ENVIRONMENTAL TRANSPORT AND OCCURRENCE OF PCB's IN 1975

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Abstract

Despite curtailment of some dispersive uses, environmental levels and rates of transport of PCB's have not changed greatly since 1972. This is probably due in part to the continued release of materials in service prior to 1971 and in part to time lags in environmental transport and dissipation.

Surprisingly high concentrations of PCB's matching Aroclor 1254 are still being found in air, in precipitation, and in dry fallout.

As yet, there is little evidence that significant quantities of PCB's are being leached from dumps.

Human exposure to PCB's is higly variable. Some sport fishermen and breast-fed infants have especially high intakes.

Almost nothing is known about the environmental behavior of chlorinated dibenzofurans.

I think the organizers of the conference may have expected me to compose a global transport model while this session was going on. I have not attempted to do this, except to make some quick calculations on the back of an envelope.

My general conclusion from what I have heard today and yesterday about the release and concentrations of PCB's in the environment in 1975 is that most of what we have learned since 1972 is reasonably consistent with the very crude model that Sarofim and I constructed in 1972. That is not to say that the model was right. All it says is that our ignorance about the exact rates and routes of transport of PCB's in the environment is nearly as profound in 1975 as it was in 1972.

I have found only one area where there does seem to be substantial quantitative discrepancy between our 1972 model and the data generated subsequently; that is, the numbers reported to us here and published in the interim,† on concentrations in air and air transport. We have heard some numbers of the order of 200 parts per trillion of PCB's in snowmelt, reports of numbers of the order of 100 nanograms per cubic meter for concentration of PCB's in air, and the number of the order of — 200 and locally up to 2,000 nanograms per square meter per day for rates of dry deposition. These are somewhat higher than we anticipated on the basis of model.

If we extrapolate up on the back of an envelope basis from 200 nanograms per square meter per day over the whole continent, that comes out to be something the order of 1,000 tons. Similarly, if you extrapolate from 100 parts per trillion in rainfall over the entire continent, you get something of the order of 1,000 tons.

Now, it may be that the numbers we heard were biased toward urban areas, where the concentrations of PCB's may be higher than they are in the United States as a whole. Even so, we are now being given numbers that suggest that at least 1,000 tons of PCB's per year are falling out onto the terrestrial environment of the United States in rain and particulate matter. That is about as large as numbers we had envisaged for total releases of PCB's into the air in 1971. What makes the problem worse is that nearly all the PCB's that are found in dry fallout, in the air, and in precipitation look like Aroclor 1254, whereas we had thought that only about half of the materials released into the environment even in 1971 would be Aroclor 1254, and a good deal of them would be Aroclor 1242.

So it seems to me that aerial releases and aerial transport are rather larger than anything we could account for according to our knowledge of the uses and releases that we surveyed in 1972. We need to find out where all this material in the air resembling Aroclor 1254 is actually coming from.

One possibility is that it may be coming from leaks from supposedly sealed uses. Perhaps we ought to be looking at transformers to see how much PCB's vaporize from them.

I would now like to go to the six questions which I posed at the beginning of this session and see what we have learned in the course of this conference toward solving these outstanding problems.

1. What happens to chlorinated dibenzofurans in the environment? I think the answer is that still we know almost nothing. We know they are being released into the environment, since they are present in small quantities in commercial PCB's. Dr. Kuratsune in his presentation yesterday indicated that they are actually formed in the environment during use, and Dr. McKinney's presentation suggested they might be formed by metabolism

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†Persson, B., *Ornis Scandinavica*, 2:127-135 (1971); Södergren, A., *PCB-Conference II 1972*:15-18 (National Swedish Environment Protection Board, 1973); Bengtson, A. A. and A. Södergren, *Ambio*, 3:84-86 (1974); Munson, T. O., Ch. 6 in *Upper Bay Survey* (Westinghouse Electric Corporation, Final Report to the Maryland Department of Natural Resources, in press).

under certain circumstances. On the other hand, Dr. Risebrough's presentation suggested that they are not retained in the bodies of birds even when they are ingested; that conflicts with Dr. Kuratsune's information that they are retained extraordinarily efficiently in human tissue.

2. What happens to PCB's in dumps? Again, we know almost nothing. Some numbers were mentioned yesterday for water leaking out of dumps; I did some back-of-the-envelope calculations which suggested that the quantities of PCB's escaping are not yet very significant. One is talking about quantities of the order of hundreds of kilograms per year nationwide—certainly not more than a few tons.

3. Are PCB's in sediments going to be covered up or are they going to be continually recycled? There have been some hints in what has been said today that they are going to be recycled. The information from Ms. McDermott about PCB's in areas where there is shipping activity, and information from Dr. Munson about the movement of PCB's in suspended sediments around Chesapeake Bay suggests that these PCB's in shallow waters are not going to stay there and be covered up and disappear. They are going to be with us for a long time into the future.

4. Is it correct that tetrachloro-biphenyls and lower chlorinated species are rapidly degraded and is there significant human exposure to these lower species? I think that we have had very adequate evidence here that tetrachloro isomers are indeed degraded rather rapidly, but not as rapidly as we would like. Dr. Sanborn's presentation just now suggested that in fish the major difference in the efficiency of uptake, retention, and metabolism comes between trichlorobiphenyls and tetrachlorobiphenyls, and that fish do indeed retain tetrachlorobiphenyls fairly efficiently. That was supported by data from the National Fish Monitoring Program, which suggested that a substantial fraction of the PCB's in the fish look like Aroclor 1242 and 1248; that means that they include substantial quantities of tetrachlorobiphenyls. This in turn implies that humans are exposed to tetrachlorobiphenyls. Although the tetrachlorobiphenyls appear to be rare in human tissue, what that tells us is that humans do not retain tetrachlorobiphenyls. It does not tell us that they are not exposed to them.

This has some important implications from the regulatory point of view. We may have to consider, for example, whether Aroclor 1016 is environmentally "safe," in the sense that modest releases can be regarded as acceptable. These data indicate that releases of Aroclor 1016 into water will lead to human exposure, at least to tetrachlorobiphenyls.

5. What is the extent of human exposure? The data derive from two sides, monitoring of human tissue and monitoring of human food. Human tissue monitoring tells us that human exposure is very widespread. Human food monitoring tells us that most PCB's in human food are in fish.

Unfortunately, that makes it very difficult to estimate human exposure quantitatively, because we know from the fish monitoring program that the levels of PCB's in fish are extraordinarily variable in space. Despite the large number of samples that have been taken by the Canadian program and by the FDA, it is very difficult to define an average exposure. I would go so far as to say that an "average" exposure is a meaningless concept, because some individuals who live in areas where fish residues are high will get exposures 100 times greater than the average, whereas those persons who live in areas where there is little contamination, or who do not like fish, will get very little.

Nevertheless, we do have some numbers for human dietary exposure. The Total Diet Program in the United States gave a figure of the order of 9 micrograms per day for the intake of the average adult. I also did some calculations from Mr. Graham's figures on the Canadian commercial fish to see how many kilograms of PCB's were brought in in Canadian commercial fish and what fraction was eaten. That led me to a figure around 5 micrograms per day for the average intake of the average person in the Canadian population. We have to remember that the average adult does not eat much fish.

Unfortunately, these figures are quite misleading because it is very easy for an individual who is a sports fisherman and who catches salmon, or trout, or chub to take in very much more than that. One calculation in our 1972 paper indicated that it would be very easy for a fisherman or a member of his family to average 300 micrograms per day: this would represent about 4 micrograms per kilogram per day for an adult.

One important point is that exposure of breast-fed infants is likely to be very much greater than that of any adult, even an individual who likes fish. Although Dr. Kutz did not give numerical estimates of PCB levels in human milk in this session, earlier data suggest that a typical level would be around 30 parts per billion.* This leads to an estimate of 4–5 micrograms per kilogram per day intake for the average breast-fed infant. There would

*PCB levels reported in human milk have been in the range 10–100 ppb: Risebrough, R. W., and V. Brodine, *Environment* 12:16-27 (1969); Westöö, G., Norén, K., and M. Andersson, *Vår Föda*, 22:10-31 (1970); Acker, L., and E. Schulte, *Naturwissenschaften*, 57:497 (1970); Savage, E. P., Tessari, J. D., Malberg, J. W., Wheeler, H. W., and J. R. Bagby, *Pesticides Monitoring Journal*, 7:1-5 (1973). A concentration of about 30 ppb would correspond to the median level of about 1 ppm reported in human fat.

be many above the average and many below.

Accordingly, when considering averages, we should remember that certain individuals are going to get 10 to 100 times the exposure of the average person, as calculated from an average diet.

6. The most complicated question posed in 1972: what would be the effect of Monsanto's curtailment of dispersive uses? A number of speakers yesterday and today have talked about decreases of PCB levels in certain areas or compartments of the environment. For example, there have been decreases in the total dietary intake estimated from the FDA Total Diet Program, in the frequency of findings of PCB's in milk and fish in the FDA's surveillance samples, and in runoff into the Southern California coastal waters. On the other hand, we have also heard about some levels that have not changed, particularly levels in fish in Lake Michigan.

There are three reasons why the curtailment of sales by Monsanto in 1971 should not have been expected to lead to an immediate reduction in environmental levels. One is that not all the closed system uses are actually closed. There are some losses that we heard about today, even from transformer and capacitor uses, which are systems as closed as we are likely to get. Secondly, and more important, there is still a large backlog of products containing PCB's, that were in service prior to 1971, which are still in service and are still being discarded and still leaching. Some of the users of hydraulic fluids, transfer fluids, compressors, and so on, are probably using PCB's that they had several years ago. Certa the scrapping of capacitors and any losses that result from disposal of transformers are going to lea releases for years into the future.

Finally, there is an environmental inertia: it tak long time after the input into the environment is cu for the levels in fish, for example, to go down. The t lags will depend on the part of the system under c sideration; it is evidently quite short for mussels Southern California, but is longer for the fish in same area. Time lags have been quite short for the s lings, which reflect terrestrial uses, and for soil residu The time lag is likely to be long for somewhere like La Michigan, which is a closed system, with a large reserv of PCB's in the sediment. So I think we should not ha hoped for a very rapid decline in PCB's since 1971.

On the other hand, it has been somewhat d appointing that it has been so difficult to find a change in the first 3 or 4 years.

One of the longest time lags of all is likely to be human tissue, because there is evidence that PCB's a retained for an extremely long time in human tissue. W will probably have to wait for some considerable tim after PCB levels have declined in fish before we see significant decline in human tissue residues.

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