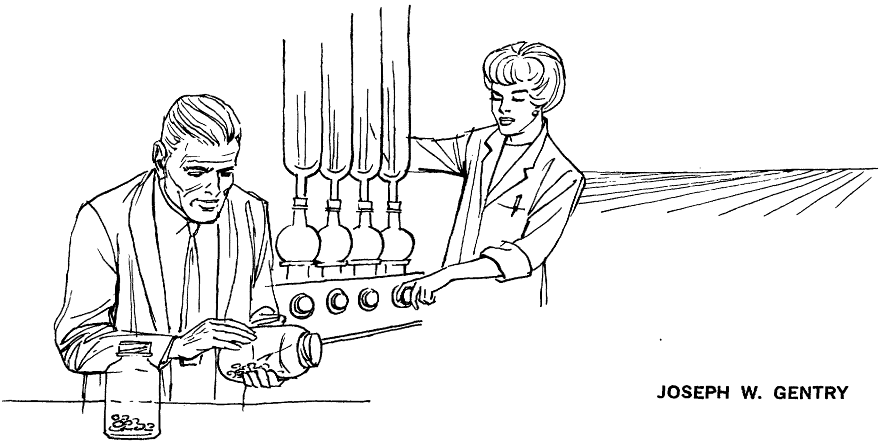
MONITORING FARM USE OF PESTICIDES



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MORE and more insecticides, fungicides, herbicides, and other pest control measures will be needed to give us more and better food. At the same time, this could contribute to contamination of our environment and might harm some beneficial animal and plant life.

The same technology that can develop effective pest controls, however, can develop materials and methods that will not cause detrimental side effects yet still assure us a plentiful supply of wholesome and safe food.

Monitoring activities, which were being initiated on a broad scale in 1965, will point out ways to avoid possible hazards from pesticide use.

Problems relating to pesticide usage received a full appraisal in a report issued by the President's Science Advisory Committee in May of 1963. Since then, each Federal Department with a responsibility for the use of pesticides, or interest in the effects of pesticide use, has increased emphasis on its activities in the field. One of the major actions which the President's Science Advisory Committee report recommended was a monitoring system to give "an assessment of the levels of pesticides in man and his environment. . . ."

The U.S. Department of Agriculture recognized its broad responsibility in the use of pesticides since it registers these materials and issues suggestions for their effective and safe use. The Department, therefore, needed a monitoring program to determine effects of the normal use of pesticides and to feed back information for guidance in decisionmaking. Especially needed was a program to give data to serve as a basis for developing the materials and methods of use that would avoid pesticide residues in the environment or hold them at a safe level.

Such a monitoring project was started on a pilot basis in the Mississippi River Delta in the spring of 1964

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by the Agricultural Research Service (ARS). This region was chosen because large amounts of insecticides had been used in cotton production for many years. The rice-growing areas of Arkansas were included because of interest in the possible contamination of water from the use of persistent pesticides as a seed treatment.

A TEAM OF ARS scientists—biologists, chemists, soil and water specialists, and statisticians—designed a broad program to investigate the impact of pesticide use upon farms selected for the study.

Main objectives of the program were to determine:

- Existing pesticide residue levels in soils, water, sediment, crops, livestock, and certain species of aquatic and land animals; and
- The impact of pesticides on nontarget animal and plant life, particularly beneficial insects.

The studies were planned for a minimum of 3 years in this area in an attempt to determine rates of accumulation or depletion of residues in various components of the environment.

FIVE LOCATIONS typical of farming practices in the Delta region were selected. Three locations were in Mississippi and two in Arkansas. Main crops on the Mississippi farms were cotton and soybeans.

Rice, soybeans, and cotton were principal crops in the Arkansas area. Some small grains, forage, and vegetables were also produced.

Each location was made up of two 1-square-mile study areas. Each area contained pastures, water sources like ponds or streams, and some wildlife. Efforts were made to find companion farms with the same makeup in crops but with contrast in their pesticide use practices.

Cooperation of State agricultural officials and the farmers involved was excellent in every case. They realized the importance of this type of a pesticide study and wanted to contribute to its success.

A TEAM LED BY a supervisory biologist was assigned to each location to conduct investigations in the field. First, the investigators laid out each area in plots or blocks for sampling purposes. Maps were diagramed to show where soil, water, crop, fish, and other samples would be collected.

Then with the assistance of the farm operators a detailed history for at least 10 years was compiled upon kinds and amounts of pesticides used on each block since the introduction of DDT and of other chlorinated hydrocarbon insecticides.

Some of the participating farm operators had excellent and accurate records on file; others had to search their memories. A lack of records on pesticide use is quite understandable. Who would have thought that someone in 1964 would be quizzing a farmer on how much DDT he used in 1948 or how much dieldrin in 1955?

In every case, nevertheless, the information obtained was good enough to give a basis for the studies.

Besides the pesticide use history, the biologist and his crew began to record details of every pesticide application made in their areas. This meant keeping complex pest control operations under constant surveillance; recording what was used, why it was used, how it was applied, weather conditions, and possible hazards to nontarget organisms at time of application. They would continue these activities for the duration of the study. In the pest control season that called for being on the job 7 days in each week.

SINCE PESTICIDES are known to move by air and water from one area to another, the biologist visited surrounding farms and cataloged the pesticides which were being used.

He was laying the groundwork or establishing a baseline against which the analytical results could be compared. In other words, to get any idea of the rate of buildup or breakdown of a pesticide in the soil, accurate figures were required on how much of the material had been applied.

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While the field crews developed their plans of work, equipment for carrying out the program was arriving at the stations.

It was a collection of strange looking items: Five-gallon water bottles, bright new sample cans, light traps, weather equipment, sweep nets, tick drags, forage cutters, pumps, boots, dippers, sieves, shovels, ice cream cups, portable freezers, jugs of alcohol to be used in insect traps, and plastic bags of all shapes and sizes.

Everything was brand new or sterilized. To work with residues at levels of sensitivity in parts per million and parts per billion, cleanliness is essential.

The central laboratory at Gulfport, Miss., was also gearing up at the same time for one of the largest analytical loads ever undertaken by a chemical laboratory in this country. More personnel, more equipment, and more space were added. Chemical supplies by the barrelfuls were being trucked in instead of the customary quarts and gallons.

Suddenly, May came. Sampling had not yet started. It was time for it. The cotton was up and growing and the soybeans were planted. Some weedkillers had already been used but no insecticide yet. A preseason sampling was needed at once.

The crews went at it. Technicians collected soil cores on a random pattern over each field, pasture, and wildlife area. They used a 2-inch-diameter corer which they plunged into the ground to a depth of 3 inches. Each type of cropland was being sampled separately.

Cores from a field were deposited in a large collecting pail, then rubbed through a quarter of an inch mesh screen. The material was passed through the screen again to insure thorough mixing. Stones, roots, grass, and other debris that would not pass through the screen were discarded. A new, 1-gallon paint container was then filled with the mixed, screened soil and sealed with an airtight lid.

The collector completed a data sheet, identifying the sample, and fastened it to the outside of the container. He cleaned up his equipment thoroughly and moved on to the next field. Soil samples were collected once each month during the first season.

The role of water as a carrier of pesticide residues is of prime interest to everyone studying the pesticide pollution problem.

Several of the Delta farms contained lakes, ponds, and sloughs which got all their water from runoff from treated fields.

Analysis of the water and the mud in these sources would show the relative amounts of residues in soil, sediment, and water. It would also furnish a base for comparison with levels found in the aquatic life, such as in turtles, frogs, and in fish.

Water was collected by using a bilge pump with an extended length of hose on the outlet.

This was a two-man job in the larger water sources. One man operated the pump while the other moved the 5-gallon glass carboy and directed the water into the bottle. In deep water a boat was necessary.

Water was taken at several places at various depths over each water source. The bottle was carefully sealed after collection, labeled, and taken to the laboratory as soon as possible for processing in order to prevent breakdown of the residue content.

Water was taken from ponds and other surface sources once each month and whenever a quick runoff occurred after rains. Wells were also sampled each month.

A sediment or mud sample was taken from the bottom of each pond, slough, or stream each time a water sample was collected. The technician used a modified soil corer for this. He waded out through the water, plunging the corer at random into the bottom until he reached solid matter. The tool was withdrawn, and the mud ejected into a 5-gallon container.

Two USDA field team members study a map of a pesticide monitoring area near Utica, Miss. In the background other team members are bringing in a fish trap.

After a representative number of cores were collected, they were mixed by stirring and a 1-gallon portion taken off and prepared in the same manner as the soil sample. An extension was used on the handle of the sampler when sediment was collected from a boat in deep water.

Interspersed with the sampling of soil and water was the collection of plants and animals for residue analysis and insects for sorting and counting.

CROPS WERE SAMPLED at or near harvest. First came wheat, oats, and hay. Later rice, cottonseed, and soybeans would be taken.

Ten pounds of material, made up of plant tissue and seeds, were collected at random over the field; two samples from each field or block. The material was placed in a plastic bag and sealed. If it was green or perishable, it was quick-frozen and kept frozen until processing in the laboratory. Freezer facilities were provided at each of the field stations.

Forage was being sampled periodically, usually following the pesticide applications in nearby areas.

LAND AND AQUATIC animals were regarded as important components of these studies. It has been demonstrated that certain animals can concentrate residues in their tissues. Other animals preying on them may magnify the residues to an even higher level in their own bodies.

Indicator species of animals were selected to try to learn what effect known amounts of pesticides applied to farms would have on their fish and wildlife complement. Only those species most

Water sample is turned on roller to mix it with a solvent solution of redistilled pentane and ether, as part of pesticide monitoring study. The pentane and ether solution absorbs any residues in the water and is drawn off for analysis after mixing.

likely to have lived their entire lives in the 1-square-mile area were chosen.

MICE, rats, cottontail rabbits, snakes, tadpoles, frogs, crayfish, turtles, and pan fish were selected as indicators. Once a month the technicians set out mice, rat, and turtle traps. It was difficult to get representative numbers of the mice and rats but turtles were so plentiful that one biologist reported "they lined up" to get into his traps.

Fish, tadpoles, and crayfish were collected by seining and the rabbits were shot with the assistance of local game officials. Collecting of snakes was left to the option of the individual biologists and technicians. The animals were chloroformed, packaged, labeled, and quick-frozen immediately to stop metabolism as quickly as possible.

A limited number of beef cattle was available in these intensively farmed areas. Samples were taken from the carcasses at slaughter.

THE INSECT STUDIES had broad objectives. One was to determine side benefits from use of pesticides on the farms. The other was to find out the impact of treatments on beneficial species.

The biologists carried out many assignments in this phase of the work. They made sweep net counts of grasshoppers, lady beetles, and bumble bees each week. They ran a light trap one night a week, then sorted out 10 indicator species from among a catch of thousands. They made tick drag counts, dipped mosquito larvae from the ponds, and counted chiggers, horse flies, and house flies.

PITFALL TRAPS were made by digging holes and placing ice cream cups half full of alcohol in them. Crawling insects like ants and ground beetles tumbled into the cups and preserved themselves for counting and recording.

Populations of earthworms, wireworms and white grubs were estimated by random digging. Then these soil forms were preserved for laboratory analysis to determine residue content.

Three colonies of honey bees, placed in each area by ARS research apiculturists, were equipped with dead bee traps and pollen traps. Counts and collections were made from these traps each day for residue analysis. Honey and nectar were also collected for analysis. In addition, the welfare of each colony was studied closely.

BY THE END of season, it was decided that little could be gained from most of the insect studies because of the impossibility of establishing true check areas in a region where pesticide use was so widespread.

Statistical examination of the data indicated the pitfall trapping and soil organism study had merit and war-

Hand-operated corer is used to collect soil samples in pesticide monitoring study.

ranted further study. These phases and the honey bee investigations were the only parts of the insect work which were continued in the study.

As THE DIFFERENT KINDS of samples were collected they were carefully packaged and stored at each station. A courier truck picked up samples each week and transported them to the Gulfport laboratory.

When the samples reached Gulfport, perishable items like green crops and animals—which had been quick-frozen when they were collected—were rushed into the freezers.

The soil, sediment, and water were placed in the processing laboratory where extraction procedures started immediately. Pesticides have to be extracted from unfrozen samples as soon as possible after collection to prevent breakdown of pesticide content. This is especially true with the organophosphate pesticides like methyl parathion.

As THE TONS of samples came in each week, water was processed first. Each water sample was transferred to a larger bottle and 1,000 milliliters of redistilled pentane and ether (3 to 1 ratio) were added as solvents. The sample was then put on a rotator and turned for 20 minutes. In this interval if pesticide residues were in the water, they would be extracted by the solvent. The solvent mixture was then drawn off in a bottle and the extract was ready for a chemical analysis.

IN PROCESSING soil samples, a 300-gram portion was weighed out. This was placed in a half gallon fruit jar and 600 ml. of redistilled hexane and isopropyl alcohol were added. The mixture was rotated for 4 hours on a wheel so that residues, if present, could be taken up in the solvent. The mixture was filtered and the solution washed twice with distilled water.

The extract containing the residues was then drawn off in a small bottle and placed in refrigeration. All samples were processed to the extract stage as soon as possible so they could be held for an indefinite period without significant deterioration or change in residue content.

After a portion of a soil or sediment sample was taken for processing, the remainder of the sample was placed in a separate building, which was especially reserved for this purpose, and held for later reference.

PERISHABLE SAMPLES like green crop material and animals were kept frozen until they were extracted. Procedures different from those used for extracting soil and water samples were employed for processing biological samples but the objective was the same: To "fix" the chemical content in an extract solution.

IN THE ANALYTICAL laboratory a sample was subjected to one of several methods to determine its pesticide residue content both qualitatively and quantitatively. The sample was first injected into a highly sensitive gas chromatograph machine and then the findings were confirmed by the thin-layer chromatographic method as needed.

Other methods available in a well-equipped laboratory—like infrared spectrophotometry—were used, depending upon the type of pesticide that was involved.

Water samples were determined down to levels in parts per billion. Soil and other samples were analyzed in parts per million.

Chemical analysis of many different kinds of pesticide residues in many different kinds of samples of environmental media is a very complex and demanding job. If nothing unusual happens, a sample will require about 3 man-hours from the time it starts through the laboratory until the time the amounts of residue it contains are computed out. Whenever a problem sample turns up, which is about 30 percent of the time, more than 2 days is required, on the average, to complete an analysis of the sample.

BY THE TIME more than 3,000 samples had been collected and analyzed in the Delta program, spring had come back again.

Preliminary results pointed out some things in the first year's work in this new field that would not be done the second year. The results also showed the need for strengthening the existing program and the need for expanding the monitoring activities to other areas of the country.

More information was needed on the fate of residues in different types of crop production. So broad-scale studies were set up in new areas.

One of these was at Mobile, Ala., on farms growing soybeans, potatoes, and other vegetables. A second was started on farms producing cotton, alfalfa, cantaloup, and lettuce at Yuma, Ariz. A third location was established near Grand Forks, N. Dak., to study the impact of pesticides used in sugarbeet and potato production.

IN THE SPRING of 1965 interest continued to grow concerning the fate of persistent pesticides in the environment. The Agriculture Department felt it needed to conduct exploratory surveys in farm areas over the country in addition to those just discussed.

To do this, sampling was conducted in important farming areas in 15 different locations. The work was limited to soil studies only. This would determine need for additional studies on other phases of the environment. Included in the study were fruit and vegetable farms in Florida, South Carolina, Georgia, North Carolina, Pennsylvania, Michigan, Washington, Colorado, Arizona, California, and in Texas.

MORE WORK on pesticides in soils was added to the Department's monitoring program in July 1965. This stemmed from an assignment by the Federal Committee on Pest Control which sponsored a minimum national pesticide monitoring program. The Agriculture Department's part in the broad program was limited to soils. Other Federal Departments designed studies to monitor pesticides in people, food, feed, fish, wildlife, water, and air.

An additional 34 sites involving areas where low amounts of pesticides or none at all had been used were selected for this pilot-scale soils program. These areas were on range and forest lands where periodic outbreaks of insects require control measures, and on wildlands—like game refuges—where pesticides have not been used. By adding the low and nonuse sites to the 21 high pesticide use sites already under investigation, a study of the pesticides in soils was placed in operation in more than 50 locations.