

an uncontrollable chemical like DDT, it will not be possible to speak of "controlled" uses.

PCB therefore appears to be another waste product of our technology that is not recycled to primary materials. Although there are unquestionable economic advantages derived from their use, the dimin-

ishing capacity of our global environment to absorb our own wastes should prompt us to consider whether — and how — we can develop a technology that can use its waste materials again and again and that does not permit any persistent wastes with biological activity to accumulate. □

Monsanto Statement on PCB

When this article was in preparation, the Monsanto Company was invited to provide a statement of its position on PCBs. A series of questions was also addressed to the company. The answers to some of these questions have been incorporated into the text of the article. Others follow the Monsanto statement.

Late in February, 1969, a West Coast newspaper carried a major feature about "a menacing new pollutant" found in the San Francisco Bay area. The article was based on marine life research carried out by Dr. Robert Risebrough of the University of California. The article stated that residues of pesticides (DDT and DDE) and polychlorinated biphenyl (PCB) were threatening the welfare of certain birds and posed a long-term threat to humans.

Monsanto manufactures polychlorinated biphenyl and markets it under our Aroclor trade name. (There are other manufacturers in Europe and Japan.) We, therefore, would like to present some additional facts.

The work done by Dr. Risebrough dates back to earlier research by other scientists who, while analyzing pesticide residues in wildlife, soil and water, encountered unknown or "interfering" substances in the parts-per-million range.

Several years ago, two Swedish scientists at Stockholm University's Institution of Analytical Chemistry, Professor Gunnar Widmark and Soren Jensen, reported they had identified these other substances. They said some of the materials were polychlorinated biphenyl or PCB. Since PCBs are not "broadcast" or spread around the land as are pesticides, the scientists theorized that the source must be the industrial wastes of PCB users.

In addition to the work of Dr. Risebrough and the Swedish scientists, there have been other studies which indicate the presence of PCBs in the environment. Monsanto is concerned over the situation and is cooperating fully with these studies.

The common uses of commercial PCB would not normally lead to its release into the natural environment.

A principal market for PCB is in electrical applications where they are used as insulating fluids for transformers and capacitors. In this use, the chemical is completely sealed in metal containers. Another market is for heat-transfer applications where the PCB fluid functions in a closed system.

PCBs are also used in several applications where the chemical is incorporated into a polymer as an integral part of the solid material. Such polymers are used in highly specialized applications as an adhesive, elastomer or surface coating.

Polychlorinated biphenyls are not sprayed or dusted on crops, woodlands or any other areas, as are pesticides. To our knowledge, they are not used in tires, house paints, household products, or major vinyl plastics, as has been charged. Therefore, conclusions as to the source of PCB reportedly found in the environment are difficult to make.

It has also been implied that polychlorinated biphenyls are "highly toxic" chemicals. This is not true. Just like other industrial chemicals and home products now in widespread use, PCBs are not hazardous when properly handled and used. During more than 40 years of U.S. production and use, cases of any toxic effect have been extremely rare — and then only where the simple precautions recommended for use were not followed.

Monsanto has research programs under way to identify the compounds, reported to be PCB, and locate their source. The programs involve precise analysis of environmental samples of water and soil. Also under way are studies to determine the biological effects of deliberate dosage of PCBs on fish and mammalian animals. Special emphasis is being paid to endocrinological effects, mineral metabolism and reproduction physiology.

Some preliminary biodegradability studies are under way. Further studies to clearly demonstrate this phenomenon are contemplated.

Very early results of chronic toxicity studies confirm that PCBs are not highly toxic. In 90-day studies on rats and other normal laboratory species, there have been no adverse effects when feedings of up to 100 parts per million were administered.

Monsanto has always cooperated on a regular basis with federal, state and university laboratories in their analysis of chlorinated hydrocarbon residues. We will

NOTES**p. 16. "... but a Monsanto bulletin..."**

Technical Bulletin O/PL-306, Organic Chemicals Division, Monsanto, St. Louis, Mo., 1968. We are informed by a Monsanto spokesman that supplies of this bulletin "have been exhausted for several months, and it is in the process of being revised . . . the old bulletin . . . covers only the plasticizer applications,

continue to do so. Additionally, Monsanto will continue to exercise the highest degree of control in its manufacturing, shipping and storing of PCB — as we do with all products. In the functional fluids market, we have carried out a program for several years for the reclamation of used PCBs to reuse these valuable materials.

The source of the marine life residue identified as PCB is not yet known. It will take extensive research on a worldwide basis, to confirm or deny these initial scientific conclusions.

Questions from ENVIRONMENT and answers from MONSANTO.

Environment: At which Monsanto plants is Aroclor manufactured?

Monsanto: In the United States, Monsanto presently manufactures its Aroclor products at plants located in Sauget, Illinois, and Anniston, Alabama.

Environment: Have you monitored emissions at those plants for the presence of PCB? If so, what were the results?

Monsanto: Extensive efforts are in practice at these plants to prevent PCB losses to the environment. These practices have been in use for many years and controls are continually being improved.

Environment: Does Monsanto itself incorporate PCB into some of its other products? If so, at which plants? Have emissions from these plants been monitored for the presence of PCB? With what results?

Monsanto: Controlling practices are also in effect to prevent loss in those manufacturing operations where Aroclor is incorporated into other Monsanto products.

Environment: Could you tell us what control measures you use to keep the PCB concentrations below the Threshold Limit Value in the plant atmosphere?

Monsanto: (No answer)

Environment: We would be pleased to receive any additional information, such as scientific reports, advertising copy, or any other material you may have on PCB. We would appreciate very much seeing copies of the original work you have done on the toxicity of Aroclors.

Monsanto: Our research department summarized some of their work and . . . I am making it an enclosure.

Editor's note: The enclosure dealt only with residue analysis, not with toxicity.

many of which are only suggested applications. To our knowledge, Aroclor plasticizers are not used in all the applications suggested in the bulletin. Primary markets are chlorinated rubber, styrene-butadiene copolymers and polysulfide sealants. Aside from plasticizers, the principal market for polychlorinated biphenyls is in electrical applications where the insulating fluids used in transformers and capacitors are completely sealed. In another major market, heat transfer applications, the fluid is used in closed systems."

"... report by Soren Jensen..."

"Report of a New Chemical Hazard," *New Scientist* 32:612, 1966.

p. 17. "... Gunnar Widmark ... human fat..."

Widmark, G., "Possible Interference by Chlorinated Biphenyls" in "Pesticide Residues" Report of the IUPAC Commission on the Development, Improvement, and Standardization of the Methods of Pesticide Residue Analysis, *Journal of the Association of Official Analytical Chemists* 50:1069, No. 5, 1967.

"Scientists in Britain..."

Holmes, D.C., J. H. Simmons and J. O'G Tatton, "Chlorinated Hydrocarbons in British Wildlife," *Nature* 216:227, 1967. Holden, A. V., and K. Marsden, *Nature* 216:1274, 1967.

"... and the Netherlands..."

Koeman, J. H., M. C. Ten Noever De Brauw and R. H. De Vos, "Chlorinated Biphenyls in Fish, Mussels and Birds from the River Rhine and the Netherlands Coastal Area," *Nature* 221:1126, March 22, 1969.

"Jensen and his colleagues ... Swedish Wildlife..."

Jensen, S. et al., "DDT in Marine Animals from Swedish Waters," *Nature* 224:247, 1969.

"... unknown compounds were polychlorinated biphenyls."

Note: Laboratory procedures in this and subsequent analyses for PCBs are described in the papers listed above and in the author's scientific papers. See especially, Risebrough, R. W., P. Reiche, D. B. Peakall, S. G. Herman and M. N. Kirven, "Polychlorinated Biphenyls in the Global Ecosystem," *Nature* 220:1098, 1968. Risebrough, R. W., P. Reiche and H. S. Olcott, "Current Progress in the Determination of the Polychlorinated Biphenyls," *Bulletin of Environmental Contamination and Toxicology* 4:192, 1969.

p. 18. "... 1,980 PCB ... 17,000 parts per million..."

Risebrough, et al., "Polychlorinated Biphenyls in the Global Ecosystem," *op. cit.* Jensen, S., *op. cit.*

p. 19. "... may be released as a vapor in the form of highly toxic fumes..."

Sax, N. Irving, *Dangerous Properties of Industrial Materials*, 2nd Ed., Reinhold Publishing Co., New York, 1963, p. 34.

p. 20. "... a complex mesh of food chains in the sea..."

Risebrough, R. W. "Chlorinated Hydrocarbons in Marine Ecosystems" in *Chemical Fallout*, Morton W. Miller and George C. Berg, editors, Charles C. Thomas, 1969.

"... 'threshold limit value' of one milligram..."

Sax, N. Irving, *op. cit.* p. 34.

"... more lightly chlorinated PCBs..."

Jensen, S. et al., *op. cit.*

"... laboratory experiment by Koeman..."

Koeman et al., *op. cit.*

"... laboratory animals ... high toxicity..."

Miller, J. W. "Pathologic Changes in Animals Exposed to a Commercial Chlorinated Diphenyl," *U.S. Public Health Record* 59:1085, 1944. McLaughlin, Joseph, Jr., Jean-Pierre Marliac, M. Jaqueline Verrett, Mary K. Mutchler and O. Garth Fitzhugh, "The Injection of Chemicals into the Yolk Sac of Fertile Eggs prior to Incubation as a Toxicity Test," *Toxicology and Applied Pharmacology* 5:760, 1963.

p. 22. "... jack mackerel fishery..."

"DDT Report Halts Fishing," *The New York Times*, Dec. 7, 1969.

"The breakdown of the estradiol..."

Results were in average amounts of polar metabolites formed in millimicromoles for each group of four birds: Control — 29.3 plus or minus 6.5; DDE — 76.2 plus or minus 13.1; DDT — 93.1 plus or minus 11.2; PCB — 160.0 plus or minus 10.5.

"J. C. Street and his co-workers..."

Street, J. C., F. M. Urry, D. J. Wagstaff and A. D. Blau, "Comparative Effects of Polychlorinated Biphenyls and Organochlorine Pesticides in Induction of Hepatic Microsomal Enzymes," presented at the 158th American Chemical Society national meeting, New York, Sept. 8-12, 1969.