HETA 97-0075-2653
Macon County Courthouse
Macon, Missouri

Max Kiefer, CIH
Jalees Razavi, MD

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Max Kiefer and Jalees Razavi of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by John Decker. Desktop publishing by Pat Lovell.

Copies of this report have been sent to employee and management representatives at Macon County Courthouse and the OSHA Regional Office. This report is not copyrighted and may be freely reproduced. Single copies will be available for a period of three years from the date of this report. To expedite your request, include a self-addressed mailing label along with your written request to:

NIOSH Publications Office
4676 Columbia Parkway
Cincinnati, Ohio 45226
800-356-4674

After this time, copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Health Hazard Evaluation Report 97-0075-2653
Macon County Courthouse
Macon, Missouri
September 1997

Max Kiefer, CIH
Jalees Razavi, MD

SUMMARY

On January 16, 1997, the National Institute for Occupational Safety and Health (NIOSH) received an employee request for a health hazard evaluation (HHE) at the Macon County government facilities in Macon, Missouri. NIOSH was asked to determine if health problems experienced by some building occupants were related to exposure to residual pesticide contamination in Buildings 1 (main courthouse) and 2 (annex). Pesticides had been applied in Building 2 on October 15, 1996, and Building 1 on October 17, 1996, in an effort to control wasps. The HHE requestors reported a number of ongoing health problems that they associated with exposure to residual pesticides; these included: nausea, tightness in chest, burning feeling in the nose and throat, headaches, sore throat, rash, itching, numbness in the lips and tongue, metallic taste in the mouth, sensitivity to odors, dizziness, mental confusion, and weakness.

On February 5-6, 1997, NIOSH investigators conducted a site visit at the Macon County government facility to review the circumstances regarding the pesticide applications; collect air, bulk, and surface samples to evaluate residual pesticide levels; and conduct confidential medical interviews with courthouse employees. Medical records from affected employees were reviewed. A follow-up site visit was conducted on April 3-4, 1997, to re-sample surfaces in Buildings 1 and 2 where residual pesticides were detected during the first visit. The areas had been recleaned, according to the pesticide manufacturer's procedures, following the first NIOSH site visit. Twenty surface samples were collected during this site visit.

No unusual volatile compounds were detected in Buildings 1, 2, or a control building. No major differences were observed among the three buildings sampled, and all displayed low levels of typical indoor air contaminants. No chlorpyrifos, acephate, methamidophos, or resmethrin were detected on any of the air samples collected.

On the first visit, low surface concentrations of the pesticides chlorpyrifos or acephate were detected on 7 of the 33 samples collected. No resmethrin was detected in any surface samples. A trace concentration of chlorpyrifos was found in 1 of the 4 samples from the control location. Occupational exposure standards for surfaces contaminated with residual pesticides have not been established. Although only small quantities of pesticides were detected, additional cleaning in Buildings 1 and 2 (annex) was recommended by the NIOSH investigator to help allay employee concerns about continuing exposure. The follow-up surface sampling on April 3-4, 1997, found low concentrations of the pesticides chlorpyrifos or methamidophos (a breakdown product of acephate), in 10 of the 20 samples collected. The levels of residue detected in the Annex were generally 50-75% lower than the concentrations detected during the February 6-7 site visit. In the Law Library, there was no consistent pattern of reduction. One potential explanation is that when

applied, the pesticides penetrated into the treated wood surfaces. Although cleaning efforts removed the surface contamination, pesticide residue may have leached out of the permeated wood.

Collectively, the health problems reported by the symptomatic employees of both buildings were not suggestive of any specific medical diagnosis or readily associated with a causative agent. Typical symptoms included frontal headaches, generalized weakness and tiredness, loss of concentration, varying degrees of itching or burning of eyes, irritation of the skin, upper respiratory tract irritation, crampy central abdominal pain, and diarrhea. The majority of workers reported their symptoms improved or resolved when they were not in the buildings or were not in contact with building contents, although some workers reported gradual worsening of their symptoms.

Soon after exposure, some workers were informed by their treating physicians that, based on exposure history and the health complaints, they suffered from pesticide poisoning. A review of those reports showed neither physical examination results nor laboratory results were suggestive of a "classical" acute or chronic pesticide poisoning. The available follow-up reports did not reveal any documented signs of chronic toxicity.

Ongoing health symptoms and complaints have been experienced by some occupants of the Macon County Courthouse Buildings 1 and 2. The health complaints began after the buildings were treated with pesticides on October 15 and 17, 1996. Airborne concentrations of pesticides in the buildings measured on February 5, 1997, were below detectable levels. The pattern of compounds detected from qualitative air sampling were similar to those found in typical indoor settings. Surface sampling found persistent residual pesticide contamination in Buildings 1 and 2 that has withstood two comprehensive cleaning efforts. The levels detected however, were very low and are not likely responsible for the health problems reported by some Macon County employees. Because of this, and because there are no surface contamination standards against which to evaluate clean-up adequacy, no further recommendations for additional cleaning and/or removal of building components are made. Removal/reduction of levels of residual pesticides may or may not resolve the concerns of some occupants.

Keywords: SIC 9211 (Courts), pesticides, chlorpyrifos (Dursban), acephate, resmethrin, synthetic pyrethroids, organophosphates, indoor applications, residue, fatigue, headaches, eye irritation, skin irritation, nausea, metallic taste, surface sampling, air sampling.

TABLE OF CONTENTS

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) on January 16, 1997, from employees at the Macon County Courthouse facilities in Macon, Missouri. The request asked NIOSH to determine if health problems experienced by some courthouse employees were related to pesticide applications on October 15 and 17, 1996, in Buildings 1 (main courthouse) and 2 (annex). Although efforts to clean residual contamination and provide medical assistance for affected employees were made, reports of health problems continued, and NIOSH was asked to conduct an HHE.

On February 5-6, 1997, representatives from NIOSH conducted a site visit at the Macon County Courthouses in Macon, Missouri. During this site visit, environmental sampling (air, surface, bulk) was conducted for residual pesticides in the problem buildings as well as at a control location, and interviews were held with the pesticide applicators and other persons involved in the initial assessment or remediation of the buildings. Confidential medical interviews were conducted with all courthouse employees, and the medical records of affected workers were reviewed.

The environmental sampling identified residual levels of pesticide on some surface samples collected in Buildings 1 and 2, and additional cleaning was recommended. On April 3-4, 1997, a follow-up site visit was conducted by NIOSH, and additional surface samples were collected to evaluate the efficacy of the cleaning.

An initial response letter describing the actions taken by NIOSH, including preliminary findings and recommendations, was issued on March 7, 1997. A letter transmitting the results of the surface sampling, with additional recommendations was sent to Macon County employer and employee representatives on March 14, 1997. On May 14, 1997, sampling results from the follow-up site were issued.

This report describes the activities and findings from both site visits made by NIOSH. Additionally, the results of literature reviews, consultations, reviews of reports from other environmental and medical assessments, and recommendations are provided.

BACKGROUND

Facility Description

Building 1 is a 2-story courthouse originally constructed in the 1860's and is the largest of the three county buildings. The first floor contains the offices of the Circuit Clerk, County Clerk, Prosecuting Attorney, County Commission, Treasurer, and Computer Support. The second floor consists of the Division 1 Circuit Court Room, Judge's Chambers, Jury Room, Law Library, Prisoner Room, and the Juvenile Office. Approximately 25 employees work in Building 1.

Building 2 (the annex), a smaller 2-story courthouse constructed in the 1890's, is adjacent to Building 1. Approximately 8 employees had been working in the building, but it was vacated at the time of the NIOSH site visit. The first floor consists of a foyer with stairwell and restroom, and the County Recorder's office. The second floor houses the Associate Circuit Court Division, including the courtroom and judge's chambers. A tunnel connects the basements of Buildings 1 and 2.

Buildings 1 and 2 are each serviced by "residential" type heating, ventilation, and air-conditioning systems. There are 4 air-handling units (AHUs) in Building 1 (2 on each floor) and 2 AHUs in Building 2. There are no provisions for the addition of conditioned outside-air to either building; all AHUs are designed for 100% recirculation of air. After filtration and conditioning, supply-air is distributed through ductwork to ceiling-mounted diffusers to occupied areas. Return-air enters the space above the false ceiling through louvers. The return-air system is

ductless; the space above the false ceiling serves as the return-air plenum back to the AHU. Both buildings are carpeted in most areas, and smoking is permitted in certain locations.

Pesticide Applications

On October 15, 1996, a commercial pest control firm was contacted to control a wasp infestation problem in Building 2. According to the applicator, the courthouse hallway windows and bathroom windows on the second floor were sprayed at approximately 3:45 p.m. with Dursban Pro®, a non-restricted use pesticide that contains 22.5% chlorpyrifos, an organophosphate pesticide. Reportedly, the pesticide was mixed at a rate of 1.3 oz/gallon water and approximately 1/16 of a gallon was used during the treatment. The applicator also indicated that he sprayed a small amount ("one shot from the can") of Orthene PT 280® in one area. This product contains 1% acephate, which is also an organophosphate pesticide. Prior to the commercial pesticide application, the facility custodian sprayed an unspecified amount of the commercially available pesticide Shoot Down® on October 15, in the second floor landing of Building 2 in an effort to control the wasps. According to the manufacturer's label, this product contains 0.15% resmethrin, a synthetic pyrethroid pesticide.

At 9:00 a.m. on October 17, 1996, the same applicator treated the windows in the Law Library on the second floor of Building 1 with Dursban Pro® at the same rate in an effort to control wasps. No Shoot Down® or Orthene PT 280® was applied in Building 1. Because of previously voiced concerns by a judge in Building 1, cloth rags were stuffed under the Law Library doors to contain the odors.

According to building records, Dursban Pro® had been previously applied in both buildings on August 12, 1996.

Reported Health Problems

In Building 2, occupant complaints of odors associated with the applications were noted, and health problems (headaches, sore throat, nausea, vomiting) were reported the day after the application (October 16). On October 17, one worker went home after feeling ill. On Friday, October 18, odors were still detectable and because of continuing health complaints all employees in the Recorder's office were sent to the local hospital by their supervisor. The reported health problems included nausea, tightness in chest, burning feeling in the nose and throat, headaches, sore throat, rash, itching, numbness in the lips and tongue, metallic taste in the mouth, sensitivity to odors, dizziness, mental confusion, and weakness. Because of the pesticide treatment and health problems, employees in Building 2 were initially relocated to the basement of Building 3 (located behind Building 2), and eventually to alternate locations in Macon.

After the application in the Law Library of Building 1, employees in the first floor Circuit Clerk's office (located directly under the Law Library), and in the second floor Juvenile office experienced the most problems, and both offices moved to off-site work space. In some areas, however, no reports of health problems associated with the application were received. Building 2 had been vacated and Building 1 was operational during the NIOSH site visit. Despite relocation to alternative work sites, some employees from both buildings continued to experience health problems they associated with the pesticide applications when they re-entered the buildings or handled material (e.g., files) from Building 1 or 2.

County Response

When the health problems were first reported to the county, the Commissioner's office took a number of actions in an effort to characterize the extent of the problem, identify contaminants that may be responsible for the symptoms, and mitigate any residual pesticide contamination in Buildings 1 and 2. These included coordinating efforts with the county

health department, the Missouri State Consultation Program (MSCP), of the Occupational Safety and Health Administration (OSHA) 7(c)-1 Program, and other agencies. The buildings were "aired" out (windows opened), and the carpeting removed from the stairwell and landing in Building 2.

An environmental consultant conducted air sampling in Buildings 1 and 2 on October 26-28, 1996, and again on November 10-12, 1996. Trace amounts of airborne chlorpyrifos were found in all three locations monitored during the sampling on October 26-28. The concentrations detected were less than 0.1% of the NIOSH Recommended Exposure Limit (REL) and the proposed OSHA Permissible Exposure Limit (PEL), and the environmental consultant concluded there was no hazard present from the chlorpyrifos and that the building could be reoccupied. During the follow up sampling on November 10-12, chlorpyrifos was detected in one of the three samples at a concentration approximately 0.01% of the proposed OSHA PEL. The investigator again concluded there was no hazard present from chlorpyrifos.

Because the health complaints persisted, an extensive cleaning of the buildings by a contractor was initiated on November 21-22. A cleaning protocol recommended by one of the pesticide manufacturers was used. This entailed thoroughly washing and wiping down all surfaces with a diluted bleach solution. This included ceiling tile, the area above the false ceiling, walls, chairs, tables, desks, equipment (phones, computers, typewriters, etc.). All books in the Recorders office and Law Library were pulled and the covers wiped with the cleaning solution. The carpet was shampooed.

Despite these efforts to mitigate any residual contamination, reports of health problems continued, and in some cases worsened, and workers in Building 2 were relocated. Building 2 was unoccupied at the time of the NIOSH site visits. However, some employees enter the building periodically to retrieve records and conduct county business.

METHODS

February 5-7, 1997, Site Visit

On February 5, an opening conference was held with representatives from the Macon County Commissioners office, the Macon County Circuit Court, and employee representatives. Representatives from the Missouri Department of Agriculture - Bureau of Pesticide Control, and MSCP were also in attendance. During this meeting, information about NIOSH was provided and the HHE request was discussed. Following the opening conference, a walkthrough inspection of both Building 1 and Building 2 was conducted to review the work areas, employee activities, and locations where pesticides had been applied. Representatives from the pest control firm were interviewed to obtain information about the location and extent of pesticide treatments in Buildings 1 and 2. A similar interview was conducted with the county employee who had applied one of the pesticides in Building 2.

On the evening of February 5, a meeting was held with 33 Macon County employee and management representatives at an off-site location to further discuss our planned activities, respond to questions, and obtain additional information about the health problems experienced. The off-site meeting had been requested by some employees who were concerned that attendance at the initial opening conference may exacerbate existing health problems or result in additional symptoms. These individuals were concerned that entering one of the buildings where the pesticides had been applied, or contact with individuals who had recently been inside one of these buildings, could potentially result in an exposure that would trigger additional health problems.

Industrial Hygiene

On February 6, area air and surface samples were collected in the following areas: The relocated Circuit

Clerk's office on 120 Vine street; Building 1 (Law Library and area where the relocated Circuit Clerk employees previously worked on the first floor); and Building 2 (Recorder's office, stairwell landing). Additional surface samples were collected from a table top in the basement of Building 3 and the facility (506 N. Missouri) where Building 2 employees (Associate Circuit Court Division) had been relocated. Instantaneous monitoring using a portable direct-reading photoionization detector (Hnu) for non-specific volatile compounds was also conducted at these locations. Because employees relocated to the 120 Vine street office had not experienced health problems after moving, samples were collected at this site for control, or comparison, purposes with the other samples.

Air sampling was conducted using two methods: 1) a broad-spectrum method that provides qualitative information on a wide variety of volatile compounds (thermal desorption tube monitoring), and 2) a method that provides quantitative information on the specific types of pesticides applied (NIOSH analytical method 5600).[1] Four morning and four afternoon samples were collected using the broad-spectrum technique, and five samples were collected using the pesticide-specific method. Thirty-six surface samples were collected from window sills, baseboards, walls, desks, tables, and shelves. After collection, the samples were placed on ice and express mailed to the NIOSH contract laboratory for analysis. A bulk sample of carpet from Building 2, insulation material from above the false ceiling in the jury room in Building 1, and a sample of the pesticide Shoot Down® applied by the county employee was also obtained and sent to the laboratory for analysis. No Dursban® was available for sampling. Specific information on the sampling and analytical methodology is provided in *Appendix A.*

Additional activities included reviewing the ventilation systems and return air pathways in Buildings 1 and 2, and inspecting the attic areas in both buildings and the basements in Buildings 2 and 3. The owner of the firm that cleaned the building on November 21-22 was interviewed.

Medical

On February 5-6, 1997, individual medical interviews were conducted with 18 symptomatic employees and group interviews were conducted with 15 employees (those with minimal symptoms or no symptoms). A later interview with a single employee was conducted by telephone on February 13, 1997. The interviewed employees included all occupants of the two buildings. The location for the interviews was at a different building from where the employees had been working.

The employee interviews covered the expected symptoms and signs of acute or chronic pesticide poisoning. The purpose of these interviews was to gain insight into employee health concerns associated with the buildings and building-related items such as computers and files. The interviews covered: a) symptoms of different organ systems and their relation to the working environment; b) symptoms that may occur due to illness affecting major physiological systems such as respiratory, cardiovascular, gastrointestinal, dermatological, neurological, and musculoskeletal systems; c) past medical and surgical histories; d) history of allergies, either medical or environmental; e) family history of cancers, and other diseases that help in ruling in or out familial or genetic factors; f) social history including habits such as smoking, alcohol drinking, and hobbies; g) occupational and environmental histories; and h) personal views and concerns about the indoor air quality and other aspects of work at the Macon County Court House, including employee-management relations.

Medical records (including medical and laboratory reports) from treating physicians were requested and reviewed.

April 3-4, 1997, Site Visit

On April 3-4, a follow-up site visit by the NIOSH Industrial Hygienist was conducted at the Macon County Court facilities. The purpose of this visit was to re-sample certain areas in Buildings 1 and 2 where residual pesticides had been detected during the first visit. On NIOSH's recommendation, the areas had been recleaned after the results of the February 5-6 sampling were received, and the follow-up sampling was conducted to assess the efficacy of the cleaning. Twenty surface samples were collected during this site visit. The samples were collected using the same protocol used for the first site visit. The samples were placed on ice and shipped to the NIOSH contract laboratory via overnight express. No air or bulk samples were collected during this site visit.

EVALUATION CRITERIA

General

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[2], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs™)[3] and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs)[4]. In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs™, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Pesticides

A pesticide is any substance or mixture intended to prevent, destroy, repel, or mitigate insects (insecticide,

miticide, acaricide), rodents (rodenticide), nematodes (nematocide), fungi (fungicide), or weeds (herbicide), designated to be a "pest." For each type of pesticide there are numerous modes of action, chemical classes, target organs, formulations, and physicochemical properties. Pesticide toxicity is equally diverse, and even within a similar chemical class individual compounds ranging from extremely toxic to practically nontoxic can be found.[5] As such, generalizations about the toxicity of pesticides cannot be made without considerable qualification and explanation. In the United States, regulatory responsibility to protect public health and the environment from the risks posed by pesticides lies with the Environmental Protection Agency (EPA) Office of Pesticide Programs. The EPA requires pesticides to be classified and labeled using signal words determined by the level of toxicity. Toxicity is based on oral, inhalation, eye, or skin effects, with categories ranging from I - IV. Pesticides in toxicity category I are considered the most toxic and require the signal words **Danger** or **Poison** (if the classification is based on oral, inhalation, or dermal toxicity). Toxicity category IV pesticides are the least toxic and are required to be labeled with the signal word **Caution**. Currently, there are 620 active ingredients (AI)* in approximately 20,000 EPA registered pesticide products.[6] In the United States alone, over one billion tons of pesticide products are used each year.[6]

Synthetic Pyrethroid Pesticides

Synthetic pyrethroid insecticides are chemically similar to natural pyrethrins. Pyrethrins are the active insecticidal ingredient in pyrethrum, which is the extract of chrysanthemum flowers and one of the oldest insecticides known to man.[5,7] Synthetic pyrethroids have been modified to increase their stability in the natural environment and make them suitable for use in agriculture.

Certain pyrethroids have been shown to be highly neurotoxic in laboratory animals when administered intravenously or orally.[7] Systemic toxicity by inhalation or dermal absorption is low, however, and there have been very few reports of human poisonings by pyrethroids. Very high absorbed doses could result in incoordination, tremor, salivation, vomiting, and convulsions.[7] Some pyrethroids have caused sensations described as stinging, burning, itching, and tingling, and numbness, when contact with the skin occurs. Sweating and exposure to the sun can enhance this discomfort. Pyrethroids are not cholinesterase inhibitors (see below). The NIOSH REL and ACGIH TLV for pyrethrum is 5 milligrams per cubic meter of air (mg/m^3).[2,3]

Resmethrin

Resmethrin is a solid synthetic pyrethroid used for flying and crawling insect control in household, greenhouse, and industrial settings.[15] Symptoms of overexposure to resmethrin are similar to those of other pyrethrins and include immediate eye irritation, skin rash, and tremors.[8] No specific occupational exposure limits have been established by OSHA, NIOSH, or ACGIH for resmethrin. Resmethrin is an EPA toxicity category III pesticide.[15] The aerosol product Shoot Down® contains 0.15% resmethrin, with the remainder containing inert ingredients including propellants and petroleum distillates.

Organophosphate Pesticides

A variety of organophosphate chemicals are commonly used as insecticides because they are biodegradable as well as effective. Organophosphate chemicals, however, can cause adverse health effects in exposed humans through the inhibition of cholinesterase (ChE) enzymes. Symptoms after exposure to organophosphate chemicals usually appear quickly, often within a few minutes to two or three hours.[5] Because of the potential for adverse health effects in workers, occupational exposure limits

**Active Ingredient is the material, or component, present in a pesticide formulation responsible for killing or controlling the target pest. Pesticides are regulated primarily on the basis of active ingredients, often expressed in terms of percent, pounds per gallon, etc.*

have been established for some organophosphate insecticides, including chlorpyrifos.

Organophosphate insecticides typically cause illnesses in humans by binding to and inhibiting acetylcholinesterase (A-ChE) at nerve endings. A-ChE is a ChE enzyme that metabolizes, and thus controls, the amount of acetylcholine (nerve impulse transmitter) available for transmitting nerve impulses. Inhibition of A-ChE causes acetylcholine to accumulate at nerve endings, resulting in increased and continued acetylcholine stimulation at those sites. Symptoms of A-ChE inhibition include the following:

- increased sweating
- blurred vision
- increased tears
- increased saliva
- increased nasal and lung secretions
- chest pain
- breathing difficulty
- wheezing
- nausea and vomiting
- abdominal cramps
- muscle weakness
- muscle twitches
- memory problems
- decreased concentration
- diarrhea

The organophosphate-ChE bond is stable and largely irreversible, so recovery of ChE activity depends on the generation of new ChE. ChE activity, therefore, can sometimes take a few months to return to normal, although the acute symptoms resolve sooner.

ChE inhibition can be measured as decreases in ChE activity. Red blood cell cholinesterase (RBC-ChE), like ChE in nerve tissues, is an A-ChE. Its rate of regeneration nearly parallels that of A-ChE in nerve tissues, making its measurement a useful method of biologically monitoring exposure to organophosphate insecticides. A significant decrease in RBC-ChE activity indicates either a recent excessive exposure or repeated exposures to amounts sufficient to depress ChE activity before recovery is complete. Other types of cholinesterase, such as plasma cholinesterase or pseudocholinesterase (P-ChE), are more sensitive to organophosphate inhibition. P-ChE activity, however, returns to baseline values earlier than RBC-ChE activity. Therefore, P-ChE values may not reflect the severity of toxicity unless blood specimens are obtained soon after exposure. P-ChE activity can also be affected by factors unrelated to organophosphate exposure, including medical conditions such as liver disease.[9] P-ChE activity is clinically useful in monitoring cases of severe organophosphate poisoning, but its use in monitoring workplace exposures is limited.

For employees with potential for occupational exposure during the manufacture and formulation of pesticides, NIOSH recommends that RBC-ChE activity be measured.[10] The range of RBC-ChE activity varies considerably among individuals who have not been exposed to organophosphate insecticides. Thus, an individual could experience a toxic decrease in RBC-ChE activity and still be within the range of values found in the general population ("normal" or reference range). For this reason, a single value within the laboratory's reference range should not necessarily be interpreted as a "normal" value. Instead, toxicity should be determined by comparing a given value with the individual's baseline value. Therefore, the NIOSH recommendations for medical monitoring of potentially exposed workers in the manufacture and formulation of pesticides include a baseline measurement of RBC-ChE activity before potential for exposure begins and periodic measurements at least annually after potential for exposure begins.[10]

NIOSH defines an unacceptable exposure to organophosphate insecticide as a decrease in RBC-ChE activity to below 70% of the baseline value.[10] The Biological Exposure Index (BEI) adopted by the ACGIH for exposure to organophosphate chemicals is an RBC-ChE activity equal to 70% of an individual's baseline.[3] The BEI represents the level of determinant which is most likely to be observed in specimens collected from a healthy worker who has been exposed to chemicals to the same extent as a worker with inhalation exposure to the TLV-TWA. BEIs apply to 8-hour exposures, five days per week. ACGIH regards biological monitoring as complementary to air monitoring and not for use as a measure of adverse effects or for diagnosis of occupational illness.[3,7]

For workers without a baseline RBC-ChE value, repeated tests have been recommended after removal from exposure to determine the level at which RBC-ChE values stabilize.[11,12] RBC-ChE values, however, may continue to increase for several months after last exposure. Therefore, RBC-ChE values should not be considered baseline until they have stabilized. To ensure validity, tests should be performed by the same laboratory using the same analytic method.

Acephate

Acephate, the active ingredient in the Orthene PT-280® insecticide, is a contact and systemic organophosphate insecticide with a strong, pungent, sulfur-like odor. Acephate is considered to be moderately persistent, with residual systemic activity of 10-15 days.[13] Acephate is a non-restricted-use, EPA toxicity category III pesticide. Orthene PT-280® is a residual crack and crevice insecticide that contains 1% acephate.[14] Occupational exposure limits for acephate have not been established by NIOSH, ACGIH, or OSHA.

Chlorpyrifos

Chlorpyrifos (CAS number 2921-88-2), the active ingredient in Dursban® is also an organophosphate insecticide. It is used to control fire ants, ornamental plant insects, stored product insects, and turf and wood destroying insects.[15] Because its half-life in soil is 30 days, it is considered a moderately persistent insecticide. The NIOSH REL and ACGIH TLV for chlorpyrifos is 200 micrograms per cubic meter ($\mu g/m^3$) as an 8-hour TWA, and the TLV has a skin notation.[2,3] OSHA has not had a PEL for chlorpyrifos since 1992, when the 11th Circuit Court of Appeals vacated the 1989 Air Contaminants Standard.[16,17] Therefore, there is no currently enforceable federal standard for this pesticide. Some states operating their own OSHA-approved job safety and health compliance programs, however, may enforce the 200 $\mu g/m^3$ limit. Chlorpyrifos-containing insecticides are classified as EPA category II or III pesticides, depending on the formulation and concentration.[15] In 1982, the National Academy of Sciences proposed an interim guideline of 10 $\mu g/m^3$ for chlorpyrifos following termiticide applications.[18]

Chlorpyrifos is widely used as an indoor and outdoor pesticide; a 1990 EPA survey found chlorpyrifos to be the fourth most common insecticide in U.S. homes.[19] Probably because of this widespread use, poison control center reports indicate that chlorpyrifos is one of the leading causes of acute insecticide poisonings in the United States.[20] Recently, the U.S. EPA and the manufacturer of chlorpyrifos, agreed on additional restrictions and strengthened protections (by changes in the registrations and labeling) to prevent potentially harmful exposure to this pesticide.[21,22] This agreement included the withdrawal of Dursban products from various flea control uses, including foggers and indoor broadcast applications. The agreement was based on a recent EPA review of the potential risks associated with the use of chlorpyrifos in households and as a termiticide.[21,23]

Skin Exposure

Exposure standards, guidelines, or recommendations by NIOSH or regulatory agencies have not been established for pesticides on skin or work clothes. However, for persons working with pesticides, skin exposures are often considered to be a more important portion of total exposure than inhalation.[24,25,26] Pesticide applications generally entail considerable contact during mixing, spraying, and handling of treated crops. Loosely bound residues on plant material can be a major source of exposure for workers.[27,28] In general, hand exposure represents a major fraction of total dermal exposure for persons working with pesticides.[29]

Surface Contamination/Indoor Applications

Standards or guidelines describing acceptable levels for surfaces contaminated with residual pesticides have not been established. Efforts to assess risks

associated with residual pesticide contamination and determine "safe" levels are difficult since exposure-response information associated with low concentrations of pesticides on surfaces is inadequate. Lack of information makes it difficult to determine "safe" levels or recommend exposure limits. Assessments that have been conducted often involve making assumptions about skin contact, absorption, and transfer rate to estimate a potential dose received.[30] These studies have usually been conducted to assess the risk to children (toddlers) in buildings. The risk is generally higher after recent application and will vary depending on the type of pesticide treatment (e.g., crack and crevice, broadcast, or fogging).

The effectiveness of clean-up measures after indoor applications have been studied. One report involved a four-member family that moved into a new residence that had been treated with a diazinon-containing pesticide.[31] Family members began experiencing health problems (fatigue, irritability, vomiting, dizziness, headache) soon after occupying the residence. A noticeable "pesticide" odor was present, and detectable levels of a diazinon metabolite were found in the occupants urine. The health complaints ceased following clean-up efforts, and urinary levels of the diazinon metabolite fell to below the limit of detection. Surface sampling was conducted prior to and after clean-up to verify the efficacy of the decontamination effort.

Assessments have been conducted to evaluate residual pesticides in indoor settings following applications.[32,33] One investigation assessed the surface and air concentrations in offices periodically for ten days after the broadcast spray application of diazinon, chlorpyrifos, and bendiocarb.[34] Airborne concentrations of diazinon and chlorpyrifos peaked about 4 hours after application, the peak concentrations however, were below occupational exposure limits. The authors concluded that reentry into rooms one day after treatment appeared to be safe, and that the deposition on furniture and floor surfaces was unlikely to cause adverse health effects in the amount detected.

Neurological and Other Effects Associated With Pesticide Exposure

Although the effects of acute exposure to pesticides are usually readily diagnosed and clinically treatable, chronic effects associated with either acute or long-term exposure are not as well understood. Pesticides (primarily organophosphates) have been associated with the development of peripheral neuropathy and chronic neurospsychological effects.[35,36,37] One study compared 100 individuals with previous acute organophosphate pesticide poisoning with controls.[35] No significant difference between subjects and controls were found by clinical neurological examination, clinical EEG, and other tests. However, significant differences were noted on neuropsychological tests, including indicators of mood, memory, and abstraction. Another study of agricultural workers was designed to assess whether single events of acute organophosphate intoxication lead to chronic neurological dysfunction.[37] The study group was tested approximately 2 years after exposure and compared to a matched control group. The study group had significantly lower levels of performance than the control group on a wide array of neuropsychological tests, including attention, memory, problem solving, reaction, and dexterity.

The development of an intolerance to chemicals involving a variety of symptoms has been reported to be associated with chlorpyrifos and other pesticides.[38,39] These are typically anecdotal reports or observations, without clinically measurable features. Such features often include claimed acquired intolerances to low-levels of chemicals previously tolerated. Symptoms reportedly related to environmental exposures are generally inconsistent with established toxicological principles.[40,41] Because of the scientific uncertainty regarding this topic, it is a subject of considerable debate. Numerous theories have been proposed, but there is no medical consensus or an explanation for this phenomenon.[42,43,44,45]

RESULTS

February 5-7, 1997, Site Visit

Industrial Hygiene

Information regarding the specific volumes, location, and timing of the pesticide applications in Buildings 1 and 2 on October 15 and 17 was conflicting as there was disagreement among the various witnesses. The applications described in this report are the minimum reported; it is uncertain if additional applications took place. The Dursban Pro® application was not unique as there is a history of at least one treatment with this pesticide in these buildings (August 1996); nor did the treatment protocol appear to be excessive or unusual. Based on discussions with the cleaning contractor, the cleaning protocol used to mitigate any potential residual contamination was comprehensive.

Air Sampling

Non-Specific VOC Monitoring

No unusual volatile compounds or sources were detected with the direct-reading monitor; there was no measurable difference between indoor and outdoor volatile organic carbon (VOC) concentrations. No unexplained readings were detected from measurements of files considered to be a possible source of contamination. No indoor environmental contaminants were identified by this monitoring that could explain the continuing symptoms among workers.

Qualitative Volatile Organic Compounds - Thermal Desorption Tubes

Eight qualitative thermal desorption tube air samples were collected in the morning and afternoon on February 6, 1997, in Buildings 1 and 2, and the control site at 120 Vine Street. Sample times were approximately 3 to 3.5 hours, and sample volumes ranged from 8.2 to 12.6 liters of air. The chromatograms were scaled the same for comparison, and the results were compared to the total ion chromatogram from the pesticide bulk sample analysis. This sampling was conducted to determine if any compounds present as inert ingredients in the pesticides could be detected.

There were no major differences observed among the three buildings sampled. All displayed low levels of typical indoor air contaminants. C_3-C_{13} alkanes, benzene, toluene, xylenes, limonene, and naphthalene were the major components identified. Samples from Building 1 also contained traces of acetic acid, 1,1,1-trichloroethane, butyl acetate, and furfural. Approximately 40 different compounds were detected on the samples. The main hydrocarbon pattern in the pesticide bulk liquid sample did not match the components detected in the air samples.

Pesticide Monitoring

No pesticides were detected on any of the air samples collected. The limits of detection (LODs) for the compounds analyzed were 0.4 micrograms (µg) [chorpyrifos], 2 µg [acephate], 1 µg [methamidophos], and 4 µg [resmethrin]. Using these limits of detection and the sample volumes of each specific sample, contaminant concentrations were calculated and are shown in Table 1.

Surface Sampling

The results of the surface sampling are shown in Table 2. Low concentrations of the pesticides chlorpyrifos or acephate, and in two cases both compounds, were detected on 7 of the 33 samples collected. No resmethrin was detected on any of the samples.

Five of the 15 samples from Building 2 had detectable levels of pesticide residue. Residue (chlorpyrifos) was detected on only 1 of the 12 samples from Building 1. A trace concentration (between the LOD and the limit of quantification [LOQ]) was found on 1 of the 4 samples from the control location.

These findings were considered somewhat unusual for two reasons. First, over 100 days passed between the applications (October 15 and 17, 1996), and sample collection (February 6-7, 1997). Because they are organophosphate compounds, both chlorpyrifos and acephate are not considered persistent pesticides. Secondly, the cleaning project described during the initial site visit seemed very comprehensive and used the protocol recommended by the chlorpyrifos manufacturer.

Although only small quantities of pesticide residue were detected, additional cleaning in Buildings 1 and 2 (annex) was recommended because removal/reduction of residual levels of pesticides may help resolve concerns as some occupants associated these findings with health problems. No discernable health effects would be expected from the minimal exposure potential associated with the measured residues.

Bulk Sampling

No resmethrin, chlorpyrifos, acephate, or methamidophos was detected in the sample of insulation material obtained from the ceiling of the Building 1 Jury Room. The limit of detection (LOD), in micrograms of contaminant per gram of sample (µg/g), for the compounds monitored were as follows:

Compound	LOD (µg/g)
Resmethrin	10
Chlorpyrifos	1
Acephate	5
Methamidophos	4

The carpet sample, approximately 15 in^2 in size, was analyzed by gas chromatography-mass spectroscopy (GC-MS) after first extracting the sample with a solvent. Both chlorpyrifos and acephate were detectable, although not quantified, in the sample. Resmethrin was not detected.

The bulk liquid sample of Shoot Down® was analyzed by GC, to quantify the amount of resmethrin present, and GC-MS (by both the NIOSH laboratory and the NIOSH contract laboratory), to identify other components in the solution. A concentration of 0.039% resmethrin was detected in the sample, which is less than that indicated on the manufacturer's label (0.15%). The balance of the sample appeared to consist of refined petroleum solvent containing a small amount of trichloroethylene and tetrachloroethylene. Other solvents identified in the bulk sample of Shoot Down® included 2-butanol, 1,1,1-trichloroethane, and various alkyl benzenes. Traces of dichloroethane, carbon tetrachloride, and xylene, were also detected.

Other

During the NIOSH site visit, the following building deficiencies were identified:

- There is no source of conditioned outside air for occupied areas in either Building 1 or 2. As such, there is no active mechanism for removing indoor pollutants other than the filtration system in the AHU or through open windows. This type of filtration is ineffective against gaseous pollutants. With this system, indoor emissions could potentially build up and eventually affect indoor air quality.
- There was a considerable amount of animal droppings, possibly from bats or pigeons, in the attic of Building 1. A 1" to 3" layer of droppings was noted between the ceiling joists in this space. Animal droppings were not found in the attic of Building 2.

Medical

At the time of the first NIOSH site visit, 22 county employees reported they had experienced symptoms, of varying severity, that they believed were associated with the pesticide applications, and 15 reported they were still affected. Three employees were off work. Some affected employees reported they experienced symptoms if they re-entered the treated buildings or had contact with personnel who had recently been in one of the buildings. Problems were also reported

when certain files, equipment (computers) and other materials from Buildings 1 or 2 were handled. Some affected employees sought medical treatment from local physicians as well as from the University of Illinois Health Services Department in Chicago, Illinois.

Collectively, health problems reported to the NIOSH investigator by the symptomatic employees of both buildings were not suggestive of any specific medical diagnosis or readily associated with a specific causative agent. Typical symptoms included frontal headaches, generalized weakness and tiredness, loss of concentration, varying degrees of itching or burning of eyes, irritation of the skin (especially at the V-area of the neck), nasal congestion, upper respiratory tract irritation, crampy central abdominal pain and diarrhea.

The majority of the workers reported that their symptoms improved or completely resolved when they were not in the buildings or were not in contact with the contents, although some workers reported gradual worsening of their symptoms.

Soon after exposure, some workers were informed by their treating physicians early on that they suffered from pesticide poisoning; this diagnosis was based on the history of the exposure and the symptoms. A review of those reports, however, showed neither physical examination findings nor laboratory results suggestive of a acute or chronic pesticide poisoning.[37,46] A review of available follow-up reports did not reveal any documented signs of chronic toxicity.

April 3-4, 1997, Site Visit

The cleaning protocol recommended by NIOSH and used by the cleaning contractor was similar to that used during the previous decontamination effort. A dilute concentration of household bleach (5.25% sodium hypochlorite diluted to a 1% concentration with water) was used to thoroughly clean all surfaces. The cleaning regimen for the window sills, frames, and baseboards included applying the cleaning solution and allowing it to remain in contact until dry and then wiped down. This process was repeated 3-5 times for each surface. Carpeting was shampooed with a commercially available cleaner (X-L Liquid Detergent, Hesco, Inc.). Cleaning was conducted in the following areas:

Building 2 (annex): upstairs bathroom, stairwell landing upstairs office wall, Recorder's office (all walls, baseboards, and window fixtures), second floor office (all walls, baseboards, and window fixtures).

Building 1: all surfaces in the upstairs law library.

Additionally, wall paneling in the foyer of Building 2 was removed.

The results of the surface sampling are depicted in Table 3. Twenty samples were collected in Building 1 (6- Law Library) and Building 2 (10 - second floor, 4 - first floor). Low concentrations of chlorpyrifos or methamidophos (a breakdown product of acephate), were detected in 10 of the 20 samples collected. Acephate, was initially reported on sample GW-9 (second floor - annex). However, since acephate is a water soluble compound that was not expected to be found in the sample, an additional confirmation step was taken to ensure that acephate, and not an artifact, was detected. This confirmation analysis using gas chromatography/mass spectrometry showed that acephate was **not** present in the sample.

The levels of residue detected in the Annex were generally 50-75% lower than the concentrations detected in samples from the February 6-7 site visit. In the Law Library, there was no consistent pattern of reduction. For example, no chlorpyrifos was detected on the west window sill during the February 6-7 site visit. However, chlorpyrifos was detected on this sill during the follow up site visit.

DISCUSSION

Ongoing health symptoms and complaints have been experienced by some occupants of the Macon County Courthouse Buildings 1 and 2. The health complaints

began after the buildings were treated with pesticides on October 15 and 17, 1996. NIOSH investigators considered whether these on-going effects could be related to the initial exposure or to residual pesticide contamination.

The extent of building occupant exposure to the insecticides applied on October 15 and 17 could not be determined. The amount of insecticide(s) applied, concentrations, and locations, could not be ascertained as conflicting information was provided to the NIOSH investigators. There were consistent reports of "insecticide" odors for several days after the initial applications. Three different pesticides were applied in Building 2, and it is not known which pesticide or carriers had the most significant impact on the symptoms experienced by some occupants. In Building 1, only one pesticide (chlorpyrifos) was applied on October 17, 1996, and the treated area was limited to the second floor Law Library. However, personnel in the first-floor Circuit Clerk's office reported being affected by this application. The Circuit Clerk's office is serviced by a different air-handling system than the second floor. Although one potential pathway is the voice tube (metal pipe approximately 3" in diameter) that connects the Law Library with the Circuit Clerk's office, the likelihood for emissions from the Law Library entering the Circuit Clerk's office appears low.

Although NIOSH investigators cannot rule out the possibility that the pesticide application resulted in some of the reported acute symptoms (upper respiratory tract and mucus membrane irritation), the findings of individual medical evaluations by employees' personal physicians were not consistent with "classical" acute or chronic pesticide poisoning. While some of the chronic symptoms among employees have been reported to be related to insecticide exposure (i.e., fatigue, headaches, and concentration problems), these symptoms are nonspecific and could be explained by many other exposures and conditions. Moreover, some chronic symptoms among employees cannot be explained by insecticide exposure.

Surface sampling found persistent residual pesticide contamination that has withstood two comprehensive cleaning efforts. Although there are no numerical standards for evaluating surface contamination, the levels detected would not normally result in biologically significant exposure, and it is not likely that these findings are etiologically related to the continuing health problems experienced by some Macon County employees. Airborne pesticides were not detected. The pattern of ambient indoor air compounds detected from the qualitative air sampling were similar to those found in typical indoor settings, and there was no difference found between the problem and control buildings.

Chlorpyrifos is one of the most commonly used pesticides and is often found on interior surfaces after building treatments. Pesticides are often used in commercial and residential buildings, and it is estimated they are used in over 90% of the households in the United States.[34,47] Detectable quantities of different pesticides, including chlorpyrifos, are often found in ambient air and on surfaces in homes and buildings.[34,48,49,32]

The finding of persistent residual contamination on some surfaces is surprising since (a) neither chlorpyrifos nor acephate are considered persistent pesticides, and (b) the second cleaning project was quite extensive and thorough. One possibility is that during the initial applications on October 15 and 16, 1997, the pesticides penetrated into wood surfaces that were treated. Although the cleaning efforts removed the surface contamination, pesticide residue could be leaching out of the permeated wood.

The only recourse for eliminating the pesticide residue may be removal of the wooden components that were treated (window sills, frames, door frames); additional cleaning may not be productive. Removal/reduction of residual levels of pesticides may help resolve employee concerns about potential health effects, but such a remediation effort can't be recommended on a toxicological basis.

RECOMMENDATIONS

Future indoor pest treatments should not take place when the building is occupied. Pest control techniques such as integrated pest management (IPM) should be followed to minimize pesticide applications. IPM includes alternative pest control methods that emphasize preventing pest damage and includes many non-chemical control methods, which can often be as effective as a chemical alternative. These techniques include blocking pest entryways, good housekeeping practices to remove food sources, and elimination of breeding sites. The Environmental Protection Agency has considerable information regarding IPM. This information can be requested by calling the National Pesticides Network, 1-800-858-7378.

Mechanical ventilation to provide sufficient conditioned outside air to building occupants should be implemented. This will likely require the services of experienced mechanical engineering or ventilation design personnel. The most generally accepted consensus standard for building ventilation criteria are provided by the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE). ASHRAE's most recently published ventilation standard, ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air (OA) supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces, and 15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors.[50] Maintaining the recommended ASHRAE outdoor air supply rates when the outdoor air is of good quality, and there are no significant indoor emission sources, should provide for acceptable indoor air quality.

Access to the attic in Building 1 should be controlled and signs should be placed on all access hatches with appropriate warnings. Pigeon or bat droppings could potentially contain infectious agents that may pose an inhalation hazard and precautions (respiratory protection) should be taken when entering the attic. Future renovations or demolition of this building may require removal of the droppings.

REFERENCES

1. NIOSH [1994]. Organophosphorous pesticides, NMAM #5600. In: NIOSH manual of analytical methods, 4th ed. Eller, RM, ed. Cinti,OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-113.

2. NIOSH [1992]. Recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

3. ACGIH [1995]. 1995-1996 threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

4. Code of Federal Regulations [1993]. 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

5. Doull J, Klaassen C, Amdur MO, eds. [1980]. Casarett and Doull's toxicology: the basic science of poisons, 2nd Ed. New York, NY: Macmillan Publishing Company, Inc.

6. EPA [1996]. Office of pesticide programs annual report for 1996. United States Environmental Protection Agency. EPA 735R96001.

7. EPA [1989]. Recognition and management of pesticide poisonings. Washington, DC: U.S. Environmental Protection Agency, Health Effects Division, Office of Pesticide Programs. EPA Publication EPA-540/9-88-001.

8. HSDB [1997]. Hazardous substance data bank, U.S. National Library of Medicine. Silver Platter (CHEM-BANK, February, 1997), Boston, USA.

9. Gallo MA, Lawryk NJ [1991]. Organic phosphorus pesticides. Chapter 16. In: Hayes WJ, Jr., Laws ER, Jr, eds. Hndbk. of Pesticide Toxicology. Vol. 2, Classes of pesticides. San Diego, CA: Academic Press, Inc.

10. NIOSH [1978]. Criteria for a recommended standard: occupational exposure during the manufacture and formulation of pesticides. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 78-174.

11. Coye MJ, Barnett PG, Midtling JE, et al [1986]. Clinical confirmation of organophosphate poisoning of agricultural workers. American Journal of Industrial Medicine *10*:399-409.

12. Coye MJ, Barnett PG, Midtling JE, et al [1987]. Clinical confirmation of organophosphate poisoning by serial cholinesterase analyses. Archives of Internal Medicine *147*:438-442.

13. Clayton GD, Clayton FE [1993]. Patty's Industrial Hygiene and Toxicology. Vol. IIA, 4th. ed. New York: John Wiley & Sons.

14. Whitmire [1995]. PT®280 Product Label. EPA Reg No. 499-230. Whitmire Research Laboratories, Inc. St. Louis, MO.

15. Sine C [1997]. Farm chemicals handbook. Vol. 83. Willoughby, OH: Meister Publishing Company.

16. Code of Federal Regulations [1989]. OSHA Table Z-1-A. 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

17. 54 (12) Fed Reg (Book 2 of 2) [1989]. Occupational Safety and Health Administration: air contaminants; final rule.

18. National Academy of Sciences. An assessment of the health risks of seven pesticides used for termite control. National Academy Press, Washington, D.C., August 1982, 37-41.

19. Whitmore R, Kelly J, Reading P [1992]. National home and garden pesticide use survey final report, volume I. Research Triangle Institute RTI/5100/17-01F. Research Triangle Park, NC.

20. Litovitz TL, Felberg L, Soloway RA, Ford M, Geller R (1995). 1994 annual report of poison control centers toxic exposure surveillance system. American Journal of Emergency Medicine 13:551-597.

21. Goldman LR [1997]. Memorandum of January 14, 1997, from L.R. Goldman, Assistant Administrator, U.S. Environmental Protection Agency, to John Hagaman, President and CEO, DowElanco.

22. DowElanco [1997]. Press release: EPA, DowElanco agree on 10 point program to further safe use of dursban. January 15, 1997. Dow Elanco, Indianapolis, IN.

23. Blondell J, Dobozy V [1997]. Review of chlorpyrifos poisoning data. Memorandum of January 14, 1997 from J. Blondell Health Statistician, and V. Dobozy, Veterinary Medical Officer, Special Review and Registration Section, Occupational and Residential Exposure Branch, Health Effects Division, Office of Prevention, Pesticides, and Toxic Substances, U.S. Environmental Protection Agency, to L. Propst, Section Head, Reregistration Branch, Special Review and Reregistration Division, Office of Prevention, Pesticides, and Toxic Substances, U.S. Environmental Protection Agency.

24. EPA [1986]. Pesticide assessment guidelines, subdivision U, applicator exposure monitoring. U.S. Environmental Protection Agency, Washington DC. EPA 540/9-87-127.

25. Mull R, McCarthy J [1986]. Guidelines for conducting mixer-loader studies. Vet Hum Toxicol 28(4):328-336.

26. Leonard J, Yeary R [1990]. Exposure of workers using hand-held equipment during urban application of pesticides to trees and ornamental shrubs. Am Ind Hyg Assoc J 51(11):605-609.

27. Iwata Y, Knaak j, Spear R, Foster R [1977]. Worker reentry into pesticide-treated crops. I. Procedure for the determination of dislodgeable pesticide residues on foliage. Bull. Environ. Contam. Toxicol. 18:649-655.

28. Brouwer R, van Maarleveld K, Ravensber L, Meuling W, de kort W, van Hemmen J [1993]. Skin contamination, airborne concentrations, and urinary metabolite excretion of propoxur during harvesting of flowers in greenhouses. Amer. J. Ind. Med. 24:593-603.

29. Fenske R, Bimbaum S, Methner M, Soto R [1989]. Methods for assessing fieldworker hand exposure to pesticides during peach harvesting. Bull. Environ. Contam. Toxicol. 43:805-813.

30. Berteau P, Knaak J, Mengle D, Schreider J [1989]. Insecticide absorption from indoor surfaces. In: ACS Symposium Series #382. Biological Monitoring for Pesticide Exposure: Measurement, Estimation, and Risk Reduction. Washington, DC:American Chemical Society, 315-326.

31. Richter E, Kowalski M [1992]. Illness and excretion of organophosphate metabolites four months after household pest extermination. Arch. Env. Health 47(2)135-138.

32. Vaccaro JR (1993). Risks associated with exposure to chlorpyrifos and chlorpyrifos formulation components. In: Racke KD, Washington, LA, eds. ACS Symposium Series #522. Pesticides in Urban Environments. Fate and Significance. Washington, DC:American Chemical Society, 283-296.

33. Fenske R, Black K, Elkner K, Lee C, Methner M, Soto R [1990]. Potential exposure and health risks of infants following indoor residential pesticide applications. AJPH 80(6):689-693.

34. Currie KL, McDonald EC, Chung LT, Higgs AR (1990). Concentrations of diazinon, chlorpyrifos, and bendiocarb after applications in offices. Am. Ind. Hyg. Assoc. J. 51(1): 23-27.

35. Savage E, Keefe T, Mounce L, Heaton R, Lewis J, Burcar P [1988]. Chronic neurological sequelae of acute organophosphate pesticide poisoning. Arch. Env. Health 43(1):38-45.

36. Rosenstock L, Daniell W, Barnhart S, Schwartz D, Demers P [1990]. Chronic neurological sequelae of occupational exposure to organophosphate insecticides. Amer. J. Ind. Med. 18:321-325.

37. Rosenstock L, Keifer M, Daniell W, McConnell R, Claypoole K [1991]. Chronic central nervous system effects of acute organophosphate intoxication. The Lancet 338:223-227.

38. MacPhail, R [1997]. Evolving concepts of chemical sensitivity. Env. Hlth. Persp. 105 (Supplement 2).

39. Cone J, Sult T [1994]. Acquired intolerance to solvents following pesticide/solvent exposure in a building: a new group of workers at risk for multiple chemical sensitivities?. In: Multiple chemical sensitivity: a scientific overview. F. Mitchell, ed. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry.

40. Fiedler N, Maccia C, Kipen H [1992]. Evaluation of chemically sensitive patients. JOM 34(5):529-538.

41. Sparks P, Daniell W, Black D, Kipen H, Altman L, Simon G, Terr A [1994]. Multiple chemical sensitivity syndrome: a clinical perspective. JOM 36(7):718-729.

42. Bolla-Wilson K, Wilson J, Bleecker M [1988]. Conditioning of physical symptoms after neurotoxic exposure. JOM 30(9):684-686.

43. ATSDR [1995]. Multiple chemical sensitivity: a scientific overview. F. Mitchell, ed. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry.

44. Mitchell F, Price P, eds [1994]. Proceedings of the conference on low-level exposure to chemicals and neurobiologic sensitivity. Toxicology and Industrial Health. Volume 10, No 4/5. April 6-7, 1994.

45. Miller C, Mitzel H [1995]. Chemical sensitivity attributed to pesticide exposure versus remodeling. Arch. Env. Hlth. 50(2):119-129.

46. Sherman JD, [1995] Organophosphate pesticides - Neurological and respiratory toxicology. Toxicology and Industrial Health. 11(1): 33-39.

47. Samimi BS [1995]. The environmental evaluation: commercial and home. In: Occupational Medicine: State of the Art Reviews. 10(1):95-118.

48. Leidy RG, Wright CG, Dupree HE Jr. (1993). Exposure levels to indoor pesticides. In: Racke Kd, Washington, LA, eds. ACS Symposium Series #522. Pesticides in Urban Environments. Fate and Significance. Washington, DC:American Chemical Society, 283-296.

49. Whitmore RW, Immerman FW, Camaan DE, Bond AE, Lewis RG, Schaum JL (1994). Non-occupational exposures to pesticides for residents of two U.S. cities. Arch Environ Contam Toxicol. 26:47-59.

50. ASHRAE [1990]. Ventilation for acceptable indoor air quality. Atlanta, GA: American Society of Heating, Refrigerating, and Air-conditioning Engineers. ANSI/ASHRAE Standard 62-1989.

Table 1
Pesticide Air Sampling Results
Macon County Government, Macon, MO
HETA 97-0075, February 6-7, 1997

Sample Location	Sample Volume (liters)	Concentration, micrograms per cubic meter of air (µg/m ^{3})			
		Chlorpyrifos	Acephate	Methamidophos	Resmethrin
120 Vine Street	565	<0.7	<3.5	<1.8	<7
Bldg 2 Rec. Office	433	<0.9	<4.6	<2.3	<9
Bldg 2 Second Floor	432	<0.9	<4.6	<2.3	<9
Circuit Clerks Office	344	<1.2	<5.8	<2.9	<12
Law Library	429	<0.9	<4.7	<2.3	<9

Table 2
Surface Sampling Results
Macon County Government, Macon, MO
HETA 97-0075, February 6-7, 1997

Sample Number	Location	Concentration Detected (micrograms per square centimeter of surface)			
		Chlorpyrifos	Acephate	Methamidophos	Resmethrin
120 Vine Street - Circuit Clerk Recorder Alternate Work Location					
GW-1	Baseboard 10 ft inside office, Right Side	**(0.02)**	ND	ND	ND
GW-2	Wall - Floor Level, 30 ft. On right side at corner near copy machine	ND	ND	ND	ND
GW-3	Change Room wall, back of office in corner near conduit	ND	ND	ND	ND
GW-4	Coat closet corner wall by J. Roberts office	ND	ND	ND	ND
506 N. Missouri, Associate Div. Of Circuit Clerk					
GW-5	Folders (blue file) from 2nd. Floor annex building stored on Judges desk	ND	ND	ND	ND
Macon County Courthouse Building 2 - Annex					
GW-9	First floor Recorders office. Baseboard under main window	**0.04**	ND	ND	ND
GW-10	First floor Recorders office. L. Waites desktop	ND	ND	ND	ND
GW-11	Cover of Book #37, Nov 1916-Jan. 1919. Dir. & Inv.- Index to Deeds. First floor	ND	ND	ND	ND
GW-12	Cover of Book #210. Warranty Deeds, 1914. First floor	ND	ND	ND	ND
GW-13	First Floor Desk top adjacent the Microfiche	ND	ND	ND	ND
GW-14	Second floor main office. Right side baseboard under the back window	**0.04**	ND	ND	ND
GW-15	Second floor main office. Baseboard under back wall window	ND	ND	ND	ND
GW-16	Second floor landing. Wall adjacent conduit where Shoot Down was applied. (40X40 cm^2)	ND	**(0.01)**	ND	ND
GW-17	Second floor main office, Stephanies desk top	ND	ND	ND	ND
GW-18	Window Sill in upstairs bathroom	**0.19**	**0.7**	ND	ND
GW-19	Top of upstairs bathroom window frame.	**0.1**	**0.95**	ND	ND
GW-20	Stairwell landing, bannister side	ND	ND	ND	ND
GW-21	Inside first floor ventilation supply register duct	ND	ND	ND	ND
GW-22	Inside first floor air handler unit, bottom of return air side.	ND	ND	ND	ND

Table 2 (continued)
Surface Sampling Results
Macon County Government, Macon, MO
HETA 97-0075, February 6-7, 1997

Sample Number	Location	Concentration Detected (micrograms per square centimeter of surface)			
		Chlorpyrifos	Acephate	Methamidophos	Resmethrin
GW-36	Inside second floor air handler unit, bottom of return air side	ND	ND	ND	ND
Building 1, Macon County Courthouse					
GW-23	Circuit Clerks office, Southwest side, bottom of corner file	ND	ND	ND	ND
GW-24	Circuit Clerks office. Footboard of main desk adjacent junction box.	ND	ND	ND	ND
GW-25	Circuit Clerks office. West window sill.	ND	ND	ND	ND
GW-26	Prosecutors office - inside vault door	ND	ND	ND	ND
GW-27	Wall behind R. Millers desk	ND	ND	ND	ND
GW-28	Inside air handler unit in Commissioners Office. Bottom of return air side	ND	ND	ND	ND
GW-29	Inside air handler unit on west side of building. Serves first floor Clerk and Prosecutor offices	ND	ND	ND	ND
GW-30	Sill above west window in Law Library, second floor	ND	ND	ND	ND
GW-31	South window sill - second floor law library	**0.04**	ND	ND	ND
GW-32	Inside air handler unit on west side of building. Second floor. Serves Jury room and west side.	ND	ND	ND	ND
GW-33	Window sill, west wall in Judge Belt's office	ND	ND	ND	ND
GW-34	Inside air handler unit on east side of second floor.	ND	ND	ND	ND
Building 3, Macon County Courthouse - Basement					
GW-35	Table top where employees temporarily worked	ND	ND	ND	ND

NOTE: Sample #s GW -6, -7, -8, were field blanks.
A surface area of approximately 400 cm^2 was wiped for each sample except where otherwise noted
Samples were collected with 3"X3" gauze pre-moistened with isopropyl alcohol.
ND = None Detected. Values in parentheses indicate the contaminant concentration was between the analytical limit of detection (LOD) and the limit of quantification (LOQ). Methamidiphos is a breakdown product of acephate.

Analytical LODs for the compounds monitored were as follows:

Compound	**LOD in micrograms per square centimeter for a 400 cm^2 sampling area**
Chlorpyrifos	0.0075
Acephate	0.025
Methamidaphos	0.02
Resmethrin	0.075

Table 3
Surface Sampling Results
Macon County Government, Macon, MO
HETA 97-0075, April 3-4, 1997

Sample Number	Location	Concentration Detected (micrograms per square centimeter of surface)		
		Chlorpyrifos	Acephate	Methamidophos
Macon County Courthouse Building 2 - Annex				
GW-7	Second floor main office, top of ceiling tile, 3rd. Tile from NE corner	ND	ND	ND
GW-8	Second floor main office. Window sill, East side, Top of sill above false ceiling	ND	ND	ND
GW-9	Second floor main office. Baseboard, left side of back (north) window	ND	ND	**(0.006)**
GW-10	Second floor main office. Baseboard under South window on East side.	ND	ND	**(0.003)**
GW-11	Second floor main office. Window sill , North window on East side.	ND	ND	ND
GW-12	Upstairs bathroom. Baseboard under west window.	**0.004**	ND	ND
GW-13	Upstairs bathroom, top of window frame, South window.	**0.05**	ND	**(0.003)**
GW-14	Upstairs bathroom. Top of soda machine	ND	ND	ND
GW-15	Upstairs landing adjacent conduit. Plaster wall (paneling had been removed)	ND	ND	ND
GW-18	Upstairs landing. East side under window.	**0.008**	ND	ND
GW-19	First floor Recorders Office, Window sill, NE side.	ND	ND	ND
GW-20	First floor Recorders Office. Baseboard between back (north) windows.	**0.019**	ND	ND
GW-21	First floor stairwell. Wall panel at foot of stairs	ND	ND	ND
GW-22	First floor Recorders Office. East Wall, South window sill..	ND	ND	ND
Building 1, Macon County Courthouse-Law Library				
GW-1	South side, top of wooden shelf	ND	ND	ND
GW-2	South window frame, upper left side	ND	ND	ND
GW-3	West window sill, left side.	**0.04**	ND	ND
GW-4	West window frame, upper right side	**0.02**	ND	ND
GW-5	Frame of door entering Law Library, bottom right side	**(0.0012)**	ND	ND
GW-6	Southwest corner, bottom wall and baseboard.	**0.003**	ND	ND

NOTE: Sample #s GW -16, -17, were field blanks.
A surface area of approximately 400 cm^2 was wiped for each sample except where otherwise noted
Samples were collected with 3"X3" gauze pre-moistened with isopropyl alcohol.
ND = None Detected. Values in parentheses indicate the contaminant concentration was between the analytical limit of detection (LOD) and the limit of quantification (LOQ). Methamidiphos is a breakdown product of acephate.

Analytical LODs for the compounds monitored were as follows:

Compound	**LOD in micrograms per square centimeter for a 400 cm^2 sampling area**
Chlorpyrifos	0.0005
Acephate	0.01
Methamidaphos	0.002

Appendix A - Sampling and Analytical Methods

Sampling and analytical methodology used during this evaluation were as follows:

Non-specific VOC Monitoring

Instantaneous measurements to assess relative levels of VOCs were obtained in various indoor and outdoor locations. This monitoring was done with an HNu Systems Model DL 101 analyzer. This portable, non-specific, direct-reading instrument uses the principle of photo ionization for detection. The sensor consists of a sealed ultraviolet light source that emits photons which are energetic enough to ionize many compounds. These ions are driven to a collector electrode where the current (proportional to concentration) is measured. A 10.2 electron volt lamp was utilized. This lamp will ionize a wide variety of organic compounds, yet exclude normal constituents of air such as nitrogen, oxygen, carbon dioxide, etc. Measurements were obtained with the instrument set on maximum sensitivity. This sampling was conducted to identify potential sources of emissions or material that may be emitting VOCs.

Organo-Phosphate Pesticide Air Sampling

Area air samples for pesticides were collected in Building 1 (Law Library and Circuit Clerks office), Building 2 (Recorders office, stairwell landing), and at the 120 Vine Street office. Calibrated air sampling pumps were placed in these areas and connected, via tygon tubing, to sample collection media. Monitoring was conducted for 8-9 hours at a nominal flow rate of 1 liter per minute. The air samples were collected using OVS-2 (OSHA Versatile Sampler) sorbent tubes. After sample collection, the pumps were post-calibrated and the samples submitted to the NIOSH contract laboratory for analysis. Field blanks were submitted with the samples. At the laboratory, the samples were desorbed and analyzed by gas chromotography (GC) using a flame photometric detector for acephate (or the breakdown product methamidophos), and chlorpyrifos (Dursban®) according to the NIOSH 4th. ed. analytical method #5600. The samples were also analyzed for resmethrin using a GC equipped with an electron capture detector.

Qualitative Volatile Organic Compounds - Thermal Desorption Tubes

Area air samples for qualitative VOC analysis were obtained with reusable Carbotrap® 300 multi-bed thermal desorption (TD) tubes, and Tenax tubes as collection media. These tubes are designed to trap a wide range of organic compounds for subsequent qualitative analysis via thermal desorption and gas chromotagraphy/mass spectroscopy (GC-MS). The Tenax tubes perform similarly to the 3-bed TD tubes except they do not trap polar or low molecular weight compounds as well as the TD tubes.

The air samples were collected using constant-volume SKC model 223 low-flow sampling pumps. The pumps are equipped with a pump stroke counter and the number of strokes necessary to pull a known volume of air was determined during calibration. This information was used to calculate the air per pump-stroke "K" factor. The pump stroke count was recorded before and after sampling and the difference used to calculate the total volume of air sampled. Flow rates and sample times were standardized (50 cc/min, 200 minute sample time, 10 liter volume) to allow for comparison of results. Duplicate samples were taken in the morning and afternoon. Field blanks were submitted with the samples. The samples were shipped to the NIOSH laboratory for analysis.

Surface Sampling

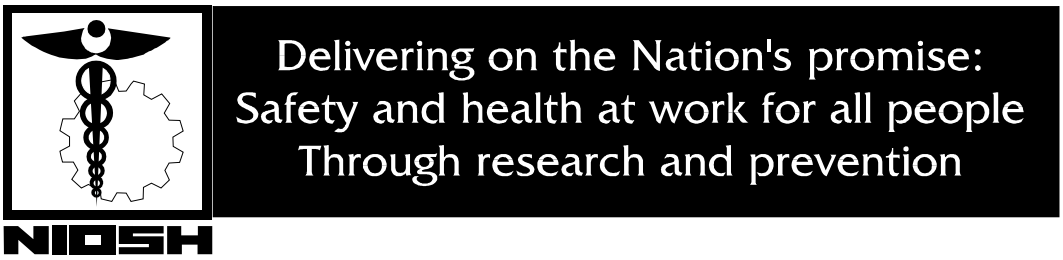
Surface wipe samples were collected to assess residual pesticide contamination in various areas of Buildings 1, 2, 3, as well as alternate work areas in Macon. The samples were collected with 3" X 3" pre-extracted cotton gauze moistened with technical-grade isopropyl alcohol. Approximately four hundred square centimeters (400 cm^2) of surface area were wiped with each gauze, and the collection technique described in NIOSH 4th. ed. Analytical method # 9100 was used. A template was used to gauge the surface area sampled. Prior to collecting the sample, protective gloves were donned to prevent cross-contamination. After collection, the samples and blanks were placed in labeled amber glass vials and shipped cold via overnight express to the NIOSH contract laboratory for analysis. At the laboratory, the samples were desorbed and analyzed by gas chromotagraphy (GC) according to the NIOSH 4th. ed. analytical method #5600. Each gauze sample was analyzed for chlopyrifos, acephate, and methamidophos using a GC equipped with a flame photometric detector, and resmethrin using an electron capture detector.

Bulk Samples

Solid bulk samples were collected and analyzed for resmethrin, chlorpyrifos, acephate, and methamidophos. A bulk sample of ceiling insulation adjacent the return air vent in the Building 1 Jury Room (second floor) was obtained, and a sample of carpet from the stairwell landing of Building 2 was collected. The carpet had been removed, wrapped in plastic and stored at an off-site location, soon after the October 15 pesticide application and prior to the first cleaning effort. The samples were sealed in labeled plastic bags and shipped to the NIOSH contract laboratory for analysis. A liquid bulk sample of the Shoot Down® pesticide was collected in a labeled glass vial and sealed with a teflon lined cap. The sample was not obtained from the original container of Shoot Down® used on October 15 (this container was unavailable), but was from the same shipment purchased by Macon County. The liquid bulk sample was shipped separately to the NIOSH contract laboratory and analyzed to determine the concentration of resmethrin and identify other major components.

An aliquot of the pesticide bulk sample was also providedd to the NIOSH laboratory for analysis. The bulk sample was analyzed by GC-MS to identify major components and determine they were also present on the thermal desorption tubes.

The insulation bulk sample was solvent extracted and analyzed via gas chromatography in a manner similar to that described for the surface wipe samples. The carpet sample was solvent extracted and analyzed via GC-MS. The liquid bulk sample was analyzed by GC with an electron capture detector to determine the concentration of resmethrin, and by GC-MS to identify other components.


NIOSH
Delivering on the Nation's promise:
Safety and health at work for all people
Through research and prevention