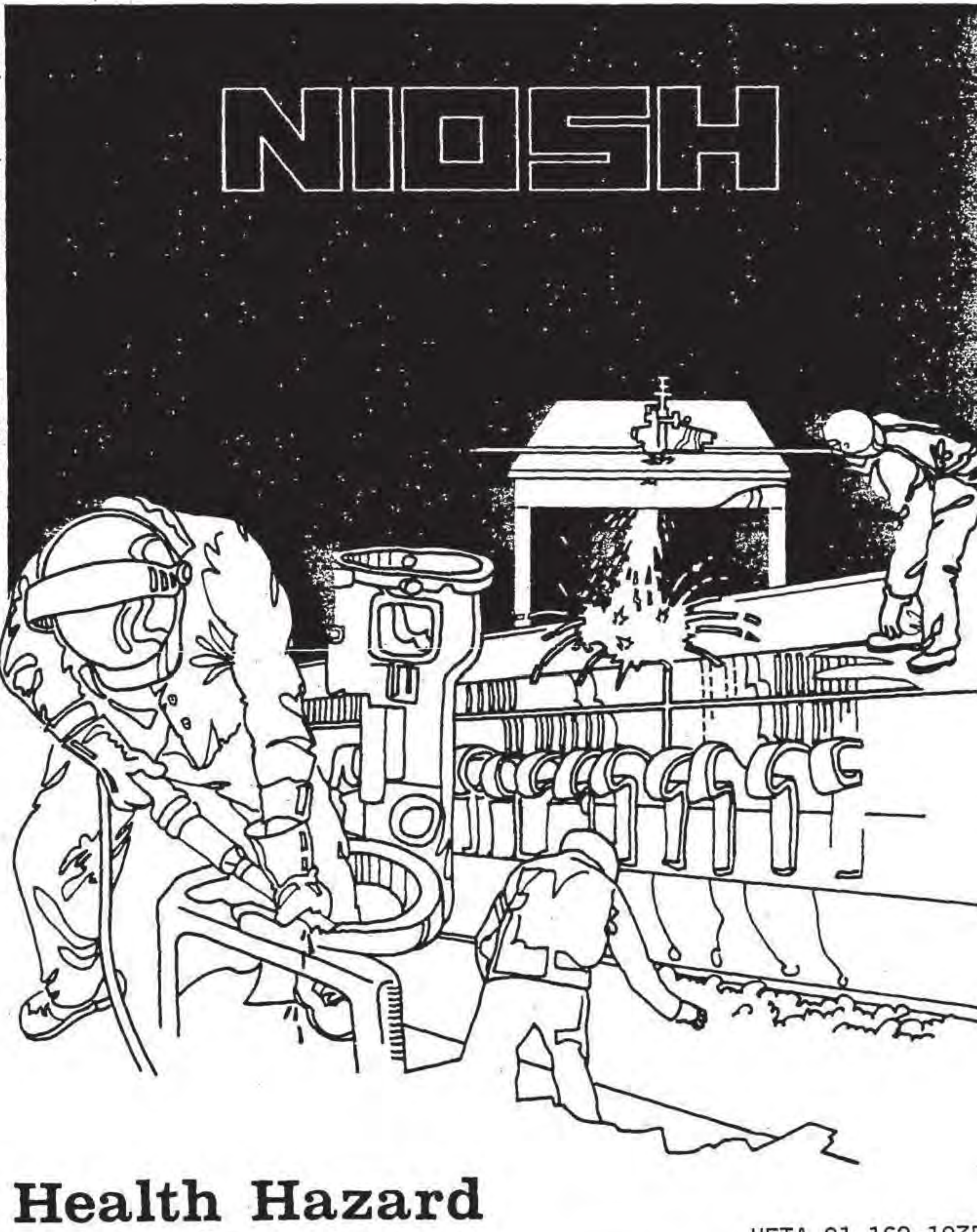
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health




# Health Hazard Evaluation Report

HETA 81-162-1935
MAUI LAND AND PINEAPPLE INC.
KAHULI, HAWAII

# 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, medical, nursing, and industrial hygiene technical and consultative assistance (TA) 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.

HETA 81-162-1935
JANUARY 1990
MAUI LAND AND PINEAPPLE INC.
KAHULI, HAWAII

NIOSH INVESTIGATORS:
Molly Joel Coye, M.D.
William N. Albrecht, M.S., Ph.D.
Thomas Sinks, Ph.D.

## I. SUMMARY

On January 13, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from Maui Land and Pineapple Inc. (MLOP). The requestor was concerned about possible worker exposure to the nematocide dibromochloropropane (DBCP) and reproductive effects resulting from this exposure. In December 1980 the Environmental Protection Agency (EPA) had requested technical assistance from NIOSH to investigate exposure to and potential reproductive health effects of DBCP use in pineapple at Maui Land and Pineapple Inc., as well as at the Dole Pineapple Corporation plantation on Lanai island.

NIOSH investigators conducted an initial walk-through at Maui Land and Pineapple on January 29, 1981. Environmental sampling was conducted during two periods, February 25-March 6 and July 14-24, 1981. Medical evaluation of the possible health effects of DBCP exposure was conducted before field preparation had begun in February-March of 1981, at mid-season in July, and after preparation had ended in October.

Overall, exposures to DBCP ranged from none detected (ND) to 618 ppb (part per billion). Twenty-one of 80 samples exceeded the OSHA PEL of 1 ppb as an 8-hour time-weighted average. This standard was based on the classification of DBCP as a potential carcinogen, not on its potential effects on the male reproductive system. The range of exposures for the eight samples taken on mulch sled attendants was 1.4 to 34.6 ppb, with the mean exposure being 10.7 ppb. Planting machine attendants had exposures ranging from 0.14 to 1.24 ppb with an average of 0.58 ppb for the 15 samples collected. The highest exposures measured during the survey were those of the first shift planting machine driver (0.98, 316, 618, and 20 ppb) for an average of 238 ppb. The three highest values were thought to have been the result of a malfunctioning valve on the planting machine. After repairs were made, the lower value of 0.98 ppb was recorded. Three samples taken on mulch machine drivers ranged from 1.68 to 3.54 ppb for an average of 2.32 ppb. Fifteen planters were sampled who worked in fields approximately two weeks post application, all were ND.

In addition to DBCP, 1,3-dichlorpropane (DCP) is also applied to the pineapple fields. DCP is used at a higher application rate than DBCP. The usual application rate is 35 to 40 gallons per acre as compared to 3 to 4 gallons per acre for DBCP. Eight mulch machine attendants were exposed to DCP over a range of 436-1964 ppb with an average exposure of 1019 ppb. Mulch sled drivers at both plantations were sampled and averaged 328 ppb for three samples.

A total of 114 men were physically examined and interviewed during the course of the medical investigation, 66 from Haliimaile Plantation and 48 from Honoloa Plantation. Of the 114 men participating, 74 (89%) were from potentially exposed job categories and 40 (89%) were from non-exposed categories. Pre-season and post-season semen samples were collected from 62 exposed (84%) and 29 unexposed (73%) of those participating in the examination and interview (75% and 64% of those initially asked, respectively).

Sperm count results were analyzed by comparing sperm samples collected prior to the application season with samples collected after the application season. Overall, neither the prevalence of oligospermia (less than 20 million sperm/ml) nor the mean difference in sperm count differed significantly when post-season samples were compared with pre-season samples. However, workers at Haliimaile plantation had an average decrease in sperm count of 19.9 million sperm per ml compared to Honoloa workers who on the average had an increase in sperm count of 5.1 million sperm per ml. For those workers with a normal pre-season sperm count, Haliimaile workers were 3 times more likely than Honoloa workers to have oligospermia after the application season. Substantial differences in exposure to DBCP at the two plantations were not in evidence. Results did not identify a relationship between oligospermia or mean change in sperm count with exposure to DBCP.

Based upon the results of this evaluation, NIOSH determined that during normal operations, exposures to DBCP were in excess of the OSHA permissible exposure limits (PEL) of 1 ppb. Sperm counts were determined both before and after an application season. Results did not identify a relationship between oligospermia or mean change in sperm count with exposure to DBCP. Recommendations designed to reduce exposures are included in this report.

KEYWORDS: SIC 0139 (Field Crops), dibromochloropropane (DBCP), 1,3-dichlorpropane (DCP), Sperm Counts, Sperm Morphology, Oligospermia, Male Reproductive Effects.

## II. INTRODUCTION

On January 13, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from Maui Land and Pineapple Inc. (MLOP). The requestor was concerned about possible worker exposure to the nematocide dibromochloropropane (DBCP) and reproductive effects resulting from this exposure. In December 1980 the Environmental Protection Agency (EPA) had requested technical assistance from NIOSH to investigate exposure to and potential reproductive health effects of DBCP use in pineapple at Maui Land and Pineapple Inc., as well as at the Dole Pineapple Corporation plantation on Lanai island.

NIOSH investigators conducted an initial walk-through at Maui Land and Pineapple on January 29, 1981. Environmental sampling was conducted during two periods, February 25-March 6 and July 14-24, 1981. Medical evaluation of the possible health effects of DBCP exposure was conducted before field preparation had begun in February-March of 1981, at mid-season in July, and after preparation had been ended in October. NIOSH and the Hawaii Pesticide Hazard Assessment Project of the Pacific Biomedical Research Center (PBRC), University of Hawaii, agreed upon a joint protocol for these investigations and the PBRC affiliated Fertility Evaluation Program at Kapiolani Children's Medical Center performed the semen analysis.

## III. BACKGROUND

Pineapple production involves the wide-scale use of many pesticides, including organophosphates, carbamates, and other halogenated hydrocarbons in addition to DBCP. In 1980, DBCP was used on three islands in Hawaii: Lanai, Maui, and Molokai. A different method of application was used on each island. On Lanai, fumigation was done by chisel-injection, followed 1 to 3 weeks later by the laying of mulch. On Maui, the injection is done at the same time that the mulch is laid, and the application rate is 3 to 4 gallons per acre. On Molokai, DBCP was applied by drip irrigation. In 1981, DBCP use was discontinued on Lanai and Molokai, where it has been replaced primarily with ethylene dibromide (EDB).

DBCP has been recognized as a cause of testicular toxicity in humans since 1977, and as a potential human carcinogen since 1973. Based on the evidence for carcinogenicity, OSHA promulgated a standard for airborne exposure to DBCP of 1 ppb (TWA) in 1978. The EPA eliminated DBCP use in the continental United States in 1978, in order to protect against potential carcinogenic effects resulting from DBCP contamination of drinking water in agricultural areas. The hydrology of the Hawaiian Islands is such that run-off from agricultural irrigation does not appear to contaminate drinking water aquifiers. Based on this fact, the EPA granted an Experimental Use Permit for DBCP application to pineapple fields in Hawaii. In their regular monitoring of drinking water sources, the Hawaii State Department of Health has not found contamination by DBCP.

Commercial pineapple fields on Maui, as on the other islands, require approximately 3 years from planting to replanting, producing two crops during this 3-year period. The first crop is harvested approximately 2 months after planting. The second crop, known as the "first ratoon", grows from the remaining plant and is harvested about a year after the first crop is harvested; in some cases, a third crop or "second ratoon" is also grown and harvested.

DBCP is incorporated into the soil as a part of the stage known as "preparation." It is applied to deter infestation of a reuniform nematode which is particularly harmful to the roots of the pineapple plant. About 1 to 3 weeks after fumigation, the pineapple crowns are planted. The rate of application used on Maui is 3 to 4 gallons of DBCP per acre at a depth of 12 inches. In addition to DBCP, 30 to 40 gallons per acre of another fumigant, 1,3-dichlorpropane (DCP) also known as Telone II (Dow, Midland, MI), is co-applied at 18 inches.

Two types of machines are used on the plantation to accomplish fumigation and preparation of the field for pineapple. Both are extreme modifications of stock D-8 caterpillar tractors. One is known as the mulching machine, or more commonly "mulch sled". This machine is capable of simultaneously injecting two types of fumigant and a fertilizer, while laying down a sixteen inch wide, continuous strip of polyethylene film. There are arrangements for three rows to be done at one time. The other machine, called the planting sled, is essentially identical, except that it has the capability to do two rows at a time. While at the same time, pineapple crowns are inserted into the plastic film and are thus planted.

The pineapple planting season begins in late February and continues until late September of each year. DBCP is used during these months. During part of the season, two eight-hour shifts operate. The pineapple cultivation cycle can be broken down into the following stages:

1. <u>Field preparation and planting</u>: Fields that have been idle for the requisite number of years are replowed. Two methods of fumigation are used, depending on the topography of the field. Easy slopes in need of irrigation are usually fumigated and planted at the same time using the planting machine. This machine simultaneously fumigates with DBCP and DCP, sets pineapple crowns into the mulch paper, and lays mulch paper and irrigation tubing. Steeper slopes not in need of irrigation are fumigated and mulched with the mulch sled.

2. <u>Field maintenance</u>: As the plants mature, boom sprayers periodically spray insecticides and herbicides on the plants. Irrigation is performed as necessary.

3. Harvesting: From 18 to 22 months after initial planting, pineapples are picked by hand and loaded into trucks.

Complete descriptions of all the job categories involved in this process may be found in Section IV. There is little turnover in most job categories. Most are skilled labor jobs. Turnover is higher among the planting machine attendants, because the work is extremely hot and dusty, and among the pickers, because wages are lower and the seasonal demand for this category of worker is higher. The workforce is largely male, although women dominate the attendant and helper categories. Japanese and Filipino are the predominant ethnic heritages of the work force.

## IV. EVALUATION DESIGN AND METHODS

### A. Environmental Sampling

Personal and area air samples for DBCP and Telone were taken using SKC Model 223-2 low volume pumps at a flow rate of 100 cc/min. The materials were collected on SKC Lot 107 100/50 charcoal tubes. At the end of each sampling day, all samples were sent to the analytical laboratory via inter-island air freight.

#### Analytical Procedure

Analytical services were contracted to the Industrial Analytical Laboratory (INALAB), Honolulu, Hawaii, and were supervised by Mr. Mark R. Hagadone. Upon receipt of the samples, the laboratory desorbed the charcoal tubes and either analyzed the eluents immediately or stored the solutions at -14°C until the analysis could be performed. Analysis was never delayed more than 72 hours.

Primary standards of DBCP and Telone were prepared by using pure reference material provided by NIOSH. These standard solutions were made by placing a known weight of the fumigant into a known volume of toluene. Working standards were prepared on a bi-weekly basis from the primary standard which was kept in a freezer at all times.

Samples were desorbed in 1% methanol-in-benzene solution. Initially both A and B sections of all samples were analyzed for the presence of DBCP and Telone. A determination was made to verify the absence of breakthrough and the amount of front section loading. Once this correlation was made, only A sections were desorbed. B sections were recapped and stored in deep freeze for later reevaluation if necessary. Any time an A section exceeded a previous loading at which no breakthrough was found to have occurred, the B section of that tube was analyzed. Throughout the entire study, no cases of breakthrough occurred in any sample.

As previously stated, charcoal tube desorption was accomplished with 1% v/v reagent grade methanol/Mallinckrodt spectograde benzene solution with a mechanical agitation period of 30 minutes at room temperature. Standard 5-ml teflon-lined septum-capped viles were used to contain the sample solution. Charcoal tube blanks of the same lot number were run in duplicate. It was noted at the time of the analysis that only Mallinckrodt spectograde benzene was sufficiently free of halogenated impurities to use for the analysis of the fumigants. All other grades of benzene that were examined (including nanograde) failed to produce contaminant-free background chromatograms.

Machine analysis was performed using an all-glass on-column injection chromatographic system. A Hewlett-Packard 5830-A Reporting Gas Chromatograph interfaced with a Tracor Model 700-A Electrolytic Conductivity Detector operated in the chloride mode was used. A 3% SP-2100 on 110/120 Supelcoport (AWS) 6' by 6mm o.d./2mm i.d. glass column was used for the analyses. The oven was temperature programmed from 60 to 110°C. Hydrogen was the carrier gas.

External standardization was employed on all analyses. Working standards were chosen to fall within a one order of magnitude maximum for the samples being analyzed. Desorption efficiency data covering both DBCP and Telone involving three concentration ranges were used to correct all measured values. An average of the three desorption efficiencies was used as a correction factor. The minimum detection limit for Telone, using the system described above, was found to be 23 ng. The minimum detection limit for DBCP was found to be 22 ng. The detection limit here is defined as a peak with a height which is double that of the baseline noise.

Stability on Collection Media

In addition to control spikes and recover experiments, stability studies of Telone and DBCP on charcoal sorbent support were evaluated over a 2-week period. Ten charcoal tubes of the same lot that were used for the field samples were spiked by INALAB personnel at the 5 ug level. After spiking, one liter of room air (25°C), 55% humidity) was drawn through the charcoal tube at 200 cc/min. After this treatment, the tubes were capped and allowed to remain at room temperature for the 2-week evaluation period. Charcoal tubes were spiked with DBCP at the 10 ug level on Maui. These tubes were sent to INALAB and also allowed to sit at room temperature. Analysis of these samples for percentage recovery was completed on an interval of about every two or three days after the initial spiking (Figure 1).

B. Medical

With the cooperation of ML&P and the ILWU Local 142 unit officers, a list of potentially exposed and unexposed job categories was prepared. All workers in the exposed categories, and a smaller sample of non-exposed workers, were invited to participate in the study. Because more than half of the workers are of Filipino origin, and many have a limited knowledge of English, Ilokano interpreters were used to discuss participation and when conducting the medical interviews. All workers were invited to attend a general informational meeting explaining the purposes of the study and the method of semen sample collection. Participating individuals were asked to abstain from sexual intercourse for 48 hours before collecting a sample.

Participating workers were interviewed and underwent physical examinations given by NIOSH physicians in the Lanai Hospital outpatient department. Examinations of the testes were included. Participants also completed a questionnaire concerning male reproduction. Pre-season semen samples were collected in February 1981; mid-season semen samples were collected in July 1981; and post-season semen samples were collected in September 1981. The workers were given clean plastic containers for the collection of semen samples, and asked to return them to the same location. The semen samples were then analyzed by Dr. Jane Rogers and technical staff of the Kapiolani Children's Medical Center.

Sperm counts were found to be log-normally distributed and for statistical analyses these data were transformed to a logarithmic scale. However, the difference between post- and pre-season sperm counts followed a normal distribution and these data were analyzed on an arithmetic scale.

V. EVALUATION CRITERIA

1. Adverse Health Effects

Dibromochloropropane (DBCP), a nematocide in use since 1955, has been recognized as a testicular toxin in animals since 1961 [1], and in humans since 1977 [2,3]. DBCP is also a bacterial mutagen [4], a suspect human carcinogen based on tests in several animal species [5], and has been associated with chromosomal abnormalities in one study of DBCP-exposed male workers [6]. Based on the evidence for carcinogenicity, OSHA issued a temporary emergency standard for DBCP in 1977, and in 1978 promulgated a final standard for airborne exposure of 1 ppb (TWA).

In 1978 the EPA prohibited DBCP use in the continental United States to protect against possible carcinogenic effects of drinking water contaminated with DBCP in areas where it is used agriculturally. An Experimental Use Permit for DBCP was granted for pineapple cultivation in Hawaii on the hydrology of the Hawaiian Islands and the characteristics of rainfall collection in aquifers, which, up to this date, have prevented DBCP contamination of drinking water on the islands.

The Hawaii State Department of Health has been responsible for monitoring drinking water for DBCP contamination on all of the islands, and has found no contamination of drinking water sources. Contamination of other waters at very low levels (parts per trillion) have been found on Oahu, where DBCP is no longer used, and on Maui in some surface streams. (See Section III).

Although epidemiologic studies done in manufacturing and formulating facilities have found lowered and absent sperm counts (azo- and oligospermia) among workers exposed to low levels of DBCP [2,3,7], there have been few studies of applicators and other field workers that are exposed to DBCP on a regular basis. Glass et al found a statistically significant decrease in sperm counts among California pesticide applicators who had a minimum of two months' exposure to DBCP during the preceding year. Although this decrease was not reported as clinically significant (defined as less than 20 million sperm/ml), there was a consistent trend showing a dose-relatedness between DBCP exposure in the past year and sperm count [8]. Sandifer et al., in a study of pesticide applicators from six states, also found a statistically significant (but not clinically significant) decrease in sperm count associated with DBCP exposure.[9]

Recently, agricultural workers involved in pineapple production on the island of Molokai in Hawaii were studied by the Pacific BioMedical Research Center. In a comparison of 13 workers potentially exposed to DBCP and EDB (4 drip irrigators, 4 agricultural research workers, and a miscellaneous group of other agricultural workers) with 18 local controls and with the fertile Honolulu population, a significant decrease in mean sperm count was detected.[10] In addition, an increase in the rate of spontaneous abortion (miscarriages) among wives of DBCP field applicators has also been reported.[11]

None of these studies of agricultural field workers, however, has compared the sperm counts of workers before exposure to DBCP with their mid- or post-season sperm counts, and none has attempted to correlate sperm count with measured occupational exposure to DBCP.

2. Reproductive Evaluation

In the evaluation of male reproductive capacity, sperm count and morphology (shape) are the simplest, most direct and reliable field methods. For the purpose of this investigation, we used the most commonly accepted definition of oligospermia (low sperm count), that is, a sperm count of less than 20 million/ml. Sperm morphology was considered within the normal range if greater than 50% were read as oval forms.

In the statistical analysis of the medical results, sperm count data were found to be log-normally distributed (see Section VI-B). The differences between sperm counts at time 1 and time 3 were slightly skewed due to 2 observations lying more than 2.6 standard deviations from the mean. These observations, an increase of 260 and 310 million sperm/ml, were for 2 workers at the Monoloa plantation, one a maintenance worker and the second non-exposed. These 2 obervations were deleted from any analysis that involved change in sperm counts over the 2 sampling periods. As a result, parametric tests including analysis of variance were used, in addition to standard tests for correlation of variables and for the interaction of variables.

## VI. RESULTS AND DISCUSSION

### A. Environmental

1. Exposure Groups

For the purposes of delineating exposures to the fumigants in use at Maui Pineapple Company, the workers can be conveniently divided into four groups.

The first group are those workers who experience point source exposures, which result from being in close proximity to the machinery that performs the fumigation in the fields. Job categories included in this group include driver (planting machine and mulch machine), planting machine luna, attendants, and supply truck driver.

The second group receives field source exposures from performing work in the field during and after fumigation. The fumigants, by their nature, are volatilized from the soil to the atmosphere. The concentration of the fumigants in the air above the field is the source of exposure. Job categories included in this group are irrigation workers, planters, crown unloaders-seed spreaders, mulch coverers, and utility workers. Workers classified in the point source group also experience field source exposures.

The third group receives intermittent exposure. These workers are maintenance shop workers called to the field to repair equipment. Often the lines which transport the fumigants through the machinery must be disconnected resulting in both point source and field source exposures. These employees wear personal respiratory protection (supplied air or air purifying respirators) when doing their jobs.

The last group to be defined includes those employees who are, for all practical considerations, non-exposed. Workers included in this group enter the field long after the fumigation has been completed, and those who are engaged in activities removed from the fields. Included in this group are pickers, fruit drivers, and office personnel.

2. Job descriptions and extent of contact/exposure.

Plant machine (Mechanical Planter)

When the planting machine is in operation, eight to fifteen workers may be in the field. During busy times of the year two shifts are operating. The job categories defined in the planting machine operation are:

a. Planting Machine Driver - this worker controls the operation of the planting machine, including direction of course, and tractor speed, which inevitably controls the rate of fumigant dispersal. He is responsible for monitoring the flow control gauges for both fumigants insuring that the pumps are operating correctly. He also actuates the check-flow valves and fumigant line blow-out procedure. There is one driver per machine who is consequently in the field at all times during the fumigation/planting.

b. Attendant - six attendants are required to perform the job of crown insertion and bed adjustment with the planting machine. When inserting the crowns, three attendants sit in chairs at the back of the planting machine facing opposite of the direction of travel. The planting machine has a wire cage reservoir on top which holds enough crowns to plant half a hectare. The attendants insert the crowns into the plastic mulch which has been properly oriented by the planting machine. Soil from the sides of the beds is pushed over the edges of the mulch to secure it to the ground by discs on the planting machine. Three attendants walk behind the machine to reinsert any misplaced crowns and to put additional soil over the mulch where necessary. After each row is planted the attendants trade positions.

c. Supervisor (luna) - Luna is the plantation term for boss or foreman. The supervisor is essentially the foreman of the planting machine operation and is responsible for the planting. He walks along side of the machine as it lays the rows and assists in replacing the rolls of mulch and drip irrigation tubing on the planting machine as they are depleted. The exposure of the supervisor depends on the direction of the wind and his proximity to the machine.

d. Assistant Supervisor - This worker performs the same functions as the supervisor and would seem to have very similar exposures.

e. Irrigation Workers - These workers come into the field when 'blocks' (i.e., 25 rows of pineapple) are completed to connect the drip irrigation tubing to the main feeder lines. The work requires two or three workers who are in the field for no more than three hours. They work in areas that were planted/fumigated two to three days or even weeks previously.

f. Crown Unloader - This man drives a specially designed truck that carries enough crowns to fill the reservoir of the planting machine. The crowns travel forward on a moving floor arrangement (traveling chains with connecting cross-members) on top of the truck and are then blown into the reservoir of the planting machine. This transfer usually takes place on level ground at the periphery of a field. Exposures are probably not substantial for the 3-4 hours he is in the field.

g. Supply or 'Nurse' Truck Driver - This worker drives the truck that supplies the other machines with supplies of fertilizer, fumigants, and water. He loads the materials at the plantation warehouse and delivers them to the machine as necessary. The planting machine travels at a rate that makes replenishment of its reservoirs necessary once a day, usually at the completion of the shift.

When loading materials, the driver is outfitted in appropriate safety gear including face-shield, and half-face NIOSH-approved respirator with either organic vapor or pesticide cartridges. The transfer operation takes about twenty minutes. All connections and/or fittings are rinsed off with 5% KOH and then water. For the majority of the day, this driver is stationed at the edge of the field or on the road between fields.

h. Grader Driver - This driver operates the grader which is required to establish roads in between the blocks. Because the planting machine travels comparatively slowly, the grader driver can keep up with the road requirements by working 4 or 5 hours every three days.

i. Maintenance Man - Personnel called to the field whenever a mechanical difficulty occurs. All lines are purged before any maintenance work is performed. If the DBCP system needs work, the machine is oriented so that the work can be done with the men on the upwind side. Maintenance workers are outfitted in SCBA full-face or half-face masks and appropriate protective clothing. The corrective measures range in time from 2-3 hours to the majority of the day.

Mulching Operation (Mulch Machine, Paper Sled, etc.)

The mulching machine is a similar modification of a diesel caterpillar tractor. This machine is used for fields when the terrain is too hilly for the top-heavy mechanical planter, or for fields that do not need irrigation. Two mulch machines are in use at ML&P; one can mulch and fumigate three pineapple beds, the other two. The mulching operation requires fewer personnel and can prepare a field for manual planting at a rate of 15 acres per day, as compared to the mechanical planter, which can plant only 3 acres per day.

a. The mulch machine driver has identical responsibilities to those of the planting machine driver, except that he does not operate the blow-out system.

b. Mulch sled attendants ride on a metal grate platform directly above the fumigation shanks on the back of the sled. They ensure that the plastic mulch paper is payed out correctly. They slice the paper at the end of each row, change spools of paper, and operate the blow-out valves for the DBCP lines before the shanks are lifted during turns at the end of a row.

c. Supervisor (mulch luna) is responsible for the operation, and coordinates field layout with the preparation supervisor.

d. Paper coverers, or mulch coverers, walk up and down the rows using hoes to cover the mulch paper with soil. There are usually 2 to 4 paper coverers per field, depending on the length of the field and the speed of the mulch machine.

e. At either plantation the supply truck driver is usually the same man that supplies the planting machine.

f. Seed spreaders are synonymous with crown unloaders. They are in the fields for only a short time each day.

g. Planters enter the field from 1 day to 3 weeks after mulching. They arrange the piles of crowns that have been brought to the field to minimize their walking about. A metal implement similar to a garden trowel is used by the planters to pierce the plastic mulch while simultaneously inserting a crown.

3. Exposures By Job Category To DBCP

Overall, exposures to DBCP were low. Exposures ranged from 618 ppb (part per billion) to none-detected (ND). However, 21 of 80 samples exceeded the OSHA PEL of 1 ppb as an 8-hour time-weighted average (Table I). This standard was based on the classification of DBCP as a potential carcinogen, not on its potential effects on the male reproductive system. The highest measured exposure was a personal sample taken on the planting machine driver at Haliimaile Plantation. It was later determined that a DBCP pump fitting was loose. After this was corrected, a similar sample showed a value of 0.98 ppb, much more representative of typical exposures measured for that job category.

Attendants

The mulch sled attendants experienced substantially higher exposures than did the planting machine attendants. The range of exposures for the eight samples taken on mulch sled attendants was 1.4 to 34.6 ppb, with the mean exposure being 10.7 ppb. The first shift (0600-1330) planting machine attendants had exposures ranging from .14 to 1.24 ppb, with an average of 0.58 ppb for the 15 samples collected. Second shift (1400-2000) planting machine attendants were sampled twelve times. Their exposures were measured between ND to 0.58 ppb with an average of 0.17 ppb.

Higher exposures among the mulch sled attendants is to be expected. Their work covers at least five times the amount of acreage that the planting machine attendants cover, and they ride immediately above the fumigation shanks. On both machines, the attendants, with one exception for one day, were women. Mulch sled attendants did not always have an opportunity to turn the blow out valve at the end of the row, probably because things were happening too quickly.

Crown unloader

Two samples were taken to determine the exposure of the crown unloader. The mean was 2.67 ppb for individual values of 0.17 and 5.17 ppb. The 0.17 ppb value is more representative of an average exposure. The higher value occurred when the unloader was near a DBCP transfer operation.

Drivers

The highest exposures measured during the survey were those of the first shift planting machine driver. Although after a subjective reappraisal of the four samples collected, the more representative value is .98 ppb. The other values obtained were 316, 618, and 20 ppb for an average of 238 ppb. The second shift mulch machine driver had one exposure determination of 1.61 ppb. Three samples taken on mulch machine drivers showed a range of 1.68 to 3.54 ppb for an average of 2.32 ppb.

Grader driver

One sample was obtained for a grader driver and no detectable level was measured.

Irrigation workers

Because these workers enter the field well after most of the other preparation steps have been completed, they experience very low, possibly background exposures. Six workers were sampled. Of those six, four were ND. The average of the remaining two was averaged in for a mean exposure value of 0.07 ppb.

Lunas

The three samples taken had values of 286, 2.82, and 0.88 ppb for an average of 96.6 ppb. The highest of the three exposures determined for the mechanical planter luna is most likely higher than usual, due to the leaky fitting. The second shift planting machine luna was sampled twice for an average exposure of 0.03 ppb. At Honoloa plantation, the mulching luna at field 64 had an exposure of 0.15 ppb.

Maintenance men

One maintenance man was monitored while performing DBCP-line repair during the nine days of the survey. The maintenance man who was sampled performed the repair on the planting machine. This worker wore a half-face, NIOSH-approved, air-purifying respirator with pesticide cartridge. His exposure for the approximately two-hour repair was 8.39 ppb.

Mulch coverers

Six samples were taken on mulch coverers. They ranged from ND to 1.44 ppb. The mean exposure was 0.54 ppb.

Planters

Two gangs of planters were sampled on consecutive days. The first day, ten were evaluated. Reports from their supervisor indicated that they had tampered with the sampling train by sticking the charcoal tubes up the exhaust of the truck, through the mulch paper, etc. Even numbered samples of this set were discarded. The next day, ten other planters was sampled, without incident. Of the fifteen samples analyzed for DBCP, all showed ND levels.

Because the field (211) in which the planters were sampled had been mulched more than two weeks prior to planting, and because climatic conditions were somewhat severe during the sampling (high trade winds, not unusual on this side of the island), data generated by ML&P are considered to be more indicative of the true exposure situation. A series of samples had been collected by Dr. Williams and his research staff on 1, 5, 8, and 13 days post mulching. Average exposure for four samples taken on planters on day 1 was 0.58 ppb. Four days later, the average value was 0.88 ppb; eight days post mulching, 1.38 ppb; and thirteen days post mulching ND. All samples were collected over a period of about four hours.

These data agree with determinations made by ML&P and NIOSH concerning the behavior (fumigant flux) of the fumigant over time after it has been applied subsurface (See Figure 2).

Supply truck driver

The supply truck driver at each plantation takes full protective measures before loading or transferring any DBCP. Three samples taken concurrently at Haliimaile during the bulk loading of 120 gallons of DBCP showed an average exposure of 75.5 ppb. Two samples taken during the transfer of DBCP from the supply truck to the tractor in a the field loading situation yielded values of 1.6 and 2.9 ppb.

4. Exposure by Job Category to DCP

DCP is used at a higher application rate than DBCP. The usual application rate is 35 to 40 gallons per acre as compared to 3 to 4 per acre for DBCP. This greater application rate coupled with the lack of adequate contaminant engineering resulted in higher exposures. Exposure levels for DCP by job category are given in Table 2.

Attendants

Eight mulch machine attendants were exposed to DCP over a range of 436-1964 ppb with an average exposure of 1019 ppb. The two row mulcher (Honoloa) attendants had about 1/2 to 1/5 the DCP exposure of the three row (Haliimaile) mulcher attendants. First shift planting machine attendants were sampled twelve times for DCP and had a mean exposure of 222 ppb over a range of 88.8 to 532 ppb. Second shift had lower exposures over the range of 13.9 to 168 ppb with a mean of 64.5 ppb for nine samples.

Crown unloader

Two samples for DCP showed 185 and 434 ppb for an average of 310 ppb.

Drivers

Mulch sled drivers at both plantations were sampled and averaged 328 ppb for three samples. First shift planting machine driver had a mean exposure value of 368 ppb over the range of 110 to 880 ppb. One determination was made for the second shift driver. His exposure was 83.2 ppb.

Grader driver

One sample was taken on this driver during mulching. An exposure of 33.0 ppb was measured.

Irrigation workers

Six samples were collected with a range of 0.6 to 15.3 ppb and a mean of 6.9 ppb.

Lunas

One sample for the mulch luna was 45.5 ppb. The first shift planting machine luna averaged 451 ppb for two samples, while the second shift luna averaged 30.3 ppb.

Maintenance men

One sample was collected. The value was 37.0 ppb.

Mulch coverers

The two-row mulch coverers (Honoloa) had an average exposure of 38.4 ppb while the three row mulch coverers (Haliimaile) averaged 275 ppb. As a group, these workers averaged 196.0 ppb over a range of 13.5 to 476 ppb.

Planters

If ML&P data for planter exposure to DCP were available, it would be considered more representative of the true exposure situation. As it stands, for the fifteen samples collected, the average exposure measured was 6.6 ppb.

Supply truck driver

During the bulk loading of DCP, one short-term (15 min) sample had a value of 247 ppb. During the bulk loading of DBCP, three samples had an average of 11.3 ppb.

Engineering controls

In all phases of DBCP storage, handling, and use, engineering controls are evident. Fumigant is stored in a separate, diked building. The floor of the building sits three feet below ground level, and is made of concrete. The walls are concrete cinder block and are continuous to two feet above ground level. The remainder of the structure is corrugated metal, and the roof is louvered to provide natural ventilation. Access to the storage is restricted to specially designated personnel. A prominently labeled emergency shower is immediately adjacent to the entrance.

ML&P has designed vapor recovery techniques into all transfer operations for DBCP. Thirty-gallon drums are moved outdoors from the shed by lift-truck. The bungs are opened and transfer is accomplished by using an impeller pump located on the supply truck. This same pump transfers the material to the planting sled. The filling of the 200-gallon reservoir on the supply truck takes about 45 minutes. One worker is responsible for the entire operation. He is outfitted at all times with a half-face, air purifying respirator with pesticide cartridge, a full-face splash shield, nitrile disposable coveralls, and neoprene rubber gloves and boots. Vapors displaced in the reservoir tank on the supply truck are vented through activated charcoal filters on the top of the tank. No superfluous personnel are allowed in the vicinity of the operation. Empty drums are set back inside the shed.

B. Medical/Epidemiologic

1. Characterization of Exposure Groups:

All workers potentially exposed to DBCP were divided into three categories: point source (those involved in the actual process of DBCP fumigation of the fields); field source (those entering the field during the 3-4 weeks of activity following fumigation with DBCP); and maintenance (those entering the field on an occasional basis to repair the DBCP fumigation tractor). These exposure categories are described in greater detail in Section IV-A. In analyzing the sperm count data, the results for the workers were initially stratified by these three exposure groupings. All three groups were then combined as "exposed" for comparison with the results of non-exposed workers. Finally, because both the nature of and NIOSH-monitored levels of DBCP exposure were highly similar for the field source and for point source workers, data for this combined field and point source group were compared with results for the non-exposed workers.

2. Participation

A total of 128 men were invited to participate in the study; 83 were potentially exposed to DBCP and 45 were from non-exposed job categories. A total of 114 men were physically examined and interviewed, 66 from Haliimaile Plantation and 48 from Honoloa Plantation. Of the 114 men participating, 74 (89%) were from potentially exposed job categories and 40 (89%) were from non-exposed categories. Pre-season and post-season semen samples were collected from 62 exposed (84%) and 29 unexposed (73%) of those participating in the examination and interview. Fifty-six exposed (76%) and 19 non-exposed (48%) workers contributed semen samples in the pre-, mid- and post-season sampling. Sperm count results were discarded for six individuals: four had one atrophic testis, one had a thickened epididymis, and one had glandular hypospadia.

3. Characteristics of the Sample Population

There was no significant difference between exposed and non-exposed groups for marital status (63% married, 34% single), current cigarette smoking (44% smokers), alcohol consumption (38% heavy drinkers), marijuana use (9%), fathering of 1 or more children (68%), place of birth (56% U.S., 42% Philippines), or, among married men, difficulty in producing a pregnancy (8%) and history of miscarriage or stillbirth (21% and 3% respectively).

4. Potential confounding variables

No significant difference for age, heavy drinking, or marijuana use was found between exposed and non-exposed groups, by exposure type, or among all four exposure groups. Total years of work in pineapple was not different between the control and the combined exposed group. When all four exposure groups were compared, field source workers had a significantly lower mean duration (5.2 years) than the other three groups (12, 17 and 17 years).

There was no significant difference for smoking between exposed and non-exposed groups or among all four exposure groups. There were significantly more smokers in the field and point source group combined as compared to non-exposed and maintenance workers. However, smoking did not effect the sperm count means, and did not correlate with sperm count. Therefore, age, drinking, smoking, marijuana use, and years of work in pineapple were not regarded as significant confounding variables.

There were differences between the two plantations for change (pre-season to post-season) in sperm count and sperm morphology. At Honoloa plantation, the mean sperm count increased 5,131,000/ml, but this change was not statistically significant. At Haliimaile, the mean sperm count decreased 19,858,00/ml. This difference was not statistically significant (p= 0.07). The change in percent of sperm with normal morphology was significantly different between plantations. At Honoloa plantation, the percentage of ovoid sperm decreased an average of 6.6%, while at Haliimaile, the percentage of ovoid-shaped sperm decreased an average of 0.3%. The differences for the two plantations was consistent across exposure groups. For all exposure groups, sperm counts decreased over the application season at Haliimaile compared to Honoloa while percent of sperm with normal morphology decreased at Honoloa compared to Haliimaile.

5. Sperm count results:

Sperm count results were analyzed for oligospermia (less than 20 million sperm/ml) and difference in sperm count between time 1 and time 3.

During the pre-season sampling, 25 of 116 (21.6%) collected samples were below 20 million sperm/ml. These subjects were excluded from consideration in the analyses of the development of oligospermia. Of these 25 subjects, 9 (36%) had sperm counts in excess of 20 million/ml at the post-season sampling.

Ninety-one subjects were considered normal at the pre-season sampling period. Of these, 25 (27.5%) had a sperm count below 20 million/ml on the post-season sample. There was no relationship between exposure and oligospermia. Twenty-seven percent of the field/point workers, 12% of maintenance workers, and 39% of the non-exposed workers had normal pre-season sperm counts and low post-season sperm counts. Workers who had normal pre-season sperm counts were more than 3 times as likely to have low post-season sperm counts if they worked at Haliimaile plantation rather then Honoloa ($p<0.03$). These results were consistent for the different exposure categories.

There was no statistically significant association between mean difference in sperm counts and exposure categories based on job title or total number of hours in potentially DBCP-exposed fields. Although the mean difference in sperm count did differ by plantation, this difference was consistent across all exposure categories. The results are described in Table 3.

6. Sperm morphology results:

Sperm morphology results were analyzed by abnormal/normal classification and by the difference in the percentage of ovoid shaped sperm between pre-season and post-season. The results are given in Table 4. During the first sampling, 36 of 116 (31%) collected samples had 50% or fewer ovoid shaped sperm and were considered as having an abnormal morphology. These subjects were excluded from consideration in the analyses of abnormal/normal morphology. Of these 36 workers, 12 (33%) had greater than 50% ovoid-shaped sperm at the third sampling period.

Eighty subjects were considered to have normal pre-season sperm morphology. Of these, 21 (26%) had abnormal sperm morphology post-season. Twenty-four percent of field/point source workers, 35% of maintenance workers, and 22% of the non-exposed workers had normal sperm morphology pre-season but were abnormal post-season. Workers with normal pre-season morpholgy and abnormal post-season morphology were no more likely to have worked at Honoloa than Haliimaile plantation (OR=1.05 p>0.10).

There was no statistically significant association between the mean difference in % of ovoid sperm (pre-season and post-season) and exposure categories based on job title or total number of hours in potentially DBCP-exposed fields. The results are described in Table 4.

## VII. CONCLUSIONS AND RECOMMENDATIONS

This study was designed to examine the effects on sperm counts and sperm morphology from DBCP exposures during pineapple farming. In general, the exposure levels observed were low, relative to those expected to effect the male reproductive system, and no association was found between the various exposure categories and sperm count or sperm morphology. It should be noted that the exposure levels for 21 of the eighty samples collected were above the OSHA PEL, which was based on DBCP's potential as a carcinogen.

In comparisons of workers at the two plantations studied, differences were noted. The pre-season to post-season change in sperm count decreased an average of 19.9 million sperm/ml for Haliimaile workers but increased an average of 5.1 million sperm/ml for Honoloa workers. In terms of oligospermia (a sperm count of less than 20 million sperm/ml), for workers with a normal pre-season sperm count, Haliimaile workers were at 3 times the risk of oligospermia after the season when compared with Honoloa workers. These findings were found to be consistent for the various exposure categories used.

It is not clear whether this represents the effect of exposure to DBCP, a sampling error, or a random occurrence. In order to represent the effect of DBCP, exposures to DBCP must have differed substantially at the two plantations. There was limited evidence for this.

1) The Haliimaile plantation used a mulch machine that planted 3 rows of pineapples at one time compared to the two row machine used at Honoloa plantation. Environmental samples for DCP for the workers using the Haliimaile machine were noted to be from 2 to 5 times greater than the exposures to workers attending the Honoloa machine. This suggests that exposures to DBCP were also higher.

2) Further evidence was noted when the pesticide valve on a Haliimaile planting machine malfunctioned, resulting in high exposures to those working in the proximity of that valve. This problem was soon corrected. However, there could have been differences in the overall maintenance of machinery at the two plantations resulting in differences in exposures. This may have been confirmed by the observation that maintenance workers at Haliimaile reported a greater number of hours of exposure to DBCP (80.06 +/- 74.13) than maintenance workers at Honoloa (8.67 +/- 11.64).

Unfortunately, the environmental survey of pesticide exposures was limited to a cross-sectional characterization by job title. The actual exposures for each individual in the study was not measured and differences in exposure at the two plantations for the participating study subjects will remain unknown. The difference in mean sperm count change by plantation was also observed in workers classified as non-exposed. This suggests that either the classification scheme for exposure was in error or that exposure to DBCP did not cause the observed difference between the two plantations.

Finally, the reliability of the sperm count data used in this study should also be questioned. The variability associated with sperm counts is extremely large. The fact that a large number of subjects classified as having oligospermia before the application season converted to normal following the application season is a case in point. Future studies should not rely on single sperm samples. Rather, studies designs should try to increase the reliability of sperm counts by collecting multiple samples at each critical point.

Recommendations formulated by ML&P, and by NIOSH in cooperation with ML&P, addressing the industrial hygiene aspects of the mulching and planting operations are as follows: (the listing of a recommendation does not necessarily imply that the situation being described was not adequately managed by ML&P).

Personal Protective Equipment

1. In atmospheres measured to contain DBCP in excess of 1 part per billion (ppb) personal protective equipment must be used. The equipment required should reflect the margin of protection afforded by working outdoors where winds have an opportunity to disperse the material into an immense volume of dilution. Therefore it is recommended that half-face, NIOSH-approved respirators with either organic vapor or pesticide cartridge be used. Full-face splash shields should also be worn in situations where large quantities of DBCP are handled or transferred.

2. Disposable PVC-coated coveralls should be worn when working with large quantities of DBCP. If a splash of DBCP soaks through the coverall, the suit should be removed immediately. If DBCP has penetrated through to the skin, the affected area should be washed with soap several times.

3. Gloves and booths should be worn when handling large volumes of DBCP and during loading of the planting mulching machines. No particular material appears to be especially impervious to DBCP. Neoprene or heavyweight polyethylene should be adequate. Gloves should be disposed periodically to insure adequate protection against the corrosive and systemic effects of the DBCP.

Spills and Leaks

4. If the situation arises in which DBCP is either spilled or leaks from a machine connection, proper decontamination procedures should be enacted. The first step in controlling exposures resulting from material outside the containment system is to remove all unnecessary personnel from the area. Second, properly equipped personnel should apply copious amounts of 5% KOH or its equivalent to the spill or the leaking fittings. This results in alkaline hydrolysis of the DBCP to a corresponding alcohol and subsequent reduction of hazard by a factor of at least 1000. Next, if the spill occurs in the field, the excess KOH should be rinsed off with plenty of water and the ground covered with clean soil from the vicinity. Machine fittings should be rinsed so that no caustic remains. If the spill occurs on concrete, the same procedure should be followed and, based on the magnitude of the spill, the two steps should be repeated. At no time should attempts be made to soak up intact DBCP.

5. Grossly contaminated clothing should be discarded, preferably burned or buried.

Equipment Breakdowns

6. Non-essential personnel should be moved upwind and away from the immediate area of a machine when a DBCP system is being repaired. If possible, the mechanics should work on the upwind side. Full face, air supplied respirators seem to be most preferred as respiratory protection. They are very adequate for the situation and provide a wide margin safety, as well as being cooler than full-face cartridge respirators.

7. Non-essential personnel should not return to the area until the mechanics have completed the repair and decontaminated the machinery.

8. The rejoined fittings should be evaluated by air sampling. The machine should not be put into operation until the check-out shows no leaks.

9. Maui Pineapple Company should proceed with their intention to retrofit all fumigation equipment with the peristaltic pumps that were being evaluated during the second NIOSH environmental survey in August, 1981. The ruggedness of the viton tubing, the lack of internal valve mechanisms, and the decreased maintenance required for the pumps should substantially diminish point source exposures. Additionally, the positive flow characteristics of the pumps will obviate the need for check- and blow-out valve arrangements.

Other

10. Regular safety committee meetings and educational programs should be enacted to inform all employees of the potential health hazards associated with the various chemicals used by ML&P in their operations. Good work practices and personal hygiene should be stressed with the goal of preventing or minimizing unnecessary inhalation or skin contact with these materials.

VIII. REFERENCES


1. Torkelson, T.R., Sadek, S.E., Rowe, V.K., Toxicologic Investigations of 1,2-Dibromo-3-Chloropropane, Toxicology and Applied Pharmacology Vol 3, 545-559 (1961).

2. Whorton, D., Krauss, R.M., Marshall S., Milby, T.H. Infertility in Male Pesticide Workers, The Lancet, 1259-1261, December 17 (1977).

3. Whorton, D., Milby, T.H., Krauss R.M., Stubbs, H.A., Testicular Function in DBCP Exposed Pesticide Workers, Journal of Occupational Medicine Vol. 21, No. 3, 161-166, March (1979).

4. Biles, R.W., Connor, T.H., Treiff, N.M., Legator, M.S. Journal of Environmental Pathology & Toxicology, Vol. 2, 301-312 (1978).

5. Evaluation of the Carcinogenic Risk of Chemicals to Humans, 1,2-Dibromo-3-Chloropropane, IARC Monographs, Vol. 20, 83-96 (1979).

6. Kapp, Jr., R.W., Picciano, D.J., Jacobson, C.B., X-Chromosomal Nondisjunction in Dibromochloropropane-Exposed Workmen, Mutation Research, Vol. 64, 47-51 (1979).

7. Potashnik, G., Yanai-Inbar, I., Sacks, M.I., Israeli, R. Effect of Dibromochloropropane on Human Testicular Function, Journal of Medical Science, Vol. 15, No. 5, 438-442, May (1979).

8. Glass, R.I., Lyness, R.N., Mengle, D.C., Powell, K.E., Kahn, E., Sperm Count Depression in Pesticide Applicators Exposed to Dibromochloropropane, American Journal of Epidemiology, Vol, 109, No. 3, 346-351 (1979).

9. Sandifer, S.H., Wilkins, R.T., Loadholt, C.B., Lane, L.G., Eldridge, J.C., Spermatogenesis in Agricultural Workers Exposed to Dibromochloropropane (DBCP), Bulletin Environmental Contamination & Toxicology, Vol. 23, 703-710 (1979).

10. Takahashi, W., Wong, L., Rogers, B., and Hale, R.W., Depression of Sperm Counts Among Agricultural Workers Exposed to Dibromochloropropane and Ethylene Dibromide Bull. Environm. Contam. Toxicol., 27, 551-558 (1981).

11. Kharrazi, M., Potashnik, G., Goldsmith, J.R., Reproductive Effects of Dibromochloropropane Israeli Journal of Medical Science, 1980 May 16 (5):403-6.

12. MacLeod, J., Wang, Y., Male Fertility Potential in Terms of Semen Quality, Fertility and Sterility 31(2):103-16, February 1979.

13. Milby, T.H., and Whorton, D., Epidemiological Assessment of Occupationally Related, Chemically Induced Sperm Count Suppression J. Occup. Med., 22(2) 77-82, February 1980.

## IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

| | |
|---|---|
| Report Prepared by: | Molly Joel Coye, M.D.<br>William N. Albrecht, M.S.<br>Thomas Sinks, Ph.D. |
| **Analytical Expertise and Consultation Provided by:** | **Mark R. Hagadone, M.S.<br>Industrial Analytical Laboratories<br>Honolulu, Hawaii<br>Wataru Takahashi, M.S.**<br>Pesticide Hazard Assessment Project<br>University of Hawaii<br>Honolulu, Hawaii |
| | Jane Rogers, Ph.D.<br>Fertility Evaluation Program<br>Kapiolani Children's Medical Center<br>Honolulu, Hawaii |
| | Donald Whorton, M.D.<br>Environmental Health Associates<br>San Francisco, California |
| Originating Office: | Hazard Evaluations and Technical Assistance Branch<br>Division of Surveillance, Hazard Evaluations, and Field Studies |
| Report Typed by: | Jenise Brassell<br>Clerk (Typing)<br>Medical Section, HETAB |

NIOSH would like to acknowledge the invaluable assistance of the following persons:

Ethel Abreu, Jotoku Asato, Deason Baybayan, Frank Bermudez, Robert Castillo, Eddie Caballos, Janet Chambers, M.D., Karen Chencin, Harry Coelho, Richard Cravalho, Carl DeMaso, Frederick Greenwood, Ph.D., Fritz Hertlein III, C.I.H., Richard Hornung, Ph.D., Roland Ibara, Edward Papa, Shiu Lee, Douglas MacCluer, Ah Quan McElrath, M.S.W., James Melius, M.D., Jane O'Mora, Jon Oshiro, Robert Pante, Leland Parks, Ph.D., Pepito Ragasa, Donald Richard, Wayne Takehara, Dr. Shaw P. Wan, David D.F. Williams, Ph.D., Lyle Wong, Ph.D., Thomas Yagi.

## X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. 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. EPA
2. Maui Land and Pineapple
3. ILWU Local 142
4. NIOSH, Region IV
5. OSHA, Region IV

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.

TABLE 1

DIBROMOCHLOROPROPANE (DBCP) EXPOSURES BY JOB CATEGORY IN PART PER BILLION

MAUI LAND AND PINEAPPLE INC.
KAHULI, HAWAII

HETA 81-162

| Number | Job Category | Zero | 0-0.1 | 0.1-1.0 | 1.0-10 | 10+ |
|---|---|---|---|---|---|---|
| 8 | Attendant Ms | | | | 6 | 2 |
| 15 | Attendant PM I | | | 13 | 2 | |
| 12 | Attendant PM II | 2 | 4 | 5 | | |
| 2 | Crown Unloader | | | 2 | | |
| 3 | Driver MS | | | | 3 | |
| 4 | Driver PM I | | | 1 | | 3 |
| 1 | Driver PM II | | | | 1 | |
| 1 | Grader Driver | 1 | | | | |
| 6 | Irrigation Worker | 4 | | 2 | | |
| 1 | Luna MS | | | 1 | | |
| 3 | Luna PM I | | | 1 | 1 | 1 |
| 2 | Luna PM II | 1 | 1 | | | |
| 1 | Maint. Man. | | | | 1 | |
| 6 | Mulch Coverer | 1 | | 4 | 1 | |
| 15 | Planter | 15 | | | | |
| 6 | Supply Truck Driver* | 1 | | | 2 | 3 |
| 86 | | 25 | 5 | 30 | 17 | 9 |

* All Short Term Samples

Luna - supervisor/foreman
MS - mulch sled
PM - planting machine
I - 1st shift
I - 2nd shift

TABLE 2

1,3-DICHLORPROPANE (DCP) EXPOSURES BY JOB CATEGORY IN PART PER BILLION

MAUI LAND AND PINEAPPLE INC.
KAHULI, HAWAII

HETA 81-162

| N= | Job Category | Zero | 0-10 | 10-100 | 100-1000 | 1000+ |
|---|---|---|---|---|---|---|
| 8 | Attendant MS | | | | 4 | 3 |
| 12 | Attendant PM I | | | 3 | 9 | |
| 9 | Attendant PM II | | | 6 | 3 | |
| 2 | Crown Unloader | | | 1 | 1 | |
| 3 | Driver MS | | | | 3 | |
| 2 | Driver PM I | | | | 2 | |
| 1 | Driver PM II | | | 1 | | |
| 1 | Grader Driver | | | 1 | | |
| 6 | Irrigation Worker | | 3 | 3 | | |
| 1 | Luna MS | | | 1 | | |
| 2 | Luna PM I | | | | 2 | |
| 2 | Luna PM II | | | 2 | | |
| 1 | Maint. Man | | | 1 | | |
| 6 | Mulch Coverer | | | 2 | 4 | |
| 15 | Planter | 6 | 4 | 5 | | |
| 5 | Supply Truck Driver* | | 1 | 2 | 2 | |
| 76 | | 6 | 8 | 28 | 31 | 3 |

* All Short Term Samples

Luna - supervisor/foreman
MS - mulch sled
PM - Planting Machine
I - 1st shift
II - 2nd shift

# TABLE 3:

Difference in sperm counts by two exposure classification schemes; job category and hours worked in potentially exposed-DBCP fields.

MAUI LAND AND PINEAPPLE INC.
KAHULI, HAWAII

HETA 81-162

A: Mean difference in sperm counts by job category.

| Exposure Group | Number | Mean Difference between 1st & 3rd Sperm Count count/ml |
|---|---|---|
| Field/point source | 35 | 2,563,000 |
| Maintenance | 2[illegible] | 13,481,000 |
| Non-exposed | [illegible] | 12,593,000 |

B: Mean difference in sperm counts by hours worked in potentially exposed-DBCP fields.

| Hours | Number | Mean Difference between 1st & 3rd Sperm Count count/ml |
|---|---|---|
| None | 28 | 12,593,000 |
| 1-99 | 17 | -1,690,000 |
| 100-599 | 20 | 1,700,000 |
| 600 + | 18 | 21,000,000 |

TABLE 4

Difference in sperm morphology by two exposure classification schemes; job category and hours worked in potentially exposed-DBCP fields.

MAUI LAND AND PINEAPPLE INC.
KAHULI, HAWAII

HETA 81-162

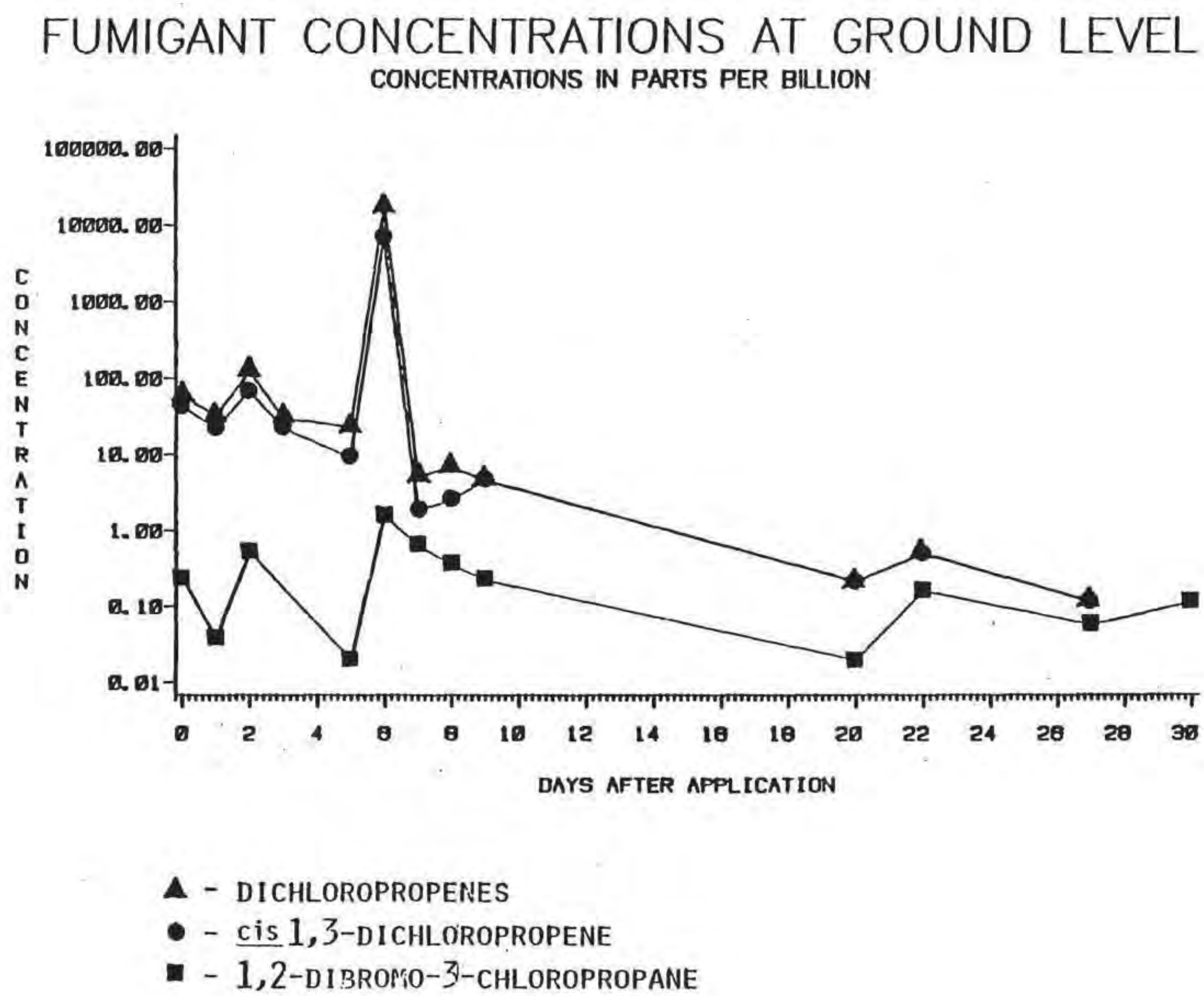
A: Mean difference in sperm counts by job category.

| Exposure Group | Number | Mean Difference in % of sperm with ovoid morphology between time 1 and time 3 |
|---|---|---|
| Field/point source | 35 | 2.69 |
| Maintenance | 26 | 4.27 |
| Non-exposed | 28 | 2.14 |

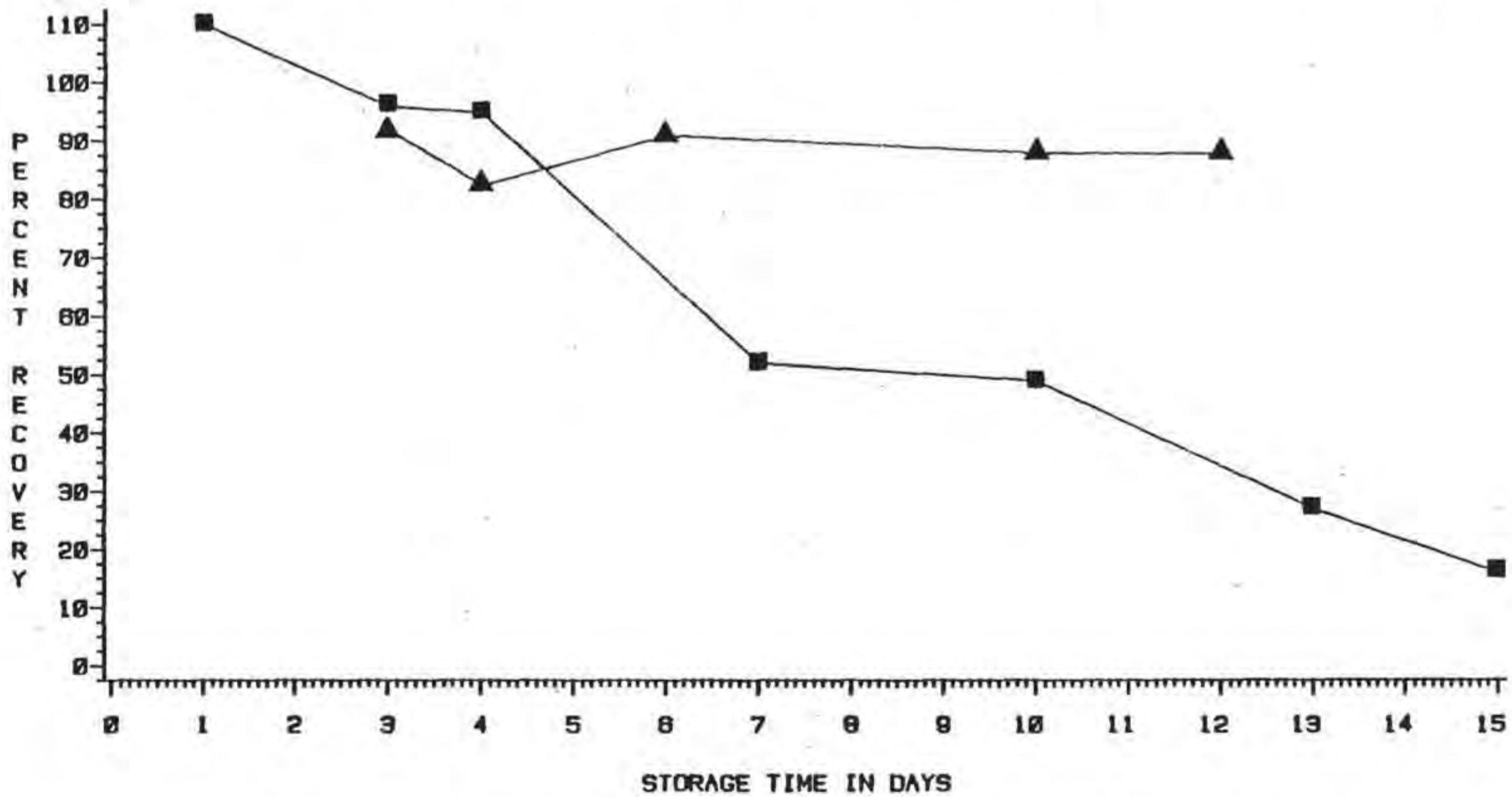
B: Mean difference in sperm counts by hours worked in potentially exposed-DBCP fields.

| Hours | Number | Mean Difference in % of sperm with ovoid morphology between time 1 and time 3 |
|---|---|---|
| None | 28 | 2.1 |
| 1-99 | 17 | 5.0 |
| 100-599 | 20 | 0.4 |
| 600 + | 18 | 4.2 |

Fig. 1


FUMIGANT CONCENTRATIONS AT GROUND LEVEL
CONCENTRATIONS IN PARTS PER BILLION
100000.00
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
CONCENTRATION
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
DAYS AFTER APPLICATION
▲ - DICHLOROPROPENES
● - cis 1,3-DICHLOROPROPENE
■ - 1,2-DIBROMO-3-CHLOROPROPANE

# PERCENT RECOVERY OF DBCP AND DICHLOROPROPENE FROM CHARCOAL TUBES OVER TIME AT 75 DEGREES




▲ - 1,3-DICHLOROPROPENE

■ - 1,2-DIBROMO-3-CHLOR[illegible]OPANE (DBCP)

Fig. 2