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Formaldehyde Concentrations in Biology Department Teaching Facilities

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Formaldehyde is an acrid gas that is both colorless and flammable. It is generally sold for commercial use as an aqueous solution, which is 37% to 50% formaldehyde by weight. The compound has become ubiquitous in modern society with extensive indirect use as the raw material for polymers, in building materials, textiles, plastics , dyes, and paints. It is utilized similarly in consumer goods such as pharmaceuticals, certain foods, deodorants, and cosmetics. Additionally, all states require its direct use in embalming fluids. Formalin solutions of concentrations in the range of 1.5% to 5% are used to prevent the biological deterioration of animal tissues for study in the life sciences. This chemical fixative renders body tissues insoluble and protects them from breakdown by microorganisms. The nitrogen atoms of the protein molecules are the initial site of reaction with the formaldehyde that results in preservation (Rainis 1983).

As students and faculty in the biological sciences can attest, low grade exposure to formaldehyde by skin contact and inhalation during dissection is quite irritating. Health effects noted upon exposure to formaldehyde at concentrations of 0.1 to 5 ppm are burning of the eyes, lacrimation, and general irritation to the upper respiratory passages. Symptoms reported for higher exposures, 10 to 20 ppm, include coughing, tightening of the chest, headache and palpitation of the heart. Long exposures at 50 to 100 ppm or more might result in pulmonary edema, pneumonitis, and even death.

There is also concern with regard to potential long term detrimental effects. Formaldehyde has been cited as a possible carcinogen in animals (Chem. Ind. Inst. Tox. 1979,1980).It is a known mutagen in laboratory experimental systems involving Drosophila, grasshoppers, flowering plants, fungi and bacteria(Auerbach et al.1977). Animal testing has led investigators to postulate that the primary damage resulting from formaldehyde exposure may involve DNA synthesis and ribosomal RNA transcription(Nocentini et al. 1980). The National Institute of Occupational Safety and Health Administration (NIOSH) investigators have been studying occupational exposure to formaldehyde for over a decade in a variety of industries. Occupations identified involving exposure to formaldehyde include: biological scientists; teachers (NIOSH 1981); and students. NIOSH industrial hygiene surveys have reported hospital autopsy rooms and embalming laboratories (Johnson 1980) as areas with unusually high concentrations of formaldehyde. This study was undertaken to assess formaldehyde concentrations in biology department dissecting facilities in the 1982-1983 academic year in order to determine if routine dissection produces levels of formaldehyde

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which were unsafe according to NIOSH and OSHA standards. Chronic formaldehyde exposure cause for greater concern than incidental exposure.

The human sensory limit is 1 ppm (Rainis 1983). The current OSHA permissible exposure limit (PEL) for formaldehyde is 3 ppm as an eight-hour time-weighted average. The ceiling concentration, the concentration that should not be exceeded even instantaneously, is 5 ppm. An acceptable maximum peak above the ceiling concentration is 10 ppm for no more than a total of 30 minutes during an eight-hour shift (OSHA 1978). NIOSH further recommended that employee exposure to formaldehyde be controlled to a concentration no greater than 1 ppm for any 30 minute sampling period (NIOSH 1976). All of the above standards were based on the irritant effects of formaldehyde since the carcinogenic potential of the compound was as yet unknown, and therefore could not be considered in developing recommendations.

MATERIALS AND METHODS

An air sampling pump, Model B-D (Code 1944), La Motte Chemical Co., Chestertown Md, was fitted with two impingers and used to gather air at sample sites at a rate of 1 liter/minute for 1 hour at each site. A chromotropic acid-sulfuric acid solution was employed to form a purple monocationic chromogen upon reaction with formaldehyde. The absorbance of the colored solution was read in a Beckman spectrophotometer at 580 nm and is proportional to the quantity of formaldehyde in the solution.

RESULTS AND DISCUSSION

Three typical sites in the biology department were chosen for sampling (Table 1). Concentrations were varied between sites due to the nature of the site sampled, and simulated conditions at a given site.

Table1. Concentration Values for Formaldehyde in Biology Department Facilities

Locations Tested		Conc. Avg.,(ppm)	Simulated Conditions
Site 1, teaching lab	Trial I	7.0	Windows closed as in winter
	Trial II	16.5	door closed; 24 cut open animals
Site 2 , rear	Trial I	1.97	Windows closed single entrance
stock room	Trial II	2.62	door open; storage room for specimens in new and previously opened containers.
Site 3,Public Hallway	Trial I	less than 1.0	Limited student movement in
	Trial II	less than 1.0	hall; cut specimens in lab; windows closed;door to hall open.

The American Conference of Governmental Industrial Hygienists has established a recommended a threshold limit value of 2 ppm as the upper limit of contaminants for which it is believed that nearly all workers may be repeatedly exposed, day after day without adverse effect. Site 1 is an often used teaching laboratory, where formalin-treated cats and fetal pigs are dissected for extended laboratory sessions. The site also contains numerous storage containers for animals in one area, as well as samples of preserved organs in containers. The formaldehyde concentrations of 7 ppm and 16.5 ppm are above both this standard and that established by OSHA. Site 2, an adjourning storage room , measured 1.97 ppm and 2.62 ppm as seen in Table 1. Although the observed level is below the eight-hour exposure standard of 3 ppm, it does exceed the 30-minute sampling level of 1 ppm as recommended by NIOSH. Finally,

Site 3, a public hallway outside another biology laboratory, showed a level measured at less than 1 ppm while specimens were laid out inside the room.

The high levels of concentration at Site 1 are significant, since a biology major might take consecutive courses in this room over a period of years, not to mention faculty that might be exposed over the duration of their career. A similar hazard for custodial help may exist with repeated exposure over the years of their employment. If windows were open while the specimens were exposed, the concentration would be less. A New York University study in their teaching laboratories demonstrated a reduction of 43% with open windows (Schwartz 1979). This site, however, receives buffeting winds and the temperature with closed windows in the winter has been recorded at 13^0 C. It would, therefore, be difficult to open the windows in winter. The level for Site 2, although exceeding the 30-minute sampling level, is not deemed a serious hazard, since staff use of this storage room at any given time is generally less than the indicated time period. The level for the hallway, Site 3, is below recommended exposure levels, the human sensory limit, and is presumed to be safe.

Airborne levels of formaldehyde vapor may be maintained below recommended exposure standards by a properly designed ventilation system. A cost effective method of removing large volumes of contaminated air from Site 1 would involve the installation of window exhaust fans. This would eliminate excessive chilling caused by open windows. A more effective but costly method would be to control emissions at the source by installation of exhaust hoods. These hoods control the hazardous vapors before they reach individuals at risk, while permitting access to work. The contaminant would then be removed from the hood's airstream by an activated charcoal filter prior to the air being vented from the building. Finally, vendors of dissection specimens should be encouraged to develop nonhazardous methods of preservation. Ward's Natural Science establishment currently offers freeze-dried specimens that are rehydrated prior to use (Rainis 1983) and employ no formaldehyde The Nasco Co. and Carolina Biological Co. offer specimens in an odorless nontoxic preservative. We hope such innovations will become standard industry wide.

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