Case Studies

Exposure to Formaldehyde Among Fish Hatchery Workers

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Introduction

The National Institute for Occupational Safety and Health (NIOSH) and the Department of Interior. Office of Managing Risk and Public Safety received requests for assistance from the U.S. Fish and Wildlife Service and the Montana Department of Health regarding formaldehyde exposures to fish hatchery workers. Although no work-related health problems were being reported among hatchery workers, the requesters wanted some documentation of formaldehyde exposure along with an assessment of current control measures. Evaluations were conducted in sis fish hatcheries in Montana, Arizona, and New Mexico.

Background

At the hatcheries, formalin concentrations of 1400 to 1700 parts per million (ppm) are used for treating trout and salmon eggs to control infections from *Saprolegniaceae* fungi. Formalin is also used to prevent parasitic infections of fingerling trout. Most of the hatcheries that were evaluated had one employer in charge of treating eggs or fingerlings. Other workers were rarely in the area during formalin treatments. Methods for applying the treatment varied among the six hatcheries as follows:

Hatchery 1

Kokanee salmon eggs were treated in the raceway (concrete troughs with continuously running water) by simply pouring 37 percent formalin into a 12-ounce cup with a hole drilled in the bottom and placing the cup at the beginning of the raceway. The employee worked in an area about 50 ft from the raceway while the eggs were being treated. No personal protective equipment was worn by the treatment operator.

Hatchery 2

The formalin treatment operator diluted 37 percent formalin with water to 3 3: I ratio. This solution was placed in chicken waterers, which dripped the solution into water that runs continuously through each stack of egg trays. There were 24,000 trout eggs per tray and eight trays per stack. The operator treated eight stacks per day. and the job took about 40 minutes. While mixing the formalin and treating the eggs, the worker wore a full-facepiece respirator with acid-gas cartridges, butyl rubber gloves, and rubber boots.

Hatchery 3

The treatment operator poured 37 percent formalin from 5-gallon plastic jugs into ten plastic dog waterers with a hole drilled in the bottom of the waterer bowl. These were set up to drip for about 1 hour into ten raceways while the operator performed other duties. After the treatment was completed, the employee returned to rinse out the waterers. While pouring the formalin and cleaning the waterers, the worker wore a half-facepiece respirator with acid-gas cartridges, a face shield, and latex rubber gloves.

Hatchery 4

The formalin treatment operator and one assistant diluted 37 percent formalin to 1660 ppm and poured the solution into the upper reservoir of a stack of egg racks. The solution was allowed to trickle down through the egg racks for about 13 minutes. During the process, employees wore half-mask respirators with acid-gas cartridges, chemical safety goggles, and nitrile rubber aprons and gloves.

Hatchery 5

Thirty-seven percent formalin was pumped from a closed container through plastic tubing to the raceway by a peristaltic pump. The eggs were treated during the work shift when employees could occasionally be near the process.

Hatchery 6

A pump was used to automatically treat trout eggs in a manner similar to hatchery 5, except that the pump was set on a timer to run at the end of the work shift after workers left the hatchery.

Methods

Two air-sampling methods were used to evaluate potential formaldehyde exposure. Air samples were collected in midget impingers containing 20 ml of 1 percent sodium bisulfite at a flow rate of 1.0 L/min. The samples were analyzed using visible absorption spectroscopy according to NIOSH Method 3500.[1] Air samples were also collected on treated XAD-2sorbent tubes at a flow rate of 0.1 L/min and analyzed by gas chromatography according to NIOSH Method 2541.[1]

Industrial hygienists most frequently chose Method 2541 due to its greater convenience, particularly for collecting personal breathing zone (PBZ) samples. Method 3500 was chosen for some of the sampling because of its greater sensitivity.

PBZ air samples were collected for the time required to complete the entire formalin treatment task (15 to 90 minutes), including cleaning up the treatment equipment.

Evaluation Criteria

Formaldehyde is a colorless gas with a pungent and irritating odor at ambient temperatures;(') its odor threshold is approximately 0.8 ppm.[2,3] Formaldehyde may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact.[2] Mild to unpleasant eye irritation occurs in acclimated workers at 2 to 10 ppm, and intolerable irritation with possible tissue damage occurs at levels above 25 ppm.[2] While the term "formaldehyde" is also used to describe various mixtures of formaldehyde, water, and alcohol, the term "formalin" more precisely describes aqueous solutions, particularly those containing 37 to 50 percent formaldehyde and 6 to 15 percent alcohol stabilizer.

Based on the results of laboratory tests which have demonstrated the carcinogenic and mutagenic activity of formaldehyde in animals, NIOSH and the Occupational Safety and Health Administration (OSHA) recommend that formaldehyde be handled in the workplace as a potential occupational carcin-

ogen.[4,5] NIOSH recommends that occupational exposures to formaldehyde be controlled to the lowest feasible concentration.(') On December 4, 1987, OSHA issued a comprehensive regulation covering occupational exposure to formaldehyde (29 CFR 1910.1045). This rule reduced the 8-hour time-weighted average (TWA) permissible exposure limit (PEL) to 1 ppm and established a 2 ppm 15-minute short-term exposure limit (STEL). The comprehensive standard also included an action level of 0.5 ppm, measured as an S-hour TWA, with provisions for employee exposure monitoring, medical surveillance, record keeping, regulated areas, emergency procedures, preferred methods to control exposure, maintenance and selection of personal protective equipment, and hazard communication. OSHA's rule was based on the consideration of a wide range of new evidence, including animal bioassays and epidemiological evidence. It was based in part on OSHA's recognition of formaldehyde as a potential occupational carcinogen as well as its irritating and sensitizing effects.(')

On May 27, 1992, OSHA amended its existing regulation for occupational exposure to formaldehyde to take effect on June 26, 1992. The final amendments lowered the 8-hour PEL for formaldehyde from 1 ppm to an B-hour TWA of 0.75 ppm. The amendments also added medical removal protection provisions to supplement the existing medical surveillance requirements for those employees suffering significant eye, nose, or throat irritation, and for those suffering from dermal irritation or sensitization from occupational exposure to formaldehyde. Additional hazard labeling, including a warning that formaldehyde presents a potential cancer hazard, is required where formaldehyde levels, under reasonably foreseeable conditions of use, may potentially exceed 0.5 ppm. The final amendments also provided for annual training of all employees exposed to formaldehyde at levels of 0.1 ppm or higher.(')

The American Conference of Governmental Industrial Hygienists (ACGIH) classifies formaldehyde as a suspected human carcinogen (i.e., a chemical substance associated with industrial processes which is suspected of inducing cancer, based on either limited epidemiological evidence or demonstration of carcinogenesis in one or more animal species by appropriate methods).(") The recommendation of ACGIH concerning a suspected human carcinogen is that worker exposures by all routes be carefully controlled to levels as low as reasonably achievable below its threshold limit value (TLV).[6] On June 2, 1992, ACGIH adopted a ceiling limit TLV of 0.3 ppm. A ceiling limit is a concentration that should not be exceeded during any part of the working exposure. ACGIH formerly recommended an S-hour TLV-TWA of 1 ppm and a 15-minute STEL of 2 ppm for formaldehyde. The revised TLV was adopted to further reduce sensory irritation for workers handling formaldehyde or formaldehyde-containing products. Moreover, ACGIH stated that because the reported dose-dependent carcinogenic effect in the rat and mouse and the inadequate epidemiologic data on the cancer risk in humans, it was advisable to reduce formaldehyde workplace exposure to the lowest possible level.[7]

Results and Discussion

PBZ formaldehyde concentrations ranged from <0.19 to 0.8 ppm, with a mean of 0.3 ppm (Table 1). Durations of exposure ranged from 15 to 90 minutes. Thus, 8-hour TWA exposures were very low, ranging from 0.006 to 0.038 ppm, with a mean of 0.02 ppm. The PBZ air sampling results show that no exposure to formaldehyde could have exceeded the OSHA STEL of 2 ppm for any 15-minute exposure period.

Exposure to formaldehyde exceeded the ACGIH ceiling TLV of 0.3 ppm in hatchery 4. Work practices and materials used in hatchery 4 were not substantially different from those used in the other hatcheries where formalin was handled, except that the work was completed in a shorter period of time. Therefore, the higher exposure concentration was mostly the result of a shorter sampling period. PBZ air sampling for peak exposures was not conducted in hatcheries 1, 2, and 3. It is likely that exposures among workers who handled formalin in these hatcheries also exceeded the ACGIH ceiling TLV of 0.3 ppm, at least for the brief periods required to pour formalin.

Most of the hatcheries were located in large open areas with large openings to the outside; therefore, formaldehyde concentrations were much lower at locations just a few feet from the treatment source or treated raceways. Formaldehyde levels also appeared to dissipate quickly. Two area air samples collected in hatchery 2 immediately after the treatment was completed were <0.05 ppm.

Conclusions

Exposure to formaldehyde was below the OSHA PELs at each of the fish hatcheries that were evaluated. However, the ACGIH ceiling limit of 0.3 ppm was exceeded in one hatchery, and was probably exceeded for brief periods in the three other hatcheries where workers handled formalin.

NIOSH does not believe there is a safe level of exposure to potential occupational carcinogens; therefore, exposure should be reduced as low as possible. Engineering controls currently being used at two of the fish hatcheries demonstrate that it is possible to greatly reduce worker exposure to formaldehyde during the treatment of fish eggs and fingerlings. These controls also eliminate potentially serious eye and skin hazards due to accidental spills or splashes that may occur when handling 37 percent formalin.

Recommendations

Exposure to formaldehyde should be reduced as low as possible by using a timer-automated pump system to treat fish fingerlings or eggs when employees are not in the area. These fluid transfer systems are relatively inexpensive compared with the ongoing costs of maintaining, replacing, and laundering OSHA-required personal protective equipment and clothing for employees who handle formalin. Peristaltic pump systems (also referred to as tubing pumps) consist of a motor drive, one or more pump heads, and tubing. For transferring formalin, one manufacturer recommends that pump heads be constructed of polysulfone, polycarbonate, or polyphenylene sulfide. Recommended tubing formulations include PharMed®, Norprene®, C-FLEX@, and polytetrafluoroethylene.

If respirators are used, they should be used as effectively as possible by instituting a comprehensive respiratory protection program in accordance with OSHA 1910.134.[8] Where respiratory protection is required, the minimum acceptable respirator for use in formaldehyde concentrations up to 10 ppm is a joint

TABLE 1. Air Formaldehyde Concentrations

Hatchery	Location	Sample Duration (Minutes)	Concentration (ppm)
1	PBZ Formalin treatment operator	30	<0.19[A]
	Treatment area	3 0	0.68[B]
	End of raceway	30	0.0458
2	PBZ Formalin treatment operator	40	(0.2)[A,C]
	Treatment area	40	0.44[A]
	Operator's desk (during treatment)	40	0.14[B]
	Center of boardroom (during treatment)	40	0.17[B]
	Operator's desk (after treatment)	60	<0.05[A]
	Center of boardroom (after treatment)	60	<0.05[A]
3	PBZ Formalin treatment operator	92	0.20"
	Treatment area	97	0.26[B]
	No. 9/10 raceway area	94	0.23[B]
	No. 7/8 raceway area	95	0.14"
	No. 5/6 raceway area	95	0.26[B]
4	PBZ Formalin treatment operator	20	(0.8)[A]
	PBZ Formalin treatment assistant	15	(0.2)[A]
5	Pump area	30	(0.2)[A]
	Egg storage area	30	0.12"
	Outflow area	30	0.16[B]
6	Pump area	25	0.0598
	Egg storage area	25	0.0738

"Samples were collected in sorbent tubes and analyzed according to NIOSH Method 2541.
[B]Samples were collected in impingers and analyzed according to NIOSH Method 3500.
[C]Values in parentheses are above the sampling and analytical limit of detection but below the sampling and analytical limit of quantitation. These should be considered as approximate values.

NIOSH- and Mine Safety and Health Administration-approved full-facepiece respirator with cartridges specifically approved for protection against formaldehyde. The cartridges must be replaced after 3 hours or at the end of the work shift, whichever is sooner.

The following precautions are required by OSHA 1910.1048 in situations where employees' eyes or skin may come into contact with formalin.[4]

- All skin contact with formalin must be prevented by the use of chemical protective clothing. Breakthrough studies indicate that garments made of butyl rubber, neoprene, nitrile rubber, chlorinated polyethylene, and polyvinylchloride offer the best resistance against formalin concentrations up to 37 percent.(')
- Hatchery owners must assure that formaldehyde-contaminated protective equipment or clothing is cleaned or laundered before its reuse. The employer must assure that no employee takes home equipment or clothing that is contaminated with formaldehyde.
- Chemical safety goggles must be worn to protect the eyes when handling formalin solutions. When a face shield is worn, chemical safety goggles are also required. Full-facepiece respirators provide adequate eye protection.
- Quick-drench showers and emergency eyewash facilities must be provided within the immediate work area of formalin treatment operators.
- Hatchery owners must make provisions to detect and contain possible formaldehyde spills, safely decontaminate the work area, and properly dispose of the waste.

References

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