U.S DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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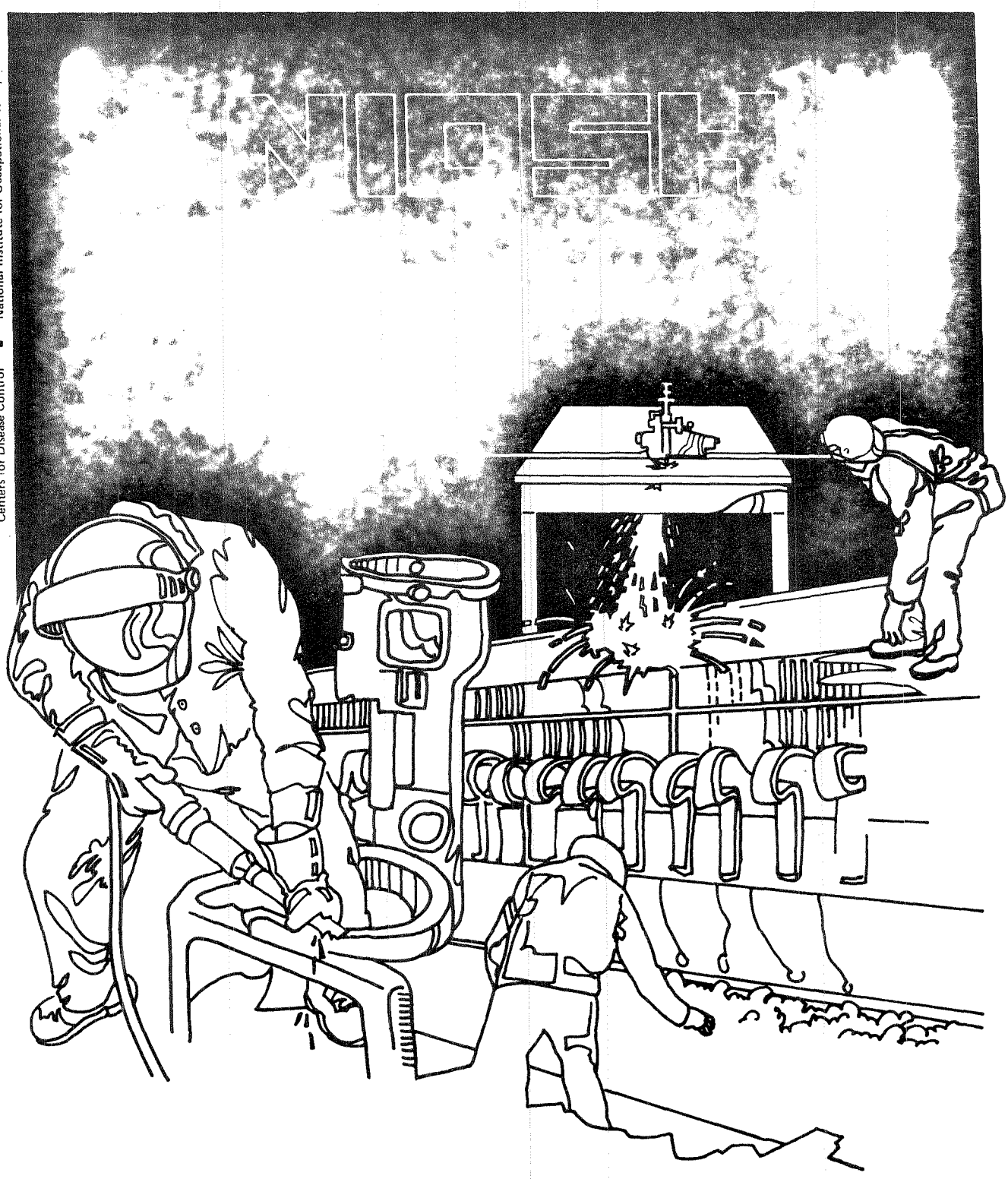

Health Hazard Evaluation Report

80-024-783

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. 699(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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HE 80-024-783
DECEMBER 1980
QUECHAN ENVIRONMENTAL FARM
YUMA, ARIZONA

NIOSH INVESTIGATOR:
Pierre Belanger, IH

I. SUMMARY

On November 5, 1979 the National Institute for Occupational Safety and Health (NIOSH) received a request from an authorized representative of the Quechan Tribe for a health hazard evaluation of the Quechan Environmental Farm, Yuma, Arizona. The requestor was concerned that workers may be exposed to pesticides (methomyl, malathion, benomyl and dexon) during the greenhouse spray operation. Thus, NIOSH was requested to evaluate the employees' work practices and protective equipment. The greenhouse spray operation involves two applicators who mix and spray pesticides onto tomato plants.

On January 25-26, 1980 NIOSH conducted an initial environmental survey at Quechan environmental farm. Twelve environmental air samples (personal and area) were collected for methomyl aerosols and vapors during the pesticide mixing and spraying operation. The other pesticides were not being used at the time of the survey.

Potential exposures to methomyl aerosols and vapors were determined using a filter followed by a sorbent tube. Methomyl aerosol concentrations (filter) ranged from less than 0.87 - 7.94 milligrams per cubic meter of air (mg/m^3). Methomyl vapors were detected on one sorbent tube at a concentration of 1.62 mg/m^3. One personal sample (9.55 mg/m^3) exceeded the threshold limit value (TLV) of 2.5 mg/m^3 recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).

One non-Indian worker (applicator), when first employed at the farm, did not use the prescribed protective equipment including a pesticide respirator and experienced pesticide poisoning symptoms which included nausea, headache and stomach cramps. These symptoms reportedly diminished later in the evening and he has not experienced a similar situation since that time. No cases of pesticide poisoning were reported by the Indians, and none were known to the U.S. Public Health Service Hospital staff.

On the basis of the data obtained during this investigation, NIOSH determined that a health hazard from overexposure to methomyl did not exist during the mixing and spraying of this pesticide, presumably due to the successful use of personal protective respirators and clothing.

Recommendations have been incorporated into the body of this report to further insure the continued success of the health and safety program.

KEYWORDS: SIC 0182 (Vegetables and Melons), tomatoes, greenhouses, pesticides, methomyl.

I. INTRODUCTION

On November 5, 1979 NIOSH received a request from an authorized representative of the Quechan Tribe to evaluate employee work practices and protective equipment used during pesticide (methomyl, malathion, benomyl and dexon) mixing and spraying.

An interim report was sent to the requestor in February 1980 subsequent to the initial survey.

II. BACKGROUND

The Quechan Environmental Farm consists of three greenhouses (1.6, 3.2 and 3.8 acre houses) of which two (1.6 and 3.8 acre) are used to grow tomato plants. The plant growing season begins in January and July. The farm employs 15-40 workers depending on the harvesting and maintenance requirements. The employees work eight hours per day, six days per week. Whenever pesticide spraying is performed, it takes 6-7 hours to spray 4.5 acres. The applicators take one ten minute break after spraying 5 bays. The applicators are given one-half hour to shower before lunch break. Two employees (applicators) are supervised to assure the proper mixing and spraying of pesticides. Although men and women are employed, only men perform the pesticide mixing and spraying tasks. The men are generally rotated to perform this function. Applicators are required to wear rubber gloves, boots, rain suit, half masked pesticide respirator and a face shield. All safety equipment is cleaned by worker after each use.

The U. S. Public Health Service Hospital staff (nursing director, pharmacist and laboratory technician), which treat Indians only, were interviewed to determine whether any cases of pesticide poisoning had been reported and/or treated. Also, the applicators and the supervisors were questioned as to whether or not there were incidents of pesticide poisoning.

One non-Indian worker did not don the required protective gear, and he experienced symptoms of pesticide poisoning which included nausea, headache and stomach cramps. These symptoms reportedly diminished later in the evening, and he has not experienced a similar situation since that time. No cases of pesticide poisoning were reported by the workers or the farm manager, and none were known to the U. S. Public Health Service Hospital staff.

1. Pesticide Storage, Inventory and Application

All pesticides are locked in a caged area of a warehouse which is controlled by the supervisor. The fungicides and insecticides used on the farm include: dexon, benlate, methomyl, malathion and methyl bromide.

Pesticides are minimally applied from seedlings to two months. The fungicides (dexon and benlate) are infrequently used. Dexon is applied with a three-gallon sprayer twice a year during the seedling stage. Benomyl is primarily sprayed onto foilage, with a 250 gallon spray tank system, during the winter. The insecticides (methomyl and malathion) are not applied until after two months. The insecticides are alternately sprayed on plants every two weeks for about two months, and once per week thereafter until harvesting is completed. Occasionally, both insecticides may be mixed together and sprayed onto the plants. Twenty-four hours generally elapses between pesticide spraying and tomato harvesting.

Methyl bromide is an insecticide which is used once per year to fumigate the greenhouse. The greenhouse is sealed off and fumigated. No one is allowed to enter during this operation.

2. Pesticide Mixing and Spraying Application

Prior to pesticide mixing, the supervisor attaches warning signs on all access doors indicating pesticide is being used. The sign remains on the access door for 24 hours until the supervisor removes the sign. Also, the greenhouse vents are partially opened and one exhaust fan is actuated.

Pesticides are mixed according to manufacturer requirements. The insecticides (methomyl and malathion) have a dilution ratio of 1 quart per 100 gallons of water. Dexon is diluted at a ratio of 3 tablespoons per gallon of water and benomyl in one pound per 100 gallons of water. The applicators normally mix two batches (480 gallons) to cover a 3.8 acre greenhouse.

Pesticides may be mixed by one of two methods. Liquid chemical mixtures are prepared using a closed mixing system with an antisyphon valve. One gallon of water is added to a mixing cylinder. The pesticide is aspirated from its container into the mixing cylinder. The mixture is then transferred to a 240-gallon spray trailer. The dry chemicals are weighed and added to the 240-gallon water trailer. The trailer has an agitator which is used to mix the dry chemical and water in order to ensure proper mixing.

A tractor is used to pull the trailer to the greenhouse. As the worker quickly walks along the row (250 feet), he sprays one side of the plants from top to bottom. Then as he returns he sprays the opposite side. The second worker pulls the hose back as the applicator walks back. The applicators alternate tasks each five bays.

Once spraying is completed, the trailer is flushed with 40-50 gallons of water which is drained onto the ground next to the greenhouse. The workers then clean their protective gear and shower.

III. EVALUATION DESIGN AND METHODS

A. ENVIRONMENTAL

Personal and area air samples were collected for methomyl during the entire work shift. None of the other pesticides were being used during the survey. Personal samplers were attached to the workers rain suit lapel under the face shield. Area samples were placed at either end of the spray trailer. The methomyl sampling train consisted of a 13 millimeter (mm) mixed ester membrane filter cassette used to collect particulate followed by a 75 milligram (mg) chromosorb 102 tube used to collect vapors through which a known volume of air was drawn. (1)

The filter contaminants (aerosols) were extracted with 1 milliliter (ml) of toluene and compared to standards prepared in the laboratory. Aliquots of the samples were analyzed using a high pressure liquid chromatograph system. Detection was accomplished by ultraviolet absorbance at a wave length of 233 nanometers. The vapor contaminants collected on the chromosorb 102 tubes (Section A and B) were desorbed separately in one ml of methanol and compared to the standards. Aliquots of the samples were analyzed by a high-pressure liquid chromatograph system.

The limit of detection for the analysis of methomyl is 0.6 microgram per sample.

IV. EVALUATION CRITERIA

A. ENVIRONMENTAL

There are several criteria used to evaluate the toxic air contaminants of an employee's work environment: (1) NIOSH Criteria Documents for a Recommended Occupational Health Standard, (2) Proposed and Recommended Threshold Limit Values (TLV's) as suggested by the American Conference of Governmental Industrial Hygienists (ACGIH), 1979, (3) The federal Occupational Safety and Health Administration (OSHA) Standards. Arizona enforces the Federal-OSHA standards through the Division of Occupational Safety and Health (DOSH).

The concentration of each contaminant is based upon current state of knowledge concerning toxicity of these substances. The criteria are designed to allow an occupational exposure for up to a 10-hour work day, 40-hour work week as a time-weighted average (TWA) over a normal working lifetime without the worker experiencing adverse health effects at or below the TWA.

The following criteria are currently used to evaluate pesticide exposures:

TABLE A

Substance	8-Hour Time-weighted Average (TWA)
Dexon[1]	----
Methomyl[2]	2.5 mg/m[a]
Malathion[3]	10 mg/m^3
Methyl Bromide[4]	20 mg/m^3
Benomyl[5]	10 mg/m^3

a) mg/m^3 - milligrams of a substance per cubic meter of air.

1) There is no established criteria for dexon.

2) The ACGIH - TLV (1979). There is no NIOSH criterion or OSHA Standard.

3) The ACGIH - TLV (1979). There is no NIOSH criterion and the OSHA Standard is 15 mg/m^3.

4) Proposed ACGIH - TLV (1979). There is no NIOSH criterion; the OSHA standard is 80 mg/m^3.

5) The ACGIH - TLV (1979). There is no NIOSH criteria or OSHA standard.

B. TOXICOLOGICAL EFFECTS

1. Dexon

Dexon is the trade name for fenaminosulf, an organophosphate pesticide used against nematodes, or worms. Organophosphate pesticides act by inhibiting the normal activity of the enzyme cholinesterase, which is required for normal function of the nervous system. Mild organophosphate poisoning may cause symptoms of headache, nausea, sweating and weakness. More severe cases may include pinpoint pupils with blurred vision, muscle twitching, mental confusion and difficulty breathing. Very severe cases lead to convulsions, unconsciousness and eventually death when the victim ceases breathing.

Reduction in the red blood cell cholinesterase levels caused by organophosphates is not reversible, and levels return to normal at a rate of approximately 1% per day as red blood cells are produced. Although red blood cell cholinesterase levels are a more reliable indicator of organophosphate poisoning, serum cholinesterase levels may also be used. Serum cholinesterase levels return to normal within 3-5 days. Because normal blood cholinesterase levels vary greatly from person to person, it is difficult to diagnose moderate poisoning in a worker without a "base-line" level to show what the normal nonexposed cholinesterase level is for that same worker. Only a very severe case with drastically reduced levels can be diagnosed with certainty. For this reason it is important for all workers who handle organophosphates frequently to have a "base-line" cholinesterase level taken when they have been away from cholinesterase-inhibiting pesticides for several weeks.

Fenaminosulf (Dexon) appears to be a relatively mild member of the organophosphate family. It is, however, a mutagen in several test systems. (2) A mutagenic chemical or substance is one which can change the genes of human cells. Mutations are thought to be possible first steps in the development of cancer, and also to be the way in which many chemicals damage the sperm and eggs of men and women workers, possible affecting their future children.

In soil, fenaminosulf (Dexon) breaks down into DMPDA (dimethyl p-phenylene diamine), which is a much stronger mutagen and which remains in the soil for approximately 100 days (3). For this reason soil recently fumigated with dexon should also be handled with caution.

2. Methomyl

Methomyl belongs to the family of insecticides known as carbamates. Carbamates act by inhibiting (depressing the normal action of) the enzyme cholinesterase, which is required for the normal function of the nervous system. Mild carbamate poisoning may cause symptoms of headache, nausea, sweating and weakness. More severe cases may include pinpoint pupils with blurred vision, muscle twitching, mental confusion, and difficulty breathing. Very severe cases lead to convulsions, unconsciousness and eventually death when the victim ceases breathing.

Carbamates enter the body through the skin, lungs and mouth. Carbamate caused reduction of the enzyme cholinesterase is short-term and reversible; because of this, blood tests for cholinesterase levels are frequently normal a short time after moderate carbamate poisoning, causing doctors to miss the diagnosis of pesticide poisoning. Carbamates vary in toxicity, and methomyl is one of the more toxic compounds in this family. (4)

Very little is known about the long-term effects of human exposure to carbamate insecticides.

3. Malathion

Malathion is an organophosphate pesticide, like Dexon which was described above. It is also a relatively mild member of the organophosphate family, although it may still be hazardous if not diluted as usual for field application. (5)

Workers applying malathion should have baseline cholinesterase levels drawn after several weeks without exposure to any organophosphates or carbamates, and should have cholinesterase levels drawn every 3 to 6 months depending on how frequently they apply malathion. Very little is known about the long-term effects of exposure to malathion.

4. Methyl Bromide

Methyl bromide is an extremely toxic halocarbon fumigant. It passes readily through both human skin and rubber protective gear, and is absorbed through the lungs and digestive system. Methyl bromide is a strong irritant, causing eye, nose, throat and skin irritation on contact. When held on the skin by clothing (gloves, belts, shoes) it can cause severe burns and blistering. Large exposures cause a chemical burn of the lungs, which may lead to death by pulmonary edema or hemorrhage (fluid or blood in the lungs). Breathing the break-down products of burning methyl bromide is also extremely hazardous.

Moderately severe exposures to methyl bromide primarily affect the nervous system. It depresses the central nervous system, causing short-term symptoms of weakness, seizures, depressed breathing and unconsciousness. Long-term effects include both physical debility (decreased sensation and control of motion) and prolonged behavioral and emotional disturbances, particularly depression. In addition,

methyl bromide exposure may lead to kidney and liver damage, which may be severe enough to lead to death from kidney failure.

It is important to note that the most severe lung effects of methyl bromide exposure may not develop for up to 48 hours after exposure. Therefore, an exposed worker who shows early symptoms of methyl bromide toxicity -- headache, dizziness, nausea and vomiting, tremors, weakness or difficulty breathing -- should be watched closely for at least 2 days after exposure. Long-term exposure to small amounts of methyl bromide may cause a defatting of the skin and chronic dermatitis. (6) Other effects of chronic low-level exposure are not known.

5. Benomyl

Benomyl (Benlate) is a carbamate insecticide, like methomyl which was described above, although it has less immediate toxicity than methomyl. Benomyl is also a moderate irritant, causing eye, throat and skin irritation which may be widespread over the body with enough exposure.

In addition, benomyl can cause a sensitization of the eyes and skin, making the worker "allergic" to further contact with benomyl. This sensitization may develop suddenly after a few weeks or many years of exposure; there is no way to predict who will become sensitized among a group of workers. (7)

In animal studies, benomyl has been shown to be a teratogen. A teratogen is a chemical or substance which can damage a fetus while it is growing in the mother's uterus. Nothing is known of the possible effect of benomyl on the reproductive systems of men and women. Little is known of the long-term effects of benomyl exposure to adults. In addition to this, benomyl is also a mutagen; this is explained in (1) above. The current Threhold Limit Value is 10 mg/m^3. (8)

V. RESULTS AND DISCUSSION

Six filter and six chromosorb tube samples were collected for methomyl particulate and vapors respectively. Aerosol concentrations (filter) ranged from less than 1.2 - 7.94 mg/m^3 with one personal sample exceeding the ACGIH TLV (2.5 mg/m^3). One chromosorb tube sample (personal) measured methomyl vapors at a concentration of 1.62 mg/m^3. Thus, one personal sample was calculated to be at a concentration of 9.55 mg/m^3. Based on the chemical mixing procedures, method of application, work practices and environmental results, the greatest risk of pesticide exposure seems to occur while the applicator walks along the rows spraying the plants from top to bottom. Exposures do not appear to occur near the spray cart. The area air sample concentrations which were below the limits of detection seem to substantiate this fact. Since workers donned the proper protective equipment, no exposures are presumed to have occurred.

The applicator's respirator pre-filter became soaked after spraying five bays thus increasing the workers resistance to breathing.

The survey team and the spray crew (liquid applicators) donned rubber rain gear in addition to other safety equipment. The investigators experienced profuse sweating as did the others during the spray operation. The greenhouse temperature was 75°-85° (F). It was learned that the greenhouse temperature approaches 100°F during the summer when the men spray the tomato plants, thus the workers are given salt tablets. The employees workload can be classified as moderate. The applicator walks at a very fast pace while pulling a hose. Normal body cooling via evaporation of perspiration cannot occur while the workers wear the impervious rain suit, thus, a potential heat stress problem may occur.

The employees wash their protective gear once they have finished spraying. However, there is no formal respirator program to ensure respirators are properly cleaned and worn.

VII. RECOMMENDATIONS

1. The methyl bromide cylinders should be properly secured to prevent them from inadvertently falling over and leaking. Also, the cylinders should be identified whether they are full or empty.

2. The company should institute a formal respirator program in accordance with the Occupational Safety and Health Act (OSHA) requirements outlined in 20 CFR Part 1910.134. The respirator program should include proper respirator selection, training and education of the user, fit testing, maintenance of equipment, proper and adequate storage, periodic evaluation of the program to determine continued effectiveness and medical determination of user.

3. The respirator prefilters should be changed after spraying of five bays or as often as is needed to present resistance to breathing.

4. The spray tank flushing should be done in a remote part of the farm where ground water contamination will not occur, or the water used to cleanse the spray tank should be sprayed onto the plants instead of draining it onto the ground near the greenhouse.

5. Baseline cholinesterase levels should be obtained on all workers applying organophosphate or carbamate pesticides; subsequently cholinesterase levels should be determined on a periodic basis (every 3-6 months) depending on the frequency of handling these pesticides.

6. Workers should be educated about the potential effects of the pesticides used in this workplace, and the significance of cholinesterase levels should be explained to them.

7. Salt tablets have potentially adverse gastrointestinal effects and should not be used. Instead, a saline solution (a simple 1 percent salt solution or commercial salt-containing beverage) should be provided.

VII. AUTHORSHIPS AND ACKNOWLEDGEMENTS

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XIII. REFERENCES

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IX. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. Quechan Environmental Farm
2. Horticultural Manager
3. U. S. Department of Labor - Region IX

For the purpose of informing the approximately twenty-five "affected employees," the employer shall promptly "post" for a period of 30 calendar days this Determination Report in a prominent place(s) near where exposed employees work.

TABLE I
SUMMARY OF AIR SAMPLES COLLECTED
FOR METHOMYL
QUECHAN ENVIRONMENTAL FARMS
YUMA, ARIZONA
January 26, 1980

Sample Number	Job Classification or Location	Sampling Period	Sampling Volume (Liters)	Sampling Train Concentration (mg/m^3)[1] Filter	Chromosorb Tube	Total Conc. (mg/m^3)
1	Applicator	0850-1400	34	7.94	1.62	9.55
2	Applicator	0845-1320	24	0.87	N.D.[2]	0.87
3	Investigator	0915-1430	36	1.30	N.D.	1.30
4	Area - Attached to Front of Trailer	0845-1430	36	N.D.	N.D.	N.D.
5	Area - Attached to Back of Trailer	0845-1430	17.8	N.D.	N.D.	N.D.
6	Applicator	1325-1435	13	1.2	N.D.	1.2

1. mg/m^3 - milligrams of a substance per cubic meter of air
2. N.D. - None Detected
3. TLV - Threshold Limit Value

TLV^3 - 2.5 mg/m^3

Limit of detection - 0.6 microgram

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