MISSOULA 1997 AMBIENT ANNUAL AVERAGE ALDEHYDE CONCENTRATIONS

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Prepared by:

Benjamin Schmidt
Missoula City-County Environmental Health
301 W. Alder
Missoula, Montana 59802

ANNUAL AVERAGE ALDEHYDE STUDY
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INTRODUCTION

The purpose of the aldehyde study was to determine the neighborhood scale annual average formaldehyde (HCHO) levels in Missoula's ambient air and to determine if these levels pose a threat to human health. During the 1993-94 winter, the Missoula City-County Health Department performed a formaldehyde screening study (MCCHD, 1994). The 1993-94 study found formaldehyde concentrations as high as 8.59 parts per billion (ppb). The annual average aldehyde study was done because inventories indicated that formaldehyde was one of the most common air toxics released to ambient air and the 1990 Clean Air Act list formaldehyde and acetaldehyde as air toxics. Formaldehyde concentrations found in the 1993-94 winter study exceeded some state annual average guidelines and since no summer air toxic data was available for Missoula, Missoula's annual average concentrations for aldehydes could not be determined. During the 1997 annual average aldehyde study, formaldehyde, acetaldehyde (CH_3CHO), and acetone (CH_3COCH_3) concentrations were measured for each sample and propanal (CH_3CH_2CHO) was measured for some of the samples collected.

Formaldehyde in the ambient air comes from vehicular exhaust, wood stoves, natural gas, industrial sources and can also form in the atmosphere by photochemical reactions (NRC, 1981).

One purpose of the 1993-94 formaldehyde study was to determine the maximum formaldehyde concentrations in Missoula's ambient air. Sample durations varied from 2.94 days to 11.1 days and were collected during periods of poor winter dispersion. The highest formaldehyde concentrations found were 8.54 parts per billion (ppb) at the intersection of Russell, Brooks and South Avenue (MFJ) and 8.59 ppb at the intersection of South and Reserve. The highest industrial site concentrations, near Louisiana Pacific and Borden Chemical, were 5.15 ppb and 4.71 ppb (MCCHD, 1994).

The first formaldehyde study was done in the winter when it was felt that stagnant air conditions, caused by Missoula's mountain valley topography combined with oxyfuel would produce the highest formaldehyde concentrations. However, some groups felt that increased volatilization from industry and increased atmospheric photochemical aldehyde formation from hydrocarbons in the summer may also produce high formaldehyde levels. Because there was no summer formaldehyde data for Missoula, samples were collected every 13 days throughout 1997 in order to determine an annual average.

STUDY DESIGN AND SAMPLING PERIODS

To find the annual average aldehyde levels in Missoula, samples were collected every 13 days from

January 10 to December 27, 1997, at Boyd Park (BP) and at 636 Stoddard (N). The Boyd Park site was located approximately 5 blocks south of the Brooks, Russell and South Avenue intersection (MFJ) on the south side of Missoula. MFJ is one of busiest intersections in Missoula and has historically had the highest carbon monoxide levels in the city. The 636 Stoddard site was located on the north side of Missoula near Interstate 90, downtown Missoula, and the railroad tracks. The industrial sites Louisiana Pacific and Borden Chemical are also on the north side of Missoula.

Sample duration was 24 hours, from midnight to midnight Mountain Standard Time. To get an annual average at the neighborhood scale, both sites were located in residential areas. In the earlier formaldehyde study, the purpose was to find the highest formaldehyde concentrations present in Missoula; so the samplers were placed at intersections and near industrial formaldehyde emitters.

MONITORING EQUIPMENT AND ANALYSIS METHODS

Active aldehyde samplers were leased from Daniel Grosjean and Associates, Inc. (DGA). The active samplers consist of a timer/clock, tubing, pump and a flowmeter. The DGA aldehyde sampler uses a 2,4-dinitrophenylhydrazine (DNPH) coated filter in a cartridge as the aldehyde trap. Samplers were calibrated a minimum of once every three months. Calibration sheets are on file at the Health Department and at DGA.

After sampling, the DNPH filters were analyzed at DGA by liquid chromatography (LC). The DNPH LC method employed in this study is a U.S. Environmental Protection Agency approved method to measure formaldehyde and other carbonyls in ambient air (method TO-11).

QUALITY CONTROL/ASSURANCE AND PRECISION

Before shipment to Missoula, each batch of DNPH cartridges prepared at DGA was analyzed by LC to verify cartridge blank concentrations. Six field blanks and six field controls were collected and analyzed by LC. All the field blanks and field controls contained very low amounts of formaldehyde, acetaldehyde and acetone. Final results are reported taking the field control data into account.

DGA verified sample recovery by carrying out two consecutive solvent (acetonitrile) elutions of the same cartridge followed by LC analysis. The second elution samples contained no detectable amounts of carbonyls. Replicate analyses was carried out on 13 samples, 8 from Boyd Park and 5 from 636 Stoddard, and carbonyl concentrations were within 2% of the original analysis. Two samples, BP3 and N3, were also reanalyzed using a different eluent (acetonitrile-water-tetrahydrofuran) to verify carbonyl structure and to resolve compounds that may coelute using DGA's standard eluent (acetonitrile-water). The samples BP9 and N9 were analyzed by chemical ionization mass spectrometry (Grosjean, et al, 1996) to also verify carbonyl structure.

The precision of the formaldehyde samplers was assessed by collecting three pairs of co-located

samples at each site. Table 1 list the co-located precision results for formaldehyde, acetaldehyde and acetone. All six of the regular samples had formaldehyde results within 0.22 ppb of the co-located samples. The acetaldehyde and acetone co-located results were all within 0.09 ppb of the regular samples. This indicates that there was a high degree of precision in the sampling technique.

TABLE 1.
CO-LOCATED PRECISION RESULTS

	Formaldehyde				Acetaldehyde				Acetone			
sampl #	reg. sampl	co-locat	ppb diff.	% diff.	reg. sampl	co-locat	ppb diff.	% diff.	reg. sampl	co-loct	ppb diff.	% diff.
BP10	0.61	0.70	0.09	14.8	0.43	0.51	0.08	18.6	0.12	0.11	0.01	8.3
BP13	0.69	0.73	0.04	5.8	0.21	0.24	0.03	14.3	0.11	0.12	0.01	9.1
BP28	0.91	0.87	0.04	4.4	1.06	1.03	0.03	2.8	0.15	0.14	0.01	6.7
N4	2.22	2.44	0.22	9.9	1.40	1.38	0.02	1.4	0.62	0.60	0.02	3.2
N16	0.95	1.02	0.07	7.4	0.18	0.19	0.01	5.6	0.17	O.18	0.01	5.9
N25	2.80	2.90	0.10	3.6	2.46	2.58	0.04	1.6	1.13	1.22	0.09	8.0

STUDY RESULTS

Tables 2 and 3 list the formaldehyde, acetaldehyde, acetone and propanal results for Boyd Park and 636 Stoddard. The two days prior to the highest aldehyde readings on Dec. 14 had low average wind speeds of 0.4 and 0.0 mph respectively.

The 1997 annual average formaldehyde levels were 1.18 ppb at Boyd Park and 1.46 ppb at 636 Stoddard. Figures 1 and 2, following Table 3, show that aldehyde concentrations tend to be higher in the winter months when dispersion conditions are worse. Annual average acetaldehyde levels were 0.77 ppb at Boyd Park and 0.85 ppb at 636 Stoddard. The acetone annual average was 0.44 ppb at Boyd Park and 0.56 ppb at 636 Stoddard. The annual average aldehyde concentrations were all slightly higher at 636 Stoddard, the site located on the north side of Missoula.

TABLE 2. BOYD PARK ALDEHYDE RESULTS

SAMPLE NUMBER	DATE	FORMALDEHYDE PPB	ACETALDEHYDE PPB	ACETONE PPB	PROPANAL PPB
BP1	1/10/97	1.40	1.08	0.80	
BP2	1/23/97	0.93	0.70	0.31	
BP3	2/5/97	1.64	1.18	0.96	
BP4	2/18/97	1.26	0.94	0.24	
BP5	3/3/97	1.08	0.80	0.32	
BP6	3/16/97	1.35	0.85	0.50	
BP7	3/29/97	0.67	0.76	0.17	
BP8[1]	4/11/97	0.56	0.54	0.50	
BP9	4/24/97	0.33	0.49	0.44	
BP10	5/7/97	0.61	0.43	0.12	
BP10C	5/7/97	0.70	0.51	0.11	
BP11	5/20/97	0.74	0.15	0.13	0.14
BP12[2]	6/3/97	0.98	0.53	0.13	0.12
BP13	6/15/97	0.69	0.21	0.11	0.10
BP13C	6/15/97	0.73	0.24	0.12	0.09
BP14	6/28/97	0.80	0.26	0.22	0.18
BP15	7/11/97	0.51	0.18	0.11	0.13
BP16	7/24/97	0.79	0.66	0.10	0.16
BP17	8/6/97	1.24	0.37	0.10	0.05
BP18	8/19/97	1.06	0.20	0.37	0.08
BP19[1]	9/1/97	1.13	0.55	0.22	0.10
BP20	9/14/97	1.17	0.83	0.28	0.17
BP21	9/27/97	0.47	0.33	0.13	0.08
BP22	10/10/97	1.34	0.93	0.78	0.16
BP23	10/23/97	1.50	0.90	0.31	0.16
BP24	11/5/97	1.55	1.11	0.70	0.13
BP25	11/18/97	2.36	1.76	1.16	0.16
BP26	12/1/97	1.78	1.13	0.91	0.13
BP27	12/14/97	4.18	2.60	2.00	0.27
BP28	12/27/97	0.91	1.06	0.15	0.09
BP28C	12/27/97	0.87	1.03	0.14	0.09

TABLE 3. 636 STODDARD ALDEHYDE RESULTS

SAMPLE NUMBER	DATE	FORMALDEHYDE PPB	ACETALDEHYDE PPB	ACETONE PPB	PROPANAL PPB
N1	1/10/97	0.78	0.81	0.76	
N2	1/23/97	2.07	1.24	0.44	
N3	2/5/97	2.53	1.38	1.12	
N4	2/18/97	2.22	1.40	0.62	
N4C	2/18/97	2.44	1.38	0.60	
N5	3/3/97	1.69	0.98	0.50	
N6	3/16/97	1.56	0.84	0.38	
N7	3/29/97	1.13	0.60	0.24	
N8	4/11/97	0.57	0.52	0.38	
N9	4/24/97	0.96	0.94	0.35	
N10	5/7/97	0.63	0.40	0.09	
N11	5/20/97	0.61	0.06	0.15	0.08
N12[2]	6/3/97	1.16	0.87	0.24	0.19
N13	6/15/97	0.77	0.26	0.27	0.07
N14	6/28/97	0.80	0.20	0.34	0.10
N15	7/11/97	0.74	0.11	0.18	0.11
N16	7/24/97	0.95	0.18	0.17	0.04
N16C	7/24/97	1.02	0.19	0.18	0.05
N17	8/6/97	1.20	0.25	0.19	0.06
N18	8/19/97	1.62	0.46	0.49	0.16
N19[1]	9/1/97	1.03	0.21	0.18	0.05
N20	9/14/97	1.02	0.64	0.32	0.20
N21	9/27/97	0.71	0.55	0.20	0.11
N22	10/10/97	1.32	0.81	1.08	0.11
N23	10/23/97	1.57	1.01	0.71	0.14
N24	11/5/97	1.58	1.24	1.50	0.13
N25	11/18/97	2.80	2.46	1.13	0.22
N25C	11/18/97	2.90	2.58	1.22	0.24
N26	12/1/97	1.44	1.06	0.98	0.10
N27	12/14/97	5.98	3.22	2.51	0.21
N28	12/27/97	1.36	0.96	0.28	0.16

Table 4 list the special sample results. The special samples were collected for a few hours during hot days to see if there were peak aldehyde concentrations from increased volatilization or

photochemical formation. For the special samples, the highest formaldehyde concentration was 1.27 ppb at 636 Stoddard on July 3, 1997. The other four special samples had formaldehyde results less than 1 ppb.

When compared to the annual average formaldehyde concentrations, the lower special sample results indicate that dispersion conditions, rather than volatilization or atmospheric photochemical formation of formaldehyde, is the prime factor affecting the ambient formaldehyde concentrations in Missoula.

TABLE 4.
SPECIAL SAMPLE ALDEHYDE RESULTS

SAMPLE NUMBER	DATE	TIME ON (MST)	TIME OFF (MST)	FORMALD. PPB	ACETALD. PPB	ACETONE PPB	PROPANAL PPB
BP1sp	6/27/97	1500	2000	0.64	0.13	0.48	0.20
BP2sp	7/11/97	1200	2000	0.49	0.57	0.04	0.25
BP3sp	7/24/97	0700	1000	0.76	1.27	1.54	0.37
N1sp	7/3/97	1230	1930	1.27	0.52	0.17	0.30
N2sp	7/17/97	0700	1000	0.66	0.53	1.68	0.15

The meaning of the special sample acetaldehyde and acetone results is less clear. On July 11 and 24, special samples were collected concurrently with regular samples at Boyd Park. While these special sample formaldehyde results were lower than the July 11 and July 24 regular sample formaldehyde results, the special sample acetaldehyde and propanal results were higher than the regular sample results. When compared to the regular 24 hour samples, the special sample results for acetaldehyde and acetone and were a mix of higher and lower values than the annual averages.

The December 14, 1997 samples (BP27 and N27) were analyzed for a total of 19 chemicals, as described in Table 5, because of their relatively high formaldehyde concentrations. The extra chemicals measured all had concentrations less than 1 ppb.

TABLE 5.

BP27 AND N27 CARBONYL CONCENTRATIONS, PPB
DECEMBER 14, 1997

CHEMICAL	N27 ppb	BP27 ppb	1994 NIOSH (TWA) ppb	1994 OSHA (PEL) ppb
FORMALDEHYDE	5.98	4.18	16	750
ACETALDEHYDE	3.22	2.60	None Given	200,000
PROPANAL	0.21	0.27	Not Listed	Not Listed
BUTANAL	0.12	0.10	Not Listed	Not Listed
PENTANAL	0.06	0.04	Not Listed	Not Listed
HEXANAL	0.10	0.08	Not Listed	Not Listed
HEPTANAL	0.06	0.04	Not Listed	Not Listed
OCTANAL	0.08	0.07	Not Listed	Not Listed
NONANAL	0.10	0.10	Not Listed	Not Listed
ACETONE	2.51	2.00	250,000	1,000,000
2-BUTANONE	0.16	0.14	200,000	200,000
ACROLEIN	0.11	0.09	100	100
CROTONALDEHYDE	0.26	0.22	2,000	2,000
BENZALDEHYDE	0.08	0.07	Not Listed	Not Listed
o-TOLUALDEHYDE	0.04	0.03	Not Listed	Not Listed
m+p-TOLUALDEHYDE	0.04	0.03	Not Listed	Not Listed
GLYOXAL	0.10	0.09	Not Listed	Not Listed
METHYL GLYOXAL	0.24	0.20	Not Listed	Not Listed
BIACETYL	0.08	0.06	Not Listed	Not Listed

The OSHA Personal Exposure Limit (PEL) is the only legal limit. The PEL is based on an eight hour work day and a 40 hour work week.
BP27 was collected at the Boyd Park sampling site. N27 was collected at the 636 Stoddard sampling site.

ALDEHYDE STANDARDS/GUIDELINES AND HEALTH EFFECTS

FORMALDEHYDE

Formaldehyde is heavier than air and can be detected by its foul odor at concentrations of 800 ppb. Because of its hydrophilic nature, most inhaled formaldehyde is absorbed by the mucus membranes in the upper respiratory tract where it can cause temporary irritation (Jakab, Risby and Hemenway, 1992). Formaldehyde reaches further into the respiratory tract when people smoke, when attached to airborne particles or when concentrations are high. At relatively high concentrations, over 3,000 ppb, formaldehyde may rarely induce a delayed asthmatic reaction. Formaldehyde also has a transient irritating effect on the mucus membrane around the eye. Once absorbed by the body, formaldehyde is quickly metabolized into non-harmful chemicals.

In one study performed on humans, a minimum risk level of 3 ppb for chronic duration inhalation exposure for formaldehyde was calculated based on the lowest observed adverse effect level of 80 ppb. The lowest observed adverse effect level was divided by 3 for human variability and by an uncertainty factor of 10 to find the minimum risk level (U.S. Department of Health & Human Services, 1997). The minimum risk level was set where no adverse health effects are expected to occur if exposures are below the minimum risk levels. Levels above the minimum risk level may not necessarily be hazardous.

The United States EPA's 1990 formaldehyde cancer unit risk estimate is 7.4×10^{-7} per 1 ppb based on monkey studies and 9.8×10^{-6} per ppb based on rat studies. The 1991 California Air Resource Board cancer unit risk estimate is 2.9×10^{-5} per ppb (Cotruvo, Joseph et.al., 1992). The cancer unit risk estimate is the chance of contracting cancer over a 70 year lifetime continuous exposure to a concentration of 1 ppb of formaldehyde. Using the first EPA risk estimate and Missoula's 1.46 annual average for formaldehyde, the individual risk of contracting cancer is (1.46 ppb) x (7.4×10^{-7} $(ppb)^{-1}$)= 1.1×10^{-6}. Another way to look at this estimate is that 1.1 people out of one million will contract cancer over a 70 year lifetime of continuous exposure to 1.46 ppb formaldehyde.

Formaldehyde is listed as a hazardous material by the Occupation Safety and Health Administration (OSHA) with a personal exposure limit of 750 ppb and an average 15 minute exposure limit of 2000 ppb. OSHA's personal exposure limit (PEL) is based on an 8 hour work day and a 40 hour work week. The National Institute for Occupational Safety and Health (NIOSH) has set a Time Weighted Average (TWA) exposure limit of 16 ppb and a ceiling exposure limit of 100 ppb. NIOSH's TWA is based on a maximum 10 hour work day and a 40 hour work week. NIOSH's Immediately Dangerous to Life and Health concentration for Formaldehyde is 20,000 ppb. Because formaldehyde is a suspected carcinogen, NIOSH recommends the most protective respirators at concentrations above the TWA and ceiling exposure limits (NIOSH, 1994).

Some local and state governments have set guidelines for ambient exposure to chemicals listed by the American Conference of Governmental Industrial Hygienists (ACGIH). For instance, Philadelphia, Pennsylvania has an annual average formaldehyde guideline of 4.8 ppb (EPA, 1992). New York State has an annual average formaldehyde guideline of 0.06 ug/m^3 (0.048 ppb). The New York guideline was set at a level where they felt there was a one in a million chance of cancer formation after 70 years exposure. This formaldehyde guideline was based on research done by the New York Department of Health (Davis, 1998). The Olympia Air Pollution Control Authority of Washington has set an ambient ceiling guideline of 50 ppb for formaldehyde (EPA, 1992). It should

be noted that these guidelines vary by three orders of magnitude and are not ambient air quality standards. The guidelines are often based on the ACGIH's 40 hour per week occupational exposure limit divided by an uncertainty factor. Also, for all these aldehydes, more research needs to be completed before accurate risk assessments can be done.

ACETALDEHYDE

The EPA acetaldehyde cancer unit risk estimate is 3.96×10^{-6} per 1 ppb (EPA, 1989). Using Missoula's high acetaldehyde annual average of 0.85 ppb, the individual risk of contracting cancer is (0.85 ppb) x (3.96×10^{-6} $(ppb)^{-1}$)= 3.37×10^{-6}. This estimate means that 3.37 people out of one million will contract cancer over a 70 year lifetime of continuous exposure to 0.85 ppb acetaldehyde.

OSHA's personal exposure limit for acetaldehyde is 200,000 ppb. NIOSH's Immediately Dangerous to Life and Health concentration for acetaldehyde is 2,000,000 ppb. Because acetaldehyde is a suspected carcinogen, NIOSH recommends the most protective respirators be used at concentrations above the PEL (NIOSH, 1994). Acetaldehyde has a pungent fruity smell and is a skin, eye, mucus membrane and respiratory tract irritant. Effects from exposure may be delayed.

The States of New York and Arizona (EPA, 1992) have set an annual average guideline of 0.5 ug/m^3 (0.27 ppb) for acetaldehyde. New York's guideline is based on a one in a million risk of cancer formation. New York's 1 hour average exposure limit for acetaldehyde is 4,500 ug/m^3 (2,459 ppb) (Davis, 1998).

ACETONE

OSHA's personal exposure limit for Acetone is 1,000,000 ppb. The NIOSH TWA is 250,000 ppb and Immediately Dangerous to Life and Health concentration for acetone is 2,500,000 ppb.

Both California and New York have set an annual average ambient guideline of 2,800 ug/m^3 (1,157 ppb) for acetone (Davis, 1998).

PROPANAL

Propanal is not listed as a hazardous substance.

DISCUSSION

One of the main objectives of the study was to find the annual average formaldehyde levels in Missoula and to determine if these levels posed a threat to human health. The formaldehyde annual average was 1.18 ppb at Boyd Park and 1.46 ppb at 636 Stoddard. The Missoula 1997 formaldehyde annual averages were less than Philadelphia's annual average guideline but higher than New York's annual average guideline. All formaldehyde samples collected had concentrations less than the Olympia Air Pollution Control Authority ambient ceiling guideline of 50 ppb.

When compared to major cities in the world, Missoula has low ambient air formaldehyde levels. For

instance, ambient formaldehyde levels have reached 159 ppb in Sao Paula, Brazil (Kabuto, Tsugane and Hamada, 1990) and a year long study in Los Angeles California had site averages between 5 and 20 ppb (Grosjean, 1994). These areas are different from Missoula in that over 90% of the formaldehyde in their ambient air is a secondary atmospheric byproduct of hydrocarbon pollution.

In 1992, formaldehyde and acetaldehyde were measured in Atlanta, Georgia, during July and August. Samples were collected between 7 a.m. and 7 p.m. on ten sample days. At Atlanta's four sample sites, formaldehyde concentrations averaged 2.70±1.21 ppb to 3.00±1.26 ppb and acetaldehyde concentrations averaged 2.63±0.99 ppb to 3.21±1.48 ppb (Grosjean, E., et al, 1993). Atlanta's aldehyde concentrations were higher than Missoula's but lower than other major cities where aldehydes have been measured. Because of Missoula's latitude and climate, photochemically based reactions are not a major contributor to aldehyde levels. In the summer months when atmospheric photochemical-hydrocarbon reactions play more of a role in formaldehyde and acetaldehyde formation, good dispersion prevents elevated hydrocarbon concentrations.

Annual average acetaldehyde concentrations ranged between 2.9 and 10.3 ppb in an eight site urban southern California study (1988-1990). Five samples collected in Chicago Illinois averaged 2.1±0.9 ppb acetaldehyde and eleven samples collected in Houston Texas averaged 2.2±1.7 acetaldehyde ppb (Grosjean, E., et al, 1993). These levels, along with the concentrations found in Atlanta, are considerably higher than Missoula's acetaldehyde annual average of 0.77 ppb and 0.85 ppb.

Another area of concern for formaldehyde is indoor air where concentrations are typically between 30-100 ppb in homes and public buildings (Crump and Gardiner, 1989), much higher than Missoula's annual average ambient concentrations. The American Society of Heating, Refrigerating, and Air Condition Engineers has set a generally accepted limit of 100 ppb formaldehyde for indoor air (ASHRAE, 1981). Formaldehyde levels over 100 ppb can cause headaches, nausea, and mucus membrane irritation in sensitive individuals. The primary sources of formaldehyde in indoor air are wood products bonded with urea-formaldehyde resin and insulation. Formaldehyde off gassing from building materials has a half life of 30-60 months (Marchant, 1986) so older buildings tend to have lower formaldehyde concentrations. Mobile homes typically have the highest levels of formaldehyde.

CONCLUSIONS

Based on this investigation, formaldehyde and acetaldehyde levels in Missoula's ambient air are higher than some state guidelines, but do not appear to pose a large threat to human health. Even so, concentrations should be kept as low as feasible because formaldehyde and acetaldehyde are suspected carcinogens. Aldehyde emissions could be lowered by adding pollution control equipment at industrial sources, replacing high formaldehyde emitting stoves and reducing vehicular traffic and congestion. There is no Environmental Protection Agency Maximum Attainable Control Technology Standard for the industrial formaldehyde emitters in Missoula. Formaldehyde emissions from woodstoves are coming down because wood stoves can no longer be installed in Missoula and inefficient woodstoves are being removed when houses are sold. The use of oxyfuels may cause a small increase in the amount of formaldehyde produced by vehicles. However, this is offset by a significant decrease in benzene, a known carcinogen, and carbon monoxide emissions.

As in other urban studies, formaldehyde and acetaldehyde were the two most common aldehydes in Missoula's ambient air. While the formaldehyde and acetaldehyde concentrations were all below the legal standards, they did exceed some state and local government ambient guidelines. If future aldehyde or air toxic studies are done, formaldehyde and acetaldehyde should be considered for analysis. The highest aldehyde concentrations can be found during the winter season when dispersion conditions are poor.

The other chemicals analyzed for all had low concentrations. Based on the current literature and research, the acetone and propanal levels in Missoula pose no threat to human health. The other chemicals analyzed for on December 14, the worst dispersion day of the study, were all below 1 ppb.