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ENVIRONMENTAL CONTAMINATION BY PCB

The PCB:s - polychlorinated biphenyls - a group of substances with widespread industrial use were found to be present in most biological systems by the Swedish chemist Sören Jensen in 1966. The discovery was quite accidental. A number of unknown substances interfered with analysis of DDT in biological samples. Dr Jensen was able to identify these as PCB:s and discovered a contamination that may be more harmful than that caused by DDT.

This issue of Environmental Planning is devoted to a review of the PCB problem in Sweden and to a presentation of the first practical method of disposal of wastes containing PCB:s. This was presented recently by the chemical company SUPRA.

What is PCB?

As indicated by the name, polychlorinated biphenyls PCB is a whole group of substances. In the biphenyl molecule (fig 1) the hydrogen (H) can be replaced with chlorine (Cl). Figure 2 gives an example of a molecule in which 6 atoms of chlorine have replaced hydrogen. Theoretically there are some 210 different polychlorinated biphenyls. Those found as environmental contaminants usually have 4 to 8 atoms of chlorine. Of the 10⅘ theoretically possible with this number of chlorine atoms 26 have so far been found in nature.

PCB is perhaps the most stable group of organic substances that exists. Stability increases with an increasing number of atoms of chlorine. The stability is the main reason for the industrial use of PCB. PCB can be boiled with strongly alkaline solutions or with sulphuric acid or nitric acid without breaking down. If the molecule contains more than 4 atoms of chlorine it will not burn or oxidize at ordinary temperatures.

Use of PCB

In 1929 the electrical industry introduced PCB in condensers and high

because PCB is non-flammable, PCB is now used in a number of different paints to make them non-flammable and resistant to chemicals and oxidation. It is used in ship bottom paints as an anti-fouling agent. Approximately 80 - 85 % of all pleasure craft and 50 - 60 % of the larger ships use paints containing PCB. Table 1 gives the approximate use of PCB in Sweden per year.

Discovery of PCB as an Environmental Contaminant

As mentioned above, PCB in the environment was discovered accidentally by Dr Sören Jensen. A number of unidentifiable substances appeared during analysis of biological material for DDT. Several different explanations were thought of and tested. It was argued that Jensen had found metabolites (break-down products) of DDT. Analysis of material from museums showed that the unknown substances were present in feathers of white tailed eagles from 1942. DDT was introduced in Sweden in 1945 and first appears in museum material from 1947.

A white tailed eagle found dead provided the solution. The unknown substances were present in sufficient quantities for analysis by mass spectrometry. This showed the substances to be PCB:s.

Later analysis of various species of animals has shown PCB to be present in most ecosystems, particularly those of the marine environment. Table 2 gives some figures for the PCB content of animals from the Baltic and the west coast of Sweden. In table 3 comparison between the concentration of PCB in seals and herring from the southern and the northern Baltic is made. (In both tables the figures for DDT are given in brackets. The concentrations are in milligrams per kilogram of tissue = ppb).

Table 2 also gives a rough indication of the concentration of PCB in the food chains in the Baltic. Figure 3 shows the relation between the species in table 2 and the pathways that PCB is transmitted by. The accumulation in food chains is caused both by the extremely high stability of PCB and its high solubility in fat.

Effects of PCB

The acute toxicity of PCB is not extremely high. There is a relationship between toxicity and chlorine content which has led to different maximum permissible concentrations in air for different degrees of chlorination. For the PCB:s with a higher number of chlorine atoms the maximum level in air is 1 milligram per cubic meter of air, and for the PCB:s with lower chlorine content it is 0,5 mg/cu m. There is no maximum level for PCB contamination of food as yet.

Typical symptoms of PCB poisoning are fatty degeneration of the liver. One case of mass death of salmon fry in a hatchery showed this typical picture and the PCB source could be traced to anti-fouling paint used in the hatchery.

Effects on workers handling PCB:s have been reported and include various damage to the skin apart from the liver degeneration mentioned above. It is estimated that the average Swede has a concentration of

PCB which varies between the limits 4 mg to 0.5 g per kg bodyweight.

Damage to chicken embryos and inhibition of hatching occurs when 0.01 ml of PCB is injected into eggs. These experiments have not been followed up in order to test the lowest level at which these effects occur.

PCB:s (and DDT) are now known to activate the metabolic enzymes of the liver. The consequence of this is an increased breakdown of certain reproductive hormones, which could result in changes of the reproductive rate in animals and man.

Sources of PCB Contamination

Most of the PCB which reaches the environment comes from waste products from industries using PCB. Until recently no methods for disposal have existed. Large but unknown amounts seem to come from incineration plants through which PCB, as mentioned earlier, passes completely unchanged into the atmosphere.

Small but significant amounts of PCB are probably used in oil furnaces as PCB often looks like ordinary mineral oil.

New Method for Disposal of PCB

Recently the Swedish industrial group SUPRA presented a method for PCB disposal which shows great promise.

PCB disposal is a by-product of an arrangement for re-use of waste oil which SUPRA put into operation at the ammonia production plant in Kvarntorp in central Sweden.

The ammonia production uses large amounts of heavy mineral oil which is converted mainly to carbon monoxide and hydrogen. This is done at extremely high temperature (1 400 degrees centigrade). The gas mixture undergoes various forms of treatment. Among these is washing out of soot particles. These are then extracted from the water and enters the process once again. The result is that very small amounts of waste are produced finally.

The extremely high temperature used in converting oil into process gas results in breakdown of many of the contaminants of waste oil. The National Environment Protection Board Research Laboratory has made careful analyses of the waste products and of process gas at various steps. They discovered that PCB was one of the substances that had been broken down.

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Recycling and Disposal in One Package

In co-operation with a firm of consulting engineers, Terra Bona, an inventory of waste oil in central Sweden was carried out. The results showed that large amounts would be available if a suitable organization for collecting the oil could be organized. This has now been done. The

organization, Reci, delivers oil to SUPRA under contract. Waste oil is collected from industries, garages, municipalities etc. A system which permits collection of quite small amounts from each individual subcontractor has been organized. Oils and waste products containing PCB are collected and added to the process. The method seems to show great promise as a model for solving several serious environmental problems in an economically attractive way.

References:

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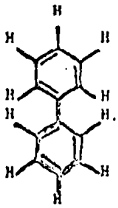


Fig. 1
Diphenyl molecule

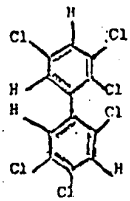


Fig. 2
PCB molecule with 6 atoms of chlorine

Table 1
Consumption of PCB in Sweden, metric tons per year

Transformers and condensers	450 – 500
PVC-paint and other paints	55
Ship bottom paints (anti-fouling)	15
Jointing compounds	35

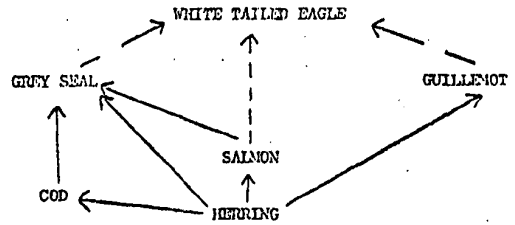
Table 2
PCB (and DDT) in some animals, milligrams per kilogram of body fat (ppb).

	West coast		Baltic (southern)	
	PCB	DDT	PCB	DDT
Mussel (Mytilus edulis)	2	(1)	4	(6)
Herring (Clupea harengus)	0.7	(2.1)	7	(17)
Salmon (Salmo salar)			2.9	(31)
Guillemot (Uria alge) eggs			250	
White tailed eagle (Haliaetus albicilla)			14 000	(25 000)

Table 3
Comparison of PCB content of seals and herring from southern and northern Baltic in milligrams per kilogram of body fat (ppb). DDT is given in brackets.

	Southern Baltic		Northern Baltic (Bothnian sea)	
Grey Seal (Halichoerus grypus)	30	(150)	13	(120)

Fig. 3



Food web relation between certain Baltic species (see table 2 and 3). Broken lines indicate transmission of environmental poisons such as DDT and PCB to the white tailed eagle through carrion of the other species.