RATES AND ROUTES OF TRANSPORT OF PCB's IN THE ENVIRONMENT

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ABSTRACT

The fragmentary information on routes, rates of entry, and ultimate fate of PCB's in the environment is reviewed with special reference to North America and adjacent parts of the oceans. Until very recently,only speculative information was available on production statistics and on quantitative patterns of use. Monsanto Chemical Company has now released figures for total U. S. sales of PCB's, which peaked at 36,500 tons in 1970, and has agreed to furnish supplementary information in time for the Durham meeting. PCB's have been used primarily as dielectric, heat transfer, and hydraulic fluids, particularly where fire resistance is important, and as plasticizers. Minor uses, accounting for less than six percent of sales, have included surface coatings and sealants, adhesives, printing inks, pesticide extenders, microencapsulation of dyes, and wax modifiers. Monsanto has recently restricted sales of certain products based on considerations of either the possibility of contamination of food products or the inability to monitor or control possible losses in the environment. Sale of PCB's for use as plasticizers and the minor uses presented above was discontinued in 1970. In addition, sale of heat transfer fluid has been curtailed and, for those applications which might lead to food contamination, discontinued. As a consequence of these measures, U. S. sales of PCB's by Monsanto have fallen by almost 50 percent to an estimated 18,800 tons in 1971. Concurrently with the control of sales Monsanto is reducing the average chlorine content of PCB's and expects that the percentage of PCB's containing 5 to 9 chlorine atoms per molecule will decrease from 44 in 1969 to 21 in 1972.

As in the case of most industrial chemicals loss figures for PCB's are practically non-existent. Some rough estimates of losses to the environment have been made from the nature of application, and the physical properties of the PCB's. These estimates suggest that a large fraction of the PCB's manufactured to date are confined in sealed containers, either in active service or discarded in dumps. Major routes into the environment appear to be to waterways and estuaries, through scrappage or leakage. Losses to the atmosphere by incineration, vaporization or co-distillation are probably relatively minor. No major direct routes to the terrestrial environment have been identified, since the past use of PCB's for pesticide formulations was small.

Additional evidence on the amounts and routes of PCB's in the environment is provided by data on environmental occurrence of PCB's, derived from both sparse measurements of PCB's in water and air, and more extensive measurements on PCB residues and ΣDDT/PCB ratios encountered in the biota. The spatial distribution of both PCB levels and ΣDDT/PCB ratios are consistent with the postulate that the discharge of PCB's into the environment has been concentrated near industrial areas, and that their subsequent transport has

been mainly through the movement of surface waters or water-borne particulates. The occurrence of PCB's in remote non-industrial sites suggests that a finite quantity of PCB's have also been transported by air-borne particulates. Co-distillation or vaporization is tentatively discounted as a major route, on the basis of the apparent lack of fractionation during transport in the environment amongst the refractory isomers of the commercial product.

PCB's have been identified in snow, rainwater, and air-borne particulates over the continental U. S., but could not be detected in particulates carried from the Pacific over the California coast. Roughly one thousand tons per year of PCB's is estimated as an upper limit for the annual deposits by air-borne particulates on the continental U. S. Estimates of the total input to the terrestrial environment, including contribution by irrigation waters, are two orders of magnitude lower than those for DDT. However, observed ΣDDT/PCB ratios in terrestrial animals are generally lower than 10. The discrepancy is so far unexplained.

The amounts of PCB's stored in freshwater fish and discharged in surface waters are relatively small. The total PCB content of freshwater biota in North America is estimated to be of the order of a few tons and the amounts discharged with surface waters, estimated from data on ΣDDT/PCB ratios in the biota, of the order of 100 tons.

The estimate of total input of PCB's into the marine environment off the U. S. coast from rivers and sewage sludge is of the order of several hundred tons per year, slightly greater than the estimates for DDT. Direct introduction to coastal waters, from industrial leaks, dumping of industrial wastes and dredge spoils, is of unknown magnitude, but probably accounts for locally high levels of PCB's and low ΣDDT/PCB ratios in coastal animals, especially on the Atlantic coast. Farther offshore, ΣDDT/PCB ratios are lower, consistent with the postulate that widespread aerial fallout is a more important route for DDT than for PCB's.

The major conclusion of the review is that only a small fraction of the total PCB production has entered the biosphere. Of the remainder, part has been destroyed by incineration, part is in captive use in heat exchanges or transformers, and part has accumulated in dumps or sediments in shallow waters from which it is leached out at an unknown but probably slow rate. The figures presented in the review are based on fragmentary evidence and are speculative; they emphasize the need for improved transport models for pollutants in the environment.