Technical Assistance — Madison County

Formaldehyde Exposure in Ambient Air
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Formaldehyde is released to the air from both industrial and natural sources. Combustion processes account directly and indirectly for most of the formaldehyde entering the atmosphere. One important source of formaldehyde is automotive exhaust from engines not equipped with catalytic converters. Photochemical production of formaldehyde from automobiles predominates over direct emissions from automobiles. Naturally occurring formaldehyde also arises from atmospheric oxidation of naturally occurring alkenes.

A survey of emission data from stationary and mobile sources was used as input for an atmospheric dispersion model to estimate outdoor air concentrations in 1990 for each of the 60,803 census tracts in the contiguous United States. The average long-term background concentration estimated for formaldehyde was 0.2 parts per billion (ppb). In a survey of ambient measurements of hazardous air pollutants, a median formaldehyde concentration of 2.5 ppb was found for a total of 1,358 samples collected at 58 different locations, both urban and rural, throughout the United States.

The contribution of various atmospheric environments to the general population's average exposure to formaldehyde is:

Source	**mg/day**
Air Outdoor air (10% of time)	0.02
Indoor air	
Home (65% of time)	
Conventional	0.5-2.0
Prefabricated (chipboard)	1.0-10.0
Workplace (25% of time)	
Without occupational exposure	0.2-0.8
With 1 mg/m^3 occupational exposure	5.0
Environmental tobacco smoke	0.1-1
Smoking (20 cigarettes per day)	1.0

Formaldehyde is removed from the atmosphere by direct photolysis (from sunlight) and oxidation by photochemically produced free radicals. Based on its rate of reaction with photochemically produced hydroxyl radicals, formaldehyde has a predicted half-life of approximately 19 hours in clean air and about 8 hours in polluted air.

A toxicological evaluation of exposure requires a comparison of calculated site-specific exposure doses (e.g., amount of the contaminant believed to enter the body at the person's body weight for an estimated duration of time) with an appropriate health guideline. Health guidelines are health-protective values that have incorporated various safety factors to account for varying human susceptibility. These guidelines are developed using human exposure data when it is available and animal data when human exposure data is not available. Health guidelines used are the Agency for Toxic Substances and Disease Registry's (ATSDR) Minimal Risk Levels (MRLs). Usually little or no information is available for a site to know exactly how much exposure is actually occurring, so in some cases, health assessors assume worse case scenarios where someone received a maximum dose. As a result, actual exposure is likely much less than the assumed exposure. In the event that the calculated, site-specific exposure dose for a chemical is greater than the established health guideline, it is then compared to exposure doses from individual studies documented in the scientific literature that have reported health effects. If a contaminant has been determined to be cancer causing (carcinogenic), a cancer risk is also estimated.

Low levels of formaldehyde can cause irritation of the eyes, nose, throat, and skin. It is possible that people with asthma may be more sensitive to the effects of inhaled formaldehyde. In deriving a chronic inhalation MRL for formaldehyde, a 1989 study correlating histological changes in the nasal mucosa in persons occupationally exposed to formaldehyde was used. Clinical symptoms of mild irritation of the eyes and upper respiratory tract and mild damage to nasal epithelial cells were observed in workers exposed for over 10 years to

an average (time-weighted average-TWA) concentration of 0.24 parts per million (ppm). This concentration is where the lowest observable adverse health effects levels (LOAEL) were observed in these workers. From the LOAEL, an uncertainty factor of 30 was used to establish the MRL to account for human variability and mild to subclinical histological changes in nasal epithelial cells. Thus, a chronic inhalation MRL for formaldehyde was set at 0.008 mg/kg/day.

Let us assume that one is exposed, on a long-term daily basis to the median formaldehyde concentration of 2.5 ppb found at 58 different locations, both urban and rural, across the United States in the survey mentioned above. To approximate and exposure dose for an adult male, let us assume that he weighs 70 kg, is outside 10% of the day, and breathes an average of 15.2 cubic meters (m^3) of air per day. The chronic exposure dose of this adult male would be approximately 0.00007 mg of formaldehyde per kilogram of body weight per day (mg/kg/day). A young child weighing 25 kg, breathing an average of 10 m^3 of air per day, and spending 10% of his/her time outdoors would have a formaldehyde exposure of approximately 0.00013 mg/kg/day.

One can see that the exposure doses to both adults and children are significantly lower that the MRL (0.008 mg/kg/day), which is considered to be a health-protective value that has various safety factors incorporated into it to account for varying human susceptibility. Specifically, the adult exposure dose is 114 times lower than the MRL and the child exposure dose is 61 times lower than the MRL.

For a more conservative measure, let us assume that one is exposed, on a long-term daily basis to an average formaldehyde concentration of 0.02 mg/day in the contribution of various atmospheric (outdoor air) environments to the general population's average exposure to formaldehyde above. The chronic exposure dose of this adult male would be approximately 0.0005 mg of formaldehyde per kilogram of body weight per day (mg/kg/day). A young child would have formaldehyde exposure of approximately 0.001 mg/kg/day. In this case, the adult exposure dose is 16 times lower than the MRL and the child exposure dose is 8 times lower than the MRL, which again, is considered to be a health-protective value that has various safety factors incorporated into it to account for varying human susceptibility.

As referenced below, several ambient air analyses in various communities throughout the United States have been conducted over the last decade. In all cases, average formaldehyde concentrations have ranged between 0.81 ppb to 8.14 ppb. Moreover, at these levels, no adverse health effects were expected from exposure to these levels on a day-to-day basis. According to ATSDR, adverse health effects from formaldehyde exposure in humans are not observed at levels below 80 ppb.

References

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