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Hadley, Massachusetts

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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by David C. Sylvain, CIH, of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Edward A. Kaiser, Ph.D. Analytical support was provided by DataChem Laboratories, and Ardith Grote, Division of Physical Sciences and Engineering (DPSE). Desktop publishing was performed by Pat Lovell. Review and preparation for printing was performed by Penny Arthur.

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Health Hazard Evaluation Report 97-0113-2720
U. S. Fish and Wildlife Service
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David C. Sylvain, CIH

SUMMARY

In February 1997, the National Institute for Occupational Safety and Health (NIOSH) received a request from the U. S. Fish and Wildlife Service (USFWS) Northeast Region, for an evaluation of formaldehyde and methanol exposure at fish hatcheries where eggs are treated with formalin to control infection by *Saprolegniaceae* fungi. Although no health problems or concerns had been reported by fish hatchery employees, the USFWS was interested in assessing the potential for employee exposure to formalin while using manual and automated treatment systems at hatcheries throughout the Northeast Region.

Between November 1997 and January 1998, site visits were conducted at North Attleboro, Pittsford, White River, Craig Brook, and Green Lake National Fish Hatcheries. Exposure to formaldehyde was evaluated during manual treatment at North Attleboro, Pittsford, and Craig Brook; and during automated treatment at White River, Green Lake, and Craig Brook (Craig Brook used manual and automated methods). Exposure to methanol was evaluated at North Attleboro, Pittsford, and White River.

Air sampling revealed formaldehyde concentrations in excess of the NIOSH recommended exposure limit (REL) and the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs®) at all hatcheries using manual methods to apply formalin treatments to salmon eggs. The Occupational Safety and Health Administration's (OSHA) short-term exposure limit (STEL) was exceeded during the first round of sampling at North Attleboro. At each of the hatcheries where manual methods were used, the highest observed concentration occurred while formalin was being transferred from a 55-gallon drum into small containers, usually plastic jugs. The extent of worker exposure during transfer depended on the amount of formalin dispensed, type of transfer equipment (e.g., electric pump, hand pump, gravity-flow via a spigot), and worker technique/skill. In addition to exposure to airborne formaldehyde during routine handling, these tasks present the risk of dermal contact due to accidental splashes or spills. Although personal protective equipment (PPE) was used at all hatcheries, it was not always selected or used correctly.

Automated egg treatment systems reduce routine employee exposure by eliminating manual handling of formalin, and by containing formalin within an enclosed system during transfer and dilution. Formaldehyde exposures during automated treatment did not exceed the TLV or OSHA STEL; however, concentrations *may* have exceeded the NIOSH ceiling of 0.1 parts per million (ppm) at two of three hatcheries where automated systems are used.

Methanol exposures were well-below all exposure guidelines and limits at all hatcheries where methanol sampling was conducted.

Formaldehyde concentrations exceeded the REL and TLV at all hatcheries where manual methods were used to treat salmon eggs with formalin. The OSHA STEL was exceeded during manual treatment at one hatchery. Formaldehyde exposures during automated treatment did not exceed the TLV or OSHA STEL. It appears that much of the routine exposure to formaldehyde during manual treatment could be eliminated by installation of a well-designed automated system at each hatchery where manual methods are used. An effective PPE program, training program, and ongoing exposure monitoring are needed at hatcheries where formalin, or other hazardous materials are used.

Keywords: SIC 0921 (Fish Hatcheries and Preserves). Formaldehyde, formalin, methanol

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INTRODUCTION

In February 1997, the National Institute for Occupational Safety and Health (NIOSH) received a request from the U. S. Fish and Wildlife Service (USFWS) Northeast Region, for an evaluation of formaldehyde and methanol exposure at fish hatcheries where eggs are treated with formalin to control infection by *Saprolegniaceae* fungi. Although no health problems or concerns had been reported by fish hatchery employees, the USFWS was interested in assessing the potential for employee exposure to formalin while using manual and automated treatment systems at hatcheries throughout the Northeast Region.

Between November 1997 and January 1998, a NIOSH investigator and the USFWS Regional Industrial Hygienist, conducted site visits at five USFWS National Fish Hatcheries (NFH). Differences between the methods of operation at the various hatcheries necessitated the evaluation of multiple sites.

BACKGROUND

Federal fish hatcheries produce millions of salmon that are released into New England rivers. Since the mid-1970's, the USFWS Northeast Region has operated a program to restore Atlantic salmon (*Salmo salar*) populations in New England rivers. Prior to the construction of dams, and overfishing during the 1800's, major populations of Atlantic salmon were found in the Merrimack, Connecticut, and Penobscot Rivers. The salmon restoration program has worked to restore populations in these rivers for a number of years, and has been expanded to include several smaller Maine rivers, and the Pawcatuck River in Rhode Island.

Some of the major activities involved in salmon restoration include capturing sea-run salmon, artificial spawning, incubating and hatching eggs, growing fish to the appropriate stage for release, releasing fish into rivers, and reconditioning previously spawned, sea-run adults (kelts).

According to literature provided by one formalin distributor, formalin has been used in fish production since 1909. Formalin used in hatcheries contains 37% formaldehyde, 6-15% methanol, and “inert ingredients.” In addition to its use in controlling fungi on eggs, formalin is used prophylactically to control parasites on salmonids, catfish, largemouth bass, and bluegill.

During incubation, salmon eggs are kept in stacks of trays where running water flows continuously over the eggs, and down the stack from tray to tray. The water passes through the stacks of trays only once: it is not recirculated. To control fungal infection, formalin is added periodically to provide a 15-minute flowthrough treatment of 1666 parts per million (ppm). The quantity of formalin used depends upon factors such as, water flow rate, number of stacks, and frequency of treatments. Formalin treatments can be applied using either manual or automated methods. Manual applications involve dispensing formalin from a 55-gallon drum into a small container(s), measuring-out specified quantities of formalin, diluting formalin with water, adding the dilute formalin to dispensers (“chicken waterers”), and hanging one chicken waterer over each stack of egg trays until the contents are drained. Automated treatments are applied using a pump to transfer formalin to a tank where it is diluted, and then piped to the trays. Neither of these methods is performed the same way at all hatcheries. The manager of each hatchery designs a disinfection procedure to suit the physical layout and disinfection requirements of the hatchery: this has resulted in a variety of procedures for handling formalin, and use of personal protective equipment (PPE).

North Attleboro NFH

The North Attleboro National Fish Hatchery (NFH), which was constructed in 1952, supplies salmon eggs to the Connecticut River restoration program. The incubation facility (“egg room”) can hold up to five million eggs in 42 stacks of egg trays, which are tended by three employees. Prophylactic formalin treatments are applied every other day for approximately three months, starting in mid-October.

At the time of the November site visit, formalin treatments were prepared and applied as follows: (1) in the furnace room, one of three hatchery employees dispenses 37% formalin from a 55-gallon drum into eleven or twelve one-gallon jugs using an electric pump; (2) in the hatchery room, measured amounts of formalin were added to chicken waterers using a graduated cylinder; (3) formalin was diluted with water; (4) chicken waterers were hung in the egg room where the contents emptied into egg trays during a 15-minute period. No employees remained in the room during the treatment. In November, PPE worn during this procedure consisted of a full-face negative-pressure respirator and disposable latex gloves. Formalin is not dispensed into jugs at the time of each treatment: the quantity that is dispensed will last approximately two weeks.

In December 1997 (between the time of the first and second NIOSH site visits), the formalin drums were moved from the furnace room to the "UV gallery." The electric pump, which had been used during the first visit, was no longer used: formalin was dispensed by gravity-flow into gallon jugs. During the January 1998 visit, PPE consisted of a full-face air-purifying respirator, full rain gear (splash protection), rubber boots, and Viton™ gloves. Other treatment operations (e.g., formalin measurement and dilution) were the same during both visits.

Pittsford NFH

Approximately 720,000 salmon eggs were incubated in the "tank room," which is located in the lower level of the main building. Formalin treatments are applied on alternate days from October through January. Treatments are applied manually to 18 stacks of egg trays using chicken waterers. The process consists of: (1) adding 600 milliliters (ml) of water to each of 12 chicken waterers; (2) dispensing 189 (ml) of 37% formalin from a gallon jug into a graduated cylinder, and adding it to a chicken waterer (this is repeated for each waterer); (3) hanging a waterer over each of 12 stacks of egg trays (person leaves the tank room after hanging the waterers); (4) after the waterers have drained, adding water and formalin to six waterers, and hanging the waterers above the six untreated stacks; (5) removing and rinsing the used chicken waterers; (6) refilling the formalin jug in preparation for the next treatment (37% formalin is dispensed into the jug via a self-closing spigot on a 55-gallon drum). PPE consisted of Playtex Argus® gloves, splash-resistant goggles, and apron (respiratory protection was not used).

Craig Brook NFH

Salmon have been produced at the Craig Brook hatchery since 1871. Early restoration efforts focused on restoring the salmon population in Maine's Penobscot River, where the salmon population was decimated in the 1800's. In addition to restoration efforts in the Penobscot, Craig Brook NFH initiated a program in 1992 which involves capturing and spawning wild salmon from several Maine rivers, and raising each river's fry separately. The fry are then returned to the river of their origin to augment the wild salmon stock.

Eggs from each of six Maine rivers are incubated in separate rooms ("bays"). Five bays, located in the receiving building, each contain five or six stacks of egg trays which are treated manually. The Penobscot bay, which contains 16 stacks of trays, is equipped with an automated treatment system.

Manual treatment involves a process which is similar to that in other hatcheries: (1) approximately three gallons of 37% formalin is hand-pumped into a carboy from a 55-gallon drum which is located in the receiving building mechanical room; (2) the carboy is taken to the bays where 285 ml is added to each chicken waterer (each waterer had been previously filled with water to a specified level—one waterer per stack); (3) waterers are placed above each stack, and drain for 15-minutes. PPE, which was worn by the person who pumped, measured, and dispensed formalin, consisted of rubber gloves, and a full-face air-purifying respirator. Another person, who assisted in placing the waterers above the stacks, wore no PPE.

At the time of the health hazard evaluation (HHE), 8 of the 16 stacks in the Penobscot incubation room were being treated using the automated system. A chemical transfer pump moves 37% formalin from a 55-gallon drum, located in the basement, into a Nalgene tank which is located above the stacks in the incubation room. The operator watches the formalin level through an observation window in the tank, and turns-off the pump when the desired level is reached (in this case, 2.4 liters). After formalin has been added, a water valve is opened to bring the solution up to the specified level. A valve at the bottom of the tank is opened, and the dilute solution is gravity-fed to the stacks of egg trays. The operator wears no PPE while operating the automated system.

White River NFH

White River NFH was constructed as the primary federal facility for producing salmon for the Connecticut River restoration program. The hatchery raises fish from fertilized eggs for release as one-year smolts, or as fry which will develop into smolts after two-years in the river.

At the time of the HHE, approximately 9.5 million salmon eggs were being incubated in approximately 66 stacks of egg trays in two "egg rooms." Automated formalin treatments are applied on alternate days from October into April. The process consists of: (1) emptying leftover, diluted formalin from the "mix tank" into a floor drain; (2) using an electric pump to transfer 37% formalin into the mix tank (8.5 gallons was pumped during the HHE); (3) adding a specified amount of water; (4) using an air compressor to pressurize the mix tank to 6.5 pound per square inch (psi); (5) opening a valve so that dilute formalin moves up through system plumbing to the stacks. There is a pressure relief valve on the mixing tank which was reportedly set at an estimated pressure of 15 psi. The maximum air pressure that could be produced by the air compressor was set at 50 psi, but could reach 100 psi if the setting were changed. No PPE was worn while operating this system; however, the operator wore gloves while filling and handling a 500 cubic centimeter (cc) intravenous bottle that was used to treat one stack of trays.

Green Lake NFH

Atlantic salmon have been raised at Green Lake NFH since 1974. Smolts and parr (3-5" fish) produced at Green Lake are released into Penobscot, St. Croix, Merrimack, and Saco watersheds.

The incubation room has a capacity of 2.7 million eggs, and is equipped with an automated treatment system which is used to apply formalin from November through January. The system consists of an electric-powered chemical transfer pump which is actuated by a switch in the incubation room. The pump transfers 37% formalin from a 55-gallon drum, located in the mechanical room, to two overhead Nalgene mixing tanks in the incubation room. Each tank serves two rows ("sections") of stacked egg trays. A system of valves allows the operator to fill one or both tanks, and to select the section(s) that will be treated. The formalin transfer system includes a bypass valve to prevent spillage in the event that the operator fails to open a valve between the pump and one of the Nalgene tanks. (The bypass valve would route the formalin back to the 55-gallon drum.) Hatchery staff reported that the supplier of system components (pump, plastic pipe, tubing, valves, controls, etc.) was consulted to ensure that the components would be compatible with formalin.

Formalin treatments are applied by: (1) setting valves to fill the desired Nalgene mixing tank; (2) pumping 37% formalin into the selected mixing tank; (3) opening a water valve to fill to the mark; (4) open a valve on the mixing tank to gravity-feed dilute formalin to eggs for 15-minutes. For Sections A, B, and C, 4.2 liters of 37% formalin is diluted with 52.99 liters of water for each section; for Section D, 3.0 liters of formalin is mixed with 37.85 liters of water. (Sections A and D were treated during the site visit.) PPE is not worn while operating this system.

METHODS

In November and December 1997, site visits were conducted at North Attleboro, Pittsford, and White River National Fish Hatcheries. During these visits, personal breathing zone (PBZ) and area air samples were collected to evaluate employee exposure to formaldehyde and methanol while preparing and administering prophylactic egg treatments. The sampling strategy used during January 1998 visits to Craig Brook, Green Lake, and a repeat visit to North Attleboro, was modified to prevent the overloading of formaldehyde sample media (encountered during analysis of the first sample set). Since the results of the first sample set indicated very low exposure to methanol, methanol sampling was not conducted during the January site visits.

During sampling visits to the first three hatcheries, each formaldehyde sample was collected using a battery-powered sampling pump to draw air through a single cartridge containing 350 milligram (mg) of silica gel coated with 2,4-dinitrophenylhydrazine (DNPH). Pumps were operated at a nominal flow rate of 1.0 liters per minute (lpm), and were calibrated before and after sampling to ensure that the desired flow rate was maintained throughout the sampling period. Formaldehyde samples were analyzed by high performance liquid chromatography (HPLC) according to NIOSH draft Method 2016 (modified). Methanol samples were collected using solid sorbent tubes (uncoated silica gel) at nominal flow rates of 0.2 lpm for PBZ samples, and 0.15 lpm for area samples. Methanol samples were analyzed by gas chromatography according to NIOSH Method 2000 (modified) (NIOSH Manual of Analytic Methods, Fourth Edition, 8/15/94).

At Craig Brook and Green Lake NFH, PBZ and area formaldehyde samples were collected using two DNPH cartridges in series, at a nominal flow rate of 1.0 lpm. Additional area samples were collected alongside DNPH area samples, to help ensure that at least one formaldehyde sample would be obtained in each area if the DNPH cartridges became overloaded. The additional samples were collected using two midget impingers in series, each containing 20 ml of 1 percent sodium bisulfite solution. The nominal flow rate for these samples was 0.5 lpm. Impinger samples were analyzed for formaldehyde by visible spectroscopy according to NIOSH Method 3500 (NIOSH Manual of Analytic Methods, Fourth Edition, 8/15/94).

During the repeat visit to North Attleboro, PBZ and area formaldehyde samples were collected using two DNPH cartridges in series, at a nominal flow rate of 0.5 lpm. Side-by-side area samples were collected using two midget impingers in series, each containing 20 ml of 1 percent sodium bisulfite solution. The nominal flow rate used to collect impinger samples at North Attleboro was 0.25 lpm. No methanol sampling was conducted during the second round of sampling at North Attleboro.

EVALUATION CRITERIA

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

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[1] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[2] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[3] NIOSH encourages employers to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard.

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

Formaldehyde

Formaldehyde and other aldehydes may be released from foam plastics, carbonless copy paper, particle board, and plywood. Formaldehyde is a constituent of tobacco smoke and of combustion gases from heating stoves and gas appliances. This chemical has also been used in the fabric and clothing industry to impart permanent press characteristics, in the manufacturer of some cosmetics, and in disinfectants and fumigants. Formaldehyde in ambient air can result from diverse sources such as automobile exhaust, combustion processes, and certain industrial activities such as the production of resins.

Exposure to low concentrations of formaldehyde may result in irritation of the eyes, nose, and throat; headaches, nausea, nasal congestion, skin rashes, and asthma-like symptoms. It is often difficult to ascribe reports of symptoms to specific concentrations of formaldehyde because people vary in their subjective responses and complaints. For example, eye irritation may occur in people exposed to formaldehyde at concentrations below 0.1 ppm. Upper airway irritation may occur at 0.1 ppm, but more typically begins at exposures of 1.0 ppm and greater.[4] Some children or elderly persons, those with pre-existing allergies or respiratory disease, and persons who have become sensitized from prior exposure may have symptoms from exposure to concentrations of formaldehyde between 0.05 and 0.10 ppm. Cases of formaldehyde-induced asthma and bronchial hyperreactivity developed specially to formaldehyde are uncommon.[5]

In two studies, formaldehyde induced a rare form of nasal cancer in rodents. Formaldehyde exposure has been identified as a possible causative factor in cancer of the upper respiratory tract in a proportionate mortality study of workers in the garment industry.[6] NIOSH and ACGIH have designated formaldehyde as a suspected human carcinogen and recommend that exposure be reduced to the lowest feasible concentration.[1,4] NIOSH has established the REL for formaldehyde at the lowest concentrations that can be reliably quantified: 0.016 ppm for up to a 10-hour TWA exposure, and 0.1 ppm as a 15-minute ceiling concentration. ACGIH has set the TLV for formaldehyde at 0.3 ppm as ceiling limit. The TLV is intended to reduce worker reports of sensory irritation.[4]

The OSHA general industry formaldehyde standard (29 CFR 1910.1048), sets the PEL for airborne exposure to formaldehyde at 0.75 ppm as an 8-hour TWA and 2 ppm as a STEL. The standard specifies requirements for exposure monitoring, medical surveillance, hazard communication, housekeeping, and recordkeeping. In addition, the OSHA standard requires that workers be informed that formaldehyde is a potential cancer hazard.

Methanol

Methanol, also known as methyl alcohol, is a common industrial solvent. Methanol can enter the body by ingestion, inhalation of vapors, and absorption of liquid through the skin. Many instances of blindness and/or death have been reported as a result of accidental methanol ingestion. Although less common than poisoning due to ingestion, chronic poisoning due to repeated exposure to high concentrations of methanol vapor has resulted in conjunctivitis, headache, giddiness, insomnia, gastric disturbances, and blindness.[4] Other symptoms of overexposure include blurred vision, constricted visual field, shortness of breath, dizziness and vertigo.[7]

The NIOSH REL and ACGIH TLV for methanol are a STEL of 250 ppm, and an 8-hour TWA of 200 ppm. The TLV and REL include a skin notation, which indicates the potential for dermal absorption. The OSHA PEL has been established as an 8-hour TWA of 200 ppm, without a STEL or skin notation.

RESULTS

Formaldehyde

Table 1 summarizes concentrations in samples collected at hatcheries where formalin treatments are applied manually. Table 2 contains data collected during automated formalin applications.

Manual Treatment

PBZ samples were collected to assess total worker exposure throughout all phases of manual application (i.e., dispensing, measuring, diluting, filling chicken waterers, cleaning-up). These "full-period" samples revealed TWA concentrations ranging from approximately 0.6 ppm to >3.8 ppm during 21 to 33-minute sampling periods at North Attleboro NFH on November 25, 1997. The actual upper limit of the range is not known because of overloading and breakthrough.

PBZ sampling also assessed worker exposure during a number of specific operations during manual application. PBZ sampling indicated that the highest short-term concentration was >5.3 ppm during a 13-minute period, while formalin was being pumped from a 55-gallon drum into 1-gallon jugs at North Attleboro NFH. As occurred during "full-period" sampling at this hatchery, the high concentration of airborne formaldehyde overloaded the sampler; thus, the actual concentration is not known, but is believed to be significantly greater than 5.3 ppm. These results are consistent with two area samples, collected in the furnace room (where pumping occurred), which were also overloaded.

A second round of sampling was conducted following changes in the method and location of dispensing formalin at North Attleboro. During the second visit, a PBZ concentration of 0.3 ppm was measured while formalin was dispensed from a 55-gallon drum during a 16-minute period. The other samples indicated concentrations similar to those found during the first round of sampling.

At Pittsford NFH, the dispensing of formalin from a 55-gallon drum into a gallon container resulted in a concentration of 2.2 ppm during a 3-minute PBZ sample. (A separate PBZ sample to identify exposure during dispensing was not collected at Craig Brook.)

The only samples which characterize exposure while formalin is measured into chicken waterers (i.e., measuring only), were collected at North Attleboro. On November 25, 1997, 1.8 ppm was measured during a 10-minute period; on 1/21/98, 1 ppm was measured during a 15-minute period. This operation did not change between visits.

Area samples were collected in egg incubation rooms during the actual treatment of the eggs, and for an additional ≈40-70 minutes thereafter. Workers did not remain in the rooms during the 52- to 86-minute periods while these samples were collected. Formaldehyde concentrations in incubation rooms ranged from 0.08 to 0.59 ppm. Despite apparent discrepancies between some side-by-side area samples, it appears that the median value of 0.04 ppm provides a reasonable estimate of formaldehyde concentrations during and after treatment. (The geometric mean concentration was not calculated because the data does not appear to fit a log-normal distribution.)

Automated Treatment

Formaldehyde concentrations, determined by PBZ sampling during automated applications, ranged from <0.07 ppm during a 9-minute period at Craig Brook, to 0.3 ppm during a 44-minute period at Green Lake. It should be noted that area samples collected on DNPH cartridges at Green Lake ranged between 0.1 and 0.3 ppm, while corresponding results for impinger samples were below the limit of quantitation. The reliability of these results (and the PBZ result) is called into question by a DNPH quality control (QC) sample that the laboratory reported as containing a quantifiable amount of formaldehyde: 15 micrograms (µg) was reported in the quality control sample, which was never opened or taken to a hatchery. The discrepancy between side-by-side sample results, in addition to the laboratory report of quantifiable amounts of formaldehyde in one of four QC samples, creates a degree of uncertainty regarding the *true* concentrations present at Green Lake, including the PBZ sample: it appears that the 0.3 ppm concentration measured in the Green Lake PBZ sample (collected with a DNPH cartridge) may overestimate worker exposure. Nothing was observed during the sampling period that could account for the 0.3 ppm readings at Green Lake: the person who operated the automated system did not handle formalin, nor did he remain in the incubation room throughout the treatment.

Area samples were collected in egg incubation rooms while dilute formalin was being applied to the eggs, and continued for a period after the formalin had been added to the egg trays. These area samples produced results which varied between the paired samples, and as well as between hatcheries. The highest and lowest concentrations in incubation room area samples were 0.3 ppm and 0.03 ppm, which were measured in side-by-side samples collected at Green Lake (0.03 ppm was below the limit of quantitation for the sample set). Since the results of DNPH *and* impinger samples appear to be approximately log-normally distributed, the geometric mean was calculated to provide an estimate of average concentration. The geometric mean concentration was 0.08 ppm.

Methanol

Table 3 summarizes methanol concentrations in samples collected at the three hatcheries where methanol exposure was evaluated. As with formaldehyde sampling, methanol PBZ sampling was conducted to assess total worker exposure during all phases of formalin application. The highest concentration, 23 ppm, was found in a 12-minute sample collected during formalin pumping at North Attleboro on November 25, 1997. The total TWA methanol exposure for this employee while preparing and applying formalin was 14 ppm during a 23-minute period. At Pittsford NFH (manual application), PBZ sampling revealed 1.7 ppm throughout all phases of the operation. At White River NFH (automated application), PBZ sampling indicated levels below the limit of quantitation (0.2 ppm). Results of area sampling were consistent with those of PBZ sampling. These results indicate low exposure to methanol vapor during egg treatment.

DISCUSSION

Air sampling revealed significant airborne formaldehyde concentrations at all hatcheries where manual methods were used. At each of these hatcheries, the highest observed concentration occurred while formalin was being transferred from a 55-gallon drum into small containers, usually plastic jugs. The extent of worker exposure during transfer depended on the amount of formalin dispensed, type of transfer equipment (e.g., electric pump, hand pump, gravity-flow via a spigot), and worker technique/skill. After transfer, formalin was measured into chicken waterers using a graduated cylinder or beaker. Both of these operations, transfer and measurement, involve the manual handling of formalin.

Use of an electric pump at North Attleboro NFH to transfer formalin from a 55-gallon drum into plastic jugs generated the highest formaldehyde concentrations that were measured at any of the hatcheries. Formaldehyde levels during use of this pump were well-above the OSHA STEL of 2 ppm. Following the November 1997 visit when these levels were measured, the drum was relocated near an exterior double-door which could be kept open while formalin was being transferred into jugs. In addition, formalin was no longer pumped, but was dispensed by gravity through a spigot. Although these changes reduced formaldehyde levels below the OSHA STEL, a second round of PBZ sampling at North Attleboro indicated that airborne formaldehyde levels still exceeded the NIOSH REL, and the ACGIH TLV. The decision to move the formalin drum near exterior doors, and to discontinue use of the electric pump was an effective short-term response; however, this will likely prove impractical during inclement weather.

In addition to exposure to airborne formaldehyde during routine handling, these tasks present the risk of dermal contact due to accidental splashes or spills. Although PPE was used at all hatcheries, it was not always selected or used correctly. In November 1997, the person who handled formalin at North Attleboro wore a full-face respirator and latex gloves: no other splash protection was used. Even though the full-face respirator provided adequate protection against splashes to the eyes and face, the glove material (latex) was not protective, and the rest of the body was totally unprotected. During the second visit, this person wore a full-face respirator, rubber boots, full rain gear, and Viton™ gloves. Permeation testing indicates that PPE made of Viton™ will provide long-term protection against continuous contact with formaldehyde and methanol.[8] At Pittsford, skin protection was appropriate; however, no respiratory protection was worn where formaldehyde levels were found to exceed the TLV. PPE used at other manual hatcheries appeared adequate for conditions observed on the sampling dates.

Automated egg treatment systems reduce routine employee exposure by eliminating manual handling of formalin, and by containing formalin within an enclosed system during transfer and dilution. At two of three hatcheries with automated systems, PBZ sampling indicated that worker exposure was below the PEL and TLV for formaldehyde. At Green Lake, samples collected on DNPH cartridges indicated the presence of quantifiable levels of formaldehyde, whereas side-by-side area samples using midget impingers indicated much lower levels. As discussed in the "Results" section of this report, it appears that this set of DNPH samples may be unreliable, and may overestimate the true concentration at Green Lake.

At hatcheries where automated systems are used, it appeared that the greatest risk of exposure to formalin would occur while moving and changing the 55-gallon formalin drum. However, automated systems create the risk of accidental contact with formalin if system components rupture or leak. At a USFWS hatchery (not evaluated during this HHE), a worker was splashed in the eyes and face when a distribution line separated at a coupling due to overpressurization. This incident highlights the importance of proper design, construction, and use of automated treatment systems.

The Material Safety Data Sheet (MSDS) from one formalin supplier provides misleading information which discounts evidence that formaldehyde is a suspected human carcinogen (ACGIH), and a potential occupational carcinogen (NIOSH and OSHA). The PPE recommendations in this MSDS, and other MSDSs, did not correctly and/or thoroughly identify the type of "rubber" that provides adequate protection against skin contact. The hazard warning labels on some formalin drums did not identify potential cancer risk. It is important that complete, accurate information is provided so that everyone in the hatcheries is aware of the extent of hazards associated with all materials, appropriate PPE, emergency response procedures, etc.

While at Craig Brook, the NIOSH investigator observed two individuals sorting eggs with a

Jensorter JH-149 egg-sorting machine. The electrically-powered Jensorter produced continuous noise that appeared to exceed 90 decibels. (A sound level meter was not available to measure the noise level.) Neither of these individuals, who were working within a few feet of the Jensorter, was wearing hearing protection. They reported that this operation (culling) occurs daily for approximately six hours per day for one month.

CONCLUSIONS

Air sampling revealed formaldehyde concentrations in excess of the REL and TLV at all hatcheries using manual methods to apply formalin treatments to salmon eggs. The OSHA STEL was exceeded at one hatchery using manual methods. Formaldehyde concentrations during automated treatment did not exceed the TLV or OSHA STEL; however, concentrations *may* have exceeded the NIOSH ceiling of 0.1 ppm at two of three hatcheries where automated systems are used. Methanol exposures were well-below all guidelines at all hatcheries where this exposure was evaluated.

Formaldehyde levels can be expected to exceed the TLV and REL during manual treatment. An effective PPE program, training program, and ongoing exposure monitoring are needed at hatcheries where formalin, or other hazardous materials are used. It appears that much of the routine exposure to formaldehyde due to manual treatment could be eliminated by installation of a well-designed automated system at each hatchery where manual methods are used.

RECOMMENDATIONS

1. An automated treatment system should be installed at each hatchery where eggs are treated with formalin. A properly designed, constructed, and maintained treatment system should prevent much of the routine formaldehyde exposure that occurs when workers handle formalin during manual treatment. The design and construction of these systems should be supervised by someone who is capable of evaluating the compatibility of formalin and system components, prevention of overpressurization of tubing or mixing vessels, and operating procedures.

2. Automated systems which are currently in use should be evaluated to determine if there are any potential hazards inherent in the design, construction, or operation of these systems.

3. The PPE program should be evaluated to ensure that appropriate PPE is selected and used at each hatchery. Attention should be given to the fit-testing and training of individuals who wear respiratory protection. Gloves should be checked to ensure that they are made of Viton™, butyl rubber, or other materials that provide protection against formaldehyde and methanol. Hatchery managers and employees should be trained in the selection and use of PPE.

4. Hazard information contained in MSDSs should be reviewed to ensure that hatchery managers and workers are provided with accurate, complete information. Revised MSDSs should be requested from formalin suppliers who provided inaccurate or misleading chemical hazard information.

5. Noise monitoring should be conducted to determine if a Hearing Conservation Program should be implemented at Craig Brook and/or other hatcheries where workers may be exposed to excessive noise.

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Table 1. Formaldehyde Air Samples - Manual Egg Treatment. USFWS (HETA 97-0113)

Sample Type	Location/Operation	Sample No.†	Time	Period (minutes)	Volume (liters)	Formaldehyde (ppm)
North Attleboro - 11/25/97						
PBZ	Furnace & Hatchery Rms. (pumping & measuring)	F1	0956-1019	23	23.7	>3.8
	Furnace Room (pumping)	F2	0956-1009	13	13.2	>5.3
	Hatchery Room (measuring)	F5	1009-1019	10	10.2	1.8
Area	Furnace Room (includes pumping)	F3	0957-1025	28	28.3	>2.9
	Furnace Room (after pumping)	F6	1030-1112	42	42.5	>1.9
	Hatchery Room (measuring)	F4	1010-1032	22	22.4	0.55
North Attleboro - 1/21/98						
PBZ	UV Gallery (dispensing into jugs)	S-1A/B	1023-1041	18	9.15	0.3
	Hatchery Room (measuring)	S-5A/B	1054-1109	15	7.63	1.
Area	UV Gallery (dispensing into jugs)	S-2A/B	1022-1039	17	8.60	0.2
		I-1A/B	1022-1039	17	4.26	0.9
	Hatchery Room	S-3A/B	1054-1120	26	13.2	0.5
		I-2A/B	1054-1120	26	6.55	0.5
	Egg Room (chicken waterers in use)	S-6A/B	1102-1208	66	33.4	0.4
		I-3A/B	1102-1207	65	16.3	0.4

Table 1. (continued) Formaldehyde Air Samples - Manual Egg Treatment. USFWS (HETA 97-0113)

Sample Type	Location/Operation	Sample No.†	Time	Period (minutes)	Volume (liters)	Formaldehyde (ppm)
Pittsford - 12/2/97						
PBZ	Tank Room (measuring, hanging waterers, & cleanup)	F9	0943-0957 1043-1051	31	31.8	1.4
	Tank & Feed Rooms (hanging waterers, cleanup, & filling jug)	F10	0943-0957 1034-1104	44	45.1	0.56
	Feed Room (filling jug)	F14	1055-1058	3	3.1	2.2
Area	Tank Room (formalin being added to egg trays using waterers)	F11	0944-1110	86	87.5	0.34
	Feed Room (during & after filling jug)	F12	1055-1114	19	19.2	0.55
	Near hatchery offices	F13	0945-1114	89	89.9	0.29
Craig Brook - 1/28/98						
PBZ	Egg Bays (pumping, measuring, hanging waterers)	S-17A/B	0947-1008	21	22.4	0.6
Area	Dennys (treatment)	S-13A/B	0951-1043	52	54.4	0.1
		I-10	0951-1043	52	26.8	0.40
	Narraguagas (treatment)	S-14A/B	0954-1054	60	63.2	0.08
		I-11	0954-1054	60	31.8	0.59
	Mechanical Room‡ (during & after pumping)	S-15A/B	0947-1048	61	64.2	0.4
		I-12	0947-1048	61	31.8	0.74

† Sample numbers beginning with "F" or "S" were collected using DNPH cartridges. Samples beginning with "I" were collected using midget impingers containing sodium bisulfite solution.

‡ Gloves, worn during formalin pumping, were placed near the area samplers; thus, formalin on the gloves may have contributed to the concentrations measured in the cartridge and impinger area samples.

ppm = Parts per million. Reported values represent the average concentration during the sampling period.

( ) = Value is between the minimum detectable concentration (MDC) and the minimum quantifiable concentration (MQC). Values in this range are semi-quantitative. The MDC and MQC are determined by the analytical limits of detection and quantitation, and the volume of the air sample.

> = Greater than. The formaldehyde concentration exceeded the capacity of the sampler.

Table 2. Formaldehyde Air Samples - Automated Egg Treatment. USFWS (HETA 97-0113)

Sample Type	Location/Operation	Sample No.†	Time	Period (minutes)	Volume (liters)	Formaldehyde (ppm)
White River - 12/3/97						
PBZ	In/near Old Egg Room (treating eggs)	F17	1312-1337	25	26.2	0.12
Area	Old Egg Room	F18	1322-1407	45	47.2	0.06
		F21	1407-1524	77	80.7	0.05
	Egg Room Desk	F20	1323-1412	49	50.2	0.16
		F23	1412-1525	73	74.8	0.05
	New Egg Room	F19	1324-1414	50	51.7	0.09
		F22	1414-1525	71	73.4	0.03
Green Lake - 1/27/98						
PBZ	Egg Room - Sections A & D	S-7A/B	1014-1058	44	45.4	0.3
Area	Egg Room - Section D	S-8A/B	1015-1059	44	45.9	0.3
		I-5	1015-1059	44	22.6	(0.03)
	Egg Room - Section A	S-9A/B	1016-1100	44	46.4	0.1
		I-6	1016-1100	44	22.8	(0.04)
	Small Boiler Room (pumping)	S-10A/B	1017-1102	45	47.7	0.2
		I-7	1017-1103	46	23.9	(0.03)
Craig Brook - 1/28/98						
PBZ	Penobscot (treatment)	S-19A/B	1216-1225	9	9.59	<0.07
Area	Lower Level (pumping)	S-20A/B	1217-1305	48	50.2	<0.01
		I-13	1217-1305	48	24.8	0.12
	Penobscot (treatment)	S-21A/B	1222-1313	51	53.7	0.1
		I-14	1222-1313	51	27.0	0.25

† Sample numbers beginning with "F" or "S" were collected using DNPH cartridges. Samples beginning with "I" were collected using midget impingers containing sodium bisulfite solution.

ppm = Parts per million. Reported values represent the average concentration during the sampling period.

( ) = Value is between the minimum detectable concentration (MDC) and the minimum quantifiable concentration (MQC). Values in this range are semi-quantitative. The MDC and MQC are determined by the analytical limits of detection and quantitation, and the volume of the air sample.

< = Less than. The formaldehyde concentration was below the MDC.

Table 3. Methanol Air Samples. USFWS, National Fish Hatcheries (HETA 97-0113)

Sample Type	Location/Operation	Sample No.	Time	Period (minutes)	Volume (liters)	Methanol (ppm)
North Attleboro (manual) - 11/25/97						
PBZ	Furnace Room (pumping)	M1	0956-1008	12	2.37	23.
	Hatchery Room (measuring)	M4	1008-1019	11	2.17	3.9
Area	Furnace Room (pumping)	M2	0956-1025	29	4.29	18.
	Hatchery Room (measuring)	M3	1010-1032	22	3.27	2.3
Pittsford (manual) - 12/2/97						
PBZ	Tank & Feed Rooms (measuring, hanging waterers, cleanup, & filling jug)	M7	0943-0957 1034-1105	45	8.79	1.7
Area	Tank Room (measuring, treating, & cleanup)	M8	0944-1110	86	12.6	0.91
	Feed Room (filling jug)	M9	1055-1113	18	2.67	2.1
White River (automated) - 12/3/97						
PBZ	In/near Old Egg Room (treating eggs)	M12	1312-1337	25	4.79	(0.2)
Area	Old Egg Room	M13	1322-1410	48	7.01	0.33
		M15	1410-1525	75	10.9	(0.1)
	New Egg Room	M14	1324-1416	52	7.71	0.52
		M16	1416-1525	69	10.2	(0.2)

ppm = Parts per million. Reported values represent the average concentration during the sampling period.
( ) = Value is between the minimum detectable concentration (MDC) and the minimum quantifiable concentration (MQC). Values in this range are semi-quantitative. The MDC and MQC are determined by the analytical limits of detection and quantitation, and the volume of the air sample.

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