item is buried at the bottom of a layer of refuse.

4.2.2 Small quantities of contaminated rags, paper, sawdust, Fuller's Earth etc arising at manufacturing and handling plants also go to landfill.

4.3 Recovery

A small but increasing amount of PCB waste, principally from transformer applications and to some extent from large capacitors, is recovered by a process involving clarification and vacuum distillation. In the case of large capacitors it is worthwhile draining off excess fluid for recovery and incineration. Some PCB is recovered from small capacitor manufacturing rejects by vacuum distillation and the change from paper to polypropylene windings (which do not absorb PCB) is increasing their recovery potential.

4.4 Other methods

4.4.1 Some materials have been stored pending the availability of acceptable disposal methods and the accumulated backlog is still being dealt with mainly by incineration.

4.4.2 With respect to dumping at sea PCBs are in effect proscribed materials under the Oslo and London conventions to which the UK is a signatory and in consequence of this a licence to dump at sea required by the Dumping at Sea Act 1974 would not be granted.

5 RECOMMENDED HANDLING PROCEDURES T FACILITATE RECLAMATION, STORAGE, TREATMENT AND FINAL DISPOSAL

5.1 Labelling of products and wastes

Modern transformers and large capacitors containing PCBs carry labels informing purchasers of the need for adequate disposal. Problems may a however with the disposal of older, unlabelled equipment. Retrospectiv labelling by manufacturers should be carried out wherever possible but units for which there are no adequate records identification may be assis by examining the original capital cost and siting of the unit and by the fa that the operating and maintenance procedures for PCB-filled units are different from those filled with hydrocarbon oils.

5.2 Methods of storage and containment

Special care should be taken in the transportation of as manufactured bulk liquid PCBs and waste liquid PCBs. They should be carried in adequ sealed and well-labelled heavy-duty containers and preferably not in standard drums. Precautions are especially important in the case of the hi chlorinated type of PCB used in transformers. Labelling of containers sha be consistent with the recommendations of the CIGRE Code of Practice the transport and use of dangerous materials. (Conférence Internationale des Grandes Réseaux Electrique à Haute Tension : Study Committee No Working Group 02 'The Properties of Askarels and recommendations for their use in electrical equipment' 1974.) It is essential that PCBs for reclas tion should be kept in sealed containers to avoid contamination of the ext environment.

5.3 Handling

5.3.1 A good standard of housekeeping should be maintained when handling PCBs.

5.3.2 The transfer of liquid PCBs from portable containers to storage tank in the factory or to the incinerator at the disposal site should be carefully conducted, and the container completely drained to ensure it is not a resid source of pollution.

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5.3.3 In the factory, leaks, spills and splashes should be avoided, and the working area should be floored with solid concrete, with a suitable coating if necessary. Pipes and tubes should be visible and easily accessible for supervision and maintenance.

5.3.4 Where there are large quantities of PCBs, bunds and dump tanks should be provided to prevent PCBs passing into the drains if the dielectric fluid is mishandled. Strict precautions should be taken to ensure that PCBs do not enter sewerage systems or water courses.

5.3.5 When handling PCBs protective gloves and clothing should be worn and care taken to avoid contact with skin and eyes: cuts and abrasions in particular should be carefully covered. Smoking, eating or drinking should be forbidden and the hands washed thoroughly after the operation.

6 POSSIBILITIES AND RECOMMENDATIONS FO RECLAMATION AND MINIMIZING WASTES

6.1 Possibilities for extending reclamation

6.1.1 At present it is not profitable to re-use PCBs from some applicati For example, the bulk of the liquid in small capacitors, a major PCB app is absorbed on the paper windings and although the PCB can be distill and recovered the operation requires care. An alternative process invol solvent extraction is used in Germany.

6.1.2 Reclamation of liquid PCBs is readily achieved by clarification as vacuum distillation at a cost substantially lower than the cost of manufa In some dielectric fluids the PCB is mixed with other materials such as chlorinated hydrocarbons and mineral oils and stabilisers which make t by normal separation techniques difficult. Also the service is only offere one centre in the UK and transport costs may in some cases make recov only marginally cheaper. The process is best suited to transformer fluids should be considered as the preferred method for them.

6.2 Use of alternative materials

6.2.1 *Transformers*
The use of transformers containing PCB in potentially high-risk situatio is not expanding significantly due to the development of alternative dielectrics and transformer designs. The substantially higher costs of the alternatives are however inhibiting a general change-over to their use.

6.2.2 *Small Capacitors*
There is an accelerating movement towards the use of alternative materi capacitors for fluorescent light fittings. A drytype capacitor, based on me polypropylene has been introduced and used in a growing proportion of fittings although it is at present about 10 per cent more expensive than th PCB-filled type. It is possible that the use of PCB-filled capacitors in this application may be largely discontinued within the next three to five yea

6.2.3 *Motors*
There is also some evidence that the use of capacitor start motors in dom appliances is diminishing due to design changes.

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7 TREATMENT AND DISPOSAL METHODS

7.1 PCB wastes should where possible be recovered.

7.2 Failing this they should where practicable be disposed of by high temperature incineration in units fitted with gas scrubbing systems and capable of achieving sustained high temperatures. Municipal incinerators are not suitable for this purpose. For complete destruction of PCBs by ...neration, the vapour must be maintained for a sufficient time at a sufficiently high temperature with sufficient excess oxygen in the combustion gases. A US publication, (Reference 1), indicates that satisfactory destruction of PCBs may be achieved by incineration for two seconds at 1100°C with 3 per cent excess oxygen and further suggests that stack emissions should not exceed 1 mg/m³ PCB. Most incinerators do not achieve the appropriate conditions but in the UK there are at least four operated by private contractors which, it is claimed, do. Two of these are capable of handling both liquids and solids but the other two can only accept liquids. Tests on emissions from one liquid and one liquid plus solids incinerator indicated that the units were capable of achieving levels lower than those stated above. The UK manufacturer of PCBs uses this method for the wastes arising in manufacture and will recommend a suitable incinerator. The incinerator is registrable under the Alkali Acts on account not only of the hydrogen chloride content of the gaseous discharge, but also its classification as a chemical incinerator.

7.3 The wastes arising from manufacture, from uses as a dielectric in transformers and from imports may be disposed of by reclamation or incineration but about a third of the PCB waste arises from capacitors and to a minor extent from the older uses of PCBs. With large power correction capacitors it is worthwhile to drain off the excess fluid for recovery or incineration. It is possible to incinerate the residual core material either directly or after a preliminary (vacuum) distillation or solvent wash to recover the PCB from the windings.

7.4 Recovery of PCBs is quite impracticable for the small capacitors fitted to electrical appliances. They cannot be easily identified, since they are not labelled, and in any case the task could be unduly laborious. Sometimes capacitors attached to electric motors are reused when the motors are recovered but more usually the articles are disposed of through the ordinary processes of refuse disposal and scrap recovery/disposal. When domestic refuse is taken direct to landfill, electric light fittings and domestic electric equipment contained in it are not normally recovered for scrap and the items are buried at the bottom of a layer of refuse. There is no information on the proportion of small capacitors containing PCB which goes to landfill.

7.5 There is no direct evidence of degredation of PCBs in landfill, though slow degradation may well occur. It seems likely, given that the PCBs (which have low water solubility) are deposited in a container from which release will be slow and that free PCBs are adsorbed on sediments, that most landfill sites pose no potential threat to water and that landfill disposal is a satisfactory method. The extra effort to segregate the capacitors is not just (see paragraph 7.4). It is suggested however, that undue concentrations at any one landfill site should be avoided. As a rough guide:

a if 5 million items are scrapped annually; and

b if they are disposed of with 35 million tonnes of domestic and industrial waste annually –

one may expect one item in every 7 tonnes, approximately equivalent to between forty-five and sixty items per 1,000m³ of landfilled domestic refuse. If the level as revealed by occasional observation were, eg one item per tonne or greater, there might be a case for investigating the cause and, if reasonably practicable, for diverting some of the items elsewhere. Such undue concentrations could be presumed to be the result of an industrial disposal.

7.6 Small intermittent quantities which cannot be conveniently handled by incineration may be disposed of by landfill provided similar guidelines on levels and concentrations as at (7.5) above are observed.

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8 CODE OF PRACTICE FOR PCBs

In the light of the foregoing the following is presented as a self-contained Code of Practice giving basic rules without supporting arguments. For the purposes of this document wastes containing more than 0·1 per cent PCBs are regarded as PCBs.

8.1 Polychlorinated biphenyls (PCBs) are a mixture of chlorinated biphenyls the degree of chlorination being adjusted to the use (the higher chlorinated PCBs in transformers, the lower in capacitors) and for the purpose of control this description also includes chlorinated ter- and higher phenyls. They are excellent dielectrics, are stable to thermal, chemical and biological degradation and are fire resistant. Annex 1 gives a list of trade names under which they are or have been marketed (1.1, 1.2).

8.2 Following the widespread detection of PCBs in the environment and particularly in predatory birds feeding on aquatic organisms, a consequence of their resistance to degradation and to their fat solubility, and following an incident in Japan where the ingestion of PCB-contaminated rice caused injury to humans and death to poultry, the Council of the OECD in February 1973 agreed to regulate their use by its members by

a abandoning their use in open systems and dispersive uses

b limiting their use in closed systems to cases where they are recoverable or non-flammability is an overriding requirement, or there is no adequate substitute.

In the UK the control is further reinforced by a voluntary scheme imposed in March 1971 by the sole manufacturer who restricts its commercial sales to dielectric applications and research purposes (1.3–6, 3.1–4).

8.3 In consequence, future uses in the UK are now confined to power correction capacitors and transformers (called controllable closed systems), because they are sealed, big, of long life and contain sufficient PCB to offer the incentive of economic recovery. Their use in non-controlled systems (small capacitors) is being abandoned as adequate substitutes become available except where fire resistance is of overriding importance (2.4, 6.1, 6.2).

8.4 The acute toxicity is low, similar to that of DDT; the chronic toxicit moderate. Some aquatic organisms are very sensitive to their presence water. PCBs concentrate in the livers of higher life forms due to their fat solubility and affect predatory birds and other organs directly and evide available to suggest they can also affect the breeding success of these many other species. The aims of control of disposal of wastes are:

a to restrict levels in human foods to the lowest practicable, and,

b to reduce the levels in the environment, especially the aquatic envir ment, by all reasonably practicable measures (3.1–4).

8.5 An estimate of present and future waste arisings is given in Annex

8.6 In all operations involving transfer of PCBs eg during draining of transformers and power capacitors or transfer to store to await disposal, care should be taken to avoid contact with skin and eyes. Cuts and abra should be covered and protective clothing and gloves worn. Hands sho washed after the operation. Smoking, drinking and eating should be pro bited in the operational area. Transfers should preferably take place on h undrained, bunded surfaces. Spills should be absorbed at once in sawd or other, preferably flammable, absorbents. Every precaution should be t to prevent ingress of PCB into sewerage systems or water courses (5.3).

8.7 Liquid wastes from transformers and power correction capacitors sl be removed as completely as possible and sent for reclamation or incine to the standards specified in 8.9 below (4.1, 4.3, 7.2, 7.3).

8.8 Wastes should be transported in labelled heavy-duty, specially secu containers, preferably not in standard drums (5.2).

8.9 Manufacturing wastes and other contaminated solid wastes (eg capacitors from which the liquid PCB has been drained) should be destr in incinerators fitted with gas scrubbing devices and capable of operatin sustained temperatures greater than 1,100°C. Mean residence time shou be at least two seconds with a minimum excess oxygen content of 3 per Stack gases and gas scrubber liquids should be sampled according to a schedule agreed with the regulatory authorities (Alkali Inspectorate and appropriate Water Authority or, in Scotland, the River Purification Autho (4.1, 7.2).

8.10 No special precautions need to be taken in the disposal of small capacitors unless there is undue concentration at one particular landfill si scrap recovery facility. If the concentration is more than one capacitor pe

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tonne of refuse, (approximately equivalent to 300 to 400 items per 1,000m³) an investigation should be made to ascertain the reason, and disposal arranged so as to approach an average concentration of not more than one unit per 7 tonnes of refuse (7.5).

8.11 Wastes not discussed above should be :

a recovered where at all possible

b destroyed in a suitable incinerator if recovery is impracticable

c buried at low concentrations in landfill if neither recovery nor incineration is possible.

ANNEX 1

Trade names

Principal trade names used for PCB-based dielectric fluids which an classified as ASKARELS

AROCLOR (UK, USA)

PYROCLOR (UK)

INERTEEN (USA)

PYRANOL (USA)

PYRALENE (FRANCE)

CLOPHEN (GERMANY)

APIROLIO (ITALY)

KANECLOR (JAPAN)

SOLVOL (USSR)

Other names were used for PCB products intended for historical appl these include :

SANTOTHERN FR (UK) Heat transfer prior to 1972

THERMINOL FR (USA) Heat transfer prior to 1972

PYDRAUL (USA) Hydraulic applications before 1972

PHENOCLOR (FRANCE)

FENCLOR (ITALY)

The trade names SANTOTHERN, THERMINOL and PYDRAUL are st use but these now refer to non-chlorinated products.

In the case of SANTOTHERN and THERMINOL only the FR series co PCBs and present-day products are not labelled as FR. In the case of PYDRAUL.S, the present series of hydraulic fluids which do not cont halogenated compounds are designated B C or E.

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ANNEX 2

Quantities of PCBs

	Manufacture	Transformers	Large capacitors	Small capacitors	Historical
Total PCBs used per annum		300 tonnes	600 tonnes	600 tonnes (likely to decrease)	
No. of units manufactured per annum		300 (only 200 for home market)	150,000–200,000	16m	
Average wt of PCB per unit		1 tonne	3 kg (range 0·75 –30 kg)	50g	
Life of unit		30 years	25 years	5–10 years	
Quantities of wastes* arising 1974)	400 tonnes (liquid)	10 tonnes (liquid)	**	250 tonnes	100 tonnes 1972–73
Estimate of future quantities of waste	Not likely to increase	1985 – 130 tonnes 2000 – 250 tonnes	1980 – 130 tonnes 2000 – 400 tonnes	1980 – 600 tonnes 1990 – 100 tonnes	

Plus up to 250 tonnes of imported material.
* Currently little waste as capacitors not brought into service until 1950s.

ANNEX 3

References

(1) National Electrical Manufactures Association 1973 Official Standards Proposal *PUB no CP-P1-73* *TR-PG-73* (Section 2, page 8)

Some further, detailed information about the properties, use and disposal of PCBs is contained in the literature listed below:

(2) CIGRE 1974 'Properties of Askarels and recommendations for their use in electrical equipment' *Study Committee No. 15 Working Group 02*

(3) OECD 1973 Document Press A(73) of February 14. *'Polychlorinated Biphenyls and the Environment'* (COM-72-10.419) distributed by the National Technical Information Service, US Department of Commerce, 5285 Port Royal Road, Springfield Va 22151, USA.

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DEPARTMENT OF THE ENVIRONMENT

Waste Management Paper No

Polychlorinated Biphenyl (PCB) Wastes

A Technical Memorandum on Reclamation, Treatment and Disposal including a Code of Practice

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BACKGROUND to the REGULATION of POLYCHLORINATED BIPHENYLS (PCB) in Canada

A report of the

TASK FORCE on PCB, April 1 1976

to the

ENVIRONMENTAL CONTAMINANTS COMMITTEE

of

ENVIRONMENT CANADA and

HEALTH & WELFARE CANADA

P 11

TECHNICAL REPORT 76-1

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Background to the Regulation of PCB in Canada

Summary

The Task force on PCBs was appointed by the Joint DOE/NH&W Committee on Environmental Contaminants in August 1975.

- to investigate and document the PCB problem in Canada
- to make recommendations concerning
  - the information that should be sought under the mandatory disclosure provisions of the Environmental Contaminants Act and
  - the information that should be provided through further government research and
  - the efficacy of the OECD's decision as Canadian controls and
  - the desirable controls on PCBs.

The Task Force examined the OECD restrictions. The Member countries agreed to control the manufacture of, and trade in, PCBs and to permit their use only as dielectric fluid in transformers and capacitors, heat transfer fluid and hydraulic fluid in mining equipment. This control includes the manufacture, import and export of bulk PCB, the institution of safe disposal measures, a labelling system and specifications for safe transport. The OECD also recommended controls on the manufacture, import and export of PCB-containing products and the elimination of PCBs from small capacitors. Other recommendations concerned the specific uses to be eliminated, the safety of replacement substances and the exchange of statistical information.

The OECD decision and recommendations can generally be carried out by regulation under the Environmental Contaminants Act, except for the recommendations concerning the labelling, the control of exports, and some aspects of the control of the disposal of surplus or waste PCBs (which can probably be managed by the provincial governments). The Canadian position within OECD was that the only permissible uses of PCBs should be for dielectric fluids for transformers and capacitors. The other uses permitted by OECD as heat transfer fluid and hydraulic fluid in mining equipment are unacceptable in Canada because they are essentially non-closed systems.

The Task Force then examined the information on the amounts of PCBs imported, used, recycled, exported and disposed of, including the amounts used in various commercial and domestic products and the amounts used in various commercial activities.

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One of the greatest problems in assessing the PCB problem has been the collection of useful information on the quantity manufactured, imported, used and disposed of. There are good data concerning the importation of PCBs in bulk for Canadian manufacturing use. Almost no other data are available on the movement of PCBs in the economy. Some quantitative information is available from monitoring the amounts or concentrations entering the environment in the recent past.

The Task Force then examined the information on levels of PCBs in various ecosystems in Canada in order to determine the source and mode of entry of PCBs into various sectors of the environment.

Despite the problems of collecting satisfactory information it is clear that the most serious identified problem of contamination by PCB is in the Great Lakes and associated regions. This is most clearly seen in the Herring Gull data where the residue levels are generally an order of magnitude above the levels found on the Atlantic coast.

That PCBs are present at higher concentrations in specific regions is confirmed as well by the fish data. Very much higher residues are found in species from the Great Lakes and St. Lawrence River compared with the coastal species. While levels of PCB in fish from the Atlantic coast are somewhat higher than in those from the Pacific coast, concentrations are well below the 2ppm guideline of the Health Protection Branch. The level in the Arctic Char from Hudson Bay indicated that this environment has a higher contamination than more northerly arctic locations. Residue levels in Polar Bear from the eastern Arctic, particularly around Hudson Bay, were higher than levels in those from the western Arctic.

The Lake Trout data from Lake Minto (Ungava, northern Quebec) confirm that PCBs are present in remote arctic freshwater ecosystems; atmospheric transport is the most probable route of contamination. Probably the same route is responsible for the contamination of small lakes in the Prairies and of the Ontario terrestrial ecosystem. This airborne PCB is of uncertain origin; it is probably the result of ineffective incineration of waste PCB and waste containing PCB.

The information from the analysis of adipose tissue of humans indicates higher levels in Ontario and Quebec and lower levels in the Prairie Provinces. Residue levels in human adipose tissue, used as an integrator of human exposure levels from all routes, indicate that higher PCB exposure is associated with the

more industrial parts of the nation. The very wide ranges reported in the Ontario surveys for the years 1971-72 and 1973-74 suggest a rather wide range of exposure.

Despite the shortcomings of the data base, it is possible to make some generalisations concerning routes into the environment. Of the wastewater treatment plant effluents sampled, nearly every plant effluent around the Great Lakes contained PCB in at least trace concentration of 5-10 ppt. A few locations, such as Toronto, Hamilton, Windsor and Saginaw, account for much of the measured discharge via this route. Control of PCB from industrial plants to these municipal wastewater treatment plants could probably reduce much of the continuing municipal discharges. The information on industrial discharges directly into the environment is fragmentary, but indicates that industrial sources do exist. Much the same conclusion can be made about landfill leachate resulting from solid waste disposal, though generally the volume of discharge would be much smaller than waste discharges from sewage treatment or industrial plants.

Sewage sludge disposal on agricultural land is another route for PCB entry into the environment. It appears that repeated applications of the sludge will result in a buildup of PCB residue in the soil. There is an indication that corn plants will take up PCB from a contaminated soil. This phenomenon needs further investigation.

Very little work has been undertaken on monitoring PCBs in the emissions from incinerator stacks, and in rain, snow or air. From the very scant data, it would appear that the atmospheric route is far more important than has previously been thought. A crude estimate of PCB entering Lake Erie in rain is 500-1000 kg/yr; for comparison, the PCB entering Lakes Erie and Ontario from municpal wastewater treatment plants in Ontario is estimated to be 250 kg/yr. The phenomenon of vaporisation of PCB from water surfaces, particularly the Great Lakes, does not appear to have been researched.

PCBs enter the Great Lakes from most of the tributaries sampled. No work appears to have been done on estimating the quantity of PCB discharges from ships and aircraft.

The Task Force considered other relevant observations concerning trends of PCB levels in the environment, types of PCB in samples, the composition of commercial mixtures and toxicological implication of PCB residues in biota. Consideration was also given to the presence of chemical species of particular toxicological importance contained in commercial PCB (e.g. chlorodibenzofurans

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or derived from commercial PCB (e.g. metabolites) and to the relative consumption by industry of the lower and higher chlorinated PCBs and their estimated losses to the environment.

The crude estimates of losses taken together with the evidence that exists of the presence (or absence) of tetrachlorobiphenyl in birds and fish indicate that tetrachlorobiphenyl and other LCBPs (lower chlorinated biphenyls) are degraded more rapidly that are HCBPs (higher chlorinated biphenyls). Because Monsanto's sales curtailement must have exerted already a great effect on losses of tetrachlorobiphenyl and other LCBPs into the environment, and because this material is more rapidly degraded than HCBP, any reduction in Canadian discharges of LCBP to the Great Lakes ecosystem that would result from new restrictions on use in electrical equipment in Canada would be only of secondary importance, when viewed against the vastly greater consumption of LCBPs in the U.S. Great Lakes region.

Conversely Canadian actions to reduce losses of HCBP to the Great Lakes ecosystem could have a large long-term effect in view of the estimated relative quantities of HCBP used in Canada and the U.S.A. within the Great Lakes region.

It is clear that Canadian control efforts alone will be insufficient to reduce environmental levels of PCBs in the Great Lakes to tolerable values. Effective action will also be necessary in the U.S. portions of the Great Lakes Basin.

The conclusions concerning the data base are presented on pages ix and x.

The summary of the Recommendations concerning information are presented on pages xi to xiii.

In the development of a rationale for control of PCB, consideration was given to the following three ways in which exposures could be reduced:

i) restricting the purposes for which PCBs may be used

ii) restricting losses into the environment from permitted uses

iii) restricting the proportion of environmentally persistent PCBs in material lost into the environment.

Of these three ways, the reduction to the greatest extent practicable of identified sources of entry of PCB into water and atmosphere is likely to be the most efficacious measure in bringing about within the next several years a worthwhile reduction in quantities of PCB entering the environment. All the traditional pollution abatement powers such as those of the federal Fisheries or Clean Air Acts and the various provincial laws should be used to the extent that they can contribute to this reduction. It is clear that the highest attainable standards of plant housekeeping must be maintained to prevent any entry of PCBs into wastewaters. It is not clear that setting a generally applicable concentration standard for PCB in industrial wastewaters under the Environmental Contaminants Act is a meaningful exercise in terms of reducing discharge of PCBs into the environment or of protecting aquatic life.

The second most efficacious tactic for causing relatively rapid decreases in loss of PCB into the environment is the elimination of the few remaining uses of PCB that can be classified as non-electrical and open-system. Elimination of various dielectric uses requires long lead times but would then give some immediate benefit.

The third way of reducing exposures to PCB is the reduction of the proportion of persistent homologs in commercially available PCB. Any major change in the specifications of the available dielectric fluids requires a long lead time for field testing of reliability.

The summary of the recommendations concerning controls are presented on pages xv to xvi.

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Renseignements de base en vue de la réglementation des biphényles polychlorés (PCB) au Canada

Résumé

Le groupe d'étude des PCB a été mis sur pied par le Comité mixte des ministères de l'Environnement et de la Santé nationale et du Bien-être social sur les contaminants de l'environnement, en août 1975,

- afin d'étudier le cas des PCB au Canada et de s'y documenter
- afin de faire des recommandations au sujet:
  - des renseignements à rechercher en vertu des articles de la Loi sur les contaminants de l'environnement, prévoyant à la communication obligatoire de renseignements sur les contaminants;
  - des renseignements à obtenir grâce à des recherches réalisées par le gouvernement;
  - de l'efficacité de la décision de l'OCDE (Organisation de coopération et de développement économiques) telle qu'applicable au Canada à la lutte contre les PCB;
  - des mesures désirables à mettre en oeuvre à l'encontre des PCB.

Le groupe d'étude a examiné les restrictions proposées par l'OCDE. Les pays membres de cette organisation ont convenu de régir la fabrication et le commerce des PCB et de ne permettre leur emploi que comme diélectrique dans les transformateurs et les condensateurs, que comme fluide caloporteur et que comme fluide hydraulique dans le matériel utilisé dans les mines. Cette décision s'applique à la fabrication, à l'importation et à l'exportation des PCB en vrac, et comporte la mise en place de mesures visant leur éliminstion sûre, ainsi que d'un système d'étiquetage et de normes en vue de leur transport sécuritaire. L'OCDE a aussi recommandé les mêmes mesures pour la fabrication, l'importation et l'exportation des produits contenant des PCB, ainsi que l'élimination de ces derniers des petits condensateurs. D'autres recommandations visaient les emplois précis de ces substances qui devaient être abandonnés, l'innocuité de celles qui devaient les remplacer, ainsi que l'échange de données statistiques.

La décision et les recommandations de l'OCDE peuvent en grande part être exécutées sous le régime de la Loi sur les contaminants de l'environnement, sauf en ce qui a trait aux recommandations visant l'étiquetage, la réglementation des exportations et certaines questions de la réglementation de l'élimination des PCB excédentaires ou résiduaires (qui pourraient être de la compétence des gouvernements provinciaux). En cette matière la position du Canada

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est que seuls devraient être permis les emplois des PCB dans les transformateurs et les condensateurs, comme diélectriques. Les autres, permis par l'OCDE (fluide caloporteur, fluide hydraulique dans le matériel d'exploitation minière) sont inacceptables au Canada, parce qu'ayant lieu en système ouvert.

Le groupe d'étude a ensuite examiné les renseignements qui portaient sur les quantités importées, utilisées, recyclées, exportées et mises au rebut, y compris les quantités entrant dans la composition de divers produits commerciaux et domestiques, ou celles qui intervenaient au cours des diverses activités commerciales ou industrielles.

L'une des principales difficultés rencontrées, lors de l'étude de la question des PCB a été la collecte de données utiles sur les quantités fabriquées, importées, utilisées et éliminées. Nous disposons de données valables en ce qui concerne l'importation en vrac des PCB destinés à l'industrie canadienne. Ce sont à peu près les seules qui existent sur leur transfert dans notre économie. Des données d'ordre quantitatif sont aussi disponibles grâce aux contrôles récents des PCB dans l'environnement.

Le groupe d'étude a ensuite examiné les données disponibles sur la présence des PCB dans les différents écosystèmes du Canada, afin d'en déterminer la provenance et le mode d'entrée.

Malgré les difficultés ayant nui à l'obtention de données satisfaisantes, il est évident que le cas le plus grave de contamination par les PCB se limite à la région des Grands lacs et les régions contiguës. L'exemple type en est le goéland argenté, dont les tissus ont des teneurs d'un ordre de grandeur plus élevé à celles qu'on observe sur la côte de l'Atlantique.

L'analyse des tissus de poissons a aussi confirmé la présence des PCB en plus fortes concentrations en certaines régions qu'en d'autres. Ces concentrations sont beaucoup plus fortes chez les espèces des Grands lacs et du fleuve Saint-Laurent que chez celles de la côte, et dans ce cas, elles sont beaucoup plus fortes chez celles de la côte de l'Atlantique que chez celles de la côte du Pacifique tout en étant bien au-dessous de la limite de 2 p.p.m. précisée dans les lignes directrices de la Direction de la protection de la santé. Chez l'omble chevalier, elles portent à croire que la baie d'Hudson est plus contaminée que les eaux situées plus au nord, tandis que chez l'ours blanc, elles sont plus fortes dans celui de l'est de l'Arctique, surtout autour de la baie d'Hudson, que dans celui de l'ouest de l'Arctique.

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L'analyse du tissus de la truite grise du lac Minto (région de l'Ungava, Nouveau-Québec) confirme le fait que les PCB ont atteint les écosystèmes d'eau douce des régions les plus reculées: cette contamination serait attribuable au transport atmosphérique. La contamination des petits lacs des Prairies et des sols de l'Ontario pourrait probablement s'expliquer par les mêmes mécanismes. L'origine des PCB atmosphériques n'est pas tout à fait connue, mais elle semblerait être la mauvaise incinération des PCB résiduaires ou de déchets en contenant.

L'analyse du tissu adipeux de l'homme accuse des concentrations supérieures en Ontario et au Québec, inférieures dans les Prairies. Ces concentrations qui permettent la sommation des taux d'exposition de l'homme aux différentes sources de contamination indiquent que l'exposition aux PCB est la plus forte dans les régions les plus industrialisées du pays. L'écart des données recueillies en Ontario, en 1971-72 et en 1973-74 porte à croire que le degré d'exposition varie énormément dans cette province.

Malgré les lacunes, il est toutefois possible d'établir un schéma général des modes d'entrée des PCB dans l'environnement. Presque tous les effluents d'installations de traitement des eaux usées de la région entourant les Grands lacs contenaient des PCB, à des concentrations au moins égales à 5 à 10 parties par billion (10^{12}). Une grande partie des rejets de cette nature était attribuable à un petit nombre de villes (Toronto, Hamilton, Windsor, Saginaw). L'arrêt des PCB d'origine industrielle, acheminés à ces usines de traitement municipales permettrait probablement de réduire une grande partie des rejets de PCB par ces dernières. Les renseignements concernant les rejets industriels directs dans l'environnement sont fragmentaires, mais indiquent que de tels rejets existent. On peut en arriver aux mêmes conclusions, à peu près, au sujet du lessivage des déchets solides mis en décharge, bien que, en général, les rejets en cause soient minimes comparativement aux rejets par l'industrie ou par les usines de traitement.

L'épandage des boues résiduaires sur les terres constitue une autre voie d'entrée des PCB dans l'environnement. Il semble que l'application répétée de ces boues amènera l'accumulation de résidus de PCB dans le sol. Il semble aussi que le maïs absorbe ces PCB. La question mériterait d'être étudiée davantage.

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Le contrôle des PCB émis par les incinérateurs, ainsi que de leur présence dans l'eau de pluie, la neige ou l'air n'est pas très avancé. D'après les données éparses dont nous disposons, il semblerait que l'entrée des PCB dans l'environnement par l'intermédiaire de l'atmosphère soit beaucoup plus importante qu'on ne l'avait d'abord cru. Une estimation grossière de l'apport de PCB dans le lac Erié par l'eau de pluie indiquerait de 500 à 1000 kg/an alors que dans ce lac et le lac Ontario, les usines municipales de traitement des eaux usées en déverseraient environ 250 kg/an. Il ne semble pas qu'on ait étudié la vaporisation des PCB à partir des nappes d'eau, particulièrement les Grands lacs.

Les PCB pénètrent dans les Grands lacs par la plupart des tributaires échantillonés. Il ne semble pas qu'on ait cherché à estimer le rejet des PCB par les bateaux et les avions.

Le groupe d'étude a examiné d'autres résultats d'observations pertinentes au sujet de l'évolution du taux de PCB dans l'environnement, des types de PCB présents dans les échantillons de la composition des mélanges commerciaux et de la toxicité des résidus de PCB dans les organismes vivants. Il a aussi examiné la question de la présence d'espèces chimiques particulièrement toxiques dans les mélanges commerciaux de PCB (par ex., les chlorodibenzofurannes) ou en provenant (par ex., certains métabolites), ainsi que celles de la consommation respective en biphényles fortement ou peu chlorés par l'industrie et de leurs pertes estimatives dans l'environnement.

L'estimation grossière des pertes, ainsi que les signes de la présence (ou de l'absence) de tétrachlorobiphényle dans le tissu des oiseaux et des poissons, indiquent que ce dernier, et les autres biphényles peu chlorés se dégradent plus rapidement que les biphényles fortement chlorés. Comme la réduction des ventes de la Monsanto a peut-être déjà eu de fortes répercussions sur les pertes de tétrachlorobiphényle et autres biphényles peu chlorés dans l'environnement, et comme ces substances se dégradent plus rapidement que les biphényles fortement chlorés, toute réduction des rejets par le Canada de biphényles peu chlorés dans l'écosystème des Grands lacs, qui proviendraient de nouvelles restrictions sur l'emploi de matériel électrique au Canada, ne serait que d'une importance secondaire, si l'on tient compte de l'emploi beaucoup plus vaste qui en est fait du côté américain.

Réciproquement, des mesures adoptées au Canada afin de réduire les pertes en biphényles fortement chlorés dans l'écosystème des Grands lacs pourraient avoir un effet accentué à long terme, si l'on considère les quantités relatives de biphényles fortement chlorés qui sont utilisées au Canada et aux Etats-Unis, dans la région en question.

Il est évident que les efforts isolés du Canada ne suffiront pas à assainir les Grands lacs et d'atteindre des teneurs tolérables en PCB. Pour cela, il faudra que les Américains se mettent aussi de la partie dans le bassin en question.

Les conclusions du groupe de travail sur les données disponibles se trouvent aux pages S12 et S14.

Le résumé des recommandations faites en vue de l'obtention de renseignements se trouve de la page S15 à S18.

Lors de l'élaboration des principes devant présider à la lutte contre les PCB, il a été tenu compte des trois méthodes suivantes par lesquelles on pourrait réduire le taux d'exposition à ces derniers:

i) Réduire les emplois des PCB;

ii) Réduire les pertes dans l'environnement provenant d'emplois permis;

iii) Réduire la proportion de PCB rémanents dans les mélanges rejetés dans l'environnement.

De ces trois méthodes, la réduction du plus grand nombre possible des voies connues d'entrée des PCB dans l'eau et l'atmosphère est celle qui devrait donner les meilleurs résultats d'ici les prochaines années à venir. A cette fin, tous les mécanismes classiques de lutte contre la pollution comme la Loi fédérale sur la lutte contre la pollution atmosphérique ou la Loi des pêcheries devraient servir dans la mesure du possible. Il est évident que les normes les plus élevées possible d'exploitation doivent être appliquées si l'on veut empêcher l'introduction des PCB dans les eaux usées industrielles. En ce sens et pour la protection de la vie aquatique, l'établissement d'une norme de concentration généralement applicable aux eaux usées sous le régime de la Loi sur les contaminants de l'environnement ne semblerait pas pouvoir donner des résultats significatifs.

Viendrait ensuite l'élimination du peu d'emplois qui restent des PCB autres qu'en électricité ou se greffant à des systèmes ouverts. L'élimination des divers emplois comme diélectriques prendrait du temps mais donnerait immédiatement certains résultats positifs.

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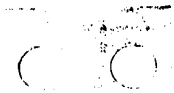
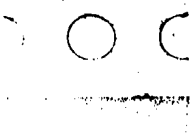
Enfin, on pourrait réduire la proportion de biphényles rémanents présents dans les mélanges commerciaux. Tout changement majeur dans les spécifications des fluides diélectriques actuels prendrait du temps avant l'application, à cause des essais de performance et de fiabilité nécessaires.

Le résumé des recommandations relatives aux restrictions se trouvent aux pages S19 et S21.









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CONCLUSIONS

Les preuves de la présence de PCB dans l'environnement

1. Les PCB sont des polluants rémanents et ubiquitaires (Partie 7.1.).

2. Dans le tissu adipeux de Canadiens, on en a décelé de 1 à 2 mg/kg. L'homme est exposé aux PCB présents dans l'environnement (Partie 7.1.6.).

3. On ne dispose, pour le degré d'exposition de l'homme, que de données sur la nourriture qu'il ingère; peu de renseignements existent sur les teneurs en PCB dans l'air et dans l'eau potable.

4. En moyenne, les Canadiens ingèrent peu de PCB, sauf s'ils consomment du poisson pris dans les Grands lacs et dans le fleuve Saint-Laurent. Cependant les données précises à cet égard ne sont pas disponibles.

5. Les PCB sont des substances biologiquement actives et toxiques pour l'homme (Partie 1.).

6. Tous les PCB sont toxiques, mais ceux qui sont fortement chlorés sont plus rémanents et sont les plus inquiétants du point de vue du degré d'exposition. Les biphényles peu chlorés (2, 3 ou 4 atomes de chlore par molécule) ont rarement été identifiés ou signalés dans les échantillons naturels sauf à proximité de leur source de rejet. Exception à ceci: le goéland argenté des Grands lacs, où l'on a trouvé environ 1 % et 10 %, respectivement, de tri- et de tétrachlorobiphényles (Partie 7.3.2.). Les dibenzofurannes chlorés, constituants ou dérivés des PCB, peuvent avoir une action toxique dans l'environnement canadien (Partie 7.3.6.1).

7. Les PCB sont rejetés dans l'eau (Partie 7.2.1.), l'atmosphère (Partie 7.2.5.) et le sol (Partie 7.2.3.) par les installations de traitement des eaux usées (Partia 7.2.1), par les décharges de déchets solides (Partie 7.2.2) et par les incinérateurs (Partie 7.2.4.). Le degré de contamination par les PCB semble être relié avec le taux relatif d'industrialisation.

8. Les Grands lacs et les régions contiguës sont les plus contaminées au Canada, jusqu'ici (Partie 7.1.).

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9. Les sources actuelles de contamination des Grands lacs sont les installations de traitement des eaux usées (Partie 7.2.1.1.), l'industrie (Partie 7.2.1.2.), les incinérateurs (Partie 7.2.4.), l'atmosphère (Partie 7.2.5.) et les tributaires (Partie 7.2.6.).

10. On ne sait pas quelle proportion du présent taux de contamination de la faune et de la flore des Grands lacs est attribuable aux rejets actuels ou antérieurs (Partie 7.2.7.3.2.).

11. Les teneurs en PCB dans les tissus de poissons et de mollusques de l'Atlantique sont supérieures à celles que l'on observe chez les espèces du Pacifique (Partie 7.1.2.2).

12. Le transport des PCB par l'atmosphère semble être la principale voie de contamination des Prairies (Partie 7.1.4.) et de l'Arctique (Partie 7.1.3.), si l'on excepte les contaminations attribuables à des rejets bruts dans l'eau.

13. Les données obtenues sur l'évolution temporelle de la contamination au Canada, depuis l'arrêt volontaire de l'emploi des PCB ne sont pas concluantes. En effet, seulement quatre ans se sont écoulés depuis, ce qui ne suffit pas à déterminer une évolution (Partie 7.3.1.) et le bien-fondé des donnés en ca sens laisse à désirer, notamment parce que seuls les biphényles fortement chlorés ont été étudiés.

14. Les PCB ont nui à la reproduction du vison d'élevage et des oiseaux prédateurs des poissons des Grands lacs (Partie 1.).

15. L'introduction accidentelle des PCB les plus rémanents, même en petites quantités, dans les écosystèmes aquatiques peut avoir des répercussions toxiques et économiques.

16. Il existe un besoin de réglementer l'importation, l'emploi et l'élimination des PCB au Canada. Il en va de même pour certaines régions des États-Unis, si l'on veut réduire l'entrée des PCB par la frontière.

17. La plupart des données disponibles ont été recueillies pour d'autres raisons que l'établissement d'un dossier général sur la contamination par les PCB au Canada: c'est pourquoi elles sont peu pertinentes.

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La collecte et l'interprétation des preuves sur les contaminants

1. Il est prioritaire de retracer l'origine des toxiques quand on en décèle l'entrée dans l'environnement en quantités notables.

2. Il est prioritaire de mieux planifier et mieux coordonner la recherche sur les toxiques présents dans l'environnement, ainsi que leur contrôle.

3. Il est prioritaire que le Ministère puisse établir des modèles approchés de la pollution.

MONS 053671

RECOMMANDATIONS

Collecte de renseignements

1. On devrait appliquer la Loi sur les contaminants de l'environnement pour obtenir des renseignements de personnes engagées dans des activités commerciales, ou industrielles et utilisant à cette fin des PCB. (V. Partie 9.1.).

2. Une demande de renseignements détaillés sur les quantités utilisées ou transformées devrait être envoyée à tous ceux qui se disent associés à l'utilisation de PCB (V. Partie 9.2.).

3. Par échantillonnages et analyses, on devrait étudier la possibilité que des dibenzofurannes chlorés aient été produits et soient maintenant utilisés au Canada comme fluides caloporteurs (V. Partie 9.2.).

4. On devrait réaliser des études sur les effets cancérigènes des PCB, ou sur leurs effets sur le reproduction, notamment s'il s'agit de substances dont l'emploi est destiné à se maintenir (V. Partie 9.3.).

5. On devrait éprouver et étudier les effets possibles sur l'environnement des substances de rechange des PCB, avant leur utilisation à grande échelle (V. Partie 9.3.).

6. Le Gouvernement devrait entreprendre d'autres recherches toxicologiques sur les PCB peu chlorés d'importance commerciale, notamment sur les composés précis qui peuvent causer le cancer (V. Partie 9.4.1.).

7. Le Gouvernement devrait entreprendre des études sur l'importance relative des différents modes d'exposition de l'homme, afin d'obtenir une estimation de l'absorption totale de PCB par le biais de la nourriture, de l'air et de l'eau (V. Partie 9.4.2.).

8. Le groupe de travail sur l'hygiène professionnelle du Sous-comité fédéral-provincial sur l'hygiène du milieu devrait mettre sur pied et coordonner un programme de surveillance et des études épidémiologiques appropriées des travailleurs professionnellement exposés aux PCB (V. Partie 9.4.2.).

9. Le Gouvernement devrait entreprendre des études épidémiologiques des personnes dont la nourriture est fortement contaminée en PCB (V. Partie 9.4.2.).

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10. Le ministère de l'Environnement devrait envisager l'élaboration de programmes de contrôle et d'expériences en vue de l'établissement de modèles mathématiques des matières toxiques. À cet égard, il est prioritaire de s'adonner à la recherche sur les processus naturels fondamentaux et d'en faire la description mathématique (V. Partie 9.4.3.).

11. Lorsqu'un composé chimique est identifié comme étant un contaminant de l'environnement pouvant être toxique, un comité devrait être mis sur pied pour planifier et coordonner les mesures à mettre en oeuvre, à l'échelle nationale, en ce qui concerne le contrôle, la recherche et la lutte par l'intermédiaire de la réglementation (V. Partie 9.4.3.).

12. Le gouvernement fédéral devrait s'attaquer aux points suivants, en recherche et développement sur les PCB (V. Partie 9.4.3.1.):

1. Contrôler et surveiller
   i) les rejets de PCB
      a) dans les effluents et dans l'atmosphère (gaz de cheminées, eaux usées, lessivage des dépôts d'ordure, etc.) et
      b) par les bateaux et avions étrangers, et
   ii) la présence des PCB dans le milieu ambiant.
2. Rechercher les sources des PCB rejetés dans les égoûts urbains.
3. Faire une étude plus poussée de chaque PCB signalé dans tous les tissus et substrats analysés afin de vérifier s'il est vrai que les biphényles peu chlorés (jusqu'à 4 atomes de chlore par molécule) sont relativement peu rémanents.
4. Mettre au point des méthodes analytiques quantitatives et qualitatives applicables aux divers dibenzofurannes chlorés présents dans les PCB.
5. Déterminer si les dibenzofurannes sont produits dans les transformateurs en service.

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6. Déterminer le rôle relatif des PCB vaporisés par rapport aux PCB particulaires, dans le transport atmosphérique, l'accent devant porter sur les émissions des incinérateurs.
7. Évaluer le rôle de l'atmosphère comme voie de transport des PCB, par analyse d'échantillons d'air, d'eau de pluie, de neige, afin de déterminer l'évolution qui se dessine à l'échelle géographique et temporelle.
8. Étudier l'importance relative du phénomène de la vaporisation comme mode d'épuration d'un milieu donné et comme source de contamination de l'atmosphère par les PCB et comme source secondaire de l'apport des PCB dans l'eau et les sols.
9. Dégager l'importance des sources locales de PCB, par rapport à celle des sources diffuses.
10. Faire des recherches afin de se documenter sur les répercussions des PCB sur les populations de poissons sauvages notamment dans les Grands lacs et dans le bassin de la rivière Saint-Jean.
11. Réunir des renseignements brefs de même nature, pour ce qui est des sources des PCB dans l'environnement, dans d'autres parties du pays, sous forme de rapports régionaux sur la question des PCB.
12. Contrôler les sources de PCB dans l'Arctique, et évaluer la possibilité de récupérer les PCB résiduaires en ces régions notamment dans les établissements humains et les bases militaires.

13. Le gouvernement fédéral devrait entreprendre les projets suivants (V. Partie 9.4.3.2.).

1. Envisager le choix d'organismes et de substrats de contrôle en vue de connaître par l'échantillonnage répétitif l'évolution de la contamination, à l'échelle géographique et temporelle. En rapport avec cela, établir une "banque" de tissus et de substrats (V. Partie 7.4.2.).

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2. Créer une base de données obtenues au Canada et aux États-Unis par le contrôle des contaminants de l'environnement (V. Partie 7.4.2.).
3. Créer un centre canadien des étalons d'analyse des contaminants de l'environnement.
4. S'assurer que le ministère puisse établir des modèles de la pollution des différents écosystèmes (V. Partie 7.4.2.).



MONS 053675

Lutte contre les PCB

1. Tous les endroits où sont stockés, transformés ou utilisés les PCB en vue d'une fabrication quelconque, comme la production de condensateurs ou de transformateurs, devraient être inspectés, pour déterminer s'il y a possibilité d'échappement de PCB dans l'eau (V. Partie II.4.2.1.).

2. L'élimination des déchets produits dans les endroits évoqués en (1) et dans tous les autres où peuvent être produits des déchets contenant des PCB devrait être inspectée. Ces endroits comprennent entre autres ceux où l'on éprouve les pyralènes (askarels) en PCB et où ont lieu la mise en service, la réparation ou la rénovation du matériel. Comme dans (1), la priorité est de découvrir si les PCB pénètrent dans les eaux usées. Il s'agit aussi de déterminer comment les huiles résiduaires de transformateurs et autres PCB liquides sont éliminés (V. Partie II.4.2.1.).

3. L'élimination du matériel électrique inutilisable qui contient des PCB est source d'inquiétude et devrait être étudiée afin de déterminer comment elle est actuellement réalisée (V. Partie II.4.2.1.). Il faudra régir de la façon la plus stricte possible l'élimination des huiles usées de transformateur pendant un demi-siècle après que les pyralènes seront tombées en désuétude (V. Partie II.4.2.2.)

4. L'élimination graduelle des PCB devrait commencer par les emplois suivants qui en sont faits:

- Préparation de moules ou de formes utilisés en microfusion
- Comme matériel d'appoint dans les dispositifs d'échange de chaleur
- Comme matériel d'appoint dans les transformateurs conçus pour fonctionner avec des fluides à base d'huile minérale.

Cette élimination devrait aussi s'appliquer à tout biphényle chloré comportant plus de deux atomes de chlore par molécule (V. Partie II.4.2.2.).

5. Un comité consultatif devrait être créé pour recommander les changements nécessaires dans la conception du matériel électrique ou dans les codes d'éthique reliés à la sécurité, dans l'industrie de la construction et chez les fabricants, avant d'interdire l'emploi de PCB dans les transformateurs (V. Partie II.4.2.2.)

6. La réglementation de l'emploi des PCB dans les condensateurs devrait passer par celle de la composition des produits (V. Partie 11.4.2.2.).

7. On devrait adopter un règlement, aux termes de l'article 18 de la Loi sur les contaminants de l'environnement afin de s'assurer que les fluides diélectriques des condensateurs contenant plus de biphényles fortement chlorés qu'on en trouve dans l'Aroclor 1016+ n'entreront pas dans la fabrication de condensateurs ni ne seront importés au Canada, en vrac ou dans des produits finis (Partie 11.4.2.3.).

+L'Aroclor 1016 est le nom commercial d'un PCB peu chloré.

8. Au départ, les règlements devraient restreindre l'emploi des PCB dans les nouveaux produits aux huiles diélectriques. L'emploi de PCB comme produit d'appoint dans le matériel électrique devrait être permis là où les exigences de la conception de ce matériel permettent cet emploi (V. Partie 11.5.1.1.).

9. On devrait régir l'emploi des PCB par un règlement adopté sous le régime de la Loi, qui en prescrirait les types d'usage et la qualité (V. Partie 11.5.1.2.).

10. On recommande d'entreprendre l'analyse des produits afin d'identifier ceux qui contiennent des PCB. Cette étude devrait porter sur des produits reconnus pour contenir des PCB et d'autres substances (V. Partie 11.5.2.).

11. Tous les gouvernements provinciaux devraient être incités à prendre des mesures visant à empêcher le rejet de PCB dans l'environnement (V. Partie 11.5.3.).

12. On devrait délivrer un permis à ceux qui sont appelés à l'entretien des transformateurs et des condensateurs contenant des PCB. (V. Partie 11.6.3.).

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13. Le gouvernement fédéral devrait prendre des mesures visant à interdire l'addition de PCB à des effluents ou à des gaz d'émission, à interdire l'élimination de déchets industriels contenant des PCB dans des décharges ou des dépotoirs ordinaires, et à interdire l'élimination des PCB dans des incinérateurs ou des installations de brûlage fonctionnant dans des mauvaises conditions. À cet égard, il faudrait contrôler l'introduction par le biais des dépotoirs, des incinérateurs, des eaux usées, traitées ou non, des PCB dans l'environnement. Quand on aura localisé des sources importantes de PCB, on verra à en déterminer la provenance exacte, et les mesures permettant d'en éliminer la cause, si possible (V. Partie 11.5.3.).

14. On devrait envisager la possibilité de régir les importations des PCB et des produits en contenant, en portant leur nom sur la liste des articles faisant l'objet de droit de douanes et accises. À cette fin, le nom des différents PCB devrait renvoyer à leurs noms commerciaux et triviaux. On devrait veiller particulièrement à régir l'importation des PCB utilisés dans les résines et cires pour microfusion (V. Partie 11.6.).

15. Le groupe d'étude recommande la mise en vigueur d'un système uniforme d'étiquettage des PCB et appuie en ce sens les efforts de l'Association canadienne des fabricants de matériel électrique (CEMA).

16. Le groupe d'étude recommande l'abandon (graduel) de l'emploi de tous les PCB très rémanents.

MONS 053678

BACKGROUND TO THE REGULATION OF PCB IN CANADA

Report of the Task Force on PCB
to
The Joint Department of Environment and National Health and Welfare
Committee on Environmental Contaminants

MONS 053679

Environment Canada / Environnement Canada

Environmental Protection / Protection de l'Environnement

Ottawa, Ontario
K1A 0H3

April 9, 1976

Dr. J.E. Brydon,
Chairman, DOE/NHW Committee
on Environmental Contaminants,
Environmental Contaminants Control Branch,
Environmental Protection Service,
Environment Canada,
Ottawa, Ontario,
K1A 0H3

Dear Dr. Brydon:

Letter of transmittal

In August of 1975 you set up a Task Force on PCBs to examine the OECD decision, document the quantities of PCB involved in Canada, the levels in different ecosystems and the routes by which PCBs are entering the environment. Finally, you asked the Task Force to recommend what kind of information was required and what controls should be prescribed by regulation under the Environmental Contaminants Act. I have much pleasure in sending you the completed report of the Task Force.

Since the Task Force was set up there has been a renewed interest in PCBs. In September, the media questioned the advisability of eating Coho Salmon from Lake Ontario. In November, Health and Welfare Canada set a temporary guideline of 2 parts per million for fish and in the same month the EPA held a conference in Chicago to highlight the PCB problem. In December, the Environmental Contaminants Act was given Royal Assent by the Governor-General. In March 1976, the International Joint Commission recommended the early and continuing discussions on controls, sale and disposal of PCBs, since PCBs accumulate in water and are a cause of concern because of the human health implications and possible adverse effects on fish. The setting up of the Task Force was therefore most timely.

The Task Force is unanimous in recommending that there is a need for an improved data base for environmental contaminants and that this can be achieved by setting up another Task Force to consider the design of monitoring and experimentation in relation to the information required for control of chemicals under the Act. The Task Force is also unanimous in recommending controls on PCBs.

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One of the recommendations in the report is that all use of persistent PCBs should be phased out. This is qualified to indicate that the phasing out is intended to follow the availability of practicable alternatives for the electrical equipment industry.

Because the report sets precedents, this recommendation is tantamount to a recommendation that no synthetic chemical shall be considered acceptable unless it has been demonstrated by reliable experimental tests not to possess the combination of properties that has led to the PCB problem.

The problem has arisen because PCBs are persistent in the environment, capable of being dispersed in the environment at the molecular level, bioaccumulative, and biologically active. The first two of these four factors can be securely guarded against by testing. Laboratory tests for bioaccumulation and biological activity may be less definitive because not all organisms or biochemical processes can be, in practice, studied. One of the prime purposes of the Environmental Contaminants Act is to bring about increased testing of chemical products to assess their acceptability for release into the environment. The recommendation for phase out of persistent PCBs, if accepted, will be the precedent for the assessment of all chemical compounds that are similarly persistent in the environment.

I would like to acknowledge the work and cooperation of all the members of the Task Force, and particularly Dr. Maurice Millson for his role in the development of the recommendations concerning controls.

Yours sincerely,

Michael Gilbertson.

Michael Gilbertson,
Leader,
Task Force on PCB.

MONS 053681

TERMS OF REFERENCE

The Task Force was established by the Joint NH&W/DOE Committee on Environmental Contaminants and was given the following terms of reference:

1. To examine the restrictions on the use of PCBs as outlined in the OECD Council decision of February 13, 1973 in order to determine their efficacy as Canadian regulations and whether alternative restrictions are required under the Act;
2. To examine the existing available information, obtained informally and voluntarily, on the amounts of PCBs imported, used, recycled, exported and disposed of, on the amounts used in various commercial activities.
3. To examine existing information on levels of PCBs in various ecosystems in Canada in order to determine the source and mode of entry of PCBs into various sectors of the environment; and on the basis of these examinations and taking into consideration such other observations as the Task Force deems relevant,
4. To make recommendations:
   (a) on the information which should be sought under the mandatory disclosure provisions of Section 4 of the Act, and on the information which should be provided through further research by the government.
   (b) on measures that are desirable for the control of the uses of PCBs and products containing PCBs and for the control of processing, manufacturing and disposal practices to prevent the release of PCBs to the environment, including specific regulations under the Act and restrictions which could be imposed by other jurisdictions.

MONS 053682

TASK FORCE MEMBERSHIP.

The Task Force comprised the following technical experts and scientists from e number of Federal Agencies and from deoartments of the Government of the Province of Ontario.

Mr. R.A. Abbott	Ontario Ministry of Environment	Toronto
Dr. J.E. Brydon	Environment Canada	Ottawa
Mr. P.S. Chamut	Environment Canada	Ottawa
Mr. L. Dwyer	Environment Canada	Ottawa
Dr. R. Frank	Ontario Ministry of Agriculture	Guelph
Mr. M. Gilbertson (Leader)	Environment Canada	Ottawa
Dr. D.L. Grant	Health and Welfare Canada	Ottawa
Dr. D.H. Harding	Ontario Ministry of Health	Toronto
Dr. K.L.E. Kaiser	Environment Canada	Burlington
Mr. T.D. Leah	Environment Canada	Burlington
Mr. P. Marsh	Environment Canada	Ottawa
Dr. M.F. Millson	Environment Canada	Ottawa
Dr. D.B. Peakall	Environment Canada	Ottawa
Dr. J.R. Roberts	National Research Council	Ottawa
Dr. G.S. Wiberg	Health and Welfare Canada	Ottawa
Mr. D.J. Williams	Environment Canada	Burlington

MONS 053683

CONCLUSIONS

Conclusions concerning the available evidence

1. PCBs are ubiquitous persistent pollutants (Section 7.1.).

2. Human adipose tissues collected in Canada had levels of 1 - 2 mg/kg of PCB residue. Humans are exposed to PCB from the environment. (Section 7.1.6.).

3. Significant data on human exposure is only available for food; a little information is also available on levels of PCB in air and potable water.

4. The average Canadian dietary intake of PCBs is low, but it is highest in these persons who consume significant quantities of freshwater fish from the Great Lakes and St. Lawrence River. Data on dietary intake of PCB in this critical group was not available.

5. PCBs are biologically active substances which are of toxicological significance to man (Section 1.).

6. All PCBs are of toxicological significance but the higher chlorinated biphenyls are much more persistent and are thus of greater concern from the standpoint of exposure. The lower chlorinated biphenyls (2, 3 and 4 chlorine atoms per molecule) have seldom been identified or reported in environmental samples except close to the source. An exception to this is in the studies on Great Lakes Herring Gulls, which contain about 1% tri and 10% tetrachlorobiphenyl (Section 7.3.2.). Chlorinated dibenzofurans, as components or derivatives of PCB, may be of toxicological significance in the Canadian environment (Section 7.3.6.1.).

7. PCBs are being liberated into water (Section 7.2.1.), air (Section 7.2.5.) and soil (Section 7.2.3.) from sewage treatment plants (Section 7.2.1.), solid waste disposal sites (Section 7.2.2.) and incinerators (Section 7.2.4.). The identified pattern of PCB contamination appears to correlate with the relative industrialisatic

8. The Great Lakes and associated regions are the most contaminated areas in Canada so far identified (Section 7.1.).

9. The present sources to the Great Lakes are from sewage treatment plants (Section 7.2.1.1.), industries, (Section 7.2.1.2.), incinerators (Section 7.2.4.), the atmosphere (Section 7.2.5.), and tributaries (Section 7.2.6.).

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10. It is uncertain what proportion of the present contamination of the Great Lakes biota is due to ongoing or to past disposal practices (Section 7.2.7.3.2.)

11. PCB residue levels in species of fish and shellfish from the Atlantic are higher than those from the Pacific. (Section 7.1.2.2.).

12. Atmospheric translocation of PCB may be the primary route of contamination of the Prairies (Section 7.1.4.) and the Arctic (Section 7.1.3.) except for contamination from possible gross discharges to water.

13. The Canadian environmental data do not show a discernible temporal trend since the implementation of the voluntary ban. However, the period of time since the ban may be too short (4 years) for a trend to have become evident (Section 7.3.1.) and the adequacy of the data for showing trends is doubtful especially because only the more highly chlorinated PCBs have been measured.

14. PCBs have contributed to reproductive problems in ranch mink and in fish-eating birds from the Great Lakes (Section 1.).

15. Accidental introduction of even small quantities of the more persistent PCB into aquatic ecosystems may be of significance both from a toxicological and an economic standpoint.

16. There is a need to control the importation, use and disposal of PCBs in Canada. Effective controls in areas of U.S. jurisdiction are also necessary to reduce entry of PCBs into the boundary environment.

17. Most of the available data was collected for purposes other than to provide an overall documentation of Canadian PCB contamination and is therefore inadequate for this purpose.

Conclusions concerning the Collection and Interpretation of Evidence Concerning Contaminants

1. There is a priority requirement for tracing the origin of toxic pollutants when these are detected entering the environment in significant quantities.

2. There is a priority requirement for better planning and coordination of research and monitoring of toxic environmental pollutants.

3. There is a priority requirement for a departmental capability to model environmental pollutants effectively.

RECOMMENDATIONS

Recommendations Concerning Information

1. The Environmental Contaminants Act should be used to obtain notification from persons who may be engaged in commercial, manufacturing or processing activity involving PCBs. (See Section 9.1.).

2. A request for detailed information on the quantities of material used or processed should be sent to all those identifying themselves as presently involved with PCBs. (See Section 9.2.).

3. The possibility that chlorinated dibenzofurans have been produced and now exist in heat transfer systems in Canada should be investigated by sampling and analysis. (See Section 9.2.).

4. Studies on carcinogenic and reproductive effects should be performed with those types of PCBs likely to continue in use. (See Section 9.3.).

5. PCB-replacements should be tested and evaluated for their possible environmental effects prior to their introduction into widespread use. (See Section 9.3.).

6. The Government should initiate further toxicological investigations for the commercially important lower chlorinated PCB. Particular attention should be given to the identification of the specific components which may cause cancer. (See Section 9.4.1.).

7. The Government should initiate studies into the relative importance of the different routes of human exposure and to obtain estimates of the total intake of PCB from food, air and water. (See Section 9.4.2.).

8. The Working Group on Occupational Health of the Federal-Provincial Subcommittee on Environmental Health should initiate and coordinate a program of surveillance and appropriate epidemiological studies of workers industrially exposed to PCBs. (See Section 9.4.2.).

9. The Government should initiate epidemiological studies of people with high dietary exposures to PCB. (See Section 9.4.2.).

10. The Department of the Environment should consider the design of monitoring and experimental programs for mathematical modelling of toxic materials. In this regard there is a priority requirement for research into fundamental environmental processes, including their mathematical descriptions. (See Section 9.4.3.).

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11. Where a chemical compound is identified as an environmental contaminant of possible toxicological importance a national committee should be convened to plan and coordinate the national response with respect to monitoring, research and control by legislation. (See Section 9.4.3.).

12. The Federal Government should initiate the following research and development on PCBs: (See Section 9.4.3.1.).

1. Monitoring and surveillance of
   i) the amounts of PCBs discharged
      a) in effluents and emissions (stack gases, wastewaters, landfill leachate, etc.), and
      b) from foreign ships and aircraft and //
   ii) levels of PCB in the ambient media.
2. Investigation of the sources of PCB discharged to municipal sewers.
3. There is a need for improved reporting of individual PCBs in all organisms and materials analysed to verify the observation that the lower chlorinated biphenyls (1, 2, 3 and 4 chlorines per molecule) are relatively non-persistent in the environment.
4. Development of analytical means to identify and measure the various chlorinated dibenzofurans which contaminate PCB.
5. Determine whether dibenzofurans are produced in transformers during use.
6. Determination of the relative role of vapour versus particle - borne PCB in aerial transport with particular emphasis on incinerator emissions.
7. Assessment of the atmosphere as a transport route through analysis of air, rain and snow samples to show geographic and temporal trends.
8. Investigations into the relative importance of the vaporisation phenomenon as a route out of an environment and as a source of PCB to the atmosphere and as a secondary source of PCB precipitation to the terrestrial and aquatic environments.
9. Clarification of the importance of localised as opposed to generalised sources of PCB.
10. Investigations to document the possible effects of PCB on wild fish populations, particularly in the Great Lakes and the St. John River system.

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11. Compilation of similar summary information with respect to sources of PCB into the environment for other parts of the country as regional PCB reports.

12. Monitoring sources of PCB in the Arctic and assessing the feasibility of recovering waste PCB from the Arctic regions particularly from settlements and military bases.

13. The Federal Government should initiate the following institutional requirements: (See Section 9.4.3.2.).

1. Consideration of the selection of monitor organisms and materials suitable for routine sampling to document geographic and temporal trends in contamination. In relation to this there is a further requirement for a tissue and materials bank. (See Section 7.4.2.).

2. Development of a repository for data on environmental contaminants from Canadian and American monitoring. (See Section 7.4.2.).

3. Development of a central Canadian repository of chemical standards for analysis of environmental contaminants.

4. Development of a departmental capability in modelling environmental pollutants in different ecosystems. (See Section 7.4.2.).

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Recommendations concerning controls

1. All premises where PCBs are stored, processed or used in a manufacturing operation such as production of capacitors or transformers, should be inspected to determine whether any process is likely to result in transfer of PCB into water. (See Section 11.4.2.1.).

2. The disposal of wastes from all premises contemplated in (1) and from all other premises where wastes that contain PCB are likely to be generated should be inspected. This should include premises where PCB askarels are tested and where service, repair, or renovation of equipment is performed. As in (1), inspection should give priority to finding out whether PCB enters wastewaters. High priority also attaches to determining how waste transformer oil and other liquid PCBs are disposed of. (See Section 11.4.2.1.).

3. The disposal of unserviceable electrical equipment that contains PCB is a matter of concern and should be investigated to determine present practices (See Section 11.4.2.1.). The strictest control of disposal of used transformer oils will be necessary for half a century after PCB-askarels are no longer used for initial fillings. (See Section 11.4.2.2.).

4. The stepwise elimination of uses should start with the following known uses:

- preparation of molds or forms in the investment casting process
- make-up in heat transfer systems
- make-up in electrical transformers designed to operate on fluids based on mineral oil

and should apply to any chlorobiphenyl containing more than two atoms of chlorine per molecule. (See Section 11.4.2.2.).

5. An Advisory Committee should be formed to recommend what changes in design of electrical equipment or in codes of practice related to safety within the building construction and manufacturing industries will be necessary before the fluids in new transformers could be restricted to non-PCB types. (See Section 11.4.2.2.).

6. Control action to affect the use of PCB in capacitors should be through control of the composition of the product. (See Section 11.4.2.2.).

7. A regulation should be made under Section 18 of the Environmental Contaminants Act to ensure that capacitor dielectric fluid containing more higher chlorinated biphenyls than does Aroclor* 1016 shall not be used in the manufacture of capacitors nor enter Canada either in bulk or in manufactured goods. (Section 11.4.2.3.).

* Aroclor 1016 is the trade name of a lower chlorinated commercial PCB.

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8. Initial regulations should restrict use of PCBs in new goods to dielectric insulating oils. The use of PCB as make-up in the servicing of electrical equipment should be permitted where the design requirements of that equipment warrant its use. (See Section 11.5.1.1.).

9. The form of the control of PCB should be by regulation under the Act prescribing uses and quality of the product. (See Section 11.5.1.2.).

10. It is recommended that an analytical survey of products should be initiated to identify products which contain PCBs. The survey should include products known to contain PCB and other products. (See Section 11.5.2.).

11. All the Provincial Governments should be urged to take steps to prevent release of PCBs into the environment. (See Section 11.5.3.).

12. There is a requirement for licensing of those involved in servicing PCB-containing transformers and capacitors. (See Section 11.5.3.).

13. The Federal Government should take action, to prohibit the addition of PCB to any aqueous effluent or gaseous emission, to prohibit the disposal of industrial wastes containing PCB in ordinary dumps or landfill operations, and to prohibit the disposal of PCBs into combustion devices that operate under inadequate conditions. In this regard there is a requirement for monitoring the quantities of PCB entering the environment at dumps, incinerators and sewage effluents and influents. Where significant sources of PCB are located, more work should be undertaken to find the origin, and remedial action should be taken to remove the cause if this is feasible. (See Section 11.5.3.).

14. The possibility of controlling the importation of PCB and products containing PCB by adding these materials to the schedule of items on the tariff of the Customs and Excise should be explored. For this purpose, PCBs should be cross-referenced to the different trade names and common names. Particular attention should be given to the control of importation of PCB in investment casting resins and waxes. (See Section 11.6.).

15. The Task Force recommends the introduction of a uniform labelling system for PCB, and supports the efforts of the Canadian Electrical Manufacturers Association (CEMA) in this regard.

16. The Task Force recommends that all uses of those PCBs that are highly persistent in the environment be phased out.

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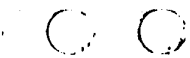



1. INTRODUCTION

   1.1. Background to the problem

   1.2. OECD action

   1.3. The Canadian legislative response and appointment of Task Force on PCB

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consider the design of monitoring and experimental programs for modelling of toxic materials.

The concept of the critical pathway, developed in radiation protection, might usefully be systematically applied to the environmental contaminants field. This might enable the Department to anticipate environmental situations rather than having to respond post facto.

Where a chemical compound is identified as an environmental contaminant of possible toxicological importance, the Task Force recommends that a national committee should be convened to plan and coordinate the national response with respect to monitoring, research, and control by legislation (Section 7.4.2.).

9.4.3.1. Research and development on PCBs

More specifically, *the Task Force identifies the following research and development on PCBs which the Federal Government should initiate.*

1. Monitoring and surveillance of
   i) the amounts of PCBs discharged
      a) in effluents and emissions (stack gases, wastewaters, landfill leachate, etc), and
      b) from foreign ships and aircraft and
   ii) levels of PCB in the ambient media.
2. Investigation of the sources of PCB discharged to municipal sewers.
3. Development of analytical methodology for the separation and quantitation of the lower chlorinated biphenyls (especially the tetrachloro-) for improved reporting of individual PCBs in all organisms and materials analysed, to verify the observation that the lower chlorinated biphenyls (1, 2, 3,and 4 chlorines per molecule) are relatively non-persistent in the environment. Little progress will be possible in this extremely important sphere until adequate analytical methodology has been developed.

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4. Development of analytical means to identify and measure the various chlorinated dibenzofurans which contaminate PCB and to survey suitable organisms for dibenzofurans.
5. Investigations to determine whether dibenzofurans are produced in transformers during use.
6. Determination of the relative role of vapour versus particle - borne PCB in aerial transport with particular emphasis on incinerator emissions.
7. Assessment of the atmosphere as a transport route through analysis of air, rain and snow samples to show geographic and temporal trends.
8. Investigations into the relative importance of the vapourisation phenomenon as a route out of an environment and as a source of PCB to the atmosphere and as a secondary source of PCB precipitation to the terrestrial and aquatic environments.
9. Clarification of the importance of localised as opposed to generalised sources of PCB.
10. Investigations to document the possible effects of PCB on wild fish populations, particularly in the Great Lakes and the St. John River system.
11. Compilation of summary information for other parts of the country as regional PCB reports on use and release of PCB to the environment.
12. Monitor sources of PCB in the Arctic and assess the feasibility of recovering waste PCB from the Arctic regions particularly from settlements and military bases.

9.4.3.2. Institutional requirements concerning contaminants

The Task Force identifies institutional requirements concerning contaminants generally, which should be initiated by the Federal Government.

1. Consideration of the selection of monitor organisms and materials suitable for routine sampling to document geographic and temporal trends in contamination. In relation to this there is a further requirement for a tissue and materials bank (Section 7.4.2.).

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2. Development of a repository for data on environmental contaminants from Canadian and American monitoring (Section 7.4.2.).
3. Develop a central Canadian repository of chemical standards for analysis of environmental contaminants.
4. Development of a departmental capability in modelling environmental pollutants in different ecosystems (Section 7.4.2.).

10. FOURTH TERM OF REFERENCE (PART B). RECOMMENDATIONS CONCERNING CONTROLS BY REGULATION

11. RESPONSE TO THE FOURTH TERM OF REFERENCE (PART B)

11.1. Rationale for developing recommendations on regulatory actions

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11.1.2.1. Restricting the purposes for which PCBs may be used

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11.5.3. Control of processing, manufacturing and disposal practices

11.6. Recommendations concerning regulations which could be imposed by Federal jurisdictions

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10. FOURTH TERM OF REFERENCE (PART B) CONCERNING CONTROLS BY REGULATION

"To make recommendations: b) on measures that are desirable for the control of the uses of PCBs and products containing PCBs and for the control of processing, manufacturing and disposal practices to prevent the release of PCBs to the environment, including specific regulations under the Act and restrictions which could be imposed by other jurisdictions".

11. RESPONSE TO THE FOURTH TERM OF REFERENCE (PART B)

11.1. Rationale for developing recommendations on regulatory actions

In developing regulations under the Environmental Contaminants Act for the control of PCB, we are setting a precedent. We have chosen, therefore, to follow a systematic approach that can serve as a guide for future deliberations as each new candidate substance for control is studied.

We can follow a systematic approach by considering in turn five major aspects:

A. What is the essential nature of the problem (Section 11.1.1.)

B. What are the ways in which the severity of the problem could be reduced (Section 11.1.2.)

C. How could these possibilities be utilised in formulating practical regulations (Section 11.2.1.)

D. What beneficial results could be expected to flow from each regulatory restriction (Section 11.2.2.)

E. What legislative authorities could make possible the introduction of these restrictions (Section 11.3.)

11.1.1. The Nature of the Problem

We are concerned with dangers posed to living things by the presence of PCBs in their environment. These dangers arise from a combination of two factors: the inherent toxicity of PCBs to particular species, and the exposure of those species to PCBs. Since we cannot control the toxicity of a given chemical compound, we must look to formulate controls that will reduce exposures. In practice we measure exposure to PCBs in two different ways. For man, we measure exposure in terms of his intake. For wildlife, we measure not the intake but the PCBs in their tissues - which tells us the constant exposure of their tissues, without need to quantify their intake or output.

Because the PCB residue measurements cannot distinguish between low values due to absence of particular groups of PCB homologs from an organism's environment, and low values due to metabolism or excretion by the organism, the phrase "reducing the exposure" comes to mean, in practice, reducing the residual content of PCBs in organisms, sediments, etc. The Task Force is not charged with proposing methods to reduce directly man's intake of PCBs but a major consideration for the Task Force is the need to reduce levels of PCBs in those sectors of the environment where the presence of PCBs has led to human exposure and to the reduced economic exploitation of fish.

11.1.2. The ways in which exposures could be reduced

There are three ways:

i) restricting the purposes for which PCBs may be used

ii) restricting losses into the environment from permitted uses

iii) restricting the proportion of environmentally persistent PCBs in material lost into the environment

These three choices are in no way mutually exclusive; they can be additive in effect. Taking each in turn:

11.1.2.1. Restricting the purposes for which PCBs may be used

There are two avenues which might be used:

a) Total prohibition. If this were the chosen route then eventually, after existing PCBs had served their time and suffered disposal, the problem from a regulatory point of view would be terminated. This appears to be the choice in Japan. We fear that North American society, having been built in the PCB era, is so complex in its inter-relationships that if we instituted a total ban we would demonstrate the truth of Barry Commoner's ecology statement: "Everything is connected to everything else", and at the same time demonstrate that chaos is not the solution to pollution.

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b) Restrict PCBs to the uses that offer the greatest benefits compared to the concomitant risk of the PCBs being released into the environment from those particular uses.

This was the basis for Monsanto's selective sales policy and for the corresponding section of the OECD decision concerning transformers and large capacitors. Looking back from early 1976, those choices still seem justified if one chooses to follow the partial ban on uses.

The OECD also included continued acceptance of PCBs in heat transfer fluid and some hydraulic fluid. These uses are of short service life with relatively high risk of loss, and that proved alternatives without PCBs have long been available. There appears to be no good reason why these uses of PCBs should be permitted in Canada.

There is a possible justification for permitting PCBs to be used as chemical intermediates in reactions where they are converted to some other chemical. Probably dichlorobiphenyl would be the only homolog of interest for these purposes. This leads us directly into the second category of ways for reducing exposures to PCBs.

11.1.2.2. The restriction of losses into the environment from permitted uses

This category covers the traditional anti-pollution field: discharge of wastewater effluents or stack-gas emissions, and disposal of solid wastes.

Industrial wastewaters from plants utilising PCBs for permitted uses should be monitored and any identified route of PCB entry into these wastewaters should be eliminated. It is not clear that setting a concentration standard for PCBs in industrial wastewater is a meaningful exercise in terms of reducing discharge of PCBs into the environment. It is very clear that the highest attainable standards of plant housekeeping must be maintained to prevent any entry of PCBs into wastewaters.

Stack-gas emissions: we lack data on this route of loss, and do not know if losses from manufacturing plants are at all significant. We know a little about PCBs near incinerators; we suspect that this could be a significant source of PCBs. Whether modifications to raise the operating temperatures of waste incinerators will partly eliminate the problem we do not know. Certainly disposal of manufacturing wastes known to contain PCBs should not be permitted in incinerators other than those known to achieve destruction of PCB. Specially designed units are capable of destroying PCBs by incineration if the PCBs are fed to the unit in an oil feed. Preliminary full-scale experiments suggest that chlorinated organic wastes, in liquid form, can be destroyed and simultaneously serve a valuable purpose in the manufacture of special grades of Portland cement.

Disposal of solid wastes: we can do little about the unidentified PCBs in the products already marketed that will inevitably be disposed of in the future. However, a few products containing PCBs from past manufacture are still in use in identifiable situations and their disposal could be subject to new regulations.

If uses of PCBs are legally restricted, we would expect industrial so-called "solid wastes" containing PCBs to be limited to

used transformer oil

used power capacitors

wastes from electrical equipment manufacturers.

All these could readily be segregated for processing in ways known to recover or destroy PCBs.

11.1.2.3. Restricting the proportion of environmentally persistent PCBs in material lost into the environment

This was the basis for Monsanto's revision of its PCB product line in Canada: Aroclor 1254 for transformers, eliminating 1260 and Aroclor 1016 for

capacitors eliminating 1242. It should be noted that changes of this kind may result in the replacement of high residues of a less toxic component by lower levels of one more toxic.

11.2. Regulatory Strategies

11.2.1. Possibilities

It is instructive to formulate alternative regulatory packages, listed in order of increasing severity.

1. Prohibition of all uses other than in transformers and capacitors, in research, and in chemical intermediates; coupled with controls on disposal of industrial sizes of electrical equipment and on manufacturing wastes.
2. As in 1, with an added restriction on the proportion of higher chlorinated (i.e. more than 4 chlorine atoms per molecule) PCBs in capacitors.
3. As in 2, with a further restriction on the proportion of medium chlorinated (more than 3 chlorine atoms per molecule) PCBs in small (disposable) capacitors.
4. Prohibition of all uses other than transformers, large capacitors and research, (a) without or (b) with a restriction on higher chlorinated PCBs in capacitors; along with controls on disposal.
5. Prohibition of all uses other than in transformers and capacitors, with a restriction on the higher chlorinated PCBs (more than 4 chlorines) for any use, plus controls on disposal. This package could possibly be modified to allow a transformer fluid with less higher chlorinated PCBs than Aroclor 1254 but more than Aroclor 1016. And the alternative regulatory treatments of small and large capacitors could be incorporated.
6. Total prohibition.

Any of the six packages could also include a restriction on the proportion of chlorodibenzofurans in dielectric fluids.

11.2.2. Feasibility and Results

It is instructive to consider what benefits would accrue from each individual control action that might be imposed.

11.2.2.1. Control of losses of PCBs to water and air in manufacturing operations (including use in electric power distribution).

The available data on PCB content of municipal sewage suggest that sewage is a very important source of PCBs entering the Great Lakes, and that the PCBs originate in industrial effluents. Therefore, an effective control on these losses would have almost immediate beneficial effect on levels of PCB residues in sediments or biota; this effect could be of such dimensions as to be of major importance. There are no data on which to base an opinion concerning losses of PCBs into the atmosphere from manufacturing operations or from "breathing" of transformers and capacitors in service. Losses of PCBs from capacitor manufacturing plants would be of the Aroclor 1016 type, which were not detected in the Shannon study of sewage. Losses from transformer operations would be of highly chlorinated Aroclor 1254 type. Losses of PCBs into water or air from operations other than in the electrical equipment industry probably constitute a relatively high fraction (on a unit time basis) of the PCBs employed in these operations.

11.2.2.2. Control of solid wastes from manufacturing operations.

Solid wastes containing PCBs originate in the manufacturing processes for electrical equipment as: drying absorbents (fuller's earth) wetted with PCBs; rags, paper and similar wiping materials wet with PCBs; capacitors that fail tests before shipment.

The present method of disposing of these wastes appears to be by landfill. This will result in a steady increase in the stock of PCBs in a small number of landfill sites for as long as this method is used, and a further result must be leaching of PCBs by water.

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It is commonly argued that percolating water in landfill will not leach appreciable quantities of PCBs from the fuller's earth filtration medium, but it is difficult to believe that leaching will not eventually remove the PCBs from landfill. Simple extraction systems should be developed so that PCBs in manufacturing wastes could be recovered by means such as solvent extraction for later disposal by destructive methods. Disposal of PCB wastes in "scientific landfill" sites that will need perpetual care is the only immediately available alternative. It should not be adjudged fully satisfactory for materials that could be truly destroyed.

11.2.2.3. Control of PCBs in effluents from municipal sewage plants

PCBs in wastewaters or ambient waters are largely associated with particulate matter, and, as has been mentioned earlier, reduction of the suspended solids content of municipal sewage effluents could bring about an immediate major reduction in the quantities of PCBs entering Canada's waterways. For other reasons, the reduction of suspended solids in the effluents has for many years been an objective of sewage treatment plants, and it is not likely that tertiary (polishing) treatment of effluents will become standard on the Ontario side of the Great Lakes in the near future.

11.2.2.4. Control of disposal of unserviceable power capacitors

Power factor correction capacitors are used by electric utilities in their distribution systems. These capacitors are also installed in the internal electric power distribution systems of industrial organisations, where they serve to "correct" the power factor and achieve lower billing from the electricity supplier; most of these units are probably located close to the utility's supply point into the industrial plant. It is, therefore, to be expected that these

capacitors could be identified and segregated from ordinary solid wastes when they have served their useful life (about 10-15 years). If burial in dumps is not acceptable, the proposed action under Section 8(1)(b) of the Environmental Contaminants Act could necessitate recovery of the PCBs from the sealed capacitor for destruction. This control provision would have the effect of removing from landfilled waste a source of future leaching of PCBs. However, the effect would, in general relate only to the quantities of less highly chlorinated PCBs in landfill leachate. At present, special landfill (see the last part of paragraph (ii) above) is the only available alternative to extractive recovery.

11.2.2.5. Control of disposal of waste transformer oil:

A large proportion of the transformer askarel now in use consists of higher chlorinated PCB homologs of the Aroclor 1254 or 1260 types. Any loss of this material into the environment, especially under conditions where it may be transported into waterways, is of critical importance. In the past, used transformer oil, without discrimination as to whether it was of the mineral oil or askarel types, has been used as a dust-laying medium or for furnace-feed. Because the 'average' askarel-filled transformer contains 2500-3500 lbs of persistent PCBs, the disposal of the oil from only one transformer by a route leading into water could add to the receiving water a quantity of PCBs equal to that in all the municipal sewage effluents in Canada in a year. This therefore is a matter of the highest importance. Disposal by deliberate combustion in a special dedicated high temperature incinerator is at present the only acceptable course, though expensive. It if should be shown that PCB-askarels can be used as a source of both chloride and heat in selected kilns in the Portland cement industry, a major obstacle to practical control of these oils will have been overcome. Some difficulty will

arise in educating those responsible for disposal of transformers in non-hazardous locations now containing a proportion of PCBs mixed with the mineral oil that originally constituted their insulating coolant, then it may be necessary, in practice, for the responsible authority (Provincial?) to require that all waste transformer oil be processed by high temperature combustion. For similar reasons, kerosene washings of transformers (from preparation for fault location and service work) should also be included in these controls. Under paragraph 8(2) of the Environmental Contaminants Act any proposed restriction of use of PCB would prohibit "offer for sale or knowingly use" with respect to road oiling, but PCB in mineral oil insulants may be difficult to identify. Under 8(1)(b) any disposal by inadequate combustion devices could be prohibited, but/might be difficult to enforce.
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11.2.2.6. Elimination of PCBs from all industrial uses except transformers and capacitors

The major proportion of the usage of PCBs for purposes other than dielectric or insulating oil in Canada has already been eliminated by Monsanto's actions several years ago. Suspected present uses are in investment casting processes, in heat exchangers, and hot melt adhesives; a more complete picture will be available when notification of involvement with PCBs is required under section 4(1) of the Environmental Contaminants Act. The rationale for choosing to eliminate non-dielectric uses of PCBs, is that these uses entail uncontrollable losses to the environment and that these losses occur at a high rate measured as a proportion of PCBs used versus time. This rationale is still applicable to support the move to eliminate the remainder of these so-called "open-system" uses. It may be advisable to word any regulation in such a way as to apply to use of PCBs for make-up in heat exchangers but not for continued use of

existing fluids. The benefits from introduction of this control would be the elimination of losses into the environment from some manufacturing operations and servicing procedures, and, in the long term, from used products that have been disposed of.

11.2.2.7. Elimination of PCBs from small capacitors

Capacitors other than the power factor correction type are used in many electrical goods, especially those involving fluorescent lighting and motors that start under load. These capacitors contain PCBs in amounts ranging from a few grams up to 500 grams, and they must be regarded as disposable items in so far as it is not feasible to arrange for their segregation from other waste at the end of their service life. The major proportion of small capacitors that are currently disposed of finds its way to landfill in ordinary garbage; it is to be expected that some small capacitors are fed to municipal incinerators or burned in open dumps in proportion to the fraction of municipal garbage so disposed of. Elimination of PCBs from small capacitors would reduce the quantity of PCBs lost to atmosphere in the essentially low temperature incinerators or fires used for garbage disposal. A high proportion of the PCB in capacitors subjected to low-temperature incineration will be carried out of the incinerator and dispersed in the atmosphere. So far as is known, in Canada all the PCB now used in manufacture of capacitors is Aroclor 1016 and consists essentially of homologs containing 4 or fewer chlorine atoms per molecule. Elimination of PCBs from manufacture of small capacitors would result in an immediate reduction in release of lower chlorinated PCBs to the environment in manufacturing wastes and a deferred reduction (after about 10 years) after the service life of the presently manufactured units expires.

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11.2.2.8. Elimination of PCBs containing more than four chlorine atoms per molecule from capacitors

Because this is essentially the step taken by the industry when switching over to use of Aroclor 1016 as the standard capacitor dielectric in 1972, there is no reason to believe that a regulation enforcing this condition would now have any effect on environmental occurrence of PCBs. Such a regulation could, however, ensure that this practice is maintained. A regulation restricting the content of higher chlorinated (>4 Cl) PCBs to a tighter specification than Aroclor 1016 might effect a slight improvement in measured PCB residues after some years. Care in wording a regulation could eliminate the possible legalisation of a dielectric that was composed entirely of tetrachloro biphenyl.

11.2.2.9. Elimination of PCBs containing more than three chlorine atoms per molecule from small capacitors

For reasons made obvious in Section 11.2.2.7, the effect of this move would be largely to eliminate some tetrachlorodiphenyls from manufacturing wastes (with immediate effect) and from losses to atmosphere or leachate (with deferred effect starting after some years' lapse). The presently used dielectric (Aroclor 1016) contains about 20% tetrachlorodiphenyl. (See Table 29).

11.2.2.10. Elimination of PCBs containing more than five chlorine atoms from all uses

This would eliminate the highly persistent PCBs from all uses. The immediate industrial effect would be the revision of design of some types of transformers to accomodate a different insulating oil. Losses of persistent PCBs during transformer filling, transport or service would cease so far as new transformers are concerned. Transformers made up to the effective date of a prohibition (say 1980) would continue to use Aroclor 1254 as fluid for fill and make-up. It is likely that transformers now being put into service will have an average service life

of more than thirty years. Therefore, a prohibition of the kind considered here would largely eliminate the loss of persistent PCBs into the environment after the early decades of the 21st century when the new transformers of the present era have almost all been scrapped. The effect of elimination of Aroclor 1254 from new transformers would eliminate a large fraction of the tetrachlorobiphenyl from the Canadian market. (See Section 11.4.2.2.).

11.2.2.11. Elimination of all PCBs from commerce

It is likely that a prohibition of this kind would have to be worded to allow continued use of PCBs of the Aroclor 1254 type for servicing of existing transformers, and the remarks in Section 11.2.2.10. would apply.

So far as capacitor manufacture and use is concerned, the loss of Aroclor 1016 into the environment from manufacturing plants would cease immediately, and loss from disposal of unserviceable units would cease at about the turn of the century after significant reduction of this loss during the 1990s.

We are not able to estimate the increased danger to the public from fire hazards due to use of more flammable replacements for PCBs in transformers or capacitors, nor the economic costs of revising codes of practice for transformer design and use and building design and zoning. Because the present Aroclor 1016 capacitor fluid contains very little of the homologs presently measured in PCB-residue analysis, no new restrictions on use of this material will change the residues as measured by present methods except in so far as these can be ascribed to the small amount of pentachlorodiphenyl and traces of higher chlorohomologs in Aroclor 1016. It seems probable that a slight change in the specification of Aroclor 1016 could achieve this result if it be desired.

If PCBs are eliminated from commerce for manufacture of new equipment it may be necessary to arrange that they remain available for the production of components that must meet special weight and service characteristics for special applications such as military aircraft.

11.3. Legislative Authorities

In the traditional fields of pollution control, a variety of federal and provincial laws already exist.

The Federal Fisheries Act is used to set industrial effluent control regulations for specific industries whose wastewater discharges contain substances which are deleterious to fish or to man's use of fish. In sectors where no such regulations exist, the general provisions of the Act which prohibit the direct or indirect discharge of such substances into waters frequented by fish, apply. Where substances have not been clearly shown to be deleterious or where small discharges are diffuse, indirect and widespread, there are difficulties in applying this legislation.

The Federal Clean Air Act contains provisions for the direct control of emissions which constitute a significant danger to human health.

The provincial governments have their own individual sets of laws, which parallel the federal legislation in many ways. Where detailed regulation of all aspects of industrial activity is concerned, provincial legislation goes beyond the ambit of federal regulation. While it is within the power of the individual provinces to regulate products within their boundaries they recognize that such regulation is better done at the national level in order to avoid confusion in the industrial sector.

Product oriented regulations are clearly the intent of Sections 8(2) and 8(4) of the Federal Environmental Contaminants Act. By adding classes of substances such as "polychlorinated biphenyls", "chlorinated biphenyls containing more than four chlorine atoms per molecule", or substances such as "tetrachlorobiphenyl" or "pentachlorobiphenyl" and specified chlorodibenzofurans, to the Schedule, it would be possible to formulate product regulations of the type necessary to implement the regulatory packages listed above (Section 11.2.) and the

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selected package recommended below (Section 11.4.).

Section 8.1. of the Environmental Contaminants Act could be used to prohibit the release of PCBs into the environment in the course of commercial, manufacturing or processing activities. If a federal intervention is necessary to control disposal of products containing PCBs or to control losses of PCBs into water or air, and these results cannot be achieved by some other federal agency, the Section 8.1. is available.

11.4. Selection of recommended regulatory package

11.4.1. Rationale

The severity of the problems posed by the presence of PCBs in the environment leaves the Task Force in no doubt that formal controls are necessary in order to ameliorate the situation (Section 7.4.[16]). The inter-relationships between use, entry into the environment, persistence, biological effects, and chemical composition of the various chlorinated biphenyls are very complex. For this reason the Task Force can only make its recommendation of a selected group of specific control measures after consideration of the previous sections of this report as a whole, and after the choice of a strategy that is expected to prove both efficacious and practicable in its application.

The Task Force recommends that all uses of those PCBs that are highly persistent in the environment be phased out. It is not practically feasible to prohibit, with immediate effect, the import or use of all persistent PCBs. In view of the widely different specifications for the present limited range of PCB-based insulating dielectric fluids, it is unlikely that alternative fluids could be made available on a commercial scale for all purposes by a predictable date. It is necessary, therefore, to recommend the adoption of a stepwise procedure for instituting controls. The order in which the steps should be taken is dependent upon factors such as practicability, rapidity of environmental response, and the scale of the danger that will be eliminated.

A major difficulty in devising adequate but not unnecessarily disruptive controls is the dependence of electric

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power distribution systems on equipment designed to use only PCB-based fluids. The availability of these fluids for several decades has resulted in a very great degree of dependence on the performance and reliability of equipment that contains them. This makes it particularly necessary for the environment protection authorities to be satisfied that the restrictions they introduce do indeed answer to dangers that exist or are likely to develop and not to dangers that though hypothetically possible, cannot be demonstrated to exist or to be likely to develop.

Of the three ways in which exposures to PCB could be reduced (11.1.2.), the reduction to the greatest extent practicable of identified sources of entry of PCB into water and atmosphere is likely to be the most efficacious measure in bringing about within the next several years a worthwhile reduction in quantities of PCB entering the environment. (Section 11.1.2.2.).

The second most efficacious tactic for causing relatively rapid decreases in loss of PCB into the environment is the elimination of the few remaining uses of PCB (Section 11.1.2.1.) that can be classified as non-electrical and open-system. Elimination of various dielectric uses requires long lead times but would then give some immediate benefit (11.2.2.7.) (11.2.2.11.).

The third way of reducing exposures to PCB (11.1.2.3.) is the reduction of the proportion of persistent homologs in commercially available PCB. Any major change in the specifications of the available dielectric fluids requires a long lead time for field testing of reliability.

11.4.2. Recommended package

11.4.2.1. Reduction of Losses from identified sources

All the pollution abatement measures mentioned in earlier sections (11.1.2., 11.2.2.1.-5., 11.3.) should be used to the extent that they can contribute to reducing the entry of PCBs in water or the atmosphere. It is

clear that these measures should be studied in relation to each industrial facility where PCBs are used in the manufacture of capacitors or in the filling of transformers. In the relatively few instances where unusually high levels of PCBs are routinely present in the effluent of sewage treatment plants, any process modifications that reduce the suspended solids concentrations in the effluents could have an important effect on the quantity of PCBs entering the aqueous environment.

The sites of identifiable sources of PCBs are likely each to have some unique features and to require a degree of individual treatment. Among the steps that should be taken, the more prominent are listed:

a) *All premises where PCBs are stored, processed or used in a manufacturing operation such as production of capacitors or transformers should be inspected to determine whether any process is likely to result in transfer of PCB into water.*

b) *The method and location of disposal of wastes from all premises contemplated in (a) and from all other premises where wastes that contain PCB are likely to be generated should be inspected. This inspection should include premises where PCB askarels are tested and where service, repair, or renovation of equipment is performed. As in (a), inspection should give priority to finding out whether PCB enters wastewaters.* High priority also attaches to determining how waste transformer oil and other liquid PCBs are disposed of.

c) *The disposal of unserviceable electrical equipment that contains PCB is a matter of concern and should be investigated to determine present practices.* Where recovery of metal (copper) is economically profitable, waste transformer oil and washings must

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be looked after (see b); this may account for the fate of a large fraction of old transformers. Power factor capacitors are at present disposed of in landfill sites. Ontario Hydro is reported to have sent scrap capacitors to a "scientific landfill". If on-going studies show that used PCB liquids can be destroyed in the Portland cement kiln and have, in consequence, an economic value, it may be possible to devise an economically feasible process for recovery of PCBs from large capacitors passing through this recovery process. Such a process must not result in residual solid wastes containing low concentrations of PCBs that are easily mobilised into the environment. Even if newly-developed dielectric fluids should capture the capacitor market, a disposal process involving their recovery and combustion would be highly preferable to disposal in landfill.

11.4.2.2. Elimination of uses of persistent PCBs.

The Task Force recommends that all uses of those PCBs that are highly persistent in the environment be phased out.

a) *The stepwise elimination of uses should start with the following known uses:*

- *preparation of molds or forms in the investment casting process*
- *make-up in heat-transfer systems*
- *make-up in electrical transformers designed to operate on fluids based on mineral-oil*

Each of these uses is either effectively "open-system" with uncontained losses or "closed-system" with little likelihood that used PCB will be effectively collected for destructive disposal. Nor is it likely that PCB used for these purposes will find its way to a disposal site where slow processes of degradation will effectively prevent its release into the open environment. For these reasons, *the elimination of*

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these uses should apply to any chlorobiphenyl containing more than two atoms of chlorine per molecule, i.e. to any polychlorobiphenyls other than the most readily degradable homologs.

b) Further steps in the elimination of uses of PCBs will depend upon the availability of adequate alternative dielectric fluids that are less toxic or less persistent than the PCB formulations that they replace. It is clear that the use of HCBP in transformers will always pose a threat to the environment through accidents or also through vandalism in service or in transportation, and through unsatisfactory disposal practices. The development of alternatives to the HCBP-transformer is very desirable. The Task Force does not possess the specialised knowledge and experience to recommend what changes in design of electrical equipment or in codes of practice related to safety within the building-construction and manufacturing industries will be necessary before the fluids in new transformers (or indeed in capacitors) could be restricted to non-PCB types. *The Task Force recommends that an advisory committee be formed to look into these problems, which are world-wide.* It is unlikely that all existing transformers using PCB askarels could be converted to non-PCB fluids, both because of possible downgrading of their performance and safety ratings and because of difficulties in identification and accident-free change-over. It is also unlikely that all the PCB fluid could be effectively removed in the change-over at reasonable cost. *The strictest control of disposal of used transformer oils will therefore be necessary for half a century after PCB-askarels are no longer used for initial fillings.* Though alternative fluids may be less

dangerous than PCBs, their escape into the environment will almost certainly be very objectionable and this Task Force foresees no likelihood that relaxation of strict control of synthetic dielectric fluids will be permitted (c.f. 11.4.2.1.c.).

c) It is not clear that the continued use of Aroclor 1016 in either small or large capacitors will necessarily contribute to measured environmental residue levels of PCB. Because exposures to them in the environment are very low, the dangers posed by di- or tri-chlorobiphenyls appear to be only slight, despite the enormous quantities that have been used. Any significant danger from the use of Aroclor 1016 in capacitors would arise from its residual content (1%) of the persistent HCBP, or from its content (21%) of the less persistent tetrachlorobiphenyl. *Any control action to affect the use of PCB in capacitors should, therefore, better be taken through the third route (11.1.2.3.) for reducing exposures by control of the compositions of the product under Section 8(6).*

Elimination of PCBs (Aroclor 1254) for manufacture of transformers would remove from the Canadian market, 99.5% of the HCBP, 69% of the tetrachlorobiphenyl, and about 0.5% of the di- and trichlorobiphenyls. Elimination of PCBs (Aroclor 1016) from capacitor manufacture would remove 0.5% of the HCBP, 31% of the tetrachlorobiphenyl and 99.5% of the di- and trichlorobiphenyls (Section 7.3.8.2.).

11.4.2.3. Reduction of the proportion of persistent homologs in commercially available PCB.

Monsanto's product realignment in 1971 eliminated Aroclor 1260 in favour of Aroclor 1254 and it has become generally accepted that the special fire-related properties of transformer askarels based on PCB would not be retained in a product based on lower chloro-homologs.

Monsanto also revised their product compositions in Canada by eliminating Aroclor 1242 in favour of Aroclor 1016 for use as the dielectric in capacitors. Aroclor 1016 contains about one-tenth as much HCBP as does Aroclor 1242 (Table 29). *The Task Force recommends that a regulation be made under Section 18 of the Environmental Contaminants Act to ensure that capacitor dielectric fluid containing more HCBP than* or tetrachlorobiphenyl *does Aroclor 1016 shall not be used in the manufacture of capacitors nor enter Canada either in bulk or in manufactured goods.*

A small advantage could be gained if the remaining fractional percentage of HCBP in Aroclor 1016 could be substantially eliminated.

The evidence of occurrence of tetrachlorobiphenyl, which constitutes about 20% of Aroclor 1016 and 1254 (Table 29), in field samples is most unsatisfactory (Sections 7.3.2., 7.3.3.). Since the sales' curtailment for open-system uses in 1971, the quantity of tetrachlorobiphenyl entering the waters of the Great Lakes region may have fallen by an order of magnitude. The tetrachlorobiphenyl in Herring Gull eggs (Section 7.3.2.) may well be a relic of a use that is discontinued. If PCB fall-out or rainwater near incinerators should be found to contain appreciable tetrachlorobiphenyl, a similar relic origin is likely, but this would be indicative that the continued use of Aroclor 1016 in small capacitors will prolong the problem. By regulations under section 18 of the Environmental Contaminants Act, the tetrachloro-homolog could be effectively removed from use in small capacitors if this were adjudged necessary; realistically, this could only be done after an adequate alternative were readily available.

For similar reasons, if the disposal of power factor correction capacitors cannot be brought under adequate control or if the disposal of wastes from plants manufacturing capacitors is found to cause danger, the HCBP remnant in Aroclor 1016 or the tetrachloro components could be prohibited or restricted when alternatives were available. For reasons implicit in the discussions in this section (11.4.2.2. and 11.4.2.3.) and in section 7.3. especially the lack of evidence of hazards posed by tetrachlorobiphenyls, the Task Force is of the opinion that grounds on which to restrict the present use of LCBP in capacitors are poor; that more evidence of the fate of tetrachlorobiphenyls is urgently needed to determine whether they are likely to reach man (via fish) as a result of their use in capacitors (c.f. 7.3.2.); and that control of the disposal of capacitor-manufacturing wastes and used phase correction capacitors is also urgently needed.

11.5. Specific Recommendations concerning Controls

In a complete progression through the processes envisaged in the application of the Environmental Contaminants Act the notification processes in 3.1., 4.1.a. and 4.1.b. would be applied. This process is already dealt with in Sections 9.1. and 9.2. The extensive accumulated information of the past decade is convincing reason for recommending that control actions be taken (7.3.(16)).

11.5.1. Control of the uses of PCB

11.5.1.1. Background to control

Canada has an obligation, as a member of OECD, to control the use of PCBs. In addition, there is sufficient toxicological information on PCB effects on organisms to indicate a strong need for control. The persistence and bioaccumulation of PCBs, particularly the higher chlorinated homologs, make them prime candidates for control under the Act.

PCBs are now in use for a multitude of purposes throughout Canada. It is neither practicable nor desirable to prohibit the continued use of this PCB, unless the continued use will

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result in a greater loss into the environment than would otherwise occur.

A particular instance is the presence of PCB in heat-transfer systems. In the past, commercial PCB formulations were used as heat transfer fluid. This fluid has been removed from a number of heat transfer systems that have been converted to operation on non-PCB substitute fluids. Nonetheless, because draining and flushing of complex engineering systems cannot in practice be completely effective, the substitute fluids are now contaminated by PCB. The Task Force does not contemplate that regulations should restrict the use of this PCB-contaminated fluid. The Task Force does recommend that use of PCB as make-up in heat transfer systems be prohibited. Many other instances of this kind could be found and should be regarded in the same way.

Initial regulations should restrict use of PCBs (other than dichlorobiphenyls, See Section 11.4.2.2.) *in new goods to dielectric insulating oils.* The use of PCB as make-up in the servicing of electrical equipment should be permitted where the design requirements of that equipment warrant its use.

11.5.1.2. Form of the control

The form of the control should be by regulation under the Act prescribing uses (8.2. and 18.c.), *and quality of the product* (8.4. and 18.2.).

More specifically:

The Ministers should:

1. Under 5.(1)(a) offer to consult with provincial governments that indicate that their provinces are likely to be materially affected by a recommendation to the Governor-in-Council under subsection 7(1) to add the substances or class

of substances to the schedule, and

2. Under 5.(1)(b) consult with other federal departments or agencies

to determine whether the danger will be eliminated by any other law. If all the dangers posed by PCBs will not be eliminated by actions under any other law, though such actions could materially assist in achieving this objective,

the Ministers should:

3. Under 5.(2)(a) and (c) recommend that the schedule be amended by adding the class of substances "chlorinated hiphenyls containing more than two atoms of chlorine per molecule" under subsection 7(1) and regulations should be made under paragraph 18(c and i) and a copy of the proposed order and regulations should be published in the Canada Gazette.

Regulation under 18(c)

PCBs may not be imported, manufactured, processed offered for sale or used for the following uses:-

1. The manufacture, compounding or supply of:-
   a) Paints
   b) Adhesives and sealants
   c) Plastics, waxes, synthetic resins or rubber
   d) Investment casting waxes or resins
   e) Lubricants, hydraulic fluids, vacuum pump fluid
   f) Carbonless copying paper
   g) Printing inks
   h) Heat transfer fluids
   i) Dedusting agents
   j) Cutting oils

k) Pesticides

l) Or any other use other than research purposes or as a dielectric or insulating oil in a transformer or capacitor.

Regulation under 18(1)

Any person engaged in the importation, manufacturing, or processing of PCBs should maintain books and records of quantities of PCBs imported, manufactured, purchased or processed and should record the quantities sold, their intended uses and the name and address of the company to which the material is sold. The above-mentioned quantities and the name(s) and address(es) of the vending company(ies) should be reported annually to the Environmental Protection Service of the Department of the Environment.

Even before fully tested non-PCB dielectric fluids are available, regulations could refer to the quality of the PCBs used for specific purposes; the wording of these regulations must await firstly the assessment of evidence concerning the following:

i) the occurrence of lower chlorinated homologs (LCBP, especially tetrachloro-) in the environment (or in biological materials) in significant quantities;

ii) continuing entry of lower chlorinated homologs into the environment in significant quantities as a result of continued use in electrical equipment;

iii) composition of potentially more acceptable capacitor dielectrics based on PCB

and secondly the development of analytical procedures that can be specified for control purposes. These subsequent regulations might well:-

i) prohibit the use in capacitor dielectrics of PCBs containing 5 or more atoms of chlorine per molecule. This would necessitate adding to the Schedule this class of substances,

ii) prohibit the import, manufacture or sale of capacitor dielectric fluid containing more than a specified concentration of chlorinated dibenzofuran. This would necessitate adding to the Schedule either the class of substances "polychlorinated dibenzofurans" or a more precisely defined class such as "tetrachloro-dibenzofurans" or specifically identified individual compounds.

Any amendment of the Schedule by addition of new substances or new classes of substances will require new consultations with other authorities pursuant to Section 5 of the Environmental Contaminants Act.

11.5.2. Control of products containing PCB

In the future the only manufactured products containing PCB will be transformers and capacitors. The transformers will contain the stable higher-chlorinated biphenyls (Aroclor 1254) but the capacitors will contain the more easily degraded lower chlorinated biphenyls (Aroclor 1016). Control of the disposal of small capacitors cannot be attempted because they are too numerous and widespread in their use. Small capacitors end up in dumps where they will slowly release PCBs as the encapsulating material disintegrates. Since LCBPs seem not to be commonly found in environmental samples except close to the source, their release from capacitors in dumps does not appear to have resulted in measurable environmental contamination.

The presence of PCB in products other than dielectrics is difficult to ascertain except by analysis of samples. The number of products which could contain PCB is extremely large but should be decreasing since the OECD countries, which are the principal trading partners of Canada, have adopted the resolution concerning PCBs. The Environmental Contaminants Act will make possible the collection of information concerning the occurrence of PCB in products (See Section 9.1.). *It is recommended that an analytical survey of products be initiated to identify products which contain PCBs. The survey should*

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include products known to contain PCB and other products.

11.5.3. Control of processing, manufacturing and disposal practices

The control of disposal of wastes, particularly disposal on land, has traditionally been regarded as primarily a responsibility of provincial governments. There is great need for cooperation between the Provinces and the Environmental Protection Service in controlling disposal activities. *All the Provincial Governments should be urged to take steps to prevent release of PCBs into the environment.* In particular, provincial authorities are in a position to direct electric power distributors and those persons in allied business enterprises to adopt both the most stringent precautions against losses of PCBs during service and the best available means of disposal.

There is a requirement for licensing of those involved in servicing PCB-containing transformers and capacitors because the dielectric fluid that is removed and the materials that become contaminated must eventually be disposed of into the environment. The disposal of this material needs to be supervised and this can only be successfully achieved through a knowledge of the individual operations through licensing by provincial governments. At this time, the only adequate method of disposal is incineration at or above 2000°F.

In addition to direct Provincial actions, *the Federal Government should take action* under Sections 8.1.b. and 18b of the Environmental Contaminants Act, or under provisions of the Clean Air Act and the Fisheries Act (Section 11.3.), *to prohibit the addition of PCB to any aqueous effluent or gaseous emission, to prohibit the disposal of industrial wastes containing PCB in ordinary dumps or landfill operations, and to prohibit the disposal of PCBs into combustion devices that operate under inadequate conditions.*

There is a requirement for monitoring the quantities of PCB entering the environment at dumps, incinerators and sewage effluents and influents. Where significant sources of PCB are located, more work should be undertaken to find the origin, and remedial action should be taken to remove the cause if this is feasible.

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11.6. Recommendations concerning regulations which could be imposed by Federal jurisdictions

Apart from the controls which would have to be imposed by the provincial government outlined above, other federal jurisdictions could assist in carrying out the operation of the Act.

The possibility of controlling the importation of PCB and products containing PCB by adding these materials to the schedule of items on the tariff of the Customs and Excise should be explored. For this purpose, PCBs should be cross-referenced to the different trade names and common names. Particular attention should be given to the control of importation of PCB in investment casting resins and waxes.

Statistics Canada may be able to assist in the collection of information concerning industrial involvement with PCB.

The OECD Council decision directed Member countires to institute a special, uniform labelling system for both bulk PCBs and PCB-containing manufactured products (See Section 3.1.4.). The Environmental Contaminants Act makes no specific provision for such requirements. In Canada, the Department of Transport, which is developing a uniform code for the transport of dangerous goods may be of assistance in meeting requirements of labelling of PCB. *The Task Force recommends the introduction of a uniform labelling system for PCB, and supports the efforts of the Canadian Electrical Manufacturers Association (CEMA) in this regard.*

Because the terms of reference of this Task Force relate to measures to control activities leading to the release of PCB to the environment the Task Force recommendations do not include measures that could be taken under the Food and Drugs Act or the Hazardous Products Act to limit direct exposures of the Canadian public to food or products containing PCB. Appendix 1 is an example of such control action already initiated under the Hazardous Products concerning the use of PCB in immersion oils for microscopy. Appendix 2 is the Information Letter sent out by Health Protection Branch to warn Hospital Administrators of this danger.

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1. INTRODUCTION

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13. APPENDIX 1

A report on PCBs in immersion oil by C.A. Franklin, J. Harrison, A. Sundaram, and G.S. Wiberg - Toxicological Evaluation Section, Environmental Health Directorate.

Although the usage of PCBs has been restricted to closed systems since the early 1970's, they continue to contaminate the environment. One of the open systems in which PCBs have been found are microscope immersion oils. Considerable quantities of immersion oil are utilized in hospital laboratories and lead to problems in two areas: (1) the exposure to laboratory technologists and (2) the environmental contamination when slides containing oil are stored or discarded.

PCBs are toxic causing chloracne and liver disease in industrial workers[1]. Ingestion of contaminated rice oil by 1000 Japanese was studied, and it was found that the toxicological responses were dose related and seemed to be more severe than those seen in animals treated with PCBs[2]. Oil that has been used for a number of years as a heat exchanger can contain a number of degradation products including chlorinated dibenzofurans which are very toxic[3], and it is probable that the contaminated rice oil contained similar toxic contaminants.

Long term toxicity studies showed no adverse effects in rats fed Aroclor 1242, 1254, and 1260 at 10 mg/kg diet[2]. At the 100 mg/kg there was increased liver weight and reduced litter survival but no change in mortality[2]. The liver effect was dose dependent and was reversible[3].

Recent studies by Kimbrough[4] indicate that Aroclor 1260 fed to female rats at 100 ppb for 21 months had a hepatocarcinogenic effect. This study showed definite carcinoma in 26 out of 184 rats, and there were neoplastic lesions in a total of 170 out of 184 treated animals. The Aroclor 1260 was not analyzed for impurities, and it is possible that there would be tetrachlorodibenzofuran in the sample. A study in monkeys[5] has shown that Aroclor 1248 given in the diet at the 100 and 300 ppm levels for 2 to 3 months caused extreme morbidity within 1 month and almost 100% mortality within 3 months. Monkeys showed signs that were similar to those seen in man including chloracne facial edema and conjunctivitis. More severely affected monkeys had gastric ulcers, liver hypertrophy, increased microsomal activity (indicative of induction), altered ketosteroid levels, dysmenorrhea and reduced birthweights of infants from exposed mothers. At dosages as low as 2.5 and 5.0 ppm, monkeys exhibited signs of PCB intoxication.

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Mink fed fish containing 10 mg/kg Aroclor 1241, 1248 and 1254 failed to reproduce and eventually died[6]. From these studies there appears to be considerable species variation to the severity of response to PCBs and this may be attributed at least in part to differences in the rate at which PCBs are metabolized. Van Miller et al.[7] have shown that 2,5,2',5'-tetrachlorobiphenyl has a half life of less than 24 hours in the rat; preliminary unpublished work by this group indicates a much longer life of this isomer in monkeys and formation of a toxic arene metabolite.

In a paper soon to be published by Barsotti et al.[8], monkeys fed Aroclor 1248 at 2.5 (3 mg/kg BW/month PCB) or 5.0 ppm for seven months before mating exhibited impaired fertility. The altered steroid hormone levels may be responsible for reproduction abnormalities[8]. Conception rates were decreased in monkeys on the 5.0 ppm diet, and there was increased resorption and early abortion at both levels. The infants were smaller at birth than controls but there were no abnormalities indicating that at least at these levels PCBs are not terstogenic in monkeys. There was accumulation of PCB in the tissues of the infants from mothers on 5.0 ppm and it remains to be seen whether this will have an effect on development. Vos and Beems[9] applied the PCBs Clophen A60, Phenoclor DP6 and Aroclor 1260 at the rate of 118 mg/da for 27 applications resulting in an exposure of 1260 mg/kg/38 days to shaved skin of rabbits. None of the Aroclor treated rabbits died whereas one half of the other groups did. In addition to the local skin effects, there was liver enlargement in all groups and lesions with the least damage observed in the Aroclor group. There was damage to the kidneys and lymphoid tissue as well.

In summary, PCBs have been shown to be more toxic to monkeys than to other species previously studied. Low levels (2.5 and 5.0 ppm) effected reproduction and resulted in increases resorption and early abortion as well as lower birthweights. In female rats PCBs have resulted in increased incidence of hepatocarcinoma and neoplastic lesions.

Immersion oils marketed under the brand names of Cargille, Crown, Nikon, Zeiss, Fisher, Harelco and Cardine Biological Supply Co. were all shown to contain 30 to 45 per cent PCBs, predominantly the 5 and 6.3 chlorinated biphenyls[10]. These levels were confirmed by analyses done at the Pesticide Monitoring Lab of the Food Research Division.

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Figures on the exact amount of immersion oil sold in Canada were not available, but an estimate based on the usage in the four hospitals surveyed and on the number of hospital beds in Canada would indicate that approximately 32,000 fl. oz. are sold per year. In Canada, 24, 766 fl. oz. are supplied by two companies, Canlab and Fisher Scientific. Both of these companies receive their immersion oil from Cargille Laboratories in New Jersey and there are 3 types of oil supplied - Type A and Type B, and Type B high viscosity. Type A oil has low fluorescence and Type B is more viscous and intended for use on biological specimens.

The sale pattern in Canada is as follows:

	TYPE A Fl. oz.	TYPE B Fl. oz.	OTHER Fl. oz.
			Type B (high viscosity)
Canlab	8,500	1,000	500
Fisher	10,171	4,542	Kit(A B) 53
	18,671	5,542	553

Two other companies which were contacted, Wild-Leitz and Zeiss, were unable to give information on the amount of oil they sold.

Cargille has been manufacturing a PCB - free Type B immersion oil for over a year. However, the Type A which is the low fluorescence oil still contains PCB. When the company started marketing the new PCB-free oil they did not withdraw existing stock. Both Fisher and Canlab have been receiving PCB free oil for approximately six months.

Wild-Leitz have been selling a PCB-free oil in Canada for the past 6 months. Zeiss would not give any verbal information on content at this time and require a written request.

Because of the number of slides screened daily, hospital laboratories are probably the heaviest users of immersion oil. The two sections where the use would occur are Microbiology and Hemetology.

Four hospitals were contacted and their usage of immersion oil was as follows:

Hospital	Beds	Type A Fl.oz/yr	Type B Fl.oz/yr	No. Slides/da under oil	Storage
Montreal General	900				
Hematology		-	576 "PCB-free"	450	cleaned and kept 1 month
Microbiology		32		400	discarded
Toronto General	1200				
Hematology			Leitz 16	20	discarded
Microbiology			192	150-200	discarded
Ottawa General	550		-		
Hematology		16	-	30	discarded
Microbiology		128	-	150	1 wk. then discarded
McKeller General	500				
Hematology		48	-	50	cleaned and stored
Microbiology			-	50	1 wk. then discarded

In the microbiology labs of the four hospitals surveyed, there are up to 200 slides/day screened under oil immersion. These slides are kept for one week and then discarded without any cleaning. The technologist would risk contact with immersion oil when dispensing it, cleaning the objective and handling the slide to place it in the storage tray. It has been estimated that one drop of oil contains 7 mg PCB, and it is conceivable that over the period of a day a technologist might be exposed to a total of one drop which would be approximately 4.2 mg/kg/month. A hematology technologist cleaning slides with xylene could be in contact with higher levels of oil depending on cleaning techniques. The dermal studies by Vos[9] showed severe toxic effects in rabbits but at a dosage of 1062 mg/kg/38 days. Barsotti[8] observed deleterious effects on reproduction in monkeys fed 3 mg/kg/month. The studies done thus indicate that PCBs are absorbed dermally[9] and that oral doses are capable of toxicity at low levels[8]. It remains to be shown whether low doses administered dermally would have similar toxic effects.

The evidence would indicate that PCBs are potentially dangerous, and a compound such as immersion oil should not be considered "safe" as present labelling states.

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The second area of concern is the environmental contamination when the slides are cleaned and discarded. The xylene that is used to clean the slides is discarded through the sewage system and the uncleaned slides incinerated. Both routes lead to the eventual contamination of water sources with an estimated 270 kg of PCB (mainly Aroclor 1254) per year.

The availability of PCB-free immersion oils would indicate that these problems of toxicity and pollution could easily be solved. Some hospitals are already using PCB-free Type B oil, and it would appear that the hospitals which use Type A low fluorescence oil, do so for convenience as the slides which are screened on the fluorescence microscope require this type of oil. However, since only 3-5% of the slides are screened this way it would seem entirely possible that they could switch to one of the PCB-free oils. Wild-Leitz has indicated that their PCB-free oil has low fluorescence and would be a suitable substitute.

CONCLUSIONS

1. PCBs are toxic to rats with the no effect level being 10 mg/kg diet in some studies, and as low as 2 mg/kg diet in others. Females are more sensitive to PCBs.
2. PCB 1260 fed to female rats at 100 ppm caused hepatocarcinoma in 26 out of 184 rats and neoplastic changes in 170 of them.
3. PCBs (1242, 1248, 1254) are toxic to mink at 10 mg/kg diet and failure of reproduction and even death resulted.
4. Monkeys fed 2.5 ppm (3 mg/kg B.W./month) (Aroclor 1248) had decreased fertility, and the infants had lowered birth weights. There were no signs of teratogenesis at birth. Reproduction in males did not appear to be affected at these levels.
5. Technologists working with immersion oil could be exposed to levels of up to 4 mg/kg B.W./month of Aroclor 1254 and 1260.
6. PCB in immersion oil could be dangerous to female technologist over long intervals.
7. Hospital laboratories are the major users of immersion oil and they use 3 times as much Type A oil as Type B oil.
8. At least 270 kg of PCBs could be entering the environment as a result of the usage of immersion oils containing PCB.

9. Caution must be used in interpretation of toxicity data because each PCB may have different effects. In general the contaminents (chlorodibenzofurans) seem to cause the problem and according to Monsanto, Aroclor 1248 has the highest concentration of chlorodibenzofuran. Monsanto now manufactures only Aroclor 1016 and 1254.

Recommendations

1. Immersion oils containing PCBs should be withdrawn because of their potential toxicity to technologist, and because the mode of disposal leads to PCB contamination of the environment.
2. All laboratories should be informed of the hazard and that suitable PCB-free substitutes exist.
3. Supplies of oil containing PCB should be collected and properly discarded.

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Information Letter / Lettre de renseignements

Health Protection Branch / Direction générale de la protection de la santé

January 21, 1976 I.L. No. 456

TO: Hospital Administrators for Attention of Clinical Laboratories and Purchasing Agents

SUBJECT: Microscope Immersion Oils

Analyses by the Health Protection Branch Laboratories have shown concentrations of 23 to 30 per cent PCBs (polychlorinated biphenyls) in a variety of microscope immersion oils which are used in laboratories.

Recent experiments have shown that PCBs are toxic at much lower levels than previously indicated, and that they cause hepatocarcinoma and decreased fertility in rats and monkeys. In man, PCBs are known to cause a variety of skin disorders, and since they are absorbed through the skin, immersion oils may be potentially hazardous. Dermal exposure may occur while wiping lens of microscopes, cleaning slides, or by spillage from oil containers.

In addition to the immediate hazard to the user, there is a concern regarding the ultimate disposal of the immersion oils containing PCBs. The practice of rinsing the microscope slides with solvents and subsequent sewerage disposal of waste solutions containing PCBs may result in substantial amounts of PCBs ending up as contaminants in potable water supplies or appearing in the food chain.

In view of the toxic effects of PCBs, the wide use of immersion oils in laboratories and the environmental concerns of PCBs as contaminants the Health Protection Branch has recommended that the sale of microscope immersion oils containing PCBs be prohibited

Le 21 janvier 1976 L.R. Nº 456

AUX: Administrateurs d'hôpitaux à l'intention des laboratoires cliniques et des acheteurs

OBJET: Huiles pour objectifs de microscope immersion

Des analyses effectuées par les laboratoires de la Direction générale de la Protection de la santé ont révélé que diverses huiles pour objectifs à immersion, utilisées dans les laboratoires, contenaient de 23 à 30 pour cent de PCB (polychlorobiphényles).

Des études récentes ont montré que les PCB sont toxiques à des concentrations plus faibles qu'on ne l'avait d'abord indiqué, et qu'ils donnent lieu à des tumeurs malignes du foie et à une diminution de la fécondité chez le rat et le singe. On sait que les PCB peuvent provoquer chez l'homme diverses affections cutanées et, comme les huiles pour objectifs à immersion peuvent être absorbées par la peau, elles constituent donc un danger potentiel. Le contact cutané peut se produire pendant le nettoyage des lentilles de microscope et des lames, ou lorsque le liquide est répandu accidentellement.

Au danger immédiat encouru par l'utilisateur s'ajoute le danger précédemment par l'évacuation des huiles après usage. Certains ont l'habitude de rincer les lames et les lamelles avec des solvants, et de jeter à l'égout les produits de rinçage, qui contiennent des PCB. Cette pratique peut donner lieu à l'accumulation de PCB dans les réserves d'eau potable et à leur apparition dans la chaîne alimentaire.

Compte tenu de la toxicité des PCB, de l'usage répandu des huiles pour objectifs à immersion dans les laboratoires et des possibilités de contamination de l'environnement, la Direction générale de la Protection de la santé a recommandé que la vente des

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under the Hazardous Products Act. Microscope immersion oils free from PCBs are currently being manufactured, and hospitals are advised to contact their suppliers.

It is strongly advised that the use of immersion oils containing PCBs be discontinued. Current supplies of such oils may be disposed of by forwarding to the nearest office of Environment Canada. For shipping purposes, containers should be wrapped in liquid-absorbing material, placed in an impact resistant package and carry the name and address of the sender.

Environmental Canada offices are located at:

Mr. E. Caldwell, (CODE 1)
Bank of Montreal Towers,
5151 George Street,
HALIFAX, N.S.
B3J 3E4

Mr. B. Munro, (CODE 1)
135 St. Claire Avenue,
TORONTO, Ontario
M4V 1P5

Mr. J. Watkins, (CODE 1)
Kapilano,
100 Park Royal,
WEST VANCOUVER, B.C.
V7T 1A2

Mr. M. Birmingham, (CODE 1)
Laboratoire du Capitaine Bernier,
1001 Pierre Dupuis,
Port St. Laurent,
LONGUEUIL, Quebec

Regional Director, (CODE 1)
Imperial Oil Bldg.,
10025 Jasper Avenue,
EDMONTON, Alberta
T5J 2Z9

huiles pour objectifs à immersion contenant des PCB soit interdite aux termes de la Loi sur les produits dangereux. Comme il se fabrique des huiles pour objectifs à immersion exempts de PCB, les hôpitaux sont priés à cet égard de se mettre en rapport avec leurs fournisseurs.

Nous vous conseillons fortement de ne plus utiliser les huiles contenant des PCB. Vous pouvez vous débarrasser des huiles actuellement en stock, en les envoyant à un bureau d'Environnement Canada. Pour l'expédition, les flacons devront être enveloppés dans un matériau absorbant, placés dans un emballage résistant aux chocs et devront porter le nom et l'adresse de l'expéditeur.

Les bureaux d'Environnement Canada sont situés aux adresses suivantes:

M. E. Caldwell (CODE 1)
Tours Banque de Montréal
5151, rue George
Halifax (N.-É.)
B3J 3E4

M. B. Munro (CODE 1)
135, ave. St. Claire
Toronto (Ontario)
M4V 1P5

M. J. Watkins (CODE 1)
Kapilano
100 Park Royal
West Vancouver B.C.
V7T 1A2

M. M. Birmingham (CODE 1)
Laboratoire du Capitaine Bernier
1001 Pierre Dupuis
Port St. Laurent
Longueuil (Québec)

Directeur régional (CODE 1)
Édifice Impérial Oil
10025 ave. Jasper
Edmonton (Alberta)
T5J 2Z9

Le Sous-ministre adjoint,

A.B. Morrison, Ph.D.,
Assistant Deputy Minister

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15. APPENDIX 3. OECD Starling Data

As part of the 14-country OECD Wildlife Sampling and Analysis Program the Canadian Wildlife Service collected Starlings at three locations in Canada (Ontario, Alberta and Prince Edward Island). Levels of PCB in Ontario and Alberta Starlings rose in 1973 and 1974, than dropped in 1975 to 1972 values. Levels in Prince Edward Island Starlings were higher in 1974 than in 1973 but did not decline in 1975 as in the other two collecting locations. The OECD will publish details of the 14-country monitoring program, including the residue levels and statistical significance of between-year variations in the Canadian data, during 1976.

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15. Appendix 3 - OECD Starling Data

As part of the Canadian contribution to the OECD Wildlife Sampling and Analysis Programme, the Canadian Wildlife Service collected nestling Starlings (15-21 days old) for analysis of the pollutant content of pectoral muscle. Three sites were chosen. In the Ontario tobacco belt, samples were collected from near Delhi, a collection was made at Fort Saskatchewan, Alberta, and the third group was from Prince Edward Island. The Starling was used as an essentially-resident monitor of terrestrial contamination.

The data are presented in Table 33 and are expressed on both wet weight and lipid bases because of the wide variation in fat content between years. When expressed on a fat weight basis, the results appear to indicate a large increase in PCB levels in Ontario nestlings in 1973 compared to 1972. A decline of similar magnitude occurred between 1974 and 1975. The highest mean value, 2.77 ppm on a lipid basis, was comparable to levels found in southern Sweden (Odsjo 1973) but lower than the majority of values reported by Johnels (1970) for Swedish Starlings.

In Alberta, there was an increase in the levels of PCB between 1973 and 1974 and a subsequent decrease between 1974 and 1975. There was an increase of a similar magnitude in the Prince Edward Island samples between 1973 and 1974, but no decline in 1975.

The Canadian Wildlife Service has requested that further interpretation of the data wait until the OECD's Working Group on the Wildlife Sampling and Analysis Programme has completed its analysis of the data and prepared its report.

TABLE 33

PCB levels (in ppm) in nestling Starlings

		N	Fresh weight Basis Geometric mean	% Fat	Lipid Weight Basis Geometric mean
Ontario	1972	19	0.001	4.3	0.02
	1973	25	0.032	1.2	2.77
	1974	19	0.037	1.7	2.25
	1975	25	0.001	1.3	0.06
Alberta	1972	25	0.008	6.7	0.12
	1973	14	0.004	2.7	0.18
	1974	17	0.011	1.5	0.76
	1975	21	0.003	1.6	0.16
P.E.I.	1973	25	0.002	2.1	0.11
	1974	25	0.012	1.9	0.67
	1975	25	0.012	1.9	0.64

REFERENCES

Odsjo, T. 1973. PCB in some Swedish terrestrial organisms. In Swedish PCB Conference National Swedish Environmental Protection Board.

Johnels, A.G. 1970. PCB-occurrence in Swedish Wildlife. In PCB Conference, Stockholm. National Swedish Environmental Protection Board.

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16. APPENDIX 4

PCBs in sewage, sewage sludge and crops

Recent investigations (Lawrence and Tosine MS.) of the PCB levels in sewage and sewage sludge in wastewater treatment plants in Southern Ontario have extended the previous work undertaken by Shannon (1976). Six sewage treatment plants in the Hamilton-Oakville area were included in the survey and represent plants receiving wastewaters from domestic and light and heavy industrial sources. Thirty-six grab samples taken over thirty-five weeks from the Hamilton plant (domestic and heavy industrial) are reported in Table 34 and indicate a mean value of 10 ppb in the raw sewage water. This is higher then that reported by Shannon (op. cit.) by an order of magnitude but the difference may be partly the result of differences in sampling techniques.

TABLE 34

PCB CONCENTRATIONS IN HAMILTON RAW SEWAGE

Date	Concentration of Aroclor 1254, ppb	Concentration of Aroclor 1260, ppb	Total Aroclor Concentration ppb
4/3/74			6.3
6/3/74			10.9
12/3/74			8.9
21/3/74			15.2
26/3/74			20.7
8/4/74			11.9
17/4/74			8.2
24/4/74			9.2
7/5/74	9.8	17.5	27.3
9/5/74	4.3	10.7	15.0
13/5/74	0.8	0.7	1.5
14/5/74	0.8	0.7	1.5
15/5/74	0.8	0.7	1.5
16/5/74	1.8	1.9	3.7
17/5/74	5.5	2.7	8.2
7/6/74			5.6
11/6/74	5.0	6.5	11.5
18/6/74	8.1	9.9	18.0
21/6/74	7.4	5.2	12.6
26/6/74	5.9	3.9	9.8
2/7/74	5.0	4.6	9.6
8/7/74	10.2	4.2	14.4
12/7/74	4.6	3.4	8.0
17/7/74	6.6	6.5	13.1
19/7/74	16.5	9.8	26.3
21/8/74	3.8	0.9	4.7
28/8/74	9.0	4.6	13.6
10/9/74	14.6	4.4	19.0
11/9/74	6.9	1.8	8.7
17/9/74	6.8	0.9	7.7
24/9/74	2.2	0.6	2.8
1/10/74	4.9	1.2	6.1
9/10/74	8.2	4.8	13.0
16/10/74	6.1	3.7	9.8
17/10/74	4.6	1.5	6.1
28/10/74	13.7	7.1	20.8
4/2/76	5.6	3.4	9.0
Mean	6.4	4.4	10.8

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Results of the other plants are reported in Table 35 and show that at the plants treating domestic and light industrial wastewaters there were elevated levels of PCB residues whereas plants treating purely domestic sewage contained concentrations.

TABLE 35

PCB CONCENTRATIONS IN RAW SEWAGE FROM FIVE SOUTHERN ONTARIO CITIES

City	Concentration of Aroclor 1254, ppb	Concentration of Aroclor 1260, ppb	Total Aroclor Concentration, ppb
Dundas	3.6	0.8	4.4
(Domestic/light industrial)	0.7	0.5	1.2
Burlington Skyway (Domestic/light industrial)	1.8	1.1	2.9
Burlington Elizabeth Gardens (Domestic)	0.6	< 0.5	0.6
Oakville West	1.9	2.4	4.3
(Domestic/light industrial)	0.7	< 0.5	0.7
Oakville East	1.1	0.5	1.6
(Domestic)	0.6	< 0.5	0.6

Table 36 shows the levels of PCBs in sludges and in sludge-treated crops. The results confirm the observations of Agriculture Canada that PCBs are taken up by some crops (See section 7.2.3. and Table 21).

TABLE 36

PCB CONCENTRATIONS IN SLUDGES AND SLUDGE TREATED CROPS

Concentration ppb	Hamilton	Newmarket	Kitchener	North Toronto
Aroclor 1254 in Sludge	81	74	111	118
Aroclor 1260 in Sludge	111	18	26	26
Total Aroclor in Sludge	192	92	137	144
Aroclor 1254 in Corn		37	29	54
Aroclor 1260 in Corn		13	16	27
Total Aroclor in Corn		50	45	81
Aroclor 1254 in Grass		108	84	47
Aroclor 1260 in Grass		120	36	24
Total Aroclor in Grass		128	120	71

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REFERENCES

Lawrence, J. and H.M. Tosine. Unpublished MS. Polychlorinated biphenyl concentrations in sewage and sludges of some waste treatment plants in southern Ontario.

Shannon, E.E., F.J. Ludwig and I. Valdmanis. Unpublished MS. Polychlorinated biphenyls (PCBs) in municipal wastewaters: an assessment of the problem in the Canadian lower Great Lakes. Environmental Protection Service, Canada. Ontario Agreement Project No. 73-3-8.

Agriculture Canada. Information submitted by Mr. C.D. Crober to Technical Subcommittee on Land Disposal of Sludge.

MONS 053851

17. APPENDIX 8. PCB IN LANDED FISH AND FISH PRODUCTS

As the result of the evaluation of new toxicological data, the Health Protection Branch of the Department of National Health and Welfare in consultation with the Fisheries Inspection Branch has recently established a temporary guideline of 2 ppm for the edible portion of fish.

PCBs are not of concern in marine fish (Table 37) and only certain freshwater species from particular geographic locations in the Great Lakes and the St. Lawrence River (Table 38) are a problem. Surveys by the Fisheries Inspection Branch indicate that amongst the marine fish, bluefin tuna had levels of 2.65 ppm and these represent levels in fish, at the top of the marine food chain. Fish oils contained 4.51 ppm. Inland fisheries outside of the Great Lakes have fish with a mean level of 0.10 ppm.

In the Great Lakes (Table 38) PCB levels are very much higher. In Lake Superior, Lake Trout contain levels of 2.02 ppm.

In Lake Huron, Coho Salmon had the highest levels at 5.11 ppm but are not generally considered a commercial species. Chub (2.09 ppm), Carp (1.55 ppm) and Suckers (1.33 ppm) had relatively high levels.

In Lake Erie, Coho Salmon (3.14 ppm) again contained the highest levels. Alewives (1.22 ppm), Carp (1.27 ppm), Mullet (1.44 ppm), Yellow Pickerel (1.16 ppm), White Bass (1.26 ppm) and Catfish (2.04 ppm) contained relatively high residues.

In Lake Ontario the highest levels were found in Eels at 17.14 ppm, Coho Salmon were again high at 4.97 ppm and catfish at 9.63 ppm. High levels were also found in Pickerel (2.09 ppm), Smelt (4.16ppm), White Perch (1.84 ppm), Northern Pike (1.96 ppm), Carp (1.69 ppm) and Rock Bass (1.76 ppm).

In the St. Lawrence River high levels were found in Sturgeon (2.32 ppm) and Eels (7.94 ppm).

Staff of the Fisheries Inspection Branch continually monitor fish for hazardous substances including residues of PCBs to ensure the safety of all fish marketed in Canada. Restrictions on the use of PCBs and the more rigid controls exercised over their disposal in the environment should result in a gradual decrease in PCB levels in the problem areas.

Because the purpose of monitoring by the Fisheries Inspection Branch is the protection of the public from the risk of buying contaminated food, the samples analysed are "edible portions" equivalent to those parts of the fish likely to be used as food by the Canadian public. Wild birds or animals that consume fish commonly eat effectively the whole fish including those parts that would not appear in the human diet. Wildlife also feeds on species of fish

not normally considered suitable as food by humans. In some species of fish there is a marked difference in PCB levels between "whole fish" and "edible portion" samplings.

TABLE 37

POLYCHLORINATED BIPHENYLS IN
COMMERCIAL FISH AND FISHERIES PRODUCTS

DESCRIPTION AND SPECIES		LANDINGS	#SAMPLES	PCB MEAN PPM
MARINE				
Groundfish	(catfish, cod, flounder, haddock, halibut, lingcod, pollock, redfish, red snapper, rockfish, sablefish, sole)	1,191,701,000	141	0.07
Pelagic-Esturial	(Alewife, capelin, dogfish, herring, mackerel, salmon, smelt, swordfish, tuna: albacore-skipjack-yellowfin, whale)	1,131,868,000	73	0.39
	Bluefin			2.65
	Eel - Maritime Provinces	762,000	10	0.56
Molluscs & Crustaceans	Clams, crabs (dungeness-queen-red-rock) lobster, mussels, oysters, scallops, shrimp	100,144,000	56	0.12
Miscellaneous	Fish oils (cod, herring, redfish)	-		4.51
	Fishmeal	-		0.16
FRESHWATER	Area West of Lake Superior			
Species include	Buffalo fish, carp, goldeye, mullet, perch, pike, pickerel, sauger, trout, whitefish.	70,000,000	113	0.10

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PCB LEVELS IN COMMERCIAL FISH (EDIBLE PORTION) FROM THE GREAT LAKES - ST. LAWRENCE RIVER SYSTEM

TABLE 38

LOCATION	MAJOR SPECIES	LANDINGS	#SAMPLES	PCB MEAN PPM
St. Lawrence River	Sturgeon	77,000	5	2.32
	Eel	435,000	216	7.94
Lake Ontario	Pickerel	3,000	10	2.09
	Bullhead	248,000	12	0.73
	Yellow Perch	699,000	10	1.23
	Smelt	103,000	17	4.16
	White Perch	290,000	22	1.84
	Northern Pike	21,000	26	1.96
	Cisco	16,000	2	0.98
	Sunfish	203,000	6	0.74
	Carp	395,000	10	1.69
	Rock Bass	42,000	18	1.76
	Catfish	24,000	8	9.63
	Eel	222,000	49	17.14
	Coho Salmon	Non Commercial	3	4.97
		2,266,000		
Lake Erie	Alewife	332,000	14	1.22
	Rock Bass	49,000	2	0.27
	Carp	41,000	7	1.27
	Yellow Perch	12,190,000	10	0.19
	Smelt	15,760,000	21	0.42
	Mullet	19,000	6	1.44
	Yellow Pickerel	234,000	9	1.16
	White Bass	2,346,000	28	1.26
	Catfish	88,000	8	2.04
	Bullhead	109,000	4	0.26
	Sheepshead (Drum)	354,000	15	0.74
	Coho Salmon	Non Commercial	8	3.14
		31,522,000		

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TABLE 38(cont'd)

Lake Huron	Chub	671,000	17	2.09
	Whitefish	950,000	8	0.95
	Carp	56,000	4	1.55
	Suckers	176,000	12	1.33
	Yellow Pickerel	269,000	9	0.61
	Sheepshead (Drum)	29,000	2	0.75
	Coho Salmon Non Commercial		6	5.11
		2,151,000		
Lake Superior	Chub	306,000	8	0.96
	Lake Herring	1,611,000	10	1.17
	Lake Trout	195,000	37	2.02
	Whitefish	328,000	11	0.68
	Smelt	788,000	6	0.35
	Yellow Perch	67,000	5	0.31
		3,295,000		

MONS 053856

1. INTRODUCTION

1.1. Background to the problem

Polychlorinated biphenyls (PCBs) are a family of chemically similar organochlorine compounds, of which at least the more highly chlorinated members are very persistent and widespread in the global environment. Because PCBs are chemically inert, and have properties of low flammability and volatility and of a high dielectric constant they have been marketed extensively for a wide variety of applications. These include uses as hydraulic fluids, heat-exchange and dielectric fluids, plasticizers for plastics and coatings extenders for pesticides and as an ingredient of caulking compounds, adhesives, paints, printing inks and carbonless copying paper. PCBs are commonly referred to by the trade name Aroclor.

PCBs are bio-magnified in food chains and have been found in tissues of fish, wildlife and of man . PCBs have been found to be a ubiquitous contaminant of water, air, land and aquatic sediments even occurring in remote arctic areas far from disposal sites.

PCBs are toxic materials. In Japan, during 1968, an outbreak of a skin disease characterized by follicular accentuation, acneform eruption, pigmentation of the skin and nails, and hypersecretion of the Meibomian gland was reported. In this epidemic, termed "Yusho", there were 1001 patients and it was found to be caused by the consumption of rice oil contaminated by PCBs. The PCB (containing 48% chlorine) which was used as a heat transfer liquid (closed system) in the production of the rice oil had leaked out and contaminated the rice oil to a level of approximately 2,000 ppm (Kuratsune et al, 1972). Some of the patients have not fully recovered.

Toxicological investigations with laboratory animals have shown that commercial PCBs produce / the following effects: - increased liver weight, increased hepatic microsomal enzyme activity, reversible changes in the liver (increased smooth endoplasmic reticulum and fatty droplet inclusion), induced chemical porphyria, decreased vitamin A storage and altered steroid metabolism (Kimbrough 1974).

Fur breeders have experienced severe losses through feeding fish from the Great Lakes to their mink (Aulerich and Ringer, 1970). High

mortality in utero and of very young kits is the primary cause of these losses but mortality amongst adults has also been documented (Aulerich, et al. 1968). Two mink reproduction studies have shown that DDT (Gilbert, 1969) and PCB (Platonow and Karstad, 1973), which contaminated the Great Lakes fish, cause these same effects.

In field studies on the Great Lakes, several species of fish-eating birds show reproductive failures. These species contain very high levels of several organochlorine pollutants and particularly PCBs (Gilbertson, 1974). The reproductive failures are characterised by high embryonic mortality and apparent poor adult nesting behaviour resulting in a high incidence of egg disappearance (Gilbertson and Hale, 1974 a and b) Several abnormal chicks have been found in the colonies and these abnormalities correspond closely with those experimentally induced by PCBs (Gilbertson et al, in press). Embryonic mortality in the developing embryos of Herring Gulls is associated with pathological signs of chick edema disease (Gilbertson and Fox,MS . 1975), a recognised poultry disease caused by PCBs and their contaminants, the chlorinated dibenzofurans.

In contrast to the situation with colonial fish-eating bird species, the effects of pollutants on aquatic organisms is extremely difficult to demonstrate in the field. This is principally because of the difficulty in observing and measuring abnormal phenomena but it is related to the possibility of several organochlorine and other pollutants being present and acting in concert. It has been reported that reproductive problems are exhibited by Lake Trout in the Muskoka lakes(Boelens and Rumsey 1972) and by Striped Bass in the St. John River (Nadswell. MS. 1975). In both ecosystems DDT and PCB are present at levels which may cause reproductive failure. Because of the difficulties in documenting effects on wild fish populations, these effects must be inferred from experimental information.

In experimental work Aroclor 1254 has been shown to cause toxic effects on protozoa, shrimps and fish (Nimmo et al, 1975, Maki & Johnson, 1975, Schimmel et al, 1974 and Halter and Johnson 1974) at the ppb level. Physiological and cytopathological effects have also been noted(Freeman and Idler 1975 and Nimmo et al, 1975) with chronic exposure. In addition Aroclor 1016 has been shown to be toxic to all

life stages of the Sheepshead Minnow (Cyprinodon variegatus) at about 30 ppb (Hansen et al. 1975).

Because PCBs are of toxicological significance to man, guidelines and tolerances have been set on the amount of PCB permitted in food and in food packaging materials. In 1972, the United States set a temporary tolerance of 5 ppm on fish imported or sold in interstate commerce. In Canada a temporary guideline of 2 ppm was set in 1975 for all fish offered for domestic sale.

Preliminary investigations have been made of the implications of the recently established Health Protection Branch PCB guideline on commercial fishing in the Great Lakes. On the basis of current (Appendix 5) data, smelt from Lake Ontario, and eels from Lake Ontario and the St. Lawrence River routinely contain levels of PCB in excess of the 2 ppm guideline. It is not anticipated at this time that these violations of the Canadian guideline will have a significant impact on the commercial fishery. The majority of the catch of these species are commonly exported to markets which have a less restrictive tolerance, or no tolerance. However, the potential for a more significant impact on commercial fishing in the Great Lakes exists, pending a more accurate appraisal of the current PCB content of various species, and the possible development of more restrictive tolerances in foreign markets .

Coho Salmon, stocked in Lake Ontario in the early 1970s, have been found to be contaminated with about 20 ppm PCB. Advice was given to sport fishermen not to eat more than one meal of fish per week and to pregnant women not to eat the fish at all. This situation and the recent findings that hepatocellular carcinomas developed in rats fed Aroclor 1260 for 21 months (Kimbrough 1975) and that normal reproduction in the monkey was disrupted at dietary levels of 2.5 µg/g (Allen 1975) have resulted in renewed interest in PCB.

The toxicology of PCBs is complicated by the presence of several chlorinated dibenzofurans in most formulations of PCB (Bowes et al, 1975). The relative contribution of these contaminants to the toxic manifestations in laboratory experimental work, in losses in mink ranching and in the natural reproduction of severely contaminated birds is difficult to assess. The presence of other pollutants such as dieldrin, DDT and metabolites, and other organochlorine substances and trace metals, in organisms further compounds the problems encountered in this kind of research.

MONS 053702

1.2. OECD action

Because PCBs are an international problem, not only in that they are widespread in their occurrence and may be transported across national boundaries but also in that they are commodities sold in international trade, the Organisation for Economic Cooperation and Development (OECD) Council, on 13 February 1973, took a decision to control PCBs. The text of the press release which announced the decision is reprinted below (OECD Press/A (73)3.).

"OECD Member countries have agreed to control the manufacture and trade of industrial chemicals known as Polychlorinated Biphenyls (PCBs), the use of which may lead to the contamination of the environment. This is the first international agreement aimed at limiting the production and use of chemicals in order to protect the environment. Only a limited number of uses, specifically listed in the OECD Council Decision and including, in particular, applications where the non-flammability of PCBs is an essential factor, would be authorized. The Decision also allows for production of PCBs for use in closed systems, such as condensers and transformers in large electrical equipment, which present minimal risks for the environment".

"The agreement recommends that Member countries in implementing the Decision give priority attention to the elimination of PCB uses in such products as heat transfer fluids for food processing, animal feed and pharmaceuticals; adhesives and sealants; hydraulic liquids, other than in mining, and lubricating oils; vacuum pump fluids and cutting oils; also pesticides".

"The OECD action stems from the widespread concern of Governments, following a series of accidents. The persistence and toxicity of PCBs first became apparent with the discovery in 1966 of traces in poisoned fish and wild birds. Accidents during the past four years have included the occurrence of PCBs in chickens caused by absorption from PCB-containing plastic wrappers; the discovery of PCBs in food wrappings due to recycling of copying paper in the production of paper pulp; the occurrence of PCBs in milk from cows given feed contaminated by PCBs through herbicides or silos where it had been stored (U.S.A., 1969, 1970, and 1971). The most serious accident involved human poisoning following leakage of heat transfer fluid in a rice oil pasteurisation plant in Japan in 1968".

"The Decision, establishing co-ordinated environmental regulatory action among OECD countries, lays stress on the ultimate need to entirely eliminate the dispersal of PCBs; it is also in line with the Resolution passed by the United Nations Conference on the Human Environment in June 1972 calling on Governments to minimise the release of dangerous or toxic substances, especially where they are persistent".

MONS 053703

1.3. The Canadian legislative response and appointment of Task Force on PCBs

There is no known manufacture of PCB in Canada. For over three years, the major importer, Monsanto Canada, has supplied PCBs only to electrical equipment manufacturers. There was no legislative power in Canada to enforce a restricted use of PCBs and the government had no power to determine whether the OECD restrictions were being honoured by industry. This situation with PCBs strongly influenced the drafting of the Environmental Contaminants Act which was introduced into the former parliament March 4, 1974, and was reintroduced into the present parliament October 11, 1974. The Act was given Royal Assent on December 2, 1975. When the Standing Committee on Fisheries and Forestry was considering Bill C-25, the Environmental Contaminants Act, the question of substances on the Schedule arose. It was mentioned that the first substance to be scheduled would probably be the polychlorinated biphenyls.

Recently, the Great Lakes Water Quality Board (1975) concluded that the PCB levels have not declined in the Lower Great Lakes region. More recently, the joint MHAW/DOE Advisory Committee on Environmental Contaminants agreed to appoint the present ad hoc interagency Task Force on PCB to investigate the problem in detail.

1.4. Other reviews and publications

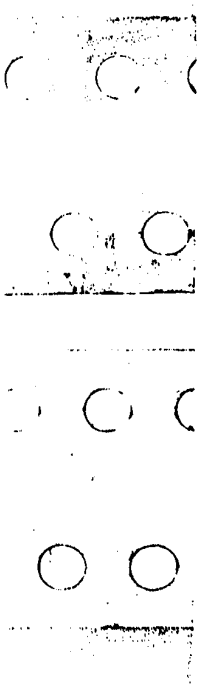
Previous reports on PCB have been made in both the United States and in Canada. In the United States, a Panel on Hazardous Trace Substances (Nelson, 1972) published a report on PCB under the auspices of the Ad Hoc Committee on Environmental Health Research. This very extensive review concerned itself with all aspects of PCBs up to the year 1972 and included recommendations on the research which should be undertaken to understand the details of the problem needed for taking appropriate regulatory action. The reader is referred to that report for aspects not covered in this Task Force Report particularly concerning information needed to build a model of PCB entry and fate within the environment.

MONS 053704

A U.S. Interdepartmental Task Force on PCB published a report in 1972 concerned with protecting the public from PCB hazards.

In Canada, a Working Group on PCB (Buxton et al. 1972) reviewed the information available in 1972 and made specific policy recommendations concerning the PCB situation.

In addition, two reviews of the chemistry and biology of PCB have been published by Hutzinger et al.(1974) and by Peakall (1975) respectively. The National Research Council is presently revising a criteria document on PCB.



MONS 053705

2. FIRST TERM OF REFERENCE CONCERNING THE OECD DECISION

3. RESPONSE TO FIRST TERM OF REFERENCE

3.1. OECD restrictions on PCB use

3.1.1. Prohibition of uses

3.1.2. Control of manufacture, import and export of bulk PCB

3.1.3. Institution of safe disposal measures

3.1.4. Labelling system

3.1.5. Precautions in transportation

3.1.6. Control of manufacture, import and export of PCB-containing products

3.1.7. Elimination of use in capacitors

3.1.8. Other uses to be eliminated

3.1.9. Safety of replacements

3.1.10. Exchange of statistical information

3.2. Summary

2. FIRST TERM OF REFERENCE CONCERNING THE OECD DECISION

"To examine the restrictions on the use of PCBs as outlined in the OECD Council decision of 14 February, 1973 in order to determine their efficacy as Canadian regulations and whether alternative restrictions are required under the Act".

3. RESPONSE TO FIRST TERM OF REFERENCE

3.1. OECD Restriction on PCB use

The Task Force carefully examined the several parts to the OECD decision and makes the following comments:

3.1.1. Prohibition of uses

The OECD (1973) decided that Member countries should ensure that PCBs should not be used for industrial or commercial uses except for,

1. Dielectric fluids for transformers or large power factor correction capacitors.
2. Heat transfer fluids.
3. Hydraulic fluids in mining equipment.
4. Small capacitors.

The Canadian position within OECD was that the only exceptions should be for dielectric fluids for transformers or large and small capacitors and associated switch gear. Therefore, the OECD exceptions for heat transfer fluids and hydraulic fluids in mining equipment were unacceptable, in the long term. In fact, so far as is known to the Task Force, PCBs have not been commercially available in Canada for use as heat transfer or hydraulic fluids since 1972 when Monsanto ceased to sell for these applications.

3.1.2. Control of manufacture, import and export of bulk PCB

OECD Member countries were directed to control the manufacture, import and export of bulk PCBs.

The Environmental Contaminants Act has the required power and provisions, to control manufacture and import but not to control the export of PCB.

3.1.3. Institution of safe disposal measures

OECD Member countries were directed to institute adequate arrangements for the recovery, regeneration, adequate incineration or other safe disposal of surplus and waste material.

The Act has no provisions to carry out this function primarily because this is largely a management control whereas the Act is based on the criminal law. Under 8(1)(b) the conditions may be prescribed under which a specified substance may not be released, into the environment; this might enable the Federal Government to make a partial response to this aspect of the problem.

3.1.4. Labelling system

OECD Member countries were directed to institute a special, uniform labelling system for both bulk PCBs and PCB-containing manufactured products.

There is no specific provision under the Act to permit the introduction of a uniform labelling system for PCBs. The Canadian Electrical Manufacturers Association (CEMA) has developed a recommended label, but it does not appear yet to be in general use. A case could be made that the absence of adequate labelling might lead to inadvertent use of the wrong product in food or feed. The contamination of cattle feed by polybromobiphenyl (a fire retardant additive for plastics) in Michigan through inadvertent switching of similarly labelled bags of nutrient supplement with the fire retardant serves as a good example.

3.1.5. Precautions in transportation

OECD Member countries were directed to establish safety specifications for containers and transport.

Again, there is no specific provision under the Act. Ministry of Transport (MOT) is developing guidelines under its uniform code for transport of hazardous goods.

3.1.6. Control of manufacture, import and export of PCB-containing products

The OECD recommended that Member countries control the manufacture, import and export of PCB-containing products.

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In this regard other Acts of Parliament are relevant to the control of PCB and products containing PCB. The Hazardous Products Act may be used to control import, advertising and sale of products hazardous to human health. The Fisheries Act may be used to control effluents where there is harm to fish or to the use of fish by man and the present Environmental Contaminants Act is intended to control emissions to safeguard human health and the environment. Under 8(4) and 18(e) of the Act regulations can be made to prohibit the import, manufacture and sale of products containing PCBs. (See Section 11.3.).

3.1.7. Elimination of use in capacitors

The OECD recommended that member countries work towards the elimination of the use of PCBs in small capacitors.

There is no management provision in the Act for this purpose, but if environmentally-suitable alternative dielectrics become available, regulations could be modified to add small capacitors to the proscribed uses of PCBs if the evidence were sufficient that the Governor-in-Council could be satisfied that a significant danger exists. (See Section 11.2.2., 11.4.2.)

3.1.8. Other uses to be eliminated

The OECD recommended that Member countries give priority attention to the elimination of the following applications of PCB:

a) heat transfer fluids, ✓
b) plasticizers in paints, inks, copying paper, adhesives and sealants ✓
c) hydraulic liquids and lubricating oils ✓
d) vacuum pump fluids and cutting oils ✓
e) pesticides ✓

All these uses can be proscribed by regulation made under 18(c)

3.1.9. Safety of replacements

The OECD recommended that Member countries request firms to use, as PCB replacements, materials which are less hazardous to human health and the environment than the range of PCBs now in use.

There are no specific provisions under the Act to request firms to use less hazardous materials as PCB replacements. It is certain that not only informal requests to this end will be made, but also that companies are becoming aware of the need to find and use less toxic replacement materials. When alternatives are available, the hazardous materials may be proscribed by regulation.

3.1.10. Exchange of statistical information

The OECD decided that at the beginning of 1974, 1975 and 1976, Member countries should exchange information on the main statistical data concerning PCBs including:

1) quantities manufactured, imported, exported, incinerated and consumed by use. In 1974 and 1975, Canada submitted to OECD information on these quantities in so far as was available; little was available other than the import and sales data of Monsanto Canada Ltd. (See Section 5.1.).

Information may be gathered under 3(1) of the Act and this information may be reported to OECD so long as it is not classified as confidential. Annual reporting of PCB quantities may also be demanded under this provision.

2) PCB replacements including identity, total amounts and individual uses and their toxicity and environmental hazard.

Under the provision for information-gathering this data may be obtained if we can specify what is wanted and depending on the classification it may be reported to OECD.

3) Disposal of surplus PCBs by incineration (including evaluation of incineration efficiency) or by other efficient means. (See Section 5.4.1.).

As a matter of practicability, control of disposal is largely a provincial responsibility: it should be possible to obtain data on waste PCB disposal from provincial authorities, if special facilities such as incinerators are in use.

3.2. Summary

The OECD decisions and recommendations can generally be carried out by regulations under the Environmental Contaminants Act. The exceptions are the recommendation concerning control of exports, labelling and control of the disposal of surplus or waste PCBs(which can probably be managed by the provincial governments). The only use of PCBs for which supplies have been made available by the main Canadian supplier (Monsanto Canada Ltd.) is as a dielectric in transformers and capacitors. It now seems appropriate, in the light of the available analytical data on environmental occurrence of the various PCBs, to reconsider the OECD recommendation for work towards the elimination of the use of PCBs in small capacitors, and to consider modifying the OECD recommendation by inserting the words "environmentally persistent" before "PCBs". (See Section 7.3.)

4. SECONN TERM OF REFERENCE CONCERNING INFORMATION ON QUANTITIES

5. RESPONSE TO SECOND TERM OF REFERENCE

5.1. Amounts of PCBs imported and used

5.2. Amounts of PCBs recycled

5.3. Amounts of PCBs exported

5.4. Amounts of PCBs disposed of

5.4.1. Incineration

5.4.2. Land Disposal

5.4.3. Sewage Influent

5.4.4. Direct Disposal to the Environment

5.5. Amounts used in various commercial and domestic products and activities

5.6. Summary

4. SECOND TERM OF REFERENCE CONCERNING INFORMATION ON QUANTITIES

"To examine the existing available information, obtained informally and voluntarily, on the amounts of PCBs imported, used, recycled, exported and disposed of, on the amounts used in various commercial and domestic products and on the amounts used in various commercial activities".

5. RESPONSE TO SECOND TERM OF REFERENCE

5.1. Amounts of PCBs Imported and Used.

The latest figures on Monsanto imports of different grades of PCBs which have been reported to OECD are given in Table 1 below; these figures have not yet been publicly released and refer to the quantities imported since the Monsanto ban in 1972. In addition 15 tonnes of PCB were imported from France in 1973.

Table 1. Tonnes of PCB imported into Canada by Monsanto, 1973-74

	1016 for use in capacitors		1254 for use in transformers	
Year	Small	Large		Total
1973	185	200	900	1285
1974	245	265	1080	1590

Figures for the years (from 1964 to 1971) prior to the Monsanto ban are shown in Table 2.

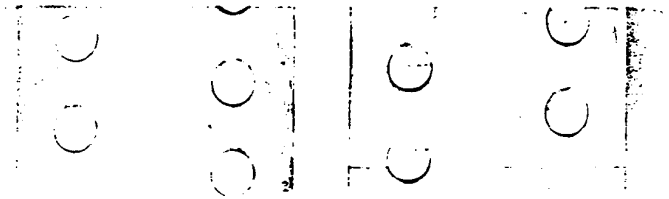
There was a sharp decrease in the quantities imported between 1970 and 1971, though the total quantities have remained nearly stable since that time.

A second aspect of the importation of PCB must be considered. PCB may be incorporated into products which are brought into Canada. These products may range from plastics, incorporating PCBs as a plasticizer, to machinery containing PCB as a lubricant, heat transfer medium or dielectric in imported transformers and capacitors. These quantities are not specifically identified and reported by the PCB manufacturer, user, importer or by government agencies and could represent a significant source of PCB to the Canadian economy and environment. Through the provisions of the Environmental Contaminants Act this information could be collected. (See Section 11.5. and 11.6.).

Investment casting waxes may contain PCB particularly decachlorobiphenyl. Since these are not supplied by Monsanto but are imported from Italy to the United States, no data are available on imports to Canada. A company called Yates, in Chicago, are the importers from a company in Milan, Italy.

TABLE 7 Tonnes of PCB by use and by type imported into Canada until Monsanto voluntary ban in 1971

	1964	1965	1966	1967	1968	1969	1970	1971
Heat transfer	4	1	17	22	20	30	76	25
Hydraulics/lubricants	58	46	103	82	89	111	164	14
Transformer/capacitor	458	1064	1239	1251	1258	1470	2015	1522
Plasticizer application	229	228	291	281	241	235	195	62
Total	749	1339	1650	1636	1608	1845	2450	1623
Aroclor 1221	1	1					2	13
1232	10	11	15	15	15	16	10	
1242	304	394	477	558	682	772	962	432
1248	76	62	95	80	63	65	93	14
1254	94	325	520	335	670	704	1090	853
1260	255	538	536	593	157	237	276	263
1262	8	8	7	6	8	8	2	
1268	1			3	1	1	1	
Montar				46	12	42	14	48
	749	1339	1650	1636	1608	1845	2450	1623



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5.2. Amounts of PCB recycled

It is useful for the purposes of this report to define what is meant by recycling since recycling is an aspect of disposal. In this context recycling includes the recovery of PCB from transformers and capacitors for re-use in transformers and capacitors or in other(non-electrical)applications. These latter may include any of the former PCB uses no longer being supplied directly by the manufacturer. These were in paints, adhesives, sealants, caulking compounds, plastics, waxes, synthetic resins and rubber, lubricants, hydraulic fluids, vacuum pump fluid, gas turbine fluid, carbonless copypaper, inks, heat transfer fluid, dedusting agents, cutting oil and pesticide extenders (Nelson 1972).

There is very little information on PCB recycling. There are reports of PCB used as a dedusting agent on the roads, probably because of mixing of several types of waste oil from industrial usage. There is a report of waste transformer-oil used as a diluent in pesticide application but it is uncertain what quantities may have been used or if the transformer oil was waste mineral oil, waste mineral oil with PCB from "topping-up" operations or waste PCB. There are hydraulic systems which still use PCB and may be "topped up" with recycled material. Similarly, this could be occurring in heat transfer systems. PCBs have been found to be excellent cutting oil additives and recyling for this use may be occurring. There is a great deal of uncertainty surrounding this aspect of PCB recycling and almost no information is available on quantities which may be recycled in this way. However these "open system uses" are possibly significant in relation to the total quantity released to the environment and undoubtedly they must have contributed to the present levels of environmental contamination. Information on quantities used in these ways could be gathered using the provisions of the Environmental Contaminants Act.

5.3. Amounts of PCBs exported

There are no known exports of PCBs per se. PCBs are exported in finished electrical products. It is assumed that the quantity of PCBs exported in products may be about the same as the quantity imported in products, however detailed information on this aspect does not exist.

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5.4. Amounts of PCB disposed of

There are several routes by which PCB may be disposed of PCB for disposal may be in the a) liquid form or as a liquid contaminant in domestic and industrial solid waste such as scrap electrical equipment and appliances or b) in the molecularly dispersed form incorporated into a solid such as a plastic product or investment casting wax. Apart from the recycling aspect already mentioned in 5.2. above, PCB from formerly approved and from present uses may be incinerated (5.4.1.), landfilled (5.4.2.) or flushed into drains that lead either into municipal sewers (5.4.3.) or directly into the open environment (5.4.4.). These several routes have been extensively reviewed by Nisbet and Sarofim (1972), and by a Panel on Hazardous Trace Substances of the U.S. Committee on Environmental Health Research (Nelson 1972). Another method of disposal which seems to be important at present is the recovery of old transformers and capacitors and storage in stackyards and warehouses until some more appropriate disposal method is generally available. There are a considerable number of companies which specialise in disposal of liquid wastes but these frequently are not the final disposal party since they may only transport the wastes to other disposal organisations.

5.4.1. Incineration

Waste PCB from transformers and capacitors may be safely disposed of by high temperature incineration. Three companies are now offering to dispose of wastes in this way. Monsanto of St. Louis and Chemtrol of Niagara Falls, N.Y., both have facilities which can incinerate waste PCB. Thermal Degradation Systems of Hamilton have facilities but they are not approved by the Ontario Ministry of the Environment. The Hamilton plant does not have scrubbers to remove the HCl formed by combustion of organochlorine materials and thereby to comply with air pollution control requirements.

Experiments are being conducted by the Water Pollution Control Directorate of E.P.S., the Ontario Ministry of the Environment and the Ontario Research Foundation, using waste PCB oil as a source of thermal energy and chloride in the cement kiln of St. Lawrence Cement at Mississauga. The advantage of using cement kilns for PCB disposal is their ubiquitous distribution, high operating temperature and long

residence time of the gases in the kiln (Berry 1975). At the Mississauge plant the evolved HCl is beneficial in removing sodium and potassium (as chlorides) from the cement clinker.

Waste transformer oil may be used as furnace fuel by industry. The oil may be primarily mineral oil, however there is evidence that this may be contaminated with PCB from "topping up" operations during servicing. PCBs would probably not be combusted at the temperatures associated with normal industrial furnaces and would consequently be volatilised and escape with the gases up the stack.

Household garbage contains PCBs in plastics, caulking compounds etc., and may be incinerated by municipalities. It is unlikely that municipal incinerators operate either at the temperature or with the retention times needed for effective destruction of PCB. Very little work has been done on the quantity of PCB in municipal garbage and no work to our knowledge has been done on the estimation of quantities of PCB in stack gases of incinerators.

Municipal sewage contains PCB and about half of this is trapped in the sludge. Some municipal sewage plants have incinerators for sludge disposal and PCBs may enter the atmosphere from their normal operation. (See Section 7.2.3.).

5.4.2. Land disposal

Spent PCB from transformers and capacitors and from the manufacture of these electrical goods are recovered and sometimes sent to landfill sites rather than for incineration. Chemtrol Disposal Services have a "scientific landfill site" in the Lewiston, Model City, Blairville area near the Niagara River, in New York. Several disposal companies transport spent PCB, either as liquid waste or contaminated solid materials from transformer and capacitor manufacturing and servicing, to this disposal site. It is understood that the landfill is lined with clay material and continuously monitored for signs of groundwater contamination. Again, estimates of the quantities disposedof in Canadian landfill and being exported to the U.S. as waste could be required under the Environmental Contaminants Act since disposal is a commercial or processing activity.

Generally, disposal of waste PCB and waste products containing PCBs in dump sites will lead to contamination of the terrestrial, aquatic and atmospheric environment, particularly in areas of high leaching and in dumps with open burning. There are no specific quantitative data on the amounts going to dumps, but the Panel on Hazardous Trace Substances considered that in North America 55% of the PCB production has been disposed of in dumps and incinerators but that only 10-20% of this was destroyed by the incineration process. This indicates that large quantities of PCB are held in landfill sites and dumps.

There is a report that about 3% of the production of small capacitors made by the Aerovox Company in Amherst, Nova Scotia was going to the municipal dump as defective products. This, together with other wastes in fuller's earth or from the degreaser in the plant could have resulted in about 3,000 gallons of Aroclor 1016 per year being diposed of in the dump. (Memo Nova Scotia Department of Public Health - 31 January 1974).

Virtually all the PCBs used in small capacitors will find their way into ordinary solid waste i.e. garbage and thereby to garbage dumps. Though they are encapsulated in other materials, the degradation of these materials will eventually release the PCBs into the environment.

Municipal sewage sludge is frequently disposed of on land. Ontario sewage sludges, which were sampled by Shannon (1975) and by Agriculture Canada, contained PCB and thus PCB is dispersed onto land through this method of sludge disposal. The quantities and subsequent fate of this material have not been followed (See Section 7.2.3. Sewage sludge disposal).

Disposal of waxes and resins containing PCBs may be by solid waste disposal into landfill. Quantities disposed of in this manner are not available.

5.4.3. Sewage Influent

Waste PCB may enter drains and sewers from plants using PCB or PCB-containing products. Shannon (1975) has reported on the quantities of PCB entering selected sewage treatment plants in Ontario in 1974. These data are

presented in Table 15. The origins of PCB in wastewater are not known in detail at this time. However, firstly a particular interest attaches to the disposal of transformer oil removed for routine checking from large transformers and possible contamination from this service. Secondly, plants producing transformers and capacitors in Hamilton, London, Peterborough and Toronto dispose of the wastewater into the municipal sewage systems for treatment. These are the probable sources of the high concentrations in the influent wastewater to the Hamilton and Toronto wastewater treatment plants (See Table 15). There appears to be a low background level of PCB discharge from all the sewage treatment plants generally amounting to less than a kilogram per plant per year. This small background level may be from leaching and weathering of materials containing PCB rather than from point sources discharging to the sewage system. It is understood that it would be very costly to follow the sewage system in a municipality to locate a point source. This expense may have to be incurred if the low continuous discharges are found to be a significant component of the biological contamination (See discussion in 7.2.6.).

In a 1975 survey of the Kawartha Lakes region near Peterborough samples of influent wastewater to treatment plants at Peterborough, Campbellford, Port Hope and Lindsay contained 0.38, 0.13, 1.31, and 1.07 ppb respectively. The PCB was of the Aroclor 1248 type at Peterborough and Port Hope and of the 1254 type at Campbellford. The type at Lindsay was not specified (MOE unpublished data).

Inspection of the Canadian General Electric capacitor plant at Peterborough showed that between 0.11 and 0.40 ppb Aroclor 1248 was present in the three storm and sanitary sewers in the plant.

In another MOE survey in 1975, the process water from the General Motors plant in St. Catherines contained 0.35 ppb Aroclor 1260 and was discharging to the Port Weller municipal treatment plant. Similarly an effluent from the Ferranti-Packard transformer plant discharged between 0.9 and 3.2 ppb PCB to the same treatment plant

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5.4.4. Disposal direct to the environment

The Canadian General Electric plant at Guelph, which manufactures transformers, discharged PCB to a marsh behind the plant. In 1972 control measures were instituted to prevent further releases of PCB to the marsh and further transport of contaminated marsh water and sediments entering the Speed and Grand Rivers. It is not known how much PCB was lost by this route before remedial action was taken. It is also uncertain what quantity of material may be stored in the marsh, however MOE is investigating this aspect.

In a survey conducted in 1975 by MOE, samples from the General Motors plant showed that the cooling water contained 2.6 ppb Aroclor 1248 and was being discharged to the Twelve Mile Creek. The process water from another G.M. plant contained 0.15 ppb Aroclor 1260 and was discharged to the Welland Canal. (MOE unpublished data).

It is not known whether other electrical manufacturing plants discharge PCB direct to the environment but it is probable that this was an extensive practice before the environmental information on PCB became documented. The possibility that some other industries may be using PCB in a heat exchanger and discharging leaked material directly into the environment can only be determined through extensive sampling and analysis. (See also 7.2.1.2. Industrial waste discharges direct to the environment).

Discharging of bilgewater from ships may be a significant source of PCB, since leakage from hydraulic pumps containing PCB will eventually end up in this material. Though PCBs are not meant to be used in hydraulic fluids in OECD countries, it is quite possible that foreign ships may be using PCBs for this purpose. The hydraulic systems on international aircraft might also contain PCB though temperature and viscosity considerations may preclude this application.

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5.5. Amounts used in various commercial and domestic products and activities

Apart from the quantities of PCB used in transformers and in small and large capacitors (reported in the Table 1) there would be no use of PCBs in Canada if the Monsanto voluntary restrictions were fully effective. Previous uses and quantities have been reported by Monsanto Chemical Company and are readily available elsewhere (Table 2). No attempt has been made to quantify the non-dielectric usages of PCBs because a specific notification under the Environmental Contaminants Act is required to identify users.

Though PCB in recycled paper is not strictly-speaking a use of PCBs, they do occur in the final product and it is appropriate at this point to make reference to the work done by Ontario Research Foundation and Health and Welfare Canada into the quantities of PCBs present in food packaging materials (Villeneuve et al. 1973). Generally, samples contained less than 1 ppm, however 15% contained between 1-10 ppm PCB and 3% contained over 10 ppm PCB. Polychlorinated terphenyls were also found in approximately the same proportions and concentrations.

Studies by Agriculture Canada found 0.12 ppm PCB in newspaper and 0.14 ppm (Aroclor 1242) in cardboard (Goldrosen A. to T.E. Rattray, Environment Canada, pers. comm.).

Carbonless copypaper containing PCB has been used in Canada since the mid-1950's. Production and sales of this type of paper reportedly ceased in 1971 when Monsanto imposed its use restrictions. National Cash Register originally held the patent for the encapsulation process and licensed some outside firms to produce the finished NCR paper. In all cases, the paper was manufactured outside Canada and was imported to be cut and printed for domestic sale. Several firms manufacture carbonless copypaper , but few reportedly ever used PCB in the process. It is suspected that quantities of forms made from this paper are currently in unused office inventories and files in Canada. It is also possible that some finished forms were exported for use whereas others were mailed outside Canada as used stationery.

Various companies in Canada using investment casting resins and waxes are using products containing PCB. The Canadian companies are believed to h

importing their supplies from the United States and may be releasing PCBs to the environment. One of the waxes contains decachloro-biphenyl as a filler (40%) which is imported from Milan, Italy by Yates of Chicago. Other waxes usually contain a polychlorinated terphenyl (60% chlorine) which is imported from France to the United States. Preliminary investigations have been initiated in Ontario.

5.6. Summary

One of the greatest problems with PCBs has been in the collection of information on quantities which are manufactured, imported, used and disposed of. There are good data concerning only the bulk importation of PCBs for Canadian manufacturing use. Almost no other data are available on the movement of PCBs in the economy. Some quantitative information is available from monitoring concerning amounts or concentrations entering the environment in the recent past.

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6. THIRD TERM OF REFERENCE CONCERNING LEVELS IN ECOSYSTEMS AND ROUTES OF ENVIRONMENTAL CONTAMINATION

7. RESPONSE TO THE THIRD TERM OF REFERENCE

7.1. Selection of ecosystems and indicators of levels

7.1.1. The Great Lakes and St. Lawrence Aquatic Ecosystems

7.1.1.1. Herring Gull Eggs

7.1.1.2. Fish

7.1.1.3. Sediments

7.1.2. Coastal Marine Ecosystems

7.1.2.1. Herring Gull Eggs

7.1.2.2. Fish

7.1.2.3. Seals

7.1.2.4. Polar Bears

7.1.3. Arctic Aquatic Ecosystems

7.1.4. Prairie Terrestrial Ecosystems

7.1.5. Ontario Terrestrial Ecosystem

7.1.6. Canadian Human Ecosystems

7.1.7. Discussion

7.2. Sources and mode of entry

7.2.1. Sewage Effluent

7.2.1.1. Municipal sewage treatment plants

7.2.1.2. Industrial waste discharges direct to the environment

7.2.2. Landfill Leachate

7.2.3. Sewage Sludge Disposal

7.2.4. Incineration

7.2.5. Levels in air, rain and snow melt

7.2.6. Tributaries to the Great Lakes

7.2.7. Discussion

7.2.7.1. Adequacy of data base

7.2.7.2. Summary of sources

7.2.7.3. Significance of inputs

7.2.7.3.1. Total quantity in sediments in each lake

7.2.7.3.2. Sources of biologically available PCB within the lakes

7.2.7.4. The objective of monitoring

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7.3. Other relevant observations

7.3.1. Trends of PCB levels in the environment

7.3.2. Types of PCB in environmental samples

7.3.3. Environmental levels of LCBPs

7.3.4. Origin of LCBPs in the environment

7.3.4.1. Possible production in chlorination plants

7.3.4.2. Possible extent of production

7.3.5. Presence of LCBPs in commercial PCB mixtures

7.3.6. Chemical species of particular toxicological importance contained in/or derived from commercial PCB

7.3.6.1. Chlorodibenzofuran (CDBF).

7.3.6.2. Single isomers of particular homologs

7.3.6.3. Metabolites

7.3.6.4. Complicating factor-complex mixtures

7.3.7. Consumption and usage of low chlorinated and higher chlorinated PCB

7.3.7.1. Total PCB usage. 1957-1974

7.3.7.2. PCB usage 1973 and 1974 and usage ratio

7.3.7.3. Implications of the usage figures

7.3.7.4. Estimated usage of PCB in the lower Great Lakes region

7.3.8. Losses to the environment

7.3.8.1. Estimates by commercial PCB type

7.3.8.2. Estimates by chloro-homolog type

7.3.8.3. Conclusion

7.4. Conclusions

6. THIRD TERM OF REFERENCE CONCERNING LEVELS IN ECOSYSTEMS AND ROUTES OF ENVIRONMENTAL CONTAMINATION

"To examine existing information on levels of PCBs in various ecosystems in Canada in order to determine the source and mode of entry of PCBs into various sectors of the environment".

7. RESPONSE TO THIRD TERM OF REFERENCE

7.1. Selection of ecosystems and indicators of levels

In responding to the first part of this section the Task Force has collected information on PCB in various materials and biological tissues. The Task Force wishes to stress that in many instances the available data was inadequate to provide more than a gross indication of contamination patterns. In a number of cases the choice of ecosystems and indicators was based on the availability of information and the data is not necessarily based on the best monitor material. The data can be divided into six distinct ecosystems as follows.

1. The Great Lakes and St. Lawrence Aquatic Ecosystem.
2. The Coastal Marine Ecosystems
   - Atlantic
   - Pacific
   - Arctic.
3. The Arctic Freshwater Ecosystem.
4. The Prairie Terrestrial Ecosystem.
5. The Ontario Terrestrial Ecosystem.
6. The Canadian Human Ecosystem.

Within these ecosystems various inanimate and biological materials have been sampled to provide indices of the degree of contamination of the ecosystems. Within the Great Lakes, for example, PCB levels in samples of Herring Gull eggs, fish and sediments, have been reported from the different basins. In the coastal marine ecosystems, samples of Herring Gull eggs, fish, seals and Polar Bears have been used as indices of the level of contamination. In the terrestrial environment eggs of Prairie Falcons and Merlins and milk of cows have been used. The general level of human exposure has been documented by using human adipose tissue as an integrator of all routes of exposure.

Because this document is concerned with the background to the development of regulations and because the selected organisms are being used solely as indicators of the level of environmental contamination, the toxicological significance of the residue levels is not discussed. For a discussion of the toxicology the reader is referred to the forthcoming PCB review by the National Research Council and the review by Peakall (1975)

7.1.1. The Great Lakes and St. Lawrence Aquatic Ecosystem

The materials which have been selected to indicate the levels of PCB contamination in the Great Lakes and St. Lawrence are Herring Gull eggs, fish, and sediments.

7.1.1.1. Herring Gull Eggs

A monitoring program, based on collecting 10 eggs from two colonies of each of the four Canadian Great Lakes, was started by the Canadian Wildlife Service in 1974. Some data are also available from earlier years. A summary of available data is shown in Table 3. The main conclusions from these data are (1) that the levels are high in the Great Lakes, especially in Lake Ontario (ca. 70-180 ppm wet wt), compared to coastal populations and (2) there is no definite evidence of a decline over the period 1972-1975 despite the restrictions on the usage of PCBs. It is concluded that substantial amounts of PCBs are still entering the Great Lakes and/or that the stability of these compounds is so great that the half life of the higher chlorinated isomers should be reckoned in terms of decades.

The levels in Lake Superior Gull eggs are similar to those found in eggs from Lake Huron (ca. 50 ppm). The former population probably acquire much of their PCB load from wintering in Lake Michigan. The highest levels are seen in the eggs from the eastern end of Lake Ontario (ca. 100-180 ppm). Eggs from the St Lawrence River below Quebec had significantly lower levels (20 ppm) of PCB contamination. Eggs of birds from the Gulf of St. Lawrence seem to be relatively uniformly contaminated with about 5 ppm.

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TABLE 3. PCB LEVELS IN HERRING GULL EGGS.

Location	Year	Sample size	Wet weight ppm	Dry weight ppm	Reference
LAKE SUPERIOR					
Ontario					
Granite Island	1973	8**	49.1	--	Ryder (1974
	1974	10	55.2	229.8	CWS report (1975)
Silver Island	1973	10**	52.3	--	Ryder (1974)
	1975	10	63.5	261.1	CWS report
Mamainse Island	1974	10	37.2	151.3	CWS report (1975)
	1975	10	54.3	224.5	CWS report (1975)
LAKE HURON					
Ontario					
O'Brien Island	1972	2	58.1	257.2	Gilbertson (1974)
Double Island	1974	10	42.1	173.0	CWS report (1975)
	1975	10	35.3	149.1	CWS report (1975)
Chantry Island	1974	10	64.5	282.0	CWS report (1975)
	1975	10	30.3	119.5	CWS report (1975)
LAKE ERIE					
Ontario					
Port Colborne	1972	2	63.6	304.2	Gilbertson (1974)
	1973	10	35.7	147.6	
	1974	10	55.1	231.4	CWS report (1975)
	1975	12	40.5	172.3	CWS report (1975)
Middle Island	1974	10	55.0	228.3	CWS report (1975)
	1975	10	54.4	222.6	CWS report (1975)
LAKE ONTARIO					
Ontario					
Niagara Peninsula	1971	21	74	--	Frank, et al (1975
Six Colonies	1972	12	130.8	356.8	Gilbertson (1974)
Muggs Island	1972	2*	73.2	343.0	Gilbertson (1974)
	1974	9	125.8	532.3	CWS report (1975)
	1975	10	82.0	339.5	CWS report (1975)
Brother Islands	1972	2*	167.0	781.6	Gilbertson (1974)
	1974	10	106.4	605.4	CWS report (1975)
	1975	10	140.4	606.4	CWS report (1975)
Black Ant Island	1972	2*	183.2	856.1	Gilbertson (1974)
ST. LAWRENCE RIVER					
Quebec					
Notre-Dame du Portage	1974	10	20.7	83.1	CWS (unpublished)
GULF OF ST. LAWRENCE					
New Brunswick					
Manawagonish Island	1973	5	3.9	17.0	CWS (unpublished)
Bathurst	1973	5	5.0	20.3	CWS (unpublished)
Prince Edward Island					
Cherry Island	1973	5	5.1	21.0	CWS (unpublished)
Nova Scotia					
Brion Island (Magdalen Islands)	1973	5	5.5	22.9	CWS (unpublished)
ATLANTIC COAST					
New Brunswick					
Bay of Fundy	1971	13	5.3	--	Zitko, (1974)
	1972	15	3.3	--	
	1973	15	3.7	--	
Newfoundland					
Great Island	1975	5	4.7	18.8	CWS (unpublished)

* also included in the colony summary
** average of two pooled samples

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7.1.1.2. Fish

Fish from the Great Lakes and the Gulf of St. Lawrence have been analysed for several years by the Fisheries Inspection Branch of Fisheries and Marine Services. Other laboratories have also analysed specimens from the Great Lakes.

Since Fisheries Inspection Branch are concerned with the PCB levels in food for human consumption, only the edible portion of the fish is analysed. From the extensive information in the files of the Fisheries Inspection Branch two species have been selected as indicators of the contamination in the different Great Lakes and St. Lawrence River. These two species are the Sucker (*Catostomus* sp.) and the Yellow Pickerel (*Stizostedion vitreum*) and the data are reported in Table 4 below. Because it is not clear whether these samples are representative of the same year class or of similar lipid content these data provide only an overview impression of contamination. For comparison, data are also provided for PCB contamination of the same species taken from Central Canada.

Neither the information from the Fisheries Inspection Branch nor that in the literature show any general temporal trend in PCB levels in fish from the Great Lakes.

Table 4. PCB in Suckers and Yellow Pickerel in the St. Lawrence Great Lakes System in ppm wet wt in the edible portion

Location	Suckers	Yellow Pickerel
Great Lakes		
Lake Superior	No data.	0.37
Lake Huron, Georgian Bay	No data	1.09
Lake Erie	1.65	1.16
Lake Ontario	1.20	2.02
St. Lawrence River		
Lac St. Francis	1.83	3.72
Lac St. Louis	0.98	1.19
Lac St. Pierre	No data	1.03
Central Canada		
Lake Winnipeg	No data	0.10
Manitoba small lakes	0.07	0.07
Saskatchewan small lakes	No data	0.10
Alberta small lakes	No data	0.10

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The Yellow Pickerel data may indicate that PCB levels in Lake Superior are the lowest within the Great Lakes system. The reported levels are much higher in Lakes Huron and Erie but are highest in Lake Ontario at approximately 2 ppm. Within the St. Lawrence River very high values were reported in Lac St. Francis, but values decrease in the Lakes further downstream. The data from central Canada indicate that the mean levels in these species from the prairies range from about 0.07 - 0.1 ppm. Probably these central Canada levels reflect background contamination from atmospheric fallout. The high levels in the Great Lakes indicate major sources of contamination. (See also Appendix 5 1.

7.1.1.3. Sediments

Hamilton Harbour

A 1972 survey of PCB in sediments in Hamilton Harbour by the Ministry of the Environment showed levels of 1,300 ppb in the canal region, 2000 to 3000 ppb in the region of the industrial waterfront and 10,000 ppb near the sewage treatment plant. These levels are the highest documented in Canada and confirm that this environment is one of the most polluted with PCBs in North America.

Lake Erie

Figure 1 shows the concentration of PCB in samples of sediments from Lake Erie which have been reported by Dr. R. Frank and Dr. R.L. Thomas of Guelph University and CCIW respectively. The distribution of PCB in sediments is complicated in the western basin by scouring in the Detroit River channel. The main source of PCB to Lake Erie is from the Detroit and Maumee Rivers. The map also indicates that there are possible additional sources on the American side.

Upper Lakes

Thirty-four (34) sediment samples have been collected from Lake Huron (including Georgian Bay) and Lake Superior (Strachan unpublished CCIW report, 1975). In Lake Huron PCBs were present at all the stations

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either at or below the level of quantitation of 10 ppb. This would suggest a fairly rapid sorting of the PCB probably associated with sorting and transport of the fine material. The sample from Saginaw Bay, where large amounts of PCB have been discharged in the past, contained only trace amounts of PCBs.

In Georgian Bay the south eastern samples from around Collingwood, Midland and Parry Sound contained 20 ppb. In the two samples from the North channel one contained 10 ppb, the other contained a trace amount of PCB.

In Lake Superior, the results indicated a large source of PCB at Marathon where the sample contained 1300 ppb. Sediment transport probably resulted in the sample from the centre of the lake containing 90 ppb, while other samples from the periphery of the lake contained only trace quantities to 20 ppb PCB.

7.1.2. Coastal Marine Ecosystems

Information is available for a limited number of organisms in the three coastal ecosystems. Herring Gull and fish data are provided for the Atlantic, Pacific and Arctic coasts. Levels of PCB in various species of seals from the Atlantic and Arctic coasts and in Polar Bears from the Arctic are presented.

7.1.2.1. Herring Gulls Eggs

Herring Gull eggs from the Atlantic coast have been collected and analysed for PCBs. The results are given in Table 3. The levels(ca. 5 ppm). in colonies from the Bay of Fundy, Nova Scotia (Zitko 1974) and from Great Island, Newfoundland are about the same as the levels in the Gulf of St. Lawrence.

7.1.2.2. Fish

Atlantic Coast and Pacific Coast

Information from the Fisheries Inspection Branch on levels of PCB in Atlantic and Pacific fish and shellfish from coastal areas have been provided for comparative purposes in Table 5.

Table 5. PCB in Atlantic and Pacific coastal fish and shellfish

	PCB in wet weight ppm	
Species	Atlantic Coast	Pacific Coast
Cod	0.086	0.010
Halibut	0.36	0.060
Flounder	0.037	0.018
Clams	0.12	0.018

The data show that levels in Atlantic fish are higher by nearly an order of magnitude compared with the Pacific fish. Because the samples were not collected to represent the distribution of industrialisation in the two regions, the data may not faithfully reflect the contamination levels .

Arctic Coast

During the study of arctic and subarctic food chains (Bowes and Jonkel 1975),collections were made of Arctic Char from Baffin, Somerset and Prince Patrick Islands in the eastern,central and western Arctic respectively. Different tissues were analysed and thus it is difficult to compare these with the Ungava freshwater samples (see Section 7.1.3. Arctic Aquatic

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Fisheries Inspection Branch. The results of the analyses are presented below in Table 6. Arctic Char from far northern regions are relatively uncontaminated. However, the levels in the Hudson Bay fish are comparable with the level in Yellow Pickerel from Lake Superior - the lowest of Great Lakes values.

Table 6. PCB in Arctic Char (*Salvelinus alpinus*).

Location - tissue	length(mm)	number	PCB in wet wt. ppm.
Baffin Island			
Liver	568	3	0.010
Somerset Island			
Whole Body	-	1	0.015
Prince Patrick Island			
Liver	417	4	0.005
Muscle	416	3	0.008

From Bowes and Jonkel 1975.

Rankin Inlet, Hudson Bay			
Edible portion	-	-	0.30

From Fisheries Inspection Branch Fisheries and Marine Service.

7.1.2.3. Seals

Atlantic Coast and Gulf of St. Lawrence

Peakall (1975) reviewed the data on PCBs in marine mammals. These have been reworked and are presented in Table 7. The information for the Harp Seal from the Atlantic coast and the Gulf of St. Lawrence indicates that the pups from the Gulf and St. Lawrence River contain PCB residues twice as high as those on the Atlantic coast. The levels in adults from the River are about a third higher than in the Gulf and on the Atlantic coast. Other species sampled include Grey Seals from Nova Scotia containing considerably higher residue values and Hooded Seals

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Table 7. Levels of PCB in Seals from Atlantic and Arctic Ecosystems

(in ppm in blubber or lipid)

	Age	Number	PCB	Ref.
Harp Seal				
St. Lawrence River				
Tadoussac-Escommains	pups	?	3	Addison et al.
	juvenile	1	3	
	adults	15	9.2	
Gulf of St.Lawrence				
Magdalen Islands	pups	10	3.0	cited in Peerce et al.
Magdalen Islands -Quebec Northshore	pups	11	2.7	Frank et al.
	juvenile	1	8.0	
	adults	12	6.1	
Atlantic Coast				
Newfoundland/Labrador	pups	6	1.2	Holden
Newfoundland/Labrador	pups	29	1.4	Frank et al.
	juveniles	11	2.5	
	adults	14	6.2	
Grey Seal				
Atlantic Coast				
Nova Scotia				
Basque Island	adults	2	32	Holden
Sable Island	adults	5	27	
Hooded Seal				
Gulf of St. Lawrence				
Magdalen Islands	adult	1	3	Holden
Harbour Seal				
Atlantic Coast				
Bay of Fundy-Grand Manan	adults	3	52.3	Gaskin
Ring Seal				
Arctic Coast				
Unspecified location	Adults	3	3	Holden
James Bay	Juvenile	1	1	Bowes and Jonkal
Eastern Arctic	adult	1	0.16	
Central Arctic	adults	4	0.55 - 1.4	
Western Arctic	adults	12	0.05 - 1.93	

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from the Magdalen Islands, with marginally lower values than the Harp Seals. Highest values were found in Harbour Seals from the Bay of Fundy.

Arctic Coast

Analyses of PCB in Arctic Ring Seals indicate that contamination in the Arctic is considerably lower than in the industrialised St. Lawrence Basin. There does not appear to be any discernible geographic trend in contamination.

7.1.2.4. Polar Bears

Bowes and Jonkel (1975) investigated the levels of organochlorine contamination in arctic and Subarctic food chains and sampled Polar Bears as indicators of levels at the top trophic stage. Because several different kinds of tissue were sampled from animals in the various locations, comparison between locations is difficult. Similarly, extreme seasonal variability of the lipid content of Polar Bears add to the problem of interpretation. Polar Bears form distinct sub-populations which have been identified and documented (Jonkel and Stirling 1972), and which are used for comparison of PCB residue levels between geographic areas.

The results are shown in Table 8, and indicate that Polar Bear subpopulations in the eastern Canadian Arctic and Subarctic have been exposed to higher levels than western populations. There is also an indication that the subpopulation in Hudson Bay and James Bay has been exposed to the highest levels of PCB.

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Table 8. PCB in tissues of Polar Bears in wet wt ppm.

Location, tissue.	Age (yrs)	Number	PCB in wet wt. ppm.
ZONE 1			
James Bay & Hudson Bay			
Fat	8 - 16	3	7.8
Liver	7	1	3.9
Muscle	Cub	2	0.15
	2.5 - 7	5	0.21
Brain	7	1	0.19
Milk	-	1	0.19
ZONE 2			
West Baffin Island, Southampton Island, Melville Peninsula			
Fat	4.5	1	3.8
Liver	17	1	1.5
Muscle	3 - 22	7	0.08
Brain	17	1	0.12
ZONE 3			
East Baffin, Devon and Ellesmere Islands			
Fat	5.5	1	2.1
Liver	-	1	1.4
Muscle	Cub	1	1.1
	4 - 15	4	0.026
ZONE 4			
Somerset, East Victoria and East Banks Islands			
Fat	5 - 18	4	2.6
Liver	2 - 3	1	3.9
Muscle	6 - 19	3	0.010
Brain	4 - 6	2	0.030
ZONE 5			
West Victoria and West Banks Islands and MacKenzie Delta			
Muscle	3 - 12	4	0.033

adapted from Bowes and Jonkel 1975.

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7.1.3. Arctic Aquatic Ecosystem

Samples of Lake Trout from a remote arctic lake were analysed for organochlorine substances including PCB (Risebrough and Berger 1971). Lake Minto (75^{0}W, 57^{0} 30'N.) is 50 miles east of Hudson's Bay and is drained by the Leaf River which flows north-east to Leaf Bay, an inlet of Ungava Bay. The area is evidently too far from existing settlements to be visited by Eskimo hunting parties and white men have little reason to go there. The most likely source of synthetic pollutants is therefore considered to be from aerial fallout. Table 9 shows the residue values from this remote location and indicates that PCBs are accumulating in biota far from the sites of original usage or disposal.

Table 9. PCB residues in Arctic fish from Lake Minto, Ungava.

Species, tissue*	Weight, gm.	% lipid	PCB wet wt ppm.
Lake Trout 1 whole fish	455	4.0	0.045
Lake Trout 2 whole fish	492	3.1	0.041
Lake Trout 3 head foreparts	2,100	5.3	0.640
Lake Trout 4 whole fish	568	3.3	0.091
Lake Trout 5 whole fish	503	3.1	0.091

* Sample size is one fish.

Trout 3 was an exceptionally large fish 35.5 inches long and only the head and foreparts, weighing 2,100 gm, were analysed. Higher PCB concentrations in the fat of trout 3 suggest trophic concentration of residues. The undigested remains of a smaller fish 21 inches long was found in the digestive tract of this fish.

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7.1.4. Prairie Terrestrial Ecosystem

PCBs have been detected in prairie raptors (birds of prey) dependent on terrestrial food webs. The source of contamination is probably from atmospheric fallout and indicates that atmospheric transport of PCB is an important route of dispersal and an important factor in raptor ecology.

Table 10 reports the levels of PCB in Prairie Falcon and Merlin eggs collected in Alberta between 1969 and 1975. The data indicate that the Prairie Falcon eggs contain about 5 ppm on a dry matter basis and the Merlin eggs contain about 7 ppm. There does not appear to have been any temporal trend during the seven years of the survey.

Although these levels are much lower than the levels in Herring Gulls/eggs from the Great Lakes, they are believed to be of toxicological significance.

Table 10

PCB Levels in Prairie Falcon and Merlin Eggs Collected in Alberta. Mean values in ppm.

	Prairie Falcon			Merlin		
	n	wet weight	dry weight	n	wet weight	dry weight
1969	38	0.71	4.55	9	0.98	5.32
1970	45	1.12	5.84	43	1.53	7.56
1971	44	1.00	5.42	28	1.61	8.59
1972	48	0.58	2.97	70	1.18	5.92
1973	38	0.95	4.95	27	1.77	7.31
1974	50	0.99	4.92	33	1.53	7.82
1975	not collected			22	1.05	5.62

R.W. Fyfe unpublished data.

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7.1.5. Ontario Terrestrial Ecosystem

The Task Force hoped to use available milk surveys as an index of the contamination level of the terrestrial environment across Canada. The most probable route of contamination is from atmospheric transport of PCB and subsequent fallout. Only information for Ontario is available and thus the index of the trend across the country could not be shown. The Ontario data are presented in Table 11 below. (Frank et al. 1975).

Table 11

Residues of PCB in milk fat of the southern region of Ontario.

	Content in butterfat (ppm)	
County	1970/1971	1973
Brant	0.14	0.11
Elgin	0.07	0.07
Essex	0.10	0.17
Haldimand	0.12	0.14
Kent	0.07	0.13
Lambton	0.08	0.13
Middlesex	0.06	0.09
Niagara	0.10	0.15
Norfolk	0.12	0.08
Oxford	0.03	0.09
Wentworth	0.15	0.10
Average	0.08	0.11

(from R. Frank et al. 1975)

In 1970-71 PCB residues in milk fat averaged 0.08 ppm for the region but varied from 0.03 ppm in Oxford to 0.15 ppm in Wentworth. It is note-worthy that heavy industrial centers are associated with Brant and Wentworth counties where the highest residues were observed. Residues in milk from Oxford, Elgin, Kent and Middlesex were lower and these areas are further from the large industrial centers.

The same trend followed in the 1973 survey. Milk from Essex and Niagara counties contained the highest PCB residues, both counties being close to large industrial centers. Milk from the counties of Elgin, Middlesex, and Oxford were low in PCB residues, these counties being more distant from large industrial centers.

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In the surveys of 1970-71 and 1973 it was calculated the total annual quantity of PCB was 1.68 and 2.32 kg respectively in the milk produced in the southern region with the greatest amounts being present in milk from Wentworth and Heldimand counties.

7.1.6. Canadian Human Ecosystems

Analyses of human adinose tissues can be used to indicate the level of exposure of humans from all routes (ingestion, absorption and inhalation). PCB residues have been reported in a number of surveys of human tissues in Canada . The analysis is always suspect unless precautions have been taken in the collection and handling of these samples.

PCB residue data in human tissue were available from two sources: (a) a survey which included samples from all regions of Canada carried out by J. Mes of the Health Protection Branch, Ottawa; (b) results obtained from Dr. R. Frank of the Provincial Pesticide Residue Laboratory in Guelph.

The result of the survey by Health Protection Branch is presented in Table 12. All samples contained detectable levels of PCBs. Central Canada values (Saskatchewan and Manitoba) are lower than the national average.

Table 12

PCB residues (ug/g) in human adipose tissue by region

Sex	Atlantic	Quebec	Ontario	Central	Western	Canada
M	0.758 (13)	1.125 (30)	1.165 (38)	0.621 (11)	0.977 (19)	1.020 (111)
F	0.593 (3)	0.723 (19)	0.859 (17)	0.377 (11)	0.684 (7)	0.685 (57)
M&F	0.727 (16)	0.959 (49)	1.070 (55)	0.499 (22)	0.898 (26)	0.907 (168)

Central = Saskatchewan and Manitoba

Western = Alberta and B.C.

The mean residue levels in human adipose tissue from Ontario residents was 1.2 ppm on a fat weight basis (range 1.0-2.0 ppm, n 29) in 1969-1970, 2.5 ppm (range ND - 18 ppm, n 282) in 1971-1972, and 2.3 ppm (range 0.6-11.0 ppm, n 129) in 1973-1974. These values indicate no trend in the six year period and a large variation in PCB exposure of humans in Ontario.

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7.1.7 Discussion

The Task Force has found difficulty in obtaining satisfactory monitor information which could be used to give a useful index of the contamination at different locations across Canada. There are, of course, within any information gathered from diffuse sources, differences in species, sampling procedures, analytical techniques in different laboratories and differences in parts of the organism or material selected for analysis. These difficulties in interpretation point out the need for a comprehensive design of sampling of materials and organisms for national monitoring of toxic substances. In this regard it is also important to maintain a high quality bank of these samples of organisms and materials so that retrospective searches may be made for newly identified toxic substances in stored sample material. It is foreseeable that a similar Task Force exercise concerned with hexachlorobenzene or mirex, for example, would meet the same problems of collection of information for across Canada.

Despite these problems of collection of information it is clear that the most serious identified problem of contamination by PCB is in the Great Lakes and associated regions. This is most clearly seen in the Herring Gull data (7.1.1.1.) where the levels are generally an order of magnitude above the levels found on the Atlantic coast.

This indication of the location of the highest PCB concentrations is confirmed by the fish data. Very much higher residues are found in species from the Great Lakes and St. Lawrence River (7.1.1.2.) compared with the coastal species (7.1.2.2.). Levels of PCB in fish from the Atlantic coast are much higher than in those from the Pacific coast (7.1.2.2.). The level in the Arctic Char from Hudson Bay (7.1.2.2.) indicated that this environment has a higher contamination than more remote arctic locations. This is confirmed by the Polar Bear data (7.1.2.4.) which indicates that the levels in the eastern Arctic, and particularly Hudson Bay, were higher than in the western Arctic. The Lake Trout data from Lake Minto (7.1.3.) confirms that PCBs contaminate remote arctic freshwater

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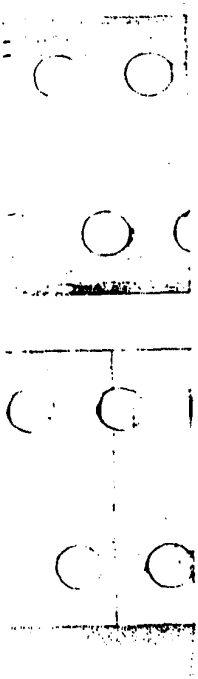
ecosystems; atmospheric transport is the most probable route of contamination. Probably the same route is responsible for the contamination of small lakes in the Prairies (7.1.4.) and of the Ontario terrestrial ecosystem (7.1.5.). The origin of this airborne PCB is uncertain but is probably the ineffective incineration of waste PCB and waste containing PCB.

The information from the analysis of adipose tissue of humans indicates higher levels in Ontario and Quebec and lower levels in Central Canada. Human adipose tissue, used as an integrator of human exposure levels from all routes, indicates that higher PCB exposure is associated with the more industrial parts of the nation. The very wide ranges reported in the Ontario surveys for the years 1971-72 and 1973-74 suggest a rather wide range of exposure.



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7.2. Sources and mode of entry

Reference is again made at this point to the work of Nisbet and Sarofim (1972) who have estimated the rates and routes of entry of PCBs into the North American environment. As was noted in Section 5.4. there are three methods of disposal of PCB. The first is incineration, the second land disposal and the third is discharge into a sewage system or directly into aquatic environment. These three routes will lead to contamination of air, land and water.

It was noted in Section (7.1.) that the greatest PCB problem exists in the Great Lakes region. The Task Force has therefore directed its attention particularly towards collection of information on sources and mode of entry to this ecosystem and considered quantities in gases from incinerators (Section 7.2.4.) and in air, rain and snow (Section 7.2.5.), in leachate from dumps (Section 7.2.2.), in effluents from sewage systems (Section 7.2.1.), in the sewage sludge disposal on land (Section 7.2.3.) and in tributary waters from the catchment basin (Section 7.2.6.).

7.2.1. Sewage effluent

7.2.1.1. Municipal sewage treatment plants

Prior to Shannon's report (1975) on PCBs in Ontario municipal wastewaters in the Great Lakes basin, no systematic sampling of effluents appears to have been made. There is an indication in a Ministry of the Environment (1974) report that the major contributor to contamination in Hamilton Harbour in 1972 was the Hamilton Sewage treatment plant. This was suggested by the results of analysis of sediment samples in which a value of 10 ppm was found at the sewage treatment plant. Data from Agriculture Canada confirms large quantities of PCB in the sludge from the Hamilton Plant (Table 19).

A report prepared by the Michigan Water Resources Commission, Department of Natural Resources reported levels of PCB in sewage treatment plants in Michigan sampled in 1971 and 1972. These plants discharged into watersheds of Lakes Michigan, Huron, St. Clair, Erie and Superior. The data are presented

in Table 13 and show that the effluent discharged from most municipalities contained approximately 1 ppb or less of PCB. However, one plant on the Saginaw River was discharging 340 ppb to the Lake Huron watershed and plants on the Raisin and Detroit Rivers discharged between 10 and 20 ppb to the Lake Erie watershed.

TABLE 13

PCB Concentrations in Municipal Wastewater Treatment Plant Effluents in Michigan 1972

Lake Basin	River	No. of Plant Effluents	Mean PCB Level (ppb)	Range (ppb)
Huron	Saginaw	3	47.45	0.21 - 340.0
	Saginaw Tributaries	3	0.31	0.10 - 1.30
St. Clair	St. Clair	1	0.40	0.28 - 0.52
	Clinton	4	0.97	0.10 - 4.50
Erie	Raisin	2	4.00	0.30 - 14.00
	Huron	7	0.15	0.10 - 0.81
	Detroit	3	1.50	0.14 - 17.00
Superior	Tahquamonon, Sturgeon and Ontonagon	3	0.17	0.10 - 0.35

(From Summary by Bedford J. and J.L. Hesse. Michigan Water Resources Commission, Department of Natural Resources.)

Later data from sewage treatment plants sampled in 1973 in Michigan State are shown in Table 14 which excludes those plants discharging less than 0.1 ppb. The information indicates that there was still an automotive plant (Hesse 1975) on the Saginaw River discharging a large amount of PCB. Other plants discharging high concentrations of PCB were found in all the watershed basins.

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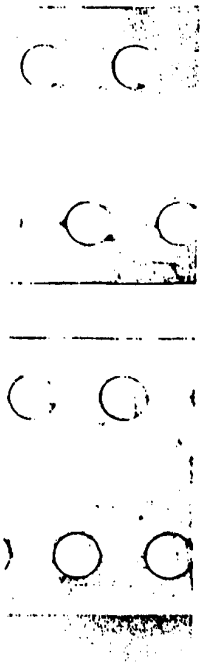

Table 14

Concentration of PCB in wastewater effluents in Michigan State in ppb. 1973. (excluding plants with 0.1 ppb or less)

Location	PCB in ppb	Type
Lake Huron Watershed		
Bay City	3.2	1242
Flint	0.16	1254
Mount Pleasant	0.29	1254
Owosso	0.12	1254
Saginaw	0.77	1242: 1254
Sault Ste-Marie	0.73	1254
Straits of Mackinac		
St-Ignace	0.31	1254
Lake St. Clair and St. Clair River Watershed		
Mount Clemens	2.9	1242: 1254
Pontiac	0.60	1242: 1254
Port Huron	1.8	1242: 1254
Detroit River Watershed		
Ann Arbor	0.25	1254
Brighton	0.33	1242: 1254
Detroit	2.15	1242
Dexter	0.23	1254
Milford	2.2	1242: 1254
Wayne County	0.40	1254
Lake Erie Watershed		
Adrian	0.26	1242: 1254
Ypsilanti	0.31	1254
Lake Superior Watershed		
Marquette	0.29	1254

(from P.A. Blakeslee. Michigan Department of Natural Resources).

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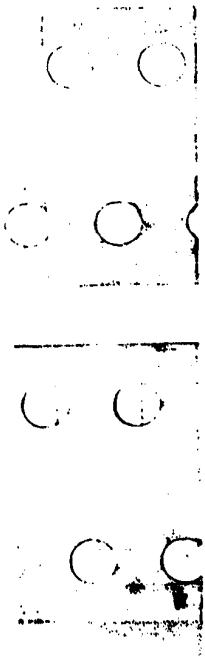

Shannon et al (1975) sampled thirty-three sewage treatment plants in 1974 to determine the concentration of PCB discharged and to estimate the total annual discharge from these plants. Most plants had effluents below the level of detection 0.1 ppb. All plants were below 0.5 ppb except Windsor which discharged at 0.9 ppb. These figures are comparable to figures for discharges from treatment plants into Lake Michigan and its tributaries (Table 14). It is significant that PCBs were detected in all the sewage treatment plants, and that the types of PCBs were identified as exclusively the so-called Aroclor 1254-1260 varieties. Reexamination of some of the chromatograms confirms the absence of measurable quantities of lower chlorinated (tetrechloro) biphenyl. However the analytical procedures were not intended to determine traces of these components. In the estimation of the total annual discharges of PCB it was found th (Table 15) most plants discharged less than a kilogram. However, Hamilton discharged approximately 26 kg, Toronto (Main) 119 kg, Toronto (Humber) 42kg, and Windsor-West 36 kg. The total quantity discharged from municipal treatment plants directly or indirectly to Lake Erie and Lake Ontario from the Canadian side was about 250 kg/year. The discharges from Toronto and Hamilton accounted for about 75% of this total discharge from the Canadian side to these two lower lakes. Of the PCB load to sewage treatment plants the plants only remove about a half from the wastewater. (Shannon *op. cit.*).

The apparent absence of previous monitoring data precludes any statement about trends in discharges of PCB or about discharges prior to and at the time of the voluntary ban in Canada.

No data appear to be available for American discharges to Lake Ontario and only fragmentary data are available for Lake Erie. Thus no complete estimate of PCB discharges can be made.

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Table 15

ESTIMATED INFLUENT AND EFFLUENT PCBs LOADINGS FOR WASTEWATER TREATMENT PLANTS IN SELECTED ONTARIO MUNICIPALITIES 1974.

LOCATION	LOADING (kg/yr)	
	INFLUENT	EFFLUENT
BURLINGTON	19.9	1.3
CHATHAM	3.3	0.7
ELMIRA	0.2	0.2
GRIMSBY	0.03	0.03
HAMILTON	154.1	25.8
KINGSTON CITY	5.9	3.9
KITCHENER	17.9	4.0
LONDON - GREENWAY	2.7	1.4
NEW HAMBURG	0.1	0.03
NEWMARKET	1.1	0.3
NIAGARA-ON-THE-LAKE	0.3	0.1
OAKVILLE	2.0	1.0
OSHAWA	1.0	1.0
OTTAWA - GREENS CREEK	32.3	10.7
PETERBOROUGH	14.9	1.5
PORT ROVER	0.6	0.2
SARNIA	3.5	2.3
TORONTO - MAIN	165.9	119.2
TORONTO - HUMBER	62.6	41.7
TORONTO HIGHLAND	3.1	3.1
TORONTO NORTH	1.5	1.5
WATERDOWN	0.02	0.02
WATERLOO	2.2	1.1
WELLAND	1.2	1.2
WINDSOR - WEST	67.5	35.8
WINDSOR - LITTLE RIVER	2.7	0.7
TOTAL	563.74	246.18

From Shannon et al. 1975 E.P.S. Report.

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In 1973, the Ontario Ministry of the Environment (Working Group C on Land Source Inputs) sampled municipal discharges to Lake Huron and Lake Superior (IJC Upper Lakes Reference Group). The results are shown in Tables 16 and 17. Significant quantities of PCB were discharged from Sault Ste-Marie into the St. Mary's River and from municipalities in the south of Georgian Bay at Collingwood, Meaford and Owen Sound. The principal municinal PCB discharges to Lake Superior were from the two plants at Thunder Bay.

TABLE 16

PCB in Canadian municinal waste discharges to Lake Huron kg/yr 1973

Location	PCB in kg/yr.
St. Mary's River	
Sault Ste-Marie	4.2
Lake Huron	
Little Current	0.066
Port McNicoll	0.050
Midland	0.10
Penetanguishene	0.033
Collingwood	1.34
Meaford	2.57
Owen Sound	2.52
Wiarton	0.083
Kincardine	0.20
Goderich	0.20
Total	11.4

(From Ontario Ministry of Environment, Working Group C on Land Source Inputs).

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TABLE 17

PCB in Canadian Municipal Waste Discharges to Lake Superior kg/yr 1973

Location	PCB in kg/yr
Thunder Bay South	1.99
Thunder Bay North	3.32
Nipigon Twp.	0.33
Schreiber	0.17
Marathon Twp.	0.50
Total	6.31

(From Ontario Ministry of Environment, Working Group C on Land Source Inputs)

In similar work under the same reference the States of Michigan, Minnesota and Wisconsin indicated that negligible quantities were entering Lake Superior from municipalities. This needs to be substantiated through further sampling and analysis. The State of Michigan estimated that 28 kg were discharged annually from municipalities to Lake Huron.

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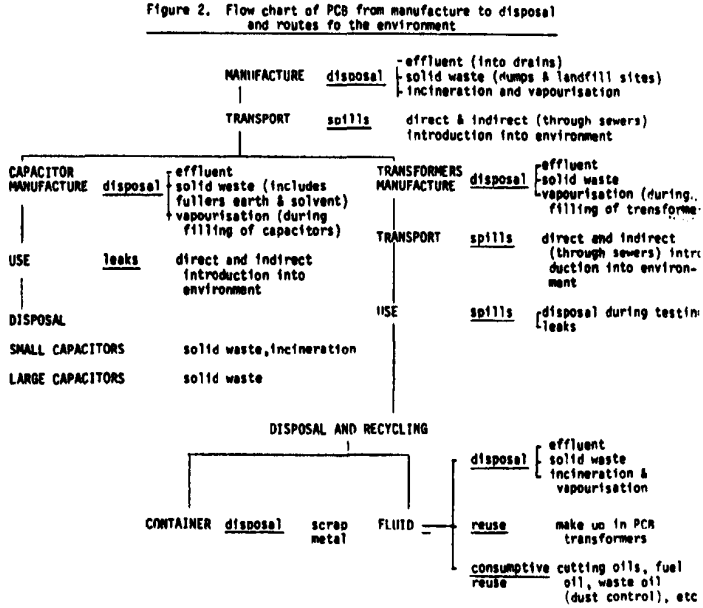
7.2.1.2. Industrial waste discharges direct to the environment

The use of PCB as a dielectric and its possible entry into the environment has been represented below as a flow chart from manufacture to final disposal for capacitors and transformers.

Figure 2. Flow chart of PCB from manufacture to disposal and routes to the environment



The manufacture of PCB may result in this substance entering the environment through drains, in solid waste and from vapourisation. In Canada, to the best of our knowledge, PCBs are not manufactured and thus this source of contamination probably does not occur. In the transportation of PCBs, from the manufacturer to the capacitor and transformer manufacturer, spills may occur resulting in seepage from the spill site.

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In the manufacture of capacitors there may be losses to the environment in drains, through solid waste disposal and possibly from vaporisation. After the manufacture of large capacitors, their use may result in PCB entering the environment by leaks. Recovery of waste PCB from capacitors for reuse in electrical or non-electrical applications is unlikely but would result in losses by all three routes if it does occur. Disposal of capacitors is generally into a landfill site.

In the manufacture of transformers, similar losses may result at each stage from the manufacturing plant, through transport and use, to final disposal.

The major routes into the environment from transformers are probably from inappropriate disposal methods such as resale for cutting oils, fuel oil for heat or as waste oil for dust control on roads, and heat exchanger make-up.

As noted above in Section 5.4.4., for a long period the C.G.E. plant at Guelph discharged waste containing PCB to a marsh behind the plant. A subsequent discharge of oil onto the surface of the PCB-contaminated area resulted in high solubilisation of the PCB and subsequent mobilisation into the Speed River flowing through the marsh. The Speed River flows into the Grand River.

Outside of the Great Lakes region, Aerovox Canada Ltd. produce a.c. oil capacitors at Amherst, Nova Scotia. The Nova Scotia Department of Health investigated the plant in January 1974 and reported that large quantities of PCBs in wastes, including about 3% of the plant production (which failed test), was discarded into the Amherst dump. It appears that measurements of PCB in the leachate from the dump have not been made.

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A study has been initiated by the Ontario Region of EPS to study the gaseous emission of PCB from the capacitor filling system at the Canadian General Electric plant at Peterborough and at the Westinghouse plant at London and transformer plant at Hamilton.

The extremely high values (2 and 3 ppm) of PCB found in Hamilton Harbour sediments close to the industrial waterfront indicates an industrial discharge direct to this environment (MOE report, 1974).

In a 1975 and 1976 survey of the petroleum refineries at Oakville (R.P. and Shell), Port Credit (Texaco) and Clarkson (Gulf), samples of effluent water and sludge were collected and analysed for PCB. The refinery effluents from the Texaco, Gulf and Shell refineries contained no detectable PCB, however, the BP refinery discharged 0.83 ppb to Lake Ontario. The Texaco plant had 0.23 ppb in the effluent from the API (American Petroleum Institute) Separator. The biotreater sludge from the Shell plant contained 1.7 ppb, from the Gulf plant 79 ppb and from the BP plant 1700 ppb. The origin of the PCB in these plants is uncertain but it appears that its former use as a heat exchanger may be the cause of the present problem.

One industrial source of PCB to the Great Lakes environment, particularly Lake Michigan, is from paper recycling plants. The PCB in carbonless copying paper and in printing inks, on the paper to be reprocessed, is partially removed and released to the environment in the washwater from the plant. PCBs in the processed paper were identified as predominantly the 1242 type The ratio of 1242 to 1254 was reported as 9:1.

In 1972, the effluent from the Abitibi Provincial paper recycling plant at Thorold on the Welland Canal was sampled for PCB. The affluent from the deinking

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process was found to contain 600 ppb. The quantity of PCB released in this way is uncertain but, as was shown above, most municipal waste treatment plant effluents contain less than 1 ppb and the Thorold plant must therefore be considered a significant source.

In 1973 industrial discharges of PCB were investigated by the Ministry of the Environment, Ontario, in the Upper Lakes (IJC Upper Lakes Reference Group). Two industrial plants at Sault Ste-Marie, Abitibi Paper Co. and Algoma Steel Corp, discharged no detectable PCB. Of particular interest would be a plant at Marathon, since this is where very high levels (1300 ppb) of PCB have been found in the sediments. Under the same IJC reference the State of Michigan estimated that industrial discharges to Lake Superior amounted to about 1.8 kg/yr and to Lake Huron about 8 kg/yr. The States of Minnesota and Wisconsin do not appear to have sampled PCB under this reference.

There is a possibility that PCBs may be discharged from investment-casting plants because these plants may use a PCB-impregnated resin mold. No information is available on the quantities of PCB used or discharged in this industry.

As has been noted in 5.4.4., foreign ships and aircraft may use PCB in their hydraulic or lubricating systems and though losses have not been quantified they may be a significant source to the environment.

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7.2.2. Landfill Leachate

Solid waste disposal dumps

The leachate from seven landfill sites in Ontario was sampled in July 1975 and analysed by the Ontario Ministry of the Environment. The results are shown in Table 18 below.

TABLE 18. CONCENTRATION OF PCB IN LANDFILL LEACHATE IN ppb. 1975.

LOCATION*	PCB in ppb.
Violet	Not detected
Beare Road	0.04
Preston	0.02
Mississauga	1.2
Brantford	0.24
Paris	0.20

* One sample analyzed from each location except from Preston where two samples gave identical results.

Waste PCB disposal into landfill sites and into solid waste disposal dumps was thought to represent the major route into the environment (Nelson 1972). More than 50% of the PCB produced was estimated to be deposited in this manner. The small amount of groundwater(containing low levels of PCB)emitted from landfill sites indicates that landfill leachate is probably not a major source of PCB into the Great Lakes environment, however these data are not extensive, do not include the most industrialized areas, and are only concerned with concentrations rather then quantities, hence the results are not conclusive.

7.2.3. Sewage Sludge Disposal

The level of PCBs in sewage sludges, soils and crops in southern Ontario was surveyed in 1972 and 1973 by Maybury *et al.* MS. Plant Products Division, Department of Agriculture, Ottawa. The results are summarized in Tables 19, 20, and 21.

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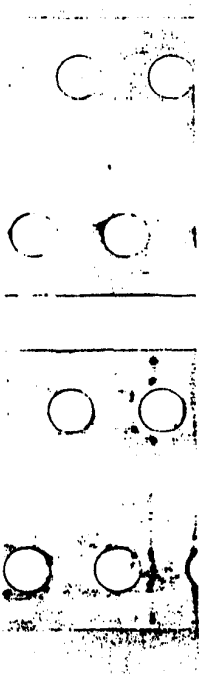

The survey indicated that sewage sludges from industrial and municipal wastewater treatment plants invariably contained PCBs. In a majority of the sludges the PCBs were present in a form resembling Aroclor 1254. In only 2 out of 40 samples (5%) the form resembled Aroclor 1260. Fifty-two per cent (21 out of 40) of the samples contained not less than 4 ppm of PCBs. Forty per cent (16 out of 40) contained 3 ppm or less.

The level of PCBs found in soils to which sewage sludge was applied was variable, ranging from nil to 370 ppb. PCBs were not detected in about one third of soil samples analyzed. Two soil samples from land in which sewage sludge application was not recorded, contained 5 ppb of PCBs, indicating that the PCBs detected in some other soil samples may not have been attributable to the application of sewage sludge. As was the case for sludges, PCBs were present in the form resembling Aroclor 1254 in a majority of the soil samples.

From the meagre data that are shown in Table 21, PCBs were detected in some tissues of mixed grain and corn. The levels which were detected in the tissues of one sample of mixed grain was 28 ppb and for two corn samples 5 and 95 ppb respectively. Tissue samples from potatoes, turnips, mangolds, tomatoes, apples and some corn did not indicate the presence of PCBs.

These results indicate that sewage sludges from industrial and municipal wastewater treatment plants can be expected to contain some PCBs. Although the ultimate fate of PCBs disposed of as landfill or as a soil supplement has not been sufficiently studied, sludges have been used for agricultural production and have been shown to result in up-take of some PCBs in crops (although levels found were considered safe). Thus, it may be concluded that there is a need to establish regulations controlling the disposal of such solid wastes in Agriculture.

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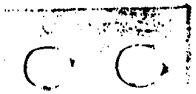
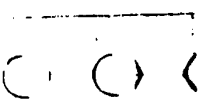
However, as PCBs may be volatilized, transported, reprecipitated, and bio-, heat-, and photo-degraded, the results from the quantitative analyses summarized in Tables 19, 20, and 21 may not provide accurate information on their occurrence in agricultural land and crops. Clearly, further studies on the occurrence and significance of polychlorinated biphenyls in the environment will be required prior to the establishment of specific regulations on PCBs in relation to agricultural production. Nevertheless, guidelines respecting safe use of unincinerated sewage sludges on farm lands are urgently required and therefore should be established at an early date.







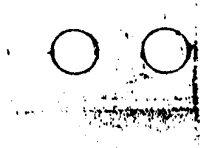


Table 19

Concentration of PCB in Ontario sewage sludge in ppm dry matter. 1972 and 1973.

Location	PCB in ppm	Aroclor Type
Lake Huron Watershed		
Barrie	3.25	1254
Newmarket	0.57	1254
Bradford	2.87	1254
Aurora	1.81	1254
Lake St. Clair and St. Clair River Watershed		
Chatham	0.87	1254
Corunna	3.93	1254
Sarnia	7.72	1254
Wallaceburg	3.2	1254
Detroit River		
West Windsor	33	1254
Little River	1.18	1254
Amherstberg	2.98	1254

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(Table 19 cont'd)

Lake Erie Watershed	PCB in ppm.	Aroclor Type
Kitchener	6.37	1254
Galt	1.45	1254
Guelph	5.46	1254
Leamington	0.18	1254
Cedar Springs (Hosp)	14.1	1254
Point Edward	1.58	1254
Brantford	3.08	1254
Stratford	4.17	1254
Lake Ontario Watershed		
Georgetown	7.14	1254
Richmond Hill	1.86	1254
Peterborough	6.79	1254
Welland	4.52	1254
Toronto (Humber)	49.45	1254
Stanford Niagara	1.76	1254
Port Weller	10.0	1254
Port Dalhousie	10.3	1254
Burlington (Drury)	9.2	1254
Burlington (Skyway)	21.0	1260
Hamilton	32.5	1254
Oakville (S.E.)	4.6	1254
Oakville (S.W.)	31.4	1254
Lakeview	12.2	1254
Clarkson	31.7	1260
North Toronto	1.55	1254
Whitby	11.6	1254
Ajax	1.76	1254
Pickering	2.92	1254
Bowmanville	11.1	1254
Oshawa	2.50	1254

(from CDA unpublished survey).

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Table 20

Concentration of PCB in ppb in soils treated with sewage sludge from southern Ontario, 1972.

Location	Source	Number of Applications	PCB in ppb	Aroclor Type
Blair	Kitchener	1	5	1254
Galt R.R. #2	Kitchener	1	N.D.	-
Norval	Georgetown	1	10	1254
Norval	Georgetown	1	7	1254
Norval	Not Known	-	N.D.	-
Georgetown	Georgetown	1	37	1254
Stratford	Stratford	Several	715	1254
Whitby	Whitby	1	N.D.	-
Ajax	Ajax	1	43	1260
Pickering	Pickering	6	150	1254
Bowmanville	Bowmanville	1	46	1254
Oshawa	Oshawa	1	N.D.	-
Vineland	Port Dalhousie	1	N.D.	-
Vineland	Port Dalhousie	1	N.D.	-
Toronto Int. Airport	Stratford	1	120	1254
Halton City	Burlington	2	150	1260
Richmond Hill	Richmond Hill	several x/yr/5 yr.	N.D.	-
Aurora	Aurora	2-3	8	1254
Ottawa	Ottawa	1	43	1254
Guelph	Guelph	20-25 yrs.	370	1260
Guelph	untreated	0	5	1254
Guelph	untreated	0	5	1254
Guelph	Guelph	1	47	1260
Guelph	Guelph	1	15	1254
Guelph	Guelph	1	23	1254
Barrie	Barrie	1	N.D.	-
Vespra	Unknown	1	N.D.	-

Table 21

Concentration of PCB in crops from fields treated with sewage sludge in ppb.

Location	Source	Crop	PCB in ppb	Aroclor Type
Galt	Kitchener	Potatoes	N.D.	-
Galt	Kitchener	Turnips	N.D.	-
Galt	Kitchener	Mangolds	N.D.	-
Norval	Georgetown	Corn	N.D.	-
Norval	untreated	Corn	N.D.	-
Norval	Georgetown	Tomatoes	N.D.	-
Norval	unknown	Corn	N.D.	-
Norval	Georgetown	Mixed grain	28	1254

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Table 21 (cont'd)

Location	Source	Crop	PCB in ppb	Aroclor Type
Georgetown	Georgetown	Apples	n.D.	-
Guelph	Guelph	Corn	5	1254
Guelph	Guelph	Corn	95	1254

(From CDA unpublished survey)

7.2.4. Incineration

Ineffective combustion of waste PCB or waste products containing PCB will result in vaporisation of PCB into the atmosphere (Nelson 1972).

At present there are no data on the emissions of PCBs from incinerators. A study has recently been initiated by the Ontario Region of EPS to determine the quantities of PCB emitted from the sludge incinerator at Ashbridges Bay, and the municipal incinerator on Commissioner Street, both in Toronto. Other parts of this study will estimate quantities from capacitor and transformer-filling plants at Peterborough, Hamilton and London.

7.2.5. Levels in air, rain and snow melt

The levels of PCB in air have been measured by Ontario Research Foundation under contract to the Ministry of the Environment, and the unpublished data are reported in Table 22. The sampling locations were a) in a heavily urban environment b) downwind of a municipal incinerator c) in a research community. The results show firstly that most of the PCB is in the gaseous phase rather than adsorbed on solids. Secondly, both urban areas had PCB levels higher than the research community and thirdly that the area downwind of the municipal incinerator has the highest levels indicating that municipal solid waste contains PCB. This PCB is also predominantly in the gaseous form.

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Table 22

Concentration of PCB in air in ng/m^3. 1974 and 1975

Location	N	Particulate*	Gaseous	Gaseous as % of total
Toronto, 67 College St.	11	0.3 -0.61	0.52-2.27	57-86
Hamilton	3	0.35-0.44	1.60-7.86	82-95
Sheridan Park	1	0.14	1.18	89

*PCB associated with particulate matter.

Rain water was collected in six agricultural watersheds by Dr. Marie Sanderson, University of Windsor, and analysed in the Provincial Pesticide Residue Testing Laboratory, Ontario Ministry of Agriculture and Food, Guelph, for polychlorinated biphenyls by Dr. R. Frank. Residues were present in all except 1 sample (Table 23). When present, PCB ranged from 0.01 to 0.1 ppb.

Table 23. Level of PCB in rainfall, 1975

Watershed	Collection dates & PCB residues (ppb)		
	27 May -23 June	24 June -28 July	29 July -3 Sept.
Big Creek, Essex	0.06	0.05	0.05
Little Ausable, Huron	0.04	0.05	0.10
Upper Canagagigue, Wellington	0.01	0.05	0.07
Middle Thames, Oxford	0.05	ND	0.10
Twenty Mile Creek, Niagara N.	0.02	0.08	0.05
Hillman Creek, Essex	0.03	0.06	0.07

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Other preliminary information from rain water samples indicates that PCBs are present at about 0.02 ppb based on four samples (three from Hamilton Harbour and one from Wisconsin,Strachan, pers. comm.). The implication from this preliminary work is that rain water is a very significant source of PCB to the aquatic environment, particularly to the Great Lakes. (See Section 7.2.7.4.).

The Wisconsin Department of Natural Resources collected samples of snow melt and analysed them for PCB. The results are presented in Table 24 and indicate that the levels are about the same order of magnitude as rainwater samples from other parts of the Great Lakes basin.

Table 24. PCB levels in Wisconsin Snow Melt, in ppb.

Location	Concentration
Green Bay	0.01
Grafton	None detected
Kewaskuon	None detected
Racine	0.17
Kenocha	0.22
Madison	0.24
Milwaukee	0.20

(From unpublished data of Wisconsin Department of Natural Resources)

From the evidence available it is not possible to show whether the PCB in rain water is of incinerator origin or from open burning at dumps or whether it is from volatilisation of PCB already in the Great Lakes.

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7.2.6. Tributaries to the Great Lakes

Baseline data for levels of PCB entering the Great Lakes from U.S. tributaries were collected between 1971 and 1972 by the Michigan Water Resources Commission. Table 25 below shows the mean values and range of PCBs found in tributary rivers entering Lakes Huron, Lake St. Clair and Lake Erie. The data show that at that time the Saginaw river contained approximately 1 part per billion of PCB with a range up to nearly 3 parts per billion. This river must have been a very significant source of PCBs to Lake Huron. Major sources to Lake St. Clair and Lake Erie contain PCBs at about 0.5 ppb and up to 1.6 ppb. It is interesting to note that these values are slightly higher than values for PCB in effluents from Ontario waste treatment plants sampled in 1975. (See Section 7.2.1.).

Table 25

Mean PCB Concentrations in Michigan Tributaries to the Great Lakes in 1971 and 1972 in ppt

Lake Basin	River	PCB's (ppt as 1254)	Range (ppt as 1254)
Huron	Saginaw	1100	450 - 2900
	Cass[1]	14	10 - 48
	Flint[1]	78	10 - 150
	Shiawassee[1]	29	10 - 73
	Tittabawassee[1]	140	22 - 230
	Au Sable	10	10 - 10
	Thunder Bay	23	10 - 37
	Cheboygan	32	10 - 53
St. Clair	Clinton	150	39 - 430
	Black	43	10 - 110
	St. Clair	10	10 - 29
Erie	Raisin	210	68 - 500
	Huron	12	10 - 39
	Rouge[2]	470	58 - 1600
	Detroit	20	10 - 53

[1]Tributary to Saginaw River
[2]Tributary to Detroit River downstream from Detroit River sampling station

(From Summary by Bedford, J. and J.L. Hesse. Michigan Water Resources Commission. Department of Natural Resources)

MONS 053761

Tributaries to Lakes Huron and Superior were sampled in 1973 by the Working Group C on Land Source Inputs of the Ontario Ministry of the Environment to calculate the quantity of PCBs entering these lakes. The information for Lake Huron (Table 26) indicates that there are very large sources into several of the tributaries. The Wanapetti River, draining the north-east corner of the Georgian Bay watershed, the Severn River draining Simcoe Lake, the Nottawasaga draining the southern end of the Georgian Bay watershed, contribute quantities of PCB to this part of Lake Huron. There do not appear to be significant tributary sources direct to the main body of Lake Huron from the Canadian side.

The data concerning tributaries to Lake Superior (Table 27) indicate that the total quantity from this source is only about two and a half kilograms per year. This is very small when compared with the total of fifty-eight kilograms to Lake Huron.

Table 26

PCB in Canadian tributaries to Lake Huron in kg/year 1973

Location	PCB in kg/yr
St. Mary's River	
East Davignon Creek	0.312
Georgian Bay	
McCurry Lake	0.021
Wanapetti River	16.6
Severn River	22.5
Nottawasaga	11.6
Bighead River	4.71
Orchard Creek	0.21
Sydenham River	2.06
Pottawatami River	0.67
	58.7

(From Working Group C, Land Source Inputs. Ministry of the Environment, Ontario)

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TABLE 27

PCB in Canadian Tributaries to Lake Superior in kg/yr. 1973.

Location	PCB in kg/yr.
Kaministikwia River	0.075
McIntyre River	0.001
McVicar Bank	0.0003
Black Sturgeon River	0.40
Nipigon River	0.40
Jackpine River	0.0027
Steel River	0.047
Prairie River	0.013
Little Pic River	0.069
Pic River	0.30
Magpie River	0.30
Wawa Creek	0.0029
Michipicoten River	0.90
Old Woman River	0.022
	2.53

(From Working Group C, Land Source Inputs. Ministry of the Environment Ontario)

Under the IJC Upper Lakes Reference the State of Michigan estimated that 108 kg/year entered Lake Superior from tributaries. Minnesota reported 1577 kg/year. Wisconsin does not appear to have sampled under this program. Michigan State reported about 680 kg/year to be entering Lake Huron from tributaries.

MONS 053763

7.2.7. Discussion

7.2.7.1. Adequacy of data base

As with the previous section on contamination levels in indicator organisms and materials, the Task Force has found there is insufficient monitoring information to give a coherent picture of the relative importance of different routes of PCB into the environment. This is particularly disturbing in the light of Recommendation 8 of the 1972 Working Group on PCB which recommended the following course of action.

"Determine whether the recommended restrictions can achieve their intended effects. This will necessitate the introduction or maintenance of monitoring and/or surveillance of the amounts of PCBs in effluents (stack gases, wastewaters, etc.) and in the ambient media. Since the use of PCBs is rapidly declining, there is urgency in establishing baseline data from which to measure progress".

7.2.7.2. Summary of Sources

Despite these shortcomings of the data base, it is possible to make some generalisations concerning routes into the environment. In wastewater treatment plant effluents that have been sampled, nearly every plant effluent around the Great Lakes contained PCB in at least trace concentrations of 5-10 ppt. A few locations, such as Toronto, Hamilton, Windsor and Saginaw, account for much of the measured discharge via this route. Control of PCB from industrial plants to these municipal wastewater treatment plants could probably reduce much of the continuing municipal discharges.

The information on industrial discharges to the environment is fragmentary, but indicates that industrial sources do exist. Much the same conclusion can be made about landfill leachate from solid waste disposal, though generally the volume of discharge may be much smaller than waste discharges from sewage treatment or industrial plants.

MONS 053764

Sewage sludge disposal on agricultural land is another route for PCB entry into the environment. It appears that applications of the sludge over several years will result in a buildup of PCB residue in the soil. There is an indication that corn plants will take up PCB from a contaminated soil. This phenomenon needs further investigation.

Very little work has been undertaken on monitoring PCBs in the emissions from incinerator stacks, and in rain, snow or air. From the very scant data, it would appear that the atmospheric route is far more important then has previously been thought. A crude estimate of PCB entering Lake Erie in rain is 500-1000 kg/yr. The phenomenon of vaporisation of PCB from water surfaces, particularly the Great Lakes does not appear to have been researched. PCBs enter the Great Lakes from most of the tributaries sampled. No work appears to have been done on estimating the quantity of PCB discharges from ships and aircraft.

7.2.7.3. Significance of inputs

In making an assessment of the significance of discharges of PCB-containing wastes to the Great Lakes environment, two factors should be considered. Firstly, the total quantity within each lake should be estimated (See Section 7.2.7.3.1.) and secondly, the relative importance (biological availability) of the PCB from each source of contamination should be assessed (See Section 7.2.7.3.2.). In considering this second factor, the sources may be from PCB (attached to particulate matter) that is in the water column as a result either of suspension of PCB from the sediment or of recent discharges containing PCB that has not yet sedimented. If recent discharges are the more important source in the contamination of biological material then the controlling of sources may markedly decrease the levels found in fish. However, if PCB-contaminated sediment is more important, then the control of present discharges may not lead to a decrease in contamination of fish for a very long time.

MOE 053765

7.2.7.3.1. Total quantity in sediments of each lake

Using the available information, crude estimates have been made of the total quantity of PCB in the sediments in each of the Great Lakes basins by multiplying the mean concentration by the weight of sediment deposited in the past 30 years. These estimates provide the order of magnitude of the quantity and should not be used as firm estimates. More accurate estimates would include consideration of the sedimentation rate in relation to the concentration of PCB present at a location and a knowledge of the vertical distribution of PCB in representative sediment cores. For the present exercise, an average concentration has been calculated from distribution maps of PCB and the average sedimentation rate has been calculated from Kemp et al. 1974. These averages are shown in Table 28 below with the estimated quantity.

Table 28. Estimated quantity of PCB in the sediments of the joint Great Lakes

Great Lake	Area sq. mi.	Average concentration ppb.	Depth contaminated cm (30 yrs)	Estimated total quantity kg
Ontario	7,600	100	10	3×10^5
Erie	10,300	100	46	1.8×10^6
Huron	23,000	4.25	4.2	1.6×10^4
Superior	31,700	30	1	3.6×10^4

The high concentration (ca. 1300 ppb) at Marathon and in the middle of the lake (90 ppb) strongly influence the average concentration calculated for Lake Superior. Disregarding the value at Marathon the mean concentration would be about 13 ppb and the estimated total quantity would be 1.6×10^4 kg.

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These estimates indicate that Lake Erie has the largest quantity of PCB by nearly an order of magnitude over Lake Ontario. The quantities in Lakes Huron and Superior are probably an order of magnitude lower again. These estimates are useful in assessing the significance of present day discharges to the basins. Improved estimates should be available by mid-1976. (Thomas, R.L., pers. comm., CCIW). The high rate of sedimentation in Lake Erie would be expected to remove PCB from the water column and render them unavailable at a greater rate than in the other lakes. However, resuspension of sediments, particularly in the shallow western basin, may result in sedimented PCBs becoming available again.

The significance of annual discharges in relation to the total quantity in the lake is not known. An annual total discharge sufficient to prevent or to retard seriously the recovery of the lake waters from contamination should be considered significant. Because contamination of the Great Lakes by PCBs has occurred over the past 30-40 years, a figure of one per cent of the total quantity has been arbitrarily chosen as a significant level.

Taking the estimates (Table 28) of the total quantities of PCB in the Great Lakes sediments, 100 kilograms would be significant in relation to Lakes Huron and Superior and 10^3 kilograms in relation to Lakes Ontario and Erie. Though the greater rate of removal of PCB by sedimentation in Lake

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Erie would increase the estimated quantity deemed a significant annual input, the estimate for Lake Erie is possibly a serious over-estimate since it assumes that the entire 46 cm is contaminated at 100 ppb and is available to the lake's dynamics. The quantity deemed significant has therefore been revised downwards to 10^3 kilograms.

On the basis of the available information it appears that the calculated atmospheric inputs to Lakes Ontario and Erie (circa 10^3 kg/yr based on measurements of the concentration in rain) are significant sources in relation to the total quantity already in the basins. The Saginaw River (circa 770 kg/yr) was a very significant source into Lake Huron and the several tributaries from Minnesota to Lake Superior (circa 1580 kg/yr) were very significant. Without determinations for atmospheric PCB in the upper Lakes the significance of this source can only be surmised to Lakes Huron and Superior. In conclusion, it must be reemphasized that the baseline data for making a complete assessment are not available, and that this situation must be remedied as soon as possible.

7.2.7.3.2. Source of biologically available PCB within the Lakes

The source of biologically available PCB (refer back to 7.2.7.3.) does not appear to have been assessed. The basic descriptions of the lake processes leading to contamination and the relative importance of the different components of the exposure do not appear to have been documented. Thus it is almost impossible to evaluate the significance of

different levels of discharge into the different Great Lakes basins in relation to the level of contamination in fish. In other words, the evidence available does not enable us to decide whether the major part of the fish contamination problem in the Great Lakes is due to present (and very recent) discharges or to the legacy of thirty years uncontrolled use of PCBs and their accumulation in biologically available form in the sediments. We are unable also to decide whether the sediments are a net source or a net sink.

This uncertainty surrounding the sources of biological contamination is a contributing factor in the assessed degree of danger posed by present PCB discharges. The uncertainty is due to the lack of properly designed monitoring and scarcity of experimentation into fundamental lake processes.

7.2.7.4. The objective of monitoring

One of the objectives of monitoring a toxic substance in the environment should be to produce sufficient information to make possible a relatively simple mathematical model of inputs and outputs and to establish the important routes and rates into and within the environment. This clearly defined objective is necessary to manage pollutants in a meaningful way, since assessment of the exposure level of organisms in the environment cannot otherwise be made. Clearly then, to achieve this objective, there is a strong requirement for integrated planning and close cooperation and collaboration between researchers and analysts and between agencies. This objective and the details of the research needed to achieve this objective have been clearly described in the first two chapters of the United States National Academy of Sciences (1975) study on "Assessing Potential Ocean Pollutants".

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7.3. Other relevant observations

7.3.1. Trends of PCB levels in the environment

In North America, Monsanto effectively closed the main source of supply of PCBs for the so-called "open-system" uses in 1970-1971. Most of these "open-system" uses took advantage of the stability of PCBs and it must be expected that there will be a lengthy time lag between sale as bulk PCBs, disposal after use, and eventual mobilisation into the environment. We have no reason to believe that there is any large systematic difference in these lag times between the general "open-system" uses of the higher chlorinated commercial PCBs (Aroclor 1254-1260) and the lower chlorinated commercial PCBs (Aroclor 1016-1242).

Both Aroclors 1242 and 1254 contain a significant proportion (20-25%) of tetrachlorobiphenyl, and Aroclor 1242 contains 9% of penta- and hexa-chlorobiphenyls (Table 29). Because of this overlap it is necessary to discuss environmental PCB levels in terms of groupings by chemical composition rather than by commercial type. For clarity of meaning in this report, the chlorobiphenyls that contain more than 4 atoms of chlorine per molecule (which are the only group commonly identified and reported in field samples) are designated higher chlorinated biphenyls - HCBP; those containing fewer than 5 atoms of chlorine (i.e. 1,2,3 or 4 atoms) per molecule are termed lower chlorinated biphenyls - LCBP.

Because HCBPs are extremely persistent in the environment their steadily increasing usage up to 1971 should be reflected by increasing levels in the environment with a marked time delay of at least several years. In fact the evidence, typified by the data in this report, seems to show no definite trend since 1972 in the HCBP levels in the Canadian environment. Four possible explanations for this absence of an upward trend are:

1) there was a rapid reduction in a significant usage with very short delay-time to mobilisation into the environment (hydraulic fluids, cutting oils),

ii) there was a rapid reduction in the HCRP content of wastewaters because of improved manufacturing or disposal practices,

iii) there is a buffer-type sink in the environment, the PCB levels of which have not been measured in such a way as to show its increasing trend; sediments may be such a buffer,

iv) the data are unreliable for this purpose.

LCBPs are, as a class, markedly less persistent in experiments simulating environmental conditions than are HCRPs. Although the time-delay between open-system uses and mobilisation into the environment may well not differ greatly between the higher and lower chlorinated PCBs, the effect of Monsanto's 1970-71 move should be a detectable downward trend in environmental levels of the LCRP long before a similar trend in the levels of the HCRP type. Information is lacking not only on trends in the environmental levels of LCBP but even on whether these substances occur generally in the environment in significant concentrations.

A recent study of PCB in the coastal environment of southern California (McDermott et al, 1975) has demonstrated that between 1972 and 1975 a great decrease (by about a factor of 10) occurred in the quantities of LCBP discharged in municipal wastewater in that region; the simultaneous decrease in quantities of HCBP discharged appears to be less dramatic. The reported decrease in LCBP discharge could be due to either Monsanto's sales curtailment or improved disposal practices on the part of users.

7.3.2. Types of PCBs in Environmental Samples

Almost exclusively, reports have classified the type of PCBs in environmental samples as Aroclor 1254 or 1254/1260. Owing to the complexity of the mixtures of early-eluting election-capturing substances in gas chromatograms of environmental samples, residues of PCBs containing 2-4 chlorines per molecule are seldom identified, quantitated and reported. ,However, various workers have specifically commented on the great predominance of the 1254 or 1260 PCBs in their samples. The CWS have re-studied their

data and find that in Herring Gull eggs from the Great Lakes there is very little dichlorohiohenyl, a little trichloro-, and much more tetrachloro-. The total LCBP is present in a quantity of the order of 10% of the amount of the HCBP. It should be stressed that these are more by way of qualitative observations than quantitative measurements. (D.J. Hallet, unpublished, Canadian Wildlife Service, Ottawa).

For comparison the tetrachlorobiphenyl content of Aroclor 1254 is 21% (Table 29). Because of the omnivorous nature of the Herring Gull and its frequenting of garbage dumps where PCB-containing wastes could be ingested, a definitive study of the diet of the Herring Gulls in the Great Lakes' colonies is needed.

Parejko et al. (1975) claim to have observed a wide range of Aroclors in Lake Trout from Lake Superior. The publication lacks details of the analytical results and of the techniques of quantification. It is not possible to estimate the proportion of LCBP in the total PCB content of the fish but the results do not suggest that this proportion is lower than the 10% level estimated to occur in Herring Gulls' eggs from Lake Ontario.

Surprisingly, a recent report of a study of PCB in rainwater suggests that predominantly HCBPs were found rather than the more volatile LCBPs.

The only extensive studies in which significant levels of LCBPs were determined in environmental samples relate to areas close to sources of gross pollution such as sewer outfalls (southern California, McDermott et al., 1975 op. cit.), industrial manufacturing discharges (Hudson River study), and waste paper recycling (Wisconsin-Lake Michigan) (Hesse 1975, Bremer 1975) and from automobile manufacturing plants in Bay City and Detroit (to Lake Huron and the Detroit River respectively) (Hesse 1975).

More extensive work is needed in the Great Lakes area of Canada to define the ratio LCBP/HCBP (and, particularly, the occurrence of tetrachlorohiohenyl) in:-

sediments

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influent and effluent of major wastewater treatment plants

fish

rainwater,

in order to demonstrate whether LCBPs are widely present in the environment at significant levels, whether they are now entering the environment as a result of use for electrical equipment, or whether their presence at significant levels is a result only of industrial history before Monsanto's sales' control. (See Section 9.4.3.1.).

7.3.3. Environmental Levels of LCBPs

As has been noted earlier, little is known about the environmental occurrence of LCBPs. Laboratory experiments using activated sludge treatment (Monsanto Canada Ltd. 1972) or model ecosystems (Metcalf et al. 1975) have demonstrated that LCBPs as a class are more readily degraded than are HCBPs. This is completely in accordance with normal expectations, and it seems quite reasonable to assume that LCBPs are, in general, more readily metabolised and chemically or physically degraded in the environment than are the HCBPs. It also seems likely that incineration will destroy LCBPs at temperatures lower than those needed for destruction of HCBPs.

For these reasons it should be expected that, if the quantities of LCBPs and HCBPs used and their methods of disposal are similar, environmental levels of LCBPs would be very much lower than the levels of HCBPs.

This is borne out by such scanty information as is available on PCB types in sewage (Section 7.2.1.) and rainwater (Section 7.2.5.). The types of PCB in biological samples may be strongly influenced by differential accumulation factors. However, the small LCBP fraction in Herring gull eggs (Section 7.3.2.) supports the contention that only low levels of LCBPs are present in the environment.

A detailed study of PCB in a pool of a large number of human fatty tissue samples in Sweden (Jensen and Sundstrom 1974) found only small amounts of LCBP. Of the total PCB residues, LCBPs made up less than 6% and only four isomers of tetrachlorobiphenyl were observed.

7.3.4. Origin of LCBPs in the Environment

It is reasonable to suppose that the major part of the LCBP found in environmental samples originates from commercial PCB of the Aroclor 1016/1242 types, but some other possible sources have been suggested.

Dechlorination of some PCB homologs has been reported (McKinney 1975) to occur *in vivo*; this provides a possible, though perhaps minor, source of LCBPs in biological samples derived from HCBPs released into the environment.

7.3.4.1. Possible production in chlorination plants

Gaffney (1974) showed that PCB was present in the trickling filters of a sewage treatment plant that practised chlorination of influent (for odour control) that contained waste biphenyl. Half the flow received by the plant originated in a textile mill that used large quantities of biphenyl as a dye carrier. However, no evidence was presented concerning the PCB content of the sewage influent and the origin of the PCB.

Recent investigations by Smith (unpublished), Carlson et al. (1975) and Johnsen (1975) have shown that biphenyl can be chlorinated under conditions that might be approached in the intermittent anti-fouling chlorination of cooling water systems in large power plants.

Smith's experiments using high concentrations of biphenyl and free chlorine in water over a period of hours produced mono- and dichlorobiphenyls. The reports of Carlson et al. and Johnsen are to the effect that a variety of chlorobiphenyls are produced in aqueous systems containing chlorine and biphenyl. The extent of chlorination varies according to the conditions: increasing chlorine dosages resulted in greater degrees of chlorination, as did lower pH or longer reaction times. Under very severe conditions (830 ppm chlorine, 5 ppm biphenyl for 1 week) trichlorobiphenyls (possibly also tetrachloro-) were produced.

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Undoubtedly, the chlorination of biphenyl and other organic compounds, if present in the water, will occur in heavily chlorinated cooling waters. Plants producing potable water, particularly those using superchlorination techniques, may produce some lower chlorinated derivatives from biphenyl.

In general, the rate of chlorination of aromatic (benzenoid) organic compounds decreases as the degree of chlorination of the nucleus increases. In studies of chlorination of benzene under industrial conditions (absence of water, iron catalyst), benzene itself reacted 8 times faster than chlorobenzene, which in turn reacted 30 times faster than the dichlorobenzenes (MacMullin 1948, Bourion 1920); further chlorination becomes even slower (Hardie 1964). Similar decreases in reaction rates for successive chlorination stages probably hold in the chlorination of biphenyl, and it seems unlikely that biphenyl would be chlorinated in appreciable quantity beyond the tetrachloro stage (two chlorine atoms in each ring), if that far, in municipal drinking waters or even in heavily chlorinated cooling waters, because the initial biphenyl content would in any case be very low.

On the other hand, sewage certainly contains HCBP, probably contains LRBP, and often will contain biphenyl itself because of the widespread use of this hydrocarbon in heat exchange fluids, dye carrier, and fruit treatment and its common production in huge annual volume in the petroleum-based de-alkylation of toluene and xylene. Whether PCB is produced by chlorination of petroleum-processing effluents depends on whether industrial practice includes chlorination of such effluents (this seems unlikely), or whether these effluents are discharged through municipal wastewater treatment plants that practise chlorination. In municipal sewage almost all the biphenyl, if present, will be associated with the suspended solids, which contain large quantities of hydrocarbons, largely of mineral oil origin. Both the suspended solids and the aqueous phase contain large

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quantities of other organic matter that is more easily attacked (oxidised or chlorinated) by chlorine than are the hydrocarbons. Under these conditions it seems unlikely that biphenyl will be chlorinated in significant quantities or that the chlorination, if it occurs, would proceed beyond the trichloro-stage. For similar reasons it appears unlikely that chlorobiphenyls in sewage would be converted to HCBP in significant quantity.

7.3.4.2. Possible extent of production

The existing concentrations of PCB in Great Lakes water used for municipal supplies has not given rise to detectable PCB levels (parts per trillion) in finished water. If, however, chlorination of this water converted 1 ppt of biphenyl or LCBP to HCBP, then this would result in an increase in the per capita dose to humans of about 1 µg per annum of HCBP, based on annual consumption of 1000 litres of water.

The Task Force has no data on the volume of water subjected to very heavy chlorination. Municipal water supply systems provide 100-200 gallons of potable water per capita per day. If, on the Canadian side of the Great Lakes, the daily use of water in systems subject to heavy chlorination were equivalent to 1000 gallons per capita, and if in all this water each day 1 ppt of biphenyl or LCBP were converted to HCBP, the annual loading of HCBP generated, assuming a population of 5×10^6, would be:

$5 \times 10^6 \times 1000 \times 4.5 \times 365 \times 10^{-12}$ kg equals 7.5 kg.

Although these calculated quantities appear small by comparison with known inputs, the actual effects of chlorination should be investigated as a matter of priority. If biphenyl is converted to LCBP under water treatment conditions, it seems certain that naphthalene and many other substances will be attacked as readily, or more readily. Naphthalene and other polynuclear aromatic hydrocarbons (PAH) are produced in very large quantities

in the petroleum-based industries, and especially in coal-using plants such as the coke ovens associated with steel-making complexes. The presence of two such complexes in Hamilton, Ontario, and the associated tar distillery or pitch processing plant must have resulted, in the course of the past several decades, in large quantities of naphthalene and other PAH passing through the former primary-treatment plant of the municipal sewage disposal system. As a result of chlorination practices at this plant, the sediments of Hamilton Harbour should provide evidence of efficacy of the production of chlorinated aromatics by this route. Further, the aquatic bird colonies of the district should show high levels of polychloronaphthalenes if extensive chlorination of aromatic hydrocarbons in wastewaters has occurred.

7.3.5. Presence of LCBP in commercial PCB mixtures

Table 29 presents Monsanto data concerning typical % compositions by homologs of Aroclors 1221, 1016, 1242 and 1254; comparable figures for Monsanto's experimental product MCS 1043 are adapted from the U.S. Interdepartmental Report (1972).

TABLE 29

Typical % Composition* of PCB Products.

Homolog (No. of Cl/Biphenyl)	Aroclor 1221	MCS 1043	Aroclor 1016	Aroclor 1242	Aroclor 1254
0	11	< 0.1	< 0.1	< 0.1	0.1
1	51	20	1	1	0.1
2	32	75	20	16	< 0.5
3	4	5	57	49	1
4	2		21	25	21
5	< 0.5		1	8	48
6	ND		< 0.1	1	23
7	ND		ND	< 0.1	6
$\frac{\sum 1,2,3,4}{\sum 1,2,3,4,5,6,7} \times 100\%$	> 99	> 99	~ 99	~ 91	~ 23

*Per Cent (W/W) by GC/MASS using area correction factors by homolog response.

ND: - None detected, < 0.01%

LCBPs are the major components of all the products in Table 29 except Aroclor 1254, which is mostly HCBP. The discontinued products Aroclor 1248 and 1260 are no doubt in use in equipment still in service. Aroclor 1260 is almost entirely HCBP; Aroclor 1248 contained major amounts of HCBP.

Such reports as are available suggest that PCB in waxes/resins for use in the investment casting process is mostly HCBP, and may contain a high proportion of decachlorobiphenyl.

7.3.6. Chemical species of particular toxicological importance contained in/or derived from commercial PCB

7.3.6.1. Chlorodibenzofuran (CDBF)

Certain CDBFs are known to be highly toxic to animals. CDBFs are known to be present in many commercial PCB samples. There is no reason to believe that the particular CDBFs in commercial PCBs are other than highly toxic.

There are no authenticated reports of CDBF in environmental samples. However, it is reported (Kuratsune 1975) that the PCB-based heat transfer fluid that was the cause of the Yusho incident contained exceptionally high levels of CDBF. It appears that much of the CDBF had been generated during use of the fluid in this high-temperature application. Three patients with Yusho who died between 1969 and 1972 were all shown to contain chlorinated dibenzofurans.

The occurrence of CDBF in commercial PCB has been investigated (Bowes et al. 1975); Table 30 reproduces the data.

TABLE 30

Chlorodibenzofuran Concentrations* in Commercial PCB Samples.

PCB	CDBF Concentration 4Cl	5Cl	6Cl	Total
Aroclor 1248	0.5	1.2	0.3	2.0
Aroclor 1254	0.1	0.2	1.4	1.7
Aroclor 1254	0.2	0.4	0.9	1.5
Aroclor 1260	0.1	0.4	0.5	1.0
Aroclor 1260	0.2	0.3	0.3	0.8
Aroclor 1016	ND	ND	ND	-
Clophen A-60	1.4	5.0	2.2	8.4
Phenoclor DP-6	0.7	10.0	2.9	13.6

* Concentration expressed as ug g^{-1} PCB.

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These data suggest that release of Aroclor 1016 into the environment does not imply concomitant release of CDBF. Subsequent transformation of the major components of Aroclor 1016 into CDBF by a hydroxylation-dehydrochlorination mechanism would yield dichloro- and trichlorodibenzofurans.

Transformers and capacitors that require PCB fluids normally operate at elevated temperatures up to 150°C. Power surges in these units are not uncommon and result in temperature excursions, internal arcing, electrical failure or mechanical rupture according to severity. The Task Force is not aware of any studies of the effects of service on the composition of askarels with particular reference to CDBF content.

7.3.6.2. Single isomers of particular homologs

Each of the toxicological effects attributed to PCB is probably comprised of contributions from a number of single isomers of the various chloro-homologs present. If, relative to the properties of other PCB isomers, some particular isomer manifests both the ability to cause exceptionally severe biological effects and an exceptional degree of environmental persistence, then it is likely that the presence of that isomer in environmental samples at concentrations capable of causing significant harm would be unrecognized unless special procedures were adopted. The adoption of such special procedures would pre-suppose knowledge of the existence and properties (including biological) of the particular isomer.

Information about the toxicological properties of individual chlorobiphenyls is limited, and there is not yet evidence that any one of them known to be present in commercial PCB causes exceptionally severe effects to the degree contemplated in the preceding paragraph. However, a chlorobiphenyl of exceptional persistence (i.e. stability to attack) may well not manifest any especially severe toxicological effects except those associated with very long term exposure; such effects are those least likely to have been studied.

7.3.6.3. Metabolites

There is ample evidence that various chlorobiphenyls are metabolised in animals by hydroxylation. This mechanism would also be expected to constitute the pathway for degradation by microorganisms. Though hydroxylated PCBs are expected to be more readily degraded in the environment than PCBs themselves, Jansson et al. (1974) have reported the detection of such hydroxylated compounds in seal and guillemot.

Metabolic studies with PCBs have shown that dihydroxy metabolites are formed and that epoxides (arene oxides) are intermediates. It is known that the carcinogenic action of some chemicals is through their epoxide metabolite. Further studies in this field are likely to be of particular importance in deciding whether any initial control actions recommended by the Task Force should be revised at a future date.

In particular, if arene oxide (Safe et al. 1975) formation proves to be a necessary step in the "carcinogenesis process" the occurrence in fish of PCB residues which are metabolised by this route is of crucial importance. A reasonable probability of arene oxide formation from a PCB requires the presence in the molecule of two vicinal unsubstituted carbon atoms. Among the structures that have been shown to be present in commercial PCBs, unsubstituted vicinal carbon atoms are likely to be found only in molecules containing fewer than six chlorine atoms. Because di- and trichlorobiphenyls are relatively non-persistent in the environment, human exposure to PCBs likely to give rise to arene oxides, centres on ingestion of tetra- and pentachlorobiphenyl in fish used as food. Every effort should therefore be made to establish what are present levels of these compounds in fish, to monitor trends through reexamination of existing chromatograms and through fresh analyses, and to determine whether (or which) present uses of Aroclor 1016 and 1254 are leading to contamination.

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7.3.6.4. Complicating factor - complex mixtures

It is clear that the task of deciding what dangers are posed by PCBs and what remedies are necessary is greatly complicated by the fact that commercial PCBs and quantitation of residues is difficult, are complex mixtures/ This is one of the factors that must be considered not only in the immediate deliberations of this Task Force, but also in applying the truly preventive aspects of the Environmental Contaminants Act in evaluating new commercial substances. Similar complicating factors have recently been noted in evaluating the hazards from chlordane and, earlier, toxaphene.

7.3.7. Consumption and Usage of Lower Chlorinated and Higher Chlorinated PCBs

7.3.7.1. Total PCB usage, 1957-1974

Total Canadian imports of PCB for the period 1957-1974 are estimated at:

22,000 tonnes, comprising

13,500 tonnes Aroclor 1254/1260 types

8,500 tonnes Aroclor 1016/1242 types

U.S. domestic sales for the same period are estimated at:

330,000 tonnes, comprising

110,000 tonnes Aroclor 1254/1260 types

220,000 tonnes Aroclor 1016/1242 types

7.3.7.2. PCB usage 1973 and 1974 and usage ratio

Data for 1973 and 1974 reflect the effects of Monsanto's sales curtailment and show that usage ratios of 1016/1242: 1254/1260 have altered markedly in the U.S.A. though not in Canada. Average import of bulk PCB into Canada per year

1968-70: 1750 tonnes

1973-74: 1450 tonnes

Average U.S. domestic consumption of PCBs

1968-70: 31,000 tonnes

1973-74: 15,500 tonnes

The ratios of the usages of lower chlorinated (Aroclor 1016 and 1242) and higher chlorinated (Aroclor 1254 and 1260) commercial PCBs for various periods are shown in Table 31. There is a difference in the trends of the usage ratios.

Table 31

Ratio of usage 1016+1242 types/1254+1260 types

	1960-65	1965-70	1973-74	1957-74
Canada	-	2:3	2:3	-
U.S.A.	3:2	3:1	4:1	2:1

7.3.7.3. Implications of the usage figures

It should be noted also that domestic sales of Aroclor 1254/1260 types in the U.S.A. increased but little over the period 1960-70 while there were large increases in the usage of Aroclor 1242 (which contain only about 9% HCBP). Monsanto's action combining elimination of sales for open-system applications and product realignment from Aroclor 1242 to 1016 should have produced major decreases in observed HCBP residue levels unless a countering mechanism is operative. This should especially have been true if other actions had also reduced release of PCB into water as a result of changed practices (in the electrical equipment manufacturing industry) or of the operation of additional sewage treatment facilities (which achieve a 50% efficiency for PCB in municipal sewage - see Section 7.2.1.1.).

That observed environmental HCBP residue levels have not notably decreased to date, despite the great decrease of usage in open-system applications, despite demonstrated decreases in PCB content of some major wastewater treatment plant effluents, and despite the coming on stream of additional treatment plants, suggests strongly that buffering mechanisms exist. A direct

buffering mechanism is presented by sediments in the Great Lakes. These sediments are in effective contact with the water column to a depth of some centimetres in the sediment; whether the present mode of this buffer relative to the water of the lakes is as a net sink or net source is unknown. An indirect buffer is the huge backlog of PCB that exists in the various stages between manufacture and mobilization into the open environment and especially in waste materials in landfill sites. (See Section 5.4.2.).

7.3.7.4. Estimated usage of PCB in the Lower Great Lakes Region

Almost 1/3 of the Canadian population, and perhaps 40% of Canadian manufacturing industry is in the Ontario Great Lakes region; historically it is reasonable to suppose that rather less than 1/2 of the PCB imported into Canada has been used in this area, giving totals of: 6000 tonnes of higher chlorinated and 4000 tonnes of lower chlorinated commercial PCBs in the period 1957-1974. The manufacturing industries in the Great Lakes region below Lake Huron (10-15% of U.S. industrial output) probably have accounted for well over 1/10 of the U.S. consumption of PCBs, or more than 11,000 tons of higher chlorinated and more than 22,000 tons of lower chlorinated commercial PCBs in the period 1957-74. At present U.S. rates of usage, a 10-15% proportion would lead to estimated annual use of 250-400 tonnes of Aroclor 1254 and 1300-2000 tonnes of Aroclor 1016-1242 in the U.S. lower Lakes region, compared with a Canadian usage (40% of imports) of 400 tonnes Aroclor 1254 and 200 tonnes Aroclor 1016. More accurate estimates of Canadian regional usage will be possible if the information-gathering powers of the Environmental Contaminants Act are used.

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Table 32 summarises these estimates of consumption in the lower Great Lakes basin.

Table 32

Estimated annual industrial consumption of PCB by Aroclor types in the Lower Great Lakes Region, (tonnes/year).

Year	Aroclor	U.S.A. (10% of Domestic Sales)	Canada (40% of Imports)	Total Lower Great Lakes Region
1973	1016/1242	1300	155	1455
	1254	250	360	610
1974	1016/1242	1300	205	1505
	1254	250	405	655

7.3.8. Losses to the Environment

7.3.8.1. Estimates by commercial PCB type

These very crude estimates (Table 32) which probably exaggerate the relative importance of Canadian industry, suggest that Canadian usage of Aroclor 1254 is potentially much more significant as a contribution to the PCB problem in the lower Great Lakes region than is Canadian usage of Aroclor 1016. Further, because transformers are longer-lived units than capacitors, and because the enormous U.S. consumption of Aroclor 1242 in the late 1960s was to a considerable extent due to short life-time uses, the PCBs lost to the environment in the Canada-U.S. lower Great lakes region from 1965 onwards must have been strongly biased toward the Aroclor $\frac{1016}{1242}$ types, perhaps giving a lower chlorinated/higher chlorinated ratio of PCBs lost to the environment as high as 5:1 or 10:1. And yet LCBPs have been found to form only a small proportion of the total PCB residues in environmental

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samples. Even though tetrachlorobiphenyls are more readily degraded than HCBPs, it might reasonably have been expected that the great preponderance of Aroclor 1016/1242 in PCB losses in the last decade would have resulted in the reporting of most PCB residues as Aroclor 1254 skewed towards Aroclor 1242. In fact, residues are usually reported routinely as Aroclor 1254 or 1254/1260 and are estimated on the basis of chromatogram peaks that do not represent the tetrachlorobiphenyl contribution.

7.3.8.2. Estimates by chloro-homolog type

From data in Tables 2 (Imports), 1 (Recent composition OECD), and 31 (Compn. of Aroclors), it has been estimated that in Canadian imports of PCB the ratio of tetrachlorobiphenyl to HCBP was about 25% in 1964-66, 40% in 1968-70 and 35% in 1973-74. Because Aroclor 1260, which is composed almost entirely of HCBP, figured very prominently in imports of PCB during 1964-67 and because it was chiefly used in a long-service application as transformer askarel, the ratio of tetrachlorobiphenyl to HCBP in PCBs originating from bulk PCB imports and later released into the aqueous environment in Canada has probably been about 40% for a decade or longer.

From the data in Tables 1 (Recent imports by Aroclor type) and 29 (Composition of Aroclors) it can be calculated that in 1973-4 commercial PCBs intended for use in transformers (Aroclor 1254) contained 99.5% of the HCBP, 69% of the tetrachlorobiphenyl and about 0.5% of the di- and trichlorobiphenyls that were imported in those years. Conversely imports of capacitor dielectric fluid (Aroclor 1016) contained 0.5% of the HCBP, 31% of the tetrachlorobiphenyl and 99.5% of the di- and trichlorobiphenyls imported in those years.

From data for domestic sales of PCBs in the U.S.A., it is estimated that the ratio of tetrachlorobiphenyl to HCBP was about 50% in 1960-63, 80% in 1966-70, and 130% in 1973-74. We must suppose that in PCBs released into an aqueous environment on the U.S. side of

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the Great Lakes (or in Canada from manufactured goods imported from the U.S.A.) the ratio of tetrachloro- to higher chlorinated biphenyl has been at least as great as these percentages and probably much greater. (See Section 7.3.8.1.).

7.3.8.3. Conclusion

These crude estimates, taken together with such evidence as exists of the presence (or absance) of tetrachlorobiphenyl in biological samples from the environment (birds (Section 7.3.3.) and fish (Section 7.3.2.)), indicate that tetrachlorobiphenyl and other LCBPs are degraded more rapidly than are HCBPs. Because Monsanto's sales curtailment must already have exertad a great effect on losses of tetrachlorobiphenyl and other LCBPs into the environment, and because this material is more rapidly degraded than HCBP, any reduction in Canadian discharges of LCBP to the Great Lakes ecosystem that could he brought about by new restrictions on use in electrical equipment in Canada would be of only secondary importance, when viewed against the vastly greater consumption of LCBPs in the U.S. Great Lakes region.

Conversely, Canadian actions to reduce losses of HCBP to the Great Lakes ecosystem could have a large effect in view of the estimated relative quantities of HCBP used in Canada and the U.S.A. within the Great Lakes Region.

It is clear that Canadian control efforts alone will be insufficient to reduce environmental levels of PCBs in the Great Lakes to tolerable values. Effective action will also be necessary in the U.S. portions of the Great Lakes Basin.

7.4. Conclusions

7.4.1. The available evidence

1. PCBs are ubiquitous persistant pollutants (Section 7.1.).

2. Human adipose tissues collected in Canada had levels of 1 - 2 mg/kg of PCB residue. Humans are exposed to PCB from the environment. (Section 7.1.6.).

3. Significant data on human exposure is only available for food; a little information is also available on levels of PCB in air and potable water.

4. The average Canadian dietary intake of PCBs is low, but it is highest in those persons who consume significant quantities of freshwater fish from the Great Lakes and St. Lawrence River. Data on dietary intake of PCB in this critical group were not available.

5. PCBs are biologically active substances which are of toxicological significance to man (Section 1.).

6. All PCBs are of toxicological significance but the higher chlorinated biphenyls are much more persistent and are thus of greater concern from the standpoint of exposure. The lower chlorinated biphenyls (2, 3 and 4 chlorine atoms per molecule) have seldom been identified or reported in environmental samples except close to the source. An exception to this is in the studies of PCB in eggs of Great Lakes Herring Gulls, which contain about 1% tri and 10% tetrachlorobiphenyl (Section 7.3.2.). Chlorinated dibenzofurans, as components or derivatives of PCB, may be of toxicological significance in the Canadian environment (Section 7.3.6.1.).

7. PCBs are being liberated into water (Section 7.2.1.), air (Section 7.2.5.) and soil (Section 7.2.3.) from sewage treatment plants (Section 7.2.1.), solid waste disposal sites (Section 7.2.2.) and incinerators (Section 7.2.4.). The identified pattern of PCB contamination appears to correlate with the relative industrialisation.

8. The Great Lakes and associated regions are the most contaminated areas in Canada so far identified (Section 7.1.).

9. The present sources to the Great Lakes are from sewage treatment plants (Section 7.2.1.1.), industries, (Section 7.2.1.2.), incinerators (Section 7.2.4.), the atmosphere (Section 7.2.5.), and tributaries (Section 7.2.6.).

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10. It is uncertain what proportion of the present contamination of the Great Lakes biota is due to ongoing or to past disposal practices (Section 7.2.7.5.).

11. PCB residue levels in species/from the Atlantic are higher than those from the Pacific (Section 7.1.2.1.). of fish and shellfish

12. Atmospheric translocation of PCB may be the primary route of contamination of the prairies (Section 7.1.4.) and the arctic (Section 7.1.3.) except for contamination from possible gross discharges to water.

13. The Canadian environmental data do not show a discernible temporal trend since the implementation of the voluntary ban. However, the period of time since the ban may be too short (4 years) for a trend to have become evident (Section 7.3.1.) and the adequacy of the data for showing trends is douhtful especially because only the more highly chlorinated PCBs have been measured.

14. PCBs have contributed to reproductive problems in ranch mink and in fish-eating birds from the Great Lakes (Section 1.).

15. Accidental introduction of even small quantities of the more persistent PCB into aquatic ecosystems may be of significance both from a toxicological and an economic standpoint.

16. There is a need to control the importation, use and disposal of PCBs in Canada. Effective controls in areas of U.S. jurisdiction/to reduce entry of PCBs into the boundary environment. are also necessary

17. Most of the available data was collected for purposes other than to provide an overall documentation of Canadian PCB contamination and is therefore inadequate for this purpose.

7.4.2. The Collection and Interpretation of evidence concerning contaminants

1. There is a priority requirement for tracing the origin of toxic pollutants when these are detected entering the environment in significant quantities.

2. There is a priority requirement for better planning and coordination of research and monitoring of toxic environmental pollutants.

3. There is a priority requirement for a departmental capability to model environmental pollutants effectively.

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8. FOURTH TERM OF REFERENCE (PART A). RECOMMENDATIONS CONCERNING COLLECTION OF INFORMATION UNDER THE PROPOSED ACT AND BY FURTHER GOVERNMENT RESEARCH

9. RESPONSE TO FOURTH TERM OF REFERENCE (PART A)

9.1. Recommendations concerning Notification

9.2. Recommendations concerning Information

9.3. Recommendations concerning Toxicological Information

9.4. Recommendations concerning Further Government Research

9.4.1. Toxicity research

9.4.2. Human exposure research and epidemiology

9.4.3. Environmental exposure research

9.4.3.1. Research and development on PCBs

9.4.3.2. Institutional requirements concerning contaminants

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8. FOURTH TERM OF REFERENCE (PART A) CONCERNING COLLECTION OF INFORMATION UNDER THE PROPOSED ACT

"To make recommendations: (a) on the information which should be sought under the mandatory disclosure provisions of Section 4 of the Act; and on the information which should be provided through further research by the government.

9. RESPONSE TO FOURTH TERM OF REFERENCE (PART A)

The greatest problem with PCBs, since their discovery in environmental samples in 1966, has been the lack of information on quantities and location of PCB use, and the lack of legislative means to demand this information. The evaluation of the hazard of any environmental pollutant is dependent on information on both the toxicity of the substance and the exposure of organisms to the substance. It is thus difficult to make any assessment of the probable toxicological effects of PCB in Canada.

9.1. Recommendations concerning Notification

4.(1)(a) *of the Environmental Contaminants Act should be followed to obtain notification from persons who may be engaged in commercial, manufacturing or processing activity involving PCBs.*

Copies of the notice in the Canada Gazette should be sent to the following:

IMPORTERS

Monsanto Canada Ltd.,
175 Rexdale Blvd.,
Toronto.

May and Baker Co. Ltd.,
701 Evans Avenue, Suite 310,
Toronto.

DISTRIBUTORS

Western Solvents and Chemicals (Canada) Ltd.

May and Baker Co. Ltd.,
701 Evans Avenue, Suite 310,
Toronto.

Monsanto Canada Ltd.,
175 Rexdale Blvd.,
Toronto.

Canada Colours and Chemicals Ltd.,
160 Bloor Street East,
Toronto.

ASSOCIATIONS (for onward distribution to members)

Canadian Electrical Manufacturers Association

Canadian Manufacturers Chemical Specialties Association

Canadian Manufacturers Association

Chemical Importers Association

Paint Manufacturers Association

POWER COMPANIES

Northern Canada Power Commission (Edmonton)

British Columbia Hydro

Calgary Power (Calgary)

Canadian Utilities (Edmonton)

Saskatchewan Power Corporation

Manitoba Hydro

Ontario Hydro

Quebec Hydro

Maritime Electric (Charlottetown)

Newfoundland and Labrador Power Corporation (St. John's)

Electric Power Commission (Fredericton)

Nova Scotia Power Corporation (Halifax)

MANUFACTURERS POSSIBLY USING PCBs IN:-

Transformers and Capacitors

Extensive listings in 1975 Canadian Trade Index.

List of Monsanto Chemical Company's customers.

1. Aerovox Canada Ltd.,
   P.O. Box 250,
   Amherst, N.S.

2. Allanson Manufacturing Co. Ltd.,
   33 Cranfield Road,
   Toronto, Ontario. M4R 3H2

3. Eastern Electric Co. Ltd.,
   5775 Ferrier Street,
   Montreal, Quebec. H4P 1N3

4. Federal Pioneer Ltd.,
   19 Waterman Avenue,
   Toronto, Ontario.

5. Ferranti Packard,
   121 Industry Street,
   Toronto, Ontario. M6N 4M3

6. Canadian General Electric Co. Ltd.,
   940 Lansdowne Avenue,
   Toronto, Ontario. M6H 3Z4

7. Markham Electric Ltd.,
   Box 276,
   Agincourt, Ontario.

8. Moloney Electric Co. of Canada Ltd.,
   213 Sterling Road,
   Toronto, Ontario. M6R 2B4

9. H.K. Porter Co. (Canada) Ltd.,
   1 Greensboro Drive,
   Rexdale, Ontario.

10. Westinghouse Canada Ltd.,
    288 Sanford Avenue N.,
    Box 510,
    Hamilton, Ontario.

SERVICE COMPANIES

Electrical Equipment Maintenance

Ainsworth Electric Co. Ltd.,
131 Bermondsey,
Toronto, Ontario.

Archer Transformers,
Lewiston,
Mississauga, Ontario.

Black and McDonald Ltd.,
101 Parliament,
Toronto, Ontario.

Bock Electric Motor Ltd.,
13 Racine Rd.,
Etobicoke, Ontario.

Burlec Limited,
125 Nantucket,
Toronto, Ontario.

Eastern Electric Co. Ltd.,
16 Taber Rd.,
Weston,
Toronto, Ontario.

Electro Mechanical Equipment,
87 Dolomite Drive,
Toronto, Ontario.

Fraser Electrical Equipment Co. Ltd.,
37 Guardsman,
Thornhill,
Toronto, Ontario.

Fraser Roderick A. Co.,
96 Keewatin,
Toronto, Ontario.

Hammond Manufacturing Co. Ltd.,
Toronto, Ontario.

K-Tek Electro Services Ltd.,
81 Howden,
Toronto, Ontario.

Lineman's Testing Laboratories of Canada Ltd.,
100 Rivalda Road,
Weston, Toronto, Ontario.

Markham Electric Ltd., (Powerline),
Passmore Avenue,
Agincourt, Ontario.

Province Wide Electrical Services Ltd.,
33 Donalbert,
Etobicoke, Ontario.

Renold Canada Ltd.,
110 Skyway Avenue,
Etobicoke, Ontario.

Rex Manufacturing,
7385 Torbram Road,
Toronto, Ontario.

Tasco Distributors,
3041 Dufferin,
Toronto, Ontario.

Toronto Electric Co. Ltd.,
72 Crockford Blvd.,
Toronto, Ontario.

Transformer and Switchgear Company Ltd.,
38 Wallace Street,
Woodbridge, Ontario.

Transformer Engineering Services,
2135 Avenue Road,
Downsview, Ontario.

Westinghouse Canada Ltd.,
55 Goldthorne Avenue,
Etobicoke, Ontario.

G.T. Wood Co. Ltd.,
3210 Wharton Way,
Mississauga, Ontario.

York Welding,
25 Baywood Drive,
Etobicoke, Ontario.

DISPOSAL SERVICES

Intermediate Disposal

Dand D Waste Haulers	Vineland
Dand D Disposal Systems Ltd.	St. Catherines
K.W. Enterprises	Toronto
Ontario Hydro	Toronto
Monsanto Canada Ltd.	175 Rexdale Blvd.
K. and D. Disposal	St. Catharines
S. Cronish and Son Ltd.	261 Wilton Ave.
Tricil Waste Management	541 Main St., Mississauga, Ont.
Plant National	
AA Liquid Waste	
Interflow Systems Ltd.	Box 3004, Station "C", Hamilton, Ont.
Markham Electric Ltd.	Box 276, Agincourt, Ont.
Westinghouse Canada Ltd.	288 Sanford Avenue N., Box 510, Hamilton, Ont.
Thermal Degradation System	605 James Street, Hamilton, Ont.

Final Disposal

*	Chemtrol Disposal Services	Model City, Lewiston, N.Y. State
	Tricil Waste Management	541 Main Street, Mississauga, Ont.
	Goodfellow Group	Mississauga, Ontario.
*	Monsanto Chemical Co.	Sauget, Illinois.
	Thermal Degradation Systems	605 James Street, Hamilton, Ont.

* These companies are not subject to Canadian law and should be approached individually rather than through Section 4 of the Act.

Paints

None identified.

Adhesives and sealants

None identified.

Plastics, waxes, synthetic resins and rubber

None identified.

Investment Casting Resins and Waxes

Cercast, Inc.,
805 Industriel Blvd.,
Montreal North, P.Q.
H1H 2Z2

Vestshell, Inc.,
10351 Pelletier,
Montreal, P.Q.
H1H 3R2

Deloro Stellite Division,
Canada Oxygen Ltd.,
Belleville, Ontario.

Design Precision Casting,
25 Eastern Avenue E.,
Brampton, Ontario.

Mid-Canada Investment Castings, Ltd.,
11 Mountainview Rd.,
Georgetown, Ontario.

Welkin Manufacturing Co., Ltd.,
824 Des Lauriers St.,
Montreal, Quebec.

International Waxes Ltd.,
50 Salome Dr.,
Scarborough, Ontario.

Lubricants, hydraulic fluids, vacuum pumps, gas transmission turbines

Budd Automotive Co. of Canada Ltd.,
Kitchener, Ontario.

Crowe Foundry - Hespeler, Ont.

Amerock Ltd. - Meaford, Ont.

Carbonless copying paper

None identified.

Heat transfer systems

Midland Industries,
Midland, Ontario.

BP Trafalgar Refinery,
Oakville, Ontario.

Dedusting agents

None identified.

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Pesticides and pesticide application

None identified.

Inks

None identified.

Cutting Oils

None identified.

9.2. Recommendations concerning Information

A request for detailed information under 4(1)(b) should be sent to all those identifying themselves as presently involved with PCBs. It should request data on the quantities of material used or processed on a retrospective basis. Voluntary disclosure of information by those formerly involved commercially with PCB should be solicited because this would be of use in assessing the previous exposure of Canadian ecosystems. Because the Act is written in the present tense and is designed to prohibit harmful actions by those engaged in any commercial, manufacturing or processing activity, the retrospective information from those no longer involved with a substance cannot be demanded for the purpose of assessing the present hazard from past releases.

A number of heat transfer systems containing PCBs will be identified through these procedures. The Japanese "Yusho" incident is attributed to the presence of chlorinated dibenzofurans (CDBFs) in the heat transfer system at much higher concentrations than in the commercially-supplied material (Section 7.3.6.1.). *The possibility that CDBFs have been produced and now exist in heat transfer systems in Canada should be investigated by sampling and analysis.* Because all heat transfer systems lose fluids the presence of elevated concentrations of CDBFs in any working fluid will necessitate prompt action. If necessary the Environmental Contaminants Act could be used to compel appropriate action.

9.3. Recommendations concerning Toxicological Information

Information on PCBs covers a very wide field from acute toxic to subtle biochemical effects. The recently documented carcinogenic and reproductive affects of PCBs have given rise to greatly increased concern. However these effects were found using PCB fractions whose sale has been discontinued (Aroclors 1248 and 1260). *Similar studies should be performed with those types of PCBs likely to continue in use.*

It is appropriate to emphasize the need for testing and evaluating PCB replacements for their possible environmental effects prior to their introduction into widespread use. Of particular concern are other halogenated biphenyls and biphenyl ethers. Dow Chemical Company has proposed a butylated monochlorodiphenyl ether as a replacement for PCBs in capacitors.

It is also appropriate to emphasize the need for testing and evaluating other halogenated organic substances which may be significant dangers as environmental contaminants. In this regard, the fire retardant, polybrominated biphenyl (Michigan Chemical Company) and decabromobiphenyl oxide (Dow Chemical Company) and the polychlorinated terphenyls (Monsanto Chemical Company) are already in commerce, proposed for use or found in environmental samples.

9.4. Recommendations for Further Government Research and Investigations

In toxicology assessment, two kinds of information are required: toxicity of the substance and the degree of exposure of the organism to the toxicant. *In both of these areas the Government should initiate further research,* as discussed below.

9.4.1. Toxicity research

There is a requirement for further toxicological investigations of the PCBs which have become important commercially, viz. the lowerchlorinated compounds. Information indicates that PCBs are carcinogenic and *particular attention should be given to the identification of the specific components which may cause cancer especially* those components that are persistent and to which humans are therefore more likely to be exposed.

9.4.2. Human exposure research and epidemiology

The relative importance of different routes of exposure is ill-defined and poorly quantitated. *The government should initiate studies into the relative importance of the different routes of exposure and to obtain estimates of the total intake of PCB from food, air and water.* Particularly, such studies should include the determination of the composition of the PCB residues by chloro homolog.

The actual consequence in man of repeated low level exposures to PCB is unknown. However, if there are adverse health effects, they are much more likely to appear in those industrial workers having higher and more sustained exposures to PCB; for example, electrical workers engaged in the filling and maintenance of transformers and in the manufacture of capacitors. *Therefore it is recommended that industrial workers exposed to PCB be identified for special study and routine surveillance.* Occupational health is largely a provincial responsibility however a federal-provincial organisation exists to coordinate studies in this area: the Subcommittee on Environmental Health's Working Group on Occupational Health. *The Task Force would urge that this body initiate and coordinate a program of surveillance and appropriate epidemiological studies.*

There is a requirement for an epidemiological study of people who have high dietary exposures to PCB. In both the occupational and dietary epidemiological studies, specific attention should be given to the determination of the spectrum of chlorobiphenyls involved.

9.4.3. Environmental exposure research

Prediction of environmental levels is a high priority requirement in the assessment of toxic chemicals but models needed for these predictions are inadequate (Section 7.4.2.). There are two parts to building these models;the collection and processing of input-output data and the mathematical description of transfers between different phases and media (Gillet et al. 1974). While the former is generally relatively straight forward provided that there is an adequate monitoring design, in Canada a systematic program has not evolved (See Section 7.2.7.3.2.). The latter part, the description of general environmental processes has also been neglected (See Section 7.2.7.3.2.) and for this reason most modelling exercises fail. *There is a priority requirement for research into fundamental environmental processes, including their mathematical descriptions. The Task Force recommends that the Department of Environment*

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