THE PROBLEM OF PESTICIDES AS POLLUTANTS OF WATER

H. P. NICHOLSON AND J. R. THOMAN *

INTRODUCTION. Water quality management today faces greater problems than at any time in history. In addition to natural contaminants, there are present as pollutants in our waters multiple chemical substances, products of our modern technology. These pollutants take on greater significance as a growing population and industrial economy increase the demands on a water supply that is static in quantity. Much of our water today is of necessity used and reused repeatedly in its journey to the seas.

One problem of water quality management centers around a lack of knowledge. For example, (1) few of the organic pollutants occurring in water have been identified specifically, (2) the long-term impacts of these pollutants, singly and in combination, upon the water consumer (man and animals living in the aquatic environment) are poorly understood, and (3) today's municipal water treatment practices, with few exceptions, are inefficient or ineffective in achieving removal of chemical contaminants present in trace quantities.

Pesticides constitute one group of many contaminants, both exotic and natural, that contribute to the problem. Pesticides have been selected for particular attention, both as water pollutants and contaminants of the general environment for two reasons. First, a cause and effect relationship is evident between certain pesticide usages and subsequent damage to fish and wildlife; and second, sampling and microanalytical methods are available (in part) to permit specific investigation.

STUDIES OF THE PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. The pesticide pollution problem evoked the interest of the Public Health Service's Water Pollution Control Division (now the Division of Water Supply and Pollution Control) soon after its establishment in 1948. Field investigations and fish bioassays to determine pesticide toxicity have been conducted at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio since the early 1950's.

The Division's Water Pollution Surveillance System was established in 1957 and by July of 1962 was analyzing monthly water samples taken at 101 stations on major rivers of the United States. Qualitative analyses for pesticides are made on these samples. DDT or dieldrin were detected in 38 samples from 10 rivers during the period May through December 1962.[1]

In early 1960, the Service asked all State fish and game conservation agencies to report instances of fish-kills attributable to pollutants entering the streams or lakes of the Nation. The response indicated that 32 percent of all fish-kills reported in 1960 was caused by agricultural chemicals. In 1961 and 1962, comparable percentages were 21 and 16 respectively.[2]

PESTICIDE POLLUTION STUDIES IN ATLANTA. In 1959, the Public Health Service's Division of Water Supply and Pollution Control began a full-scale investigation of the impact of pesticides on water quality. Headquarters for the study are in Atlanta, Georgia. This project operated last year on a budget of $216,000.

The project's purpose is to evaluate the occurrence of pesticides in both ground and surface waters to learn: (a) how general this occurrence may be, (b) what the

* Chief, Pesticide Pollution Studies and Regional Program Director, respectively, Division of Water Supply and Pollution Control, Public Health Service, U. S. Department of Health, Education, and Welfare, Region IV, Atlanta, Georgia.

[1] A. W. Breidenbach, and J. J. Lichtenburg. 1963. Identification of DDT and dieldrin in rivers—a report of the National Water Quality Network. Science 141(3584):899–900.

[2] Pollution-Caused Fish Kills, 1960, 1961, and 1962 (three reports), Basic Data Branch, Division Water Supply and Pollution Control, Public Health Service, DHEW, Washington, D. C.

less obvious effects may be on organisms living in the aquatic environment, (c) what factors relate to the presence or absence of selected pesticides in water, (d) how well pesticides are removed in the normal potable water treatment process, and finally, (e) how pesticide pollution can be controlled. These questions have many ramifications involving multiple disciplines. Twenty scientists and auxiliary persons now make up the Pesticide Pollution Studies staff in Atlanta. Disciplines represented include entomology, limnology, microbiology, chemistry, physiology, and sanitary engineering.

RESULTS OF STUDIES. To date, instances of both surface and ground water pesticide contamination have been found at concentrations ranging from the low parts per trillion to the low parts per billion. Standard water treatment consisting of lime-alum coagulation, sedimentation, sand filtration, pH adjustment, and disinfection does not appear to reduce the concentration of chlorinated hydrocarbon-type insecticides such as toxaphene, BHC, and dieldrin; nor does activated charcoal when applied at the usual rates for taste and odor control.

Pesticides get into surface water by transport in surface water runoff, through direct application as by wind-blown spray or aerial application, and through accidents such as might occur while filling a spray rig from a creek; or even, as has happened at least twice, by means of a truck load of pesticides striking a bridge abutment.

The occurrence in surface waters of pesticides in quantities below the level acutely toxic to aquatic life may be rather common in areas of routine pesticide usage. However, not all pesticide pollution of water is related to agricultural usage. At least one instance is on record where a manufacturer of an insectide experienced difficulty with a waste treatment facility and released partially treated wastes until the difficulty could be overcome. Industrial uses of pesticides are also known, such as use of dieldrin to insect-proof cloth fabrics or for the control of filter files in sewage treatment plants, and the use of fungicides in the paper manufacturing process.

Pesticides recovered from surface waters include the insecticides DDT, TDE, toxaphene, dieldrin, endrin, BHC, aldrin, parathion, and diazinon. The herbicides, 2,4-D, 2,4,5-T, and fenac also have been recovered. Parathion has been recovered in water from wells dug as deep as 185 feet.

In one of our studies (Flint Creek, Alabama) a stream draining 400 square miles of land has been under continuous surveillance since 1959 and cotton is a major crop. The insecticides toxaphene and BHC both have been present in stream and treated municipal water throughout the year every year of the study.[3] Concentrations ranging from five parts per trillion to maximums of 0.4 part per billion for toxaphene, and 1.0 part per billion for BHC have been recorded. Such concentrations have not been associated with toxic effects in human or aquatic life.

SIGNIFICANCE TO AQUATIC LIFE. In 1959 and 1960, biological investigations were conducted in Flint Creek to determine effects on aquatic life of chronic contamination of the water environment by sub-lethal quantities of toxaphene and BHC.[4] So far as was determined, bottom organisms and fish populations were not reduced in number or species composition. Neither was there a demonstrated effect on zooplankton, although numbers were too meager to permit critical study. Zooplankton populations of low order are normal for turbid streams of the Southeast similar to Flint Creek. Biological field studies will

[3] H. P. Nicholson, A. R. Grzenda, G. J. Lauer, W. S. Cox, and J. I. Teasley. *Water Pollution by Insecticides in an Agricultural River Basin.* Part I. *Occurrence in River and Treated Municipal Water.* In press. Limnology and Oceanography.

[4] A. R. Grzenda, G. J. Lauer, and H. P. Nicholson. *Water Pollution by Insecticides in an Agricultural River Basin.* Part II. *The Zooplankton, Bottom Fauna, and Fish.* In press. Limnology and Oceanography.

reveal catastrophic effects of a toxicant on the biota, but methodology generally is not sufficiently refined to permit identification of more subtle damage resulting from long exposure at sub-acute levels.

SIGNIFICANCE TO HUMAN CONSUMER.—The significance of pesticide occurrence in domestic water supplies has not been investigated. In its report contained in the Public Health Service Drinking Water Standards . . . 1962,[5] the Advisory Committee appointed by the Public Health Service to revise earlier standards stated:

"Consideration was given to the more common cholorinated hydrocarbon and organophosphate insecticides, but the information available was not sufficient to establish specific limits for these chemicals. Moreover, the concentrations of these chemicals, where tested, have been below those which would constitute a known health hazard. The Committee believes that pollution of water supplies with such contaminants can become significant and urges that the problem be kept under closer surveillance. Further, the Committee recommends that regulatory actions be taken to minimize concentrations of such chemicals in drinking water."

Although the quantities of pesticides found thus far in water are small, they may conceivably affect human health, especially since man is also exposed to pesticides from multiple other sources. Pesticides will be considered potentially dangerous until their long-term impacts, singly and in combination, on biological systems become understood more completely.

WHAT CAN BE DONE TO CONTROL PESTICIDE POLLUTION. Pending more complete investigation of low level toxicity, a number of actions would serve to minimize the impact of pesticides on water quality. One would be to improve legal control of aerial application of pesticides where needed. This is the most difficult means of application to control physically because of the airplane's speed and its altitude, but incorrect or careless application of pesticides can be minimized and adequate maintenance of equipment can be assured.

A second desirable step would be to improve the education of pesticide users concerning the consequences of pesticide misuse. New information is becoming available constantly and should be made available to the user as quickly as possible.

A third control is continued effort to promote and improve soil conservation practices, especially as they relate to retardation of surface water runoff. The Public Health Service Studies have shown that transport of pesticides in surface water runoff can be a significant means of surface water contamination.

Fourth, greater dependence on the use of short-lived pesticides would help. Many in use today were developed specifically to have long residual pesticidal capabilities. These will have continued value, but their use may well be restricted to situations where environmental contamination possibilities are minimal.

Fifth, search for more selectively toxic chemicals should continue. The pesticide TFM (3-Trifluoromethyl-4-nitrophenol) used to control the sea lamprey in the Great Lakes is an example of success in this area of research.

Sixth, part of the answer can lie in learning how to use more effectively non-chemical pest control methods.

FUTURE RESEARCH PROGRAM. As research continues in the field of pesticide pollution, other control measures will be suggested. These may be expected to develop from new knowledge concerning the behavior in soil and water of specific pesticides. This behavior may be expected to relate to chemical and physical characteristics of the pesticides, pesticidal formulations, and the soils themselves; topography of the land; meteorological factors; cultural practices; vegetative cover; and biochemical effects associated with the microflora of soils and water.

Specifically, we need to know:

a. How specific pesticides enter water

[5] Anonymous. *Public Health Service Drinking Water Standards*, 1962, PHS Bulletin #956.

and why; and, fully as important, which ones do not contaminate water and why. This information will tell us which pesticides are safe to use and where, from a water quality standpoint.

b. What are the effects of pesticides on human water consumers and dwellers in the aquatic environment. This involves, among other things, an exploration of the implications of biological magnification.

c. Which pesticides can and cannot be removed from potable water supplies by current treatment practices and what new methods of water treatment will remove them.

d. How extensive is ground water contamination by pesticides and what is the nature and significance of such contamination.

The research program for the future calls for expanded efforts to supply the needed new knowledge. Currently a materials balance study is being conducted in the Flint Creek Basin in Alabama to equate quantities of pesticides applied to farm crops with quantities carried away by the stream as related to meteorological factors. Simultaneously, work is underway on the problems of biological magnification and ground water contamination. The results of these studies will contribute toward the ultimate objective of controlling pesticide pollution. When that is accomplished, there still remains the whole realm of other non-point source pollutants to consider.