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MEMPHIS WOOD PRESERVING COMPANY
HORN LAKE, MISSISSIPPI

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SUMMARY

In July of 1991, the Occupational Safety and Health Administration (OSHA) requested technical assistance from the National Institute for Occupational Safety and Health (NIOSH) in investigating the potential for exposure to arsenic among workers at the Memphis Wood Preserving Company in Horn Lake, Mississippi. OSHA investigators had begun an investigation at this facility in response to a physician report of an elevated urinary arsenic level in an employee. Because the company uses chromated copper arsenate (CCA) as the wood preservative, OSHA believed there was an ongoing potential for arsenic exposure among employees and requested NIOSH to perform biological sampling for arsenic.

On July 24, 1991, NIOSH investigators performed a walk-through inspection of the Horn Lake facility to determine the potential for arsenic exposure. During a return visit on August 7, private interviews were conducted with all nine of the employees, and urine samples were collected following the interviews. At the request of OSHA, interviews and urine samples were also obtained from all but one (14/15) of the employees at another wood preserving company using CCA; the Thomas Wood Preserving Company in Granada, Mississippi. This was done to increase the number of study participants since the employees at the Thomas Wood Preserving Company are similarly exposed. Of these 23 total employees, 17 were laborers, three were clerical personnel, and three were in management.

During private interviews, laborers reported the most frequent exposure to the arsenic-containing wood preservative, followed by management, with clerical personnel reporting the lowest frequency of exposure. Potential routes of exposure were observed to be skin contact, ingestion, and inhalation. Urinary (inorganic) arsenic levels were lowest in samples from the clerical staff, intermediate in the those from management, and highest in the samples from the laborers. However, the difference between the clerical and management levels was not statistically significant. Therefore, results from the clerical and management staff were combined and compared to the labor group's values. The mean urinary arsenic level was found to be significantly higher in the 17 laborers (13 µg per gram of creatinine) than that of the six clerical/management staff ($P<.01$). Levels of urinary chromium and copper were not elevated in either group.

None of the employees (including clerical, management and laborers) reported any symptoms of arsenic overexposure. All of the arsenic levels were less than 50 µg per gram of creatinine, a level below which there are usually no overt symptoms. However, in eleven (48%) of the employees (all from the labor group), inorganic arsenic levels exceeded 10µg/g creatinine, the upper end of the normal range for the general population. Since arsenic is considered to be a cause of skin and lung cancer, NIOSH recommends that exposure be reduced to the lowest feasible level.

The data collected from the employees at the Memphis and Thomas Wood Preserving Companies provide evidence that reported increased contact with the CCA wood preservative used at these facilities is associated with higher levels of urinary arsenic. The clerical and management staff had levels of arsenic within a range that is considered normal for the general population (less than 10 µg per gram of creatinine). Laborers had significantly higher (though probably not toxic) levels (an average of 13 µg per gram of creatinine), and reported more exposure to the CCA than either the clerical or management staff. Specific recommendations are made to decrease arsenic exposure among employees.

Keywords: wood preserving (SIC 2491), arsenic, chromated copper arsenate, biological sampling, cancer.

INTRODUCTION

In July of 1991, the Occupational Safety and Health Administration (OSHA) received a physician report of a high level of urinary arsenic in an employee of the Memphis Wood Preserving Company in Horn Lake, Mississippi. This company uses chromated copper arsenate (CCA), an aqueous arsenical, as a wood preservative. After a preliminary investigation, OSHA requested technical assistance from the National Institute for Occupational Safety and Health (NIOSH) in performing biological sampling for arsenic to assess the arsenic exposure among employees.

BACKGROUND

Facility

The Memphis Wood Preserving Company is a facility where wood is pressure treated with aqueous CCA, a preservative and insect repellant. The company was built in 1987 by OSMOSE Wood Preserving, Inc. (located in Griffin, Georgia) as part of a franchise, and is family owned and operated. OSMOSE supplies the CCA and provides maintenance services to the plant. It consists of a large outside area where wood is stored; a small, one-story office building which houses office staff and electronic equipment to run the treatment process; four holding tanks outside the office building; a large cylinder where wood is treated; and an outdoor, covered concrete area where stacking and initial drying of wood occurs.

On July 24, 1991, NIOSH investigators conducted an initial site visit at the Memphis Wood Preserving Company, at which time a walk-through inspection of the facility was performed. A return visit was made on August 7, 1991 when private medical interviews and biological sampling were conducted with the employees.

Process Description

The following is a description of the process used at the Memphis company. NIOSH investigators did not observe the process at the Thomas company, although we were informed that the two companies use a similar process.

A 50% concentrate solution of CCA (OSMOSE K-33-C, EPA REG. NO. 3008-36) is delivered in bulk by tanker truck from OSMOSE, and is stored in a large holding tank. This solution consists of arsenic pentoxide (17%), copper oxide (9.25%), chromic acid (23.75%) and water (50%). The 50% concentrate solution is diluted with water and stored in two other holding tanks as either a 40% or 25% solution. The 40% solution is used to treat wood that will be placed either below the ground or under water (e.g., a fence post or a dock), and the 25% solution is used for wood that will remain above ground level (e.g., a residential deck). Treatment is controlled electronically from a room adjacent to the main office.

To begin the treatment process, approximately 13,000-15,000 board-feet of wood is loaded onto a rail car called a "tram", secured with metal girders, and pushed into a 62 X 6 foot treatment cylinder with a fork lift. The cylinder is then sealed by closing

the pressure sealing hatch. A vacuum is pulled for 3-4 minutes inside the cylinder to draw moisture from the wood cells and prepare the wood to absorb the preservative. The dilute preservative solution is then pumped into the cylinder from the holding tank, and the cylinder is pressurized to 140 pounds/inch^2 (psi) for short durations until the wood is saturated with the chemical (approximately 20 minutes). The treatment solution is then pumped back into the storage tank for reuse. A final vacuum is drawn on the cylinder for approximately 27 minutes to pull out excess liquid. Finally, the cylinder is opened and the tram is pulled from the cylinder with a fork lift attached to a steel wire cable extending the full length of the tram unit. The newly treated wood is unloaded from the tram with the fork lift and stacked on the covered concrete area to drip dry for 36-48 hours. It is then moved off of the concrete area into the open field. The finished product is shipped out as soon as 48 hours after treatment.

Arsenic

The arsenic in the CCA wood preservative is an inorganic arsenic compound, arsenic pentoxide. Compounds of inorganic arsenic produce the following health effects: dermatitis (skin inflammation), keratoses (horny growths on the skin), peripheral neuropathies (diseases of the nerves of the extremities), peripheral vascular diseases (diseases of the arteries and veins of the extremities), and cancer of the skin, liver, and lungs.[1] Arsenic compounds are mainly absorbed via the respiratory and gastrointestinal routes. Over 90% of the ingested amount of water soluble compounds in humans and animals is absorbed. Oral ingestion from contaminated hands may result in absorption of toxicologically significant amounts of arsenic.[2] In addition, experiments on rats have shown that arsenic in aqueous solutions can penetrate through intact skin.[3]

The major elimination pathways of inorganic arsenic are metabolism and urinary excretion. The total amount excreted in urine accounts for about 60% of the absorbed amount.[4,5] Inorganic arsenic metabolites appear in urine shortly after the start of exposure. The concentration rises slowly during the first days of the exposure, and then levels off.[5] If a worker's exposure on following days is similar, the arsenic concentration in urine remains more or less the same.

Arsenic is present in water, food and polluted air.[6] Smoking is also a source of exposure to arsenic (12 to 42 µg per cigarette).[7] Therefore, it is found in the urine of people who have no occupational exposure to arsenic. Concentrations of inorganic arsenic and its metabolites in the urine of the general population are usually below 10 micrograms per gram (µg/g) of creatinine*.[8]

NIOSH recommends that arsenic and all its inorganic compounds be controlled and handled as potential human carcinogens in the workplace, and that exposure be

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* Since arsenic concentrations in urine are dependent on urine output, creatinine determination in the same specimen is necessary because creatinine is usually excreted at a constant rate.[1]

reduced to the lowest feasible limit. The NIOSH recommended exposure limit (REL) for arsenic and all its inorganic compounds is 2 micrograms of arsenic per cubic meter ($\mu g/m^3$) of air as a ceiling concentration determined in any 15-minute sampling period.[9] The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for inorganic arsenic is 10 $\mu g/m^3$ of air as a time-weighted average (TWA) over an 8-hour workshift.[10] The American Conference of Governmental Industrial Hygienists (ACGIH) has recently recommended a biological exposure index (BEI) of 50 µg of arsenic per gram of creatinine.[1] This BEI was based on a review of data that showed that preclinical effects from arsenic exposure can occur at urinary concentrations as low as 71 µg. The choice of 50 was considered reasonable to allow a margin of safety.

METHODS

Environmental

Sampling for airborne arsenic was not performed by NIOSH because this had already been done by OSHA investigators. Therefore, a visual inspection was performed to assess the likelihood for non-airborne exposures to the CCA, such as skin contact or ingestion. NIOSH conducted a walk-through inspection of the office building, the cylinder control room, the treatment cylinder, the CCA and water storage tanks, the worker break facility, and the wood loading, unloading and drying areas. The OSHA sampling data was reviewed.

Medical

The medical evaluation was conducted with employees at the Horn Lake facility and, at OSHA's request, at another CCA-using wood preserving company owned by the same family, the Thomas Wood Preserving Company in Granada, Mississippi. Private medical interviews were conducted with all but one (23/24) of the employees, and urine samples were collected following the interviews. In addition, an interview and urine sample were obtained from the "index case" (the person who was initially found to have a high urinary arsenic level, prompting the OSHA investigation) who no longer worked at the facility.

The urine samples were collected privately by each individual and transferred into preservative-containing plastic bottles supplied by the analyzing laboratory. They were shipped by overnight mail to the laboratory. The method for arsenic analysis was specific for inorganic arsenic and its metabolites (methylarsonic acid and cacodylic acid). Urine samples were also analyzed for levels of chromium and copper since these compounds are also present in the CCA wood preservative.

Based on interview data, the workers were divided into two exposure categories. To assess the potential for work-related exposure to arsenic, mean urine arsenic levels were compared between these two groups using the Student's T-test.

OSHA 200 logs were not available to review because the company did not maintain them.

RESULTS

Medical

A total of 24 people submitted urine samples for arsenic evaluation. The index case's results were excluded from the analyses because he was not a current employee.

The remaining 23 persons included in the analyses consisted of three clerical staff (all female), three management staff (all male), and 17 laborers (all male). Table 1 shows the mean (average), standard deviation, and range of urine arsenic values for these groups. The clerical and management staff results were combined because their arsenic levels were not significantly different from each other. Analysis of mean urine arsenic levels using the Student's T-test revealed that clerical and management personnel had significantly lower levels of urinary arsenic than laborers ($P<.01$).

In the private interviews, clerical staff reported the least contact with the CCA, labor the most contact, and management an intermediate amount of contact. Several of the laborers reported having climbed into the treatment cylinder for repair or other procedures, at times when the cylinder was still filled with wood. Some reported that their clothing and skin would become soaked with the CCA material when this occurred. The reported levels of contact coincide with the levels of urinary arsenic found in the three groups (see Figure 1), suggesting that urinary arsenic levels increase with increased exposure to the CCA at work. The labor group, however, contained more smokers (77%) than the clerical/management group (33%). None of the employees reported any symptoms of arsenic exposure.

The levels of chromium and copper in the urine samples submitted by the 23 employees were all within normal limits. Table 2 shows the normal values for these substances and for arsenic, and the ranges of values found in the employees.

Exposure Potential

Dermal (skin) contact with the chemically treated wood is possible during removal of the wood stack from the cylinder, especially if the steel cable breaks and has to be reattached. Also, several of the metal girders were noted to snap open during treatment or removal of the wood stack. These are replaced or reattached by hand after removal of the wood from the cylinder, allowing for contact with wet wood. During the NIOSH site visit, wrist-length rubber gloves and rubber aprons were worn by persons handling the wood. Exposure to the upper arms was occurring because workers frequently used their shoulders and upper body to push the heavy, wet stacks of lumber.

Ingestion of arsenic may result if hand-to-mouth contact occurs after handling wood or touching contaminated surfaces. Smoking and eating were allowed in the work area, and several employees were observed eating and/or smoking while operating the fork lift and while loading or unloading wood. The worker break room is next to the concrete drying area, where wood chips and other debris are swept up two times per

week. Dust from the sweeping operation, or dust transported by the wind, could contaminate food surfaces inside the break room. Arsenic was detected in wipe samples taken by OSHA from eating surfaces inside this room. Smoking and eating are activities that promote ingestion of any CCA that may be present on hands.

Inhalation of arsenic particles may occur during the twice-weekly sweeping of the concrete drying area. Bulk samples of debris collected by OSHA from the concrete drying area contained 5% arsenic. Dust swept from the drip-dried wood is likely to become airborne, either during the sweeping process or during windy weather. No air samples were collected during the dry-sweeping task, but personal air samples collected by OSHA during other tasks showed arsenic levels from 2.9 to 6.6 $\mu g/m^3$. The dry-sweeping procedure is likely to generate much higher airborne arsenic concentrations.

There were no eye wash stations at the facility. A shower was located in the office building, but it was filled with cleaning paraphernalia and office supplies, making it inaccessible in an emergency. Training and education with regard to the hazardous chemicals used at this facility consist of having the employee read material safety data sheets (MSDS) and sign their name as an indication that they have done so. Worker turnover rate is high, and shift work is utilized in accordance with customer demand for treated wood.

DISCUSSION AND CONCLUSIONS

The urinary arsenic levels found in the employees at the Memphis and Thomas Wood Preserving Companies is consistent with exposure to the CCA wood preservative used at these facilities. The clerical and management staff had levels of arsenic within a range that is considered normal for the general population, (less than 10 µg per gram of creatinine). Laborers had levels significantly above the clerical/management level (an average of 13 µg per gram of creatinine), and reported more exposure to the CCA than either the clerical or management staff. None of the employees (including clerical, management and laborers) reported any symptoms of arsenic overexposure. This is not unusual since all of the levels were less than 50 µg per gram of creatinine, a level below which there are usually no overt symptoms. However, cancer in its early stages is often not associated with overt symptoms. Since arsenic is considered to be a cause of skin and lung cancer, NIOSH recommends that exposure be reduced to the lowest feasible level. In this instance, the lowest feasible level would correspond to urine arsenic levels below 10 µg per gram of creatinine, preferably within the range of the unexposed clerical staff (a mean of 2.3 µg per gram of creatinine).

A route of exposure that was not addressed by this NIOSH investigation, but nevertheless is of concern, is exposure away from the work site. High levels of arsenic in dust have been found in the homes of workers with occupational exposure to arsenic wood preservatives.[11] The likely cause for this is contamination of clothes, skin, hair, etc. Exposure of young children to arsenic in the home is of particular concern because of their natural hand-to-mouth tendencies. Work uniforms are available at the Memphis Wood Preserving company, but at a cost of $8.00 per week to the employees. At the time of this investigation, only two employees had elected to purchase the uniforms, and these employees wore their uniforms

home. In addition, there are no accessible shower facilities for the workers to use prior to going home, nor does the company provide a changing room with separate lockers for street clothes and work clothes. Shoes, another potential source for household contamination, are not provided by the company, and there is no requirement for work shoes to remain at work.

RECOMMENDATIONS

1. Under no circumstances should a person be allowed to enter the cylinder while the cylinder is loaded with wood. The limited space between the wood and the walls of the cylinder, and the 60-foot length makes a workable rescue plan virtually impossible. Other means should be employed to remove trams if there is cable detachment.

2. Clean, impervious upper body clothing and gloves should be worn while handling the wet, freshly treated wood. Means should be made available to rinse and clean the protective clothing after use. If protective equipment is not cleaned, it will quickly become contaminated and possibly exacerbate dermal contact. The workers should also be trained to recognize when the protective clothing should be replaced.

3. Frequent washing of hands should be required, especially before eating or smoking cigarettes. A clean, accessible washing area should be provided.

4. An outside door should be added to the wash room so workers can enter without passing through the worker break room.

5. The break room door should be routinely kept shut to prevent arsenic contaminated windblown dust from entering. Eating surfaces inside the break room should be cleaned at least daily.

6. Smoking, eating food, or drinking liquids should not be allowed during those parts of the treatment process that may expose the workers to the wood treatment formulation (e.g., manually opening/closing the cylinder doors, moving trams out of the cylinder, or handling the freshly treated wood).[12] Ideally, these activities should not be allowed anywhere on the grounds where there is potential for exposure to CCA.

7. A safe method to clean the dried treatment chemicals from the concrete pad must be implemented. We recommend that the company hire a professional industrial hygiene consultant to observe the dry sweeping task and perform analytical sampling for airborne arsenic levels. Suggestions and limitations include:

    a) Wet cleaning, rather than dry sweeping, which would minimize airborne dust. However, liquid hazardous waste would be generated during this process and proper disposal would be required.

    b) A high-efficiency particulate air (HEPA)-filtered vacuum system is preferred over dry sweeping, although it may be impossible to maintain the equipment because the concrete pad is outside and rain water or foreign

debris could easily damage the HEPA filter. In addition, attention to the proper disposal of the dust collected by the vacuum system would be required.

c) A central vacuum system with several hook-up ports distributed throughout the concrete pad could be installed. This would allow collecting the dried preserving chemicals in a central location. Precautions designed to prevent employee exposure to arsenic-containing dust must be taken when servicing any such system and when disposing of the materials collected.

d) If dry sweeping the concrete pad is continued, precautions need to be taken to limit exposure. Because the concentration of airborne arsenic generated during the dry sweeping operation has not been determined, the employer must require the sweeper to wear a properly fitted, well-maintained, high efficiency filter respirator which has been MSHA[**]/NIOSH-approved for inorganic arsenic. Details on the implementation of a respiratory protection program can be found in the OSHA regulations outlined in 29 CFR 1910.134. Hooded, disposable Tyvex™ coveralls should also be worn by the sweeper to prevent arsenic-contaminated dust from collecting on the employee's hair and clothing.

8. Work clothes should be provided by the employer at no charge to the employee, and the clothes should be cleaned professionally on a daily basis by a laundry equipped to handle industrial clothing.

9. Work clothing and work shoes/boots should remain at the plant. Under no circumstances should work clothing/shoes/boots be worn in employees' automobiles or brought into their homes.

10. A changing area, including a shower, should be provided for employees. The changing area should be equipped with double lockers for separation of employee work clothes and street clothes.

11. Rubber boots that are impervious to the wood preservative should be supplied at no charge to the employee, and worn for work on the concrete pad. The boots should be cleaned daily.

12. An emergency shower and eye wash stations should be installed as soon as possible. These must be free from obstruction and not used for any purpose other than that intended (e.g., no storage of office supplies).

[**] Mine Safety and Health Administration

13. A local hospital should be informed as to the operation conducted at the Memphis and Thomas Wood Preserving Companies and, in the case of exposure requiring medical care, employees should be instructed to inform the health care personnel that they work with an arsenic-containing chemical.

14. Up-to-date and accurate work-related injury and illness records should be maintained in accordance with OSHA requirements.

15. A complete hazard communication program should be implemented. Management should also be informed of the health hazards associated with aqueous arsenical wood preserving chemicals.

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Copies of this report have been sent to:

Management at the Memphis and Thomas Wood Preserving Companies
Occupational Safety and Health Administration

For the purposes of informing the affected employees, copies of the report should be posted in a prominent place accessible to the employees, for a period of 30 calendar days.

Table 1
Urine Arsenic Levels in Employees at the Memphis and Thomas Wood Preserving Companies
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Group	Number in Group	Mean (Average)*	Standard Deviation*	Range*
Clerical	3	2.3	1.2	1-3
Management	3	3.6	0.6	3-4
Labor	17	13.0**	7.6	2-28
Clerical + Management	6	3.0**	1.1	1-4

* All values are measured in micrograms of arsenic per gram of urinary creatinine.
** The level of significance for the difference between the labor group mean and the clerical+management group mean is P<.01 (Student's T-test).

Table 2
Urinary Chromium, Copper, and Arsenic: Normal Values and Values in Memphis and Thomas Wood Preserving Companies' Employees
HHE # 91-314 August 7-8, 1991

Substance	Normal Levels	Range in Employees
Arsenic *	<10	1-28
Chromium *	<5	0.3-2.0
Copper **	<70	20-40

* Values are measured in micrograms of per gram of urinary creatinine.
** Values are measured in micrograms per liter of urine.