Health Risk Evaluation of Site Specific Ambient Air Measurements in Garfield County, Colorado (October – December 2018)

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Executive Summary

As part of an ongoing air monitoring plan, Garfield County Public Health (GCPH) collected air samples October through December, 2018 to measure multiple volatile organic compounds (VOCs) near an oil and gas site in Battlement Mesa, Colorado. GCPH requested the Oil and Gas Health Information and Response (OGHIR) program at the Colorado Department of Public Health and Environment (CDPHE) to conduct a health risk evaluation of these VOC air samples.

Although these data are limited, the main findings from this evaluation indicate:

- All air concentrations of individual and combined VOCs were below long-term non-cancer health guideline values established by state and federal agencies (Table 1-2). Four of the 53 detected VOCs did not have health guideline values and therefore, were not evaluated.
- Although all individual VOCs were below health guideline values, the non-cancer hazard quotients and cancer risk estimates were generally higher in the downwind samples and grab sample compared to the upwind samples (Table 2).
    - The downwind grab sample in October (#1) had a hazard index of 1.49. Additional review identified that all other downwind and upwind samples collected during this quarter had a hazard index below 1 (0.05 – 0.7) and therefore, this downwind sample likely does not represent ongoing chronic conditions.
- Cancer risks estimates for benzene and ethylbenzene individually and combined were within the US EPA generally acceptable risk range of 1 to 100 in a million (Table 3).

Overall, the evaluation of the air samples during this time indicates a low risk of cancer and long-term non-cancer health effects due to VOC exposure in the vicinity of this oil and gas operation.

Background

Garfield County Public Health (GCPH) is conducting an ongoing evaluation of the air quality near an oil and gas site in Battlement Mesa, Colorado. GCPH requested the Oil and Gas Health Information and Response (OGHIR) Program at the Colorado Department of Public Health and Environment (CDPHE) conduct a health risk evaluation of the measured VOCs from the fourth quarter air sampling period of 2018.

Purpose

The purpose of this assessment was to evaluate whether people living near this site were at risk of harmful health effects from exposures to volatile organic compounds (VOCs) in the air.

Methods

VOC air sampling

GCPH contracted Air Resource Specialists (ARS) to design and build a conditional sampler to collect air samples south of the URSA well pad in Battlement Mesa. One or two samples per month from October to December, 2018 were collected over a week long period with a conditional sampler designed to collect ambient air samples when the wind was coming from the direction of the oil and gas site (termed downwind). Grab samples were also collected. Samples were analyzed for VOC's following EPA's Method TO-12. Details of the VOC sampling study are available via GCPH/ARS.

Health risk evaluation

This screening level health risk evaluation is consistent with the US Environmental Protection Agency guidance[1].

1. Exposure Evaluation
   The objective of an exposure evaluation is to select air monitoring data that most closely represent the amount of the VOC that would be inhaled by a person living in the area. Because these samples were integrated over approximately 1-2 weeks, they more likely represent long-term exposures rather than short-term (i.e. one hour or less) exposures. For the purposes of this screening level assessment, long-term exposure conservatively assumes a person lives or stays near a given monitoring location for 24 hours per day, 365 days per year, for a lifetime (i.e., 70 years). It also assumes the measured concentrations of the VOCs in the air remain constant over the entire 70-year exposure period. Since the conditional samplers are activated from wind direction, this exposure would also assume a constant wind direction.

2. Health Effect Evaluation
   Non-cancer health effects: A non-cancer health guideline value (HGV) is defined as the exposure level that is likely to be without appreciable risk of adverse non-cancer health effects in an exposed population, including sensitive individuals. The HGV for each VOC is expressed as a concentration in units of parts per billion. Long-term (chronic) HGVs were used to compare to the air measurements. There were no long-term HGV's for 1-nonene, 1-octene, 1-undecene, and 2-methyl-1-butene and therefore, these VOCs were not evaluated in this health risk assessment. Ethane is considered an asphyxiant at extremely high exposures with no other toxicological effects and was also not evaluated.

[1] US EPA (2004). Air Toxics Technical Resource Manual, EPA-453-K-04-001A.

Cancer health effects: An inhalation unit risk (IUR) is an estimate of the increased excess cancer risk from inhalation exposure to a VOC for a lifetime. Two VOCs had IURs derived by either the US EPA (benzene) or the California EPA (ethylbenzene) and are evaluated in this assessment.

3. Risk Characterization

Non-cancer health effects

Individual VOCs: A hazard quotient (HQ) was determined for each individual VOC that had an established HGV. This ratio is a risk estimate that compares average air concentration for each VOC to its established long-term HGV. HQs are an indication of whether there is potential cause for concern for adverse health effects.

Combined VOCs: When simultaneous exposures to multiple chemicals in the air can occur, it is important to evaluate the potential for risks to human health from combined exposures. To evaluate the combined risk, a Hazard Index or HI is used. An HI is calculated by adding together all of the individual HQs. This total HI is a conservative approximation of the total non-cancer risk for exposure to all of the VOCs.

HQs and HIs are calculated as follows:

$$HQ = \frac{\text{air measurement}}{HGV}$$

HQ = Hazard Quotient
HGV = Health Guideline Value

$$HI = HQ1+HQ2+HQ3+....$$

HQs and HIs are evaluated as follows:

- If HQ or HI is less than 1, no further evaluation is necessary and it can generally be concluded that potential for adverse health effects from the exposures measured in this study is low.
- If HQ or HI is greater than or equal to 1, further evaluation is recommended.

Cancer health effects:

For VOCs that could cause cancer, VOC concentrations associated with $1x10^{-6}$ (one in one million) to $1x10^{-4}$ (one in ten thousand) excess cancer risk levels were used as comparison values. For example, a risk level of one in a million ($1x10^{-6}$) implies that up to one out of one million equally exposed people could contract cancer if exposed continuously (i.e., 24 hours per day) to the specific concentration over a lifetime (i.e., 70 years). This would be in addition to those cancer cases that would normally occur in an unexposed population of one million people. The level of cancer risk that is of concern is a matter of individual, community, and regulatory judgment. The EPA typically considers risks below 1×10^{-6} to be so small as to be negligible. Therefore, the EPA uses a cancer risk of one in a million (1×10^{-6}) as a regulatory goal, which means that regulatory programs are generally designed to try to reduce risk to this level. However, the EPA considers all cancer risks lower than 1 in 10,000 ($1x10^{-4}$) to be "acceptable".

Combined cancer risks were also evaluated for all known cancer causing VOCs. This approach assumes the combined effect of each of the VOCs is additive.

Results

- All air concentrations of individual VOCs were below long-term non-cancer health guideline values (Table 1-2). Four of the 53 detected VOCs did not have health guideline values and therefore, were not evaluated.
- Although all individual VOCs were below health guideline values, the non-cancer hazard quotients and cancer risk estimates were generally higher in the downwind conditional samples and grab samples compared to the upwind samples (Table 2).
    - The downwind grab sample in October (#1) had a hazard index of 1.49. Additional review identified that all other downwind and upwind samples collected during this quarter had a hazard index below 1 (0.05 – 0.7) and therefore, this single sample likely does not represent ongoing chronic conditions.
- Cancer risks estimates for benzene and ethylbenzene individually or together were within the acceptable risk range of 1 to 100 in a million (Table 3).

Limitations

The following limitations must be considered when interpreting the results from this air sampling:

- The conditional air sampling represents a “snapshot” of VOC concentrations from all sources in the area during separate week long periods. This sampling technique may not accurately capture peak exposures, and samples collected under different conditions and times may have different results.
- Other substances that may be emitted from oil and gas operations were not sampled in this study and exposure to these substances may result in additional health risk.

Conclusions

The evaluation of the air samples during this time indicates a low risk of long-term harmful health effects due to VOC exposure in the vicinity of this oil and gas operation. Although one grab sample exceeded a HI of 1 for chronic exposures, all other samples collected during this period were below 1, and therefore, this single sample likely does not represent ongoing chronic conditions. Evaluation of long-term trends of this air sampling is recommended to continue to monitor risks from chronic exposures.

Table 1. Downwind air measurements in 2018 compared to non-cancer long-term (chronic) health guideline values (HGV). All values are in ppbV.

Substance*	October #1[+]	October #2	November #1	December #1[+]	December #2	Chronic HGV
1,2,3-Trimethylbenzene	0.09	ND	ND	0.03	ND	12 [I]
1,2,4-Trimethylbenzene	0.44	0.06	0.06	0.18	0.04	12 [I]
1,3,5-Trimethylbenzene	0.53	ND	0.04	0.21	0.03	12 [I]
1-Hexene	ND	0.01	0.01	ND	0.01	50 [T]
1-Pentene	0.04	0.03	0.03	0.01	0.02	560 [T]
2,2-Dimethylbutane	0.38	0.05	0.08	0.48	0.10	100 [T]
2,3,4-Trimethylpentane	0.02	ND	ND	0.01	ND	124 [P]
2,3-Dimethylbutane	0.89	0.08	0.15	0.91	0.17	99 [T]
2,3-Dimethylpentane	0.74	0.04	0.09	0.43	0.07	2200 [R]
2,4-Dimethylpentane	0.52	0.02	0.07	0.34	0.06	2200 [T]
2-Methyl-2-butene	0.03	ND	ND	ND	ND	560 [T]
2-Methylheptane	2.13	0.03	0.22	0.93	0.13	390 [T]
2-Methylhexane	2.76	0.10	ND	1.44	0.29	2200 [T]
2-Methylpentane	3.50	0.38	0.58	3.05	0.64	99 [T]
3-Methylheptane	1.68	0.02	0.18	0.74	0.10	390 [T]
3-Methylhexane	2.60	0.09	0.32	1.39	0.26	2200 [T]
3-Methylpentane	2.18	0.18	0.35	1.87	0.40	100 [T]
Acetylene	0.09	0.35	0.54	0.38	0.64	2500 [T]
a-Pinene	ND	ND	ND	0.01	ND	63 [T]
Benzene	2.18	0.15	0.39	1.18	0.35	9 [I]
Cyclohexane	5.67	0.26	0.80	3.75	0.69	1743 [I]
Cyclopentane	0.44	0.06	0.09	0.46	0.11	120 [T]
Ethylbenzene	0.33	0.02	0.04	0.14	0.03	230 [T]
Ethylene	1.15	1.50	1.17	0.86	0.97	5300 [T]
Isobutane	5.08	3.25	1.83	11.38	2.55	10000 [T]
Isopentane	6.66	ND	ND	8.94	ND	8000 [T]
Isoprene	0.03	ND	0.01	ND	ND	2 [T]
Isopropylbenzene	ND	ND	ND	ND	ND	81 [I]
Methylcyclohexane	15.00	0.37	1.77	7.73	1.21	400 [T]
Methylcyclopentane	3.75	0.21	0.54	2.62	0.53	75 [T]
m-Ethyltoluene	0.27	ND	0.03	0.12	0.03	25 [T]
m-Xylene/p-Xylene	3.89	0.06	0.36	1.58	0.23	23 [I]
n-Butane	6.08	3.43	2.29	13.05	3.10	10000 [T]
n-Decane	1.05	0.02	0.08	0.42	0.08	175 [T]

n-Dodecane	0.05	ND	0.01	0.03	ND	**3.8** [P]
n-Heptane	6.09	0.17	0.72	3.03	0.51	**2200** [T]
n-Hexane	6.12	0.44	0.85	4.15	0.90	**198** [I]
n-Nonane	2.43	0.03	0.20	0.96	0.14	**3.8** [P]
n-Octane	5.78	0.09	0.59	2.46	0.34	**124** [P]
n-Pentane	4.58	0.96	1.60	6.18	1.41	**8000** [T]
n-Propylbenzene	0.09	ND	ND	0.03	ND	**51** [T]
n-Undecane	0.27	ND	0.03	0.11	0.03	**55** [T]
o-Ethyltoluene	0.25	ND	ND	0.10	0.02	**25** [T]
o-Xylene	0.54	0.02	0.06	0.22	0.05	**23** [I]
Propane	15.23	13.50	6.70	36.33	9.17	**8000** [T]
Propylene	0.21	0.20	0.14	0.10	0.11	**1743** [C]
Toluene	5.63	0.18	1.01	2.51	0.62	**1327** [I]
trans-2-Pentene	ND	ND	ND	ND	ND	**560** [T]

*Only substances that were above the detection limit in at least one sample and had a health guideline value are reported in the table. +Denotes grab sample. I = US EPA; A = ATSDR (US Agency for Toxic Substances and Disease Registry); P= PPRTV (US EPA Provisional Peer Reviewed Toxicity Values); C= CalEPA (California Office of Environmental Health Hazard Assessment); T= TCEQ (Texas Commission on Environmental Quality).

Table 2. Non-cancer long-term risk estimates for individual and combined VOCs for the highest hazard indices of both downwind and upwind samples. The risk estimate, or HQ, is the ratio that compares the air concentration for each VOC to long- term HGV (see methods). A value below 1 indicates that the air concentration was below the HGV.

Substance*	Downwind HQ (Oct. #1)	Upwind HQ (Dec.)
1,2,3-Trimethylbenzene	0.01	ND
1,2,4-Trimethylbenzene	0.04	0.00
1,3,5-Trimethylbenzene	0.04	0.00
1-Hexene	ND	0.00
1-Pentene	0.00	0.00
2,2-Dimethylbutane	0.00	0.00
2,3,4-Trimethylpentane	0.00	ND
2,3-Dimethylbutane	0.01	0.00
2,3-Dimethylpentane	0.00	0.00
2,4-Dimethylpentane	0.00	0.00
2-Methyl-2-butene	0.00	ND
2-Methylheptane	0.01	0.00
2-Methylhexane	0.00	ND
2-Methylpentane	0.04	0.00
3-Methylheptane	0.00	0.00
3-Methylhexane	0.00	0.00
3-Methylpentane	0.02	0.00
Acetylene	0.00	0.00
a-Pinene	ND	ND
Benzene	0.24	0.02
Cyclohexane	0.00	0.00
Cyclopentane	0.00	0.00
Ethylbenzene	0.00	0.00
Ethylene	0.00	0.00
Isobutane	0.00	0.00
Isopentane	0.00	ND
Isoprene	0.02	0.01
Isopropylbenzene	ND	0.00
Methylcyclohexane	0.04	0.00
Methylcyclopentane	0.05	0.00
m-Ethyltoluene	0.01	ND
m-Xylene/p-Xylene	0.17	0.00

n-Butane	0.00	0.00
n-Decane	0.01	0.00
n-Dodecane	0.01	ND
n-Heptane	0.00	0.00
n-Hexane	0.03	0.00
n-Nonane	0.64	0.01
n-Octane	0.05	0.00
n-Pentane	0.00	0.00
n-Propylbenzene	0.00	ND
n-Undecane	0.00	0.00
o-Ethyltoluene	0.01	ND
o-Xylene	0.02	0.00
Propane	0.00	0.00
Propylene	0.00	0.00
Toluene	0.00	0.00
trans-2-Pentene	ND	ND
Hazard Index (HI)	**1.49**	**0.05**

*Only substances that were above the detection limit in at least one sample and had a health guideline value are reported in the table.

Table 3. Summary of air measurements compared to lowest VOC concentration at each risk level within the generally "acceptable"[1] risk range (1 to 100 in a million).

Substance	Range of Air Measurement[2] (ppb)	Cancer Risk Estimate		
		Air Concentration at 1 in a million (ppb)	Air Concentration at 10 in a million (ppb)	Air Concentration at 100 in a million (ppb)
Benzene[3]	0.15 - 2.18	0.041	0.41	4.1
Ethylbenzene[4]	0.01 - 0.33	0.092	0.92	9.2

[1]A one in a million cancer risk ($1x10^{-6}$) is considered a minimal cancer risk. A 100 in a million cancer risk ($1x10^{4}$) is considered the upper limit of the US EPA "acceptable" range.
[2]Range of air measurements of all samples (upwind and downwind).
[3]Risk estimates determined using the US EPA inhalation unit risk of 7.8 $x10^{-6}$ per µg/m^3.
[4]Risk estimates determined using the CalEPA inhalation unit risk of $2.5x10^{-6}$ per µg/m^3.