

Health Risk Evaluation from Inhalation of VOCs in Ambient Air Near Woolley-Sosa and Erie Champlin Oil and Gas Sites

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Executive Summary

The Oil and Gas Health Information and Response (OGHIR) Program at the Colorado Department of Public Health and Environment (CDPHE) received a large volume of calls since December 2016 from residents in multiple neighborhoods in Erie reporting odor and health concerns possibly related to emissions from Woolley-Sosa and Erie Champlin sites. Evaluation of health concerns reported by residents in the vicinity of the Woolly Sosa and Erie Champlain sites suggest upper respiratory irritation and physiological responses to odorous substances in the air. OGHIR has documented that many of these concerns occurred temporally with drilling operations on the Woolly Sosa site when wind direction was coming from the direction of the well pad.

Based on the large volume of ongoing health concerns, OGHIR deployed the Colorado Air Monitoring Mobile Laboratory (CAMML) on March 7-8 and March 20-23, to measure volatile organic compounds (VOCs) in the air where residents have reported health symptoms and odors. These measurements were compared to health based reference levels set by federal and state agencies to estimate the potential for short and long term health risks to residents living in the vicinity of these oil and gas sites. The evaluation indicated that all air concentrations of individual and combined VOCs were below non-cancer health-based reference values. Cancer risks estimates for benzene, ethylbenzene, and the two VOCs combined were less than one in one hundred thousand, which is generally considered to be within the acceptable risk range.

In conclusion, using currently available measurement technology and risk assessment methods, OGHIR is unable to document conditions that suggest an ongoing health hazard at this time. However, although the CAMML measures a large number of substances related to oil and gas emissions, there may be other substances that were not measured that may contribute to the respiratory irritation and odor concerns reported by residents.

OGHIR is continuing to monitor health concerns in the vicinity of the Woolly Sosa and Erie Champlain sites. Residents with ongoing health concerns are encouraged to contact OGHIR.

Background

Since December 2016, the Oil and Gas Health Information and Response Program (OGHIR) at the Colorado Department of Public Health and Environment (CDPHE) has logged concerns from 82 residents in multiple neighborhoods in Erie reporting odors and health symptoms possibly related to emissions from two well sites. The two sites are the Woolley-Sosa site, where new wells were being drilled, and the Erie Champlin site. The main health symptoms reported include irritation of the eyes, nose and throat, respiratory effects, headaches, and nausea.

As part of an initial health investigation, OGHIR conducted three separate screening level health risk evaluations from single whole air (canister) samples of volatile organic compounds (VOCs) collected in the Erie Village neighborhood between December 13, 2016 and February 16, 2017 during times when residents reported strong odors and/or health symptoms. The air concentrations of VOCs in all samples were below health-based reference limits established by federal and/or state agencies. The reports are available online at: www.colorado.gov/oghealth.

While OGHIR has only been logging health concerns since October of 2015, the number and frequency of health concerns reported in association with the Woolly Sosa and Erie Champlain sites are much higher than other sites in the state. In response to continuing reports of health concerns, the Colorado Air Monitoring Mobile Laboratory (CAMML) was deployed to a location between the Woolley-Sosa oil and gas site and the Erie Village neighborhood on March 7-8 and March 20-23 to conduct more extensive air monitoring.

Purpose

The purpose of this investigation was to measure substances in the air where residents have reported health symptoms and odors. These measurements were used to estimate the risk of health effects to residents living in the vicinity of these oil and gas sites.

Methods

Air Sampling

The CAMML was deployed on March 7-8 and March 20-23, 2017. One or more residents reported health effects and/or odors on each day of testing. The CAMML was parked in a field to the southwest of the Woolley-Sosa well pad, situated in between the well pad and the residential community (latitude: 40.064230° / longitude: -105.055983°). Outdoor air samples were collected at an inlet height of 16-18 feet from the ground. Thirty minute integrate VOC air samples were collected hourly, totaling 102 hours of continuous sample collection during the two deployments. Based on analysis of site-collected meteorological data, wind direction indicated the CAMML was downwind of the well pad and wind speed was within an acceptable range (2-10 mph) for the majority of the sampling period. The air samples were collected using a Markes UNITY 2 Air Server tenax-based sorbent thermal desorption system and analyzed using a Thermo Scientific ISQ Series GC MS.

Health Risk Evaluation

1. **Exposure Assessment:** The air concentrations of VOCs were used to represent two different potential exposure scenarios:
 - A) The maximum air concentration of a VOC during any one hour period was used to represent acute (short-term) exposure. An acute exposure period would be an intermittent, infrequent exposure that could occur for a few hours to a few days.

B) The average air concentration of a VOC during the entire sampling period was used to represent a chronic (long-term) exposure. A chronic exposure assumes a prolonged continuous exposure over the lifetime of an individual.

2. **Health Effects Assessment:** Federal or state established short and long-term exposure guidelines for each VOC (termed health based reference level in this report- HBRL) were selected in a manner consistent with the US Environmental Protection Agency (EPA) risk assessment guidelines for air toxics*. These limits are generally based on the most sensitive, chemical-induced health effect considered to be relevant to humans and include a large margin of safety to account for uncertainties in the studies and sensitive people in the population. For non-cancer health effects, the HBRL is the exposure level below which health effects are not expected to occur. Methane, ethane and propylene data were collected but were not evaluated in the health assessment since they have very low potential to produce health effects and therefore, do not have short-term and/or long-term health screening levels.

For VOCs that could cause cancer, VOC concentrations associated with 1×10^{-6} (one in one million) to 1×10^{-4} (one in ten thousand) cancer risk levels were used. For example, a risk level of one in a million (1×10^{-6}) implies a likelihood that up to 1 out of one million equally exposed people would 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. A one in a million cancer risk is considered a minimal cancer risk. A one in ten thousand cancer risk is considered the upper limit of the US EPA “acceptable” range.

3. **Risk Characterization:**

Non-cancer:

Individual VOCs: A hazard quotient (HQ) was determined for each individual VOC. This ratio is a risk estimate that compares the maximum and average air concentrations for each VOC to short- and long-term HBRLs.

Combined VOCs: Evaluating the combined risks to human health from multiple VOCs is an important component to understanding the potential for health effects to occur from oil and gas emissions. A Hazard Index (HI) was derived by adding all the HQs (labeled as “All” in Figure 1). This total HI is a conservative approximation of the total potential non-cancer risk estimate of all VOCs.

HQs are calculated as follows:

$\text{Short-term HQ} = \frac{\text{maximum air concentration}}{\text{HBRL (short-term)}}$
$\text{Long-term HQ} = \frac{\text{average air concentration}}{\text{HBRL (long-term)}}$
$\text{HI} = \text{sum of all HQ's}$
$\text{HQ} = \text{Hazard Quotient}$
$\text{HBRL} = \text{Health Based Reference Level}$

* Air Toxics Technical Resource Manual, EPA-453-K-04-001A, April 2004

- *If HQ or HI is less than 1*, no further evaluation is necessary and it can be concluded that potential for harmful health effects from the exposures measured in this study is low, even for sensitive populations.
- *If HQ or HI is greater than 1*, further evaluation is conducted.

Cancer:

To estimate increased cancer risks, the lowest VOC concentration at each risk level within the generally “acceptable” risk range (1×10^{-4} to 1×10^{-6}) was selected. 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 and combined VOCs were below non-cancer health-based reference values (Table 1, Figure 1).
- Cancer risks estimates for benzene and ethylbenzene and the two VOCs combined were less than one in one hundred thousand, which is below the midpoint of the acceptable risk range (Table 2).

Limitations

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

- This air sampling represents a “snapshot” of VOC concentrations from all emission sources in the area. Samples collected under different conditions could have different results.
- Other substances that may be emitted from oil and gas were not sampled in this study and exposure to these substances may result in additional health risk.

Conclusions

Evaluation of health concerns reported by residents in the vicinity of the Woolly Sosa and Erie Champlain sites suggest upper respiratory irritation and physiological responses to odorous substances in the air. OGHIR has documented that many of these concerns occurred temporally with drilling operations on the Woolly Sosa site when wind direction was coming from the direction of the well pad.

To further evaluate the reported health concerns, the Colorado Air Monitoring Mobile Laboratory (CAMML) was deployed to the site March 7-8 and March 20-23. The evaluation of the air samples during this time indicates a low potential risk of harmful health effects due to VOC exposures in the vicinity of the Woolly Sosa and Erie Champlain sites. Using currently available measurement technology and risk assessment methods, OGHIR is unable to document conditions that suggest an ongoing health hazard at this time. However, although the CAMML measures a large number of substances related to oil and gas emissions, there may be other substances that were not measured that may contribute to the respiratory irritation and odor concerns reported by residents.

Next Steps

OGHIR is continuing to monitor health concerns in the vicinity of the Woolly Sosa and Erie Champlain sites. Residents with ongoing health concerns are encouraged to contact OGHIR.

Table 1. Summary of air data compared to short- and long-term non-cancer health based reference levels

Substance	Air Measurements (ppbv)		Health Based Reference Levels (ppbv)	
	Maximum	Average	Short-Term	Long-Term
1,2,3-Trimethylbenzene	0.94	0.19	3000 ^I	12 ^I
1,2,4-Trimethylbenzene	0.96	0.24	3000 ^T	12 ^I
1,3,5-Trimethylbenzene	0.93	0.25	3000 ^T	12 ^I
2,2,4-Trimethylpentane	0.99	0.28	750 ^T	75 ^T
2,3,4-Trimethylpentane	1.00	0.24	750 ^T	75 ^T
2,2-Dimethylbutane	ND	ND	8300 ^R	2200 ^R
2,3-Dimethylbutane	1.00	0.32	8300 ^R	2200 ^R
2,3-Dimethylpentane	0.99	0.32	8300 ^R	2200 ^R
2,4-Dimethylpentane	0.96	0.33	8300 ^T	2200 ^T
2-Butene (cis)	0.70	0.18	15000 ^T	700 ^T
2-Butene (trans)	5.99	0.58	15000 ^T	700 ^T
2-Methylheptane	0.98	0.26	4100 ^T	380 ^T
2-Methylhexane	0.98	0.24	8300 ^T	2200 ^T
2-Pentene (cis)	0.75	0.30	12000 ^T	560 ^T
2-Pentene (trans)	0.92	0.19	12000 ^T	560 ^T
2-Methylpentane	0.99	0.30	990 ^T	90 ^T
3-Methylheptane	0.98	0.31	4100 ^T	380 ^T
3-Methylhexane	0.98	0.28	8300 ^T	2200 ^T
3-Methylpentane	0.92	0.27	1000 ^T	100 ^T
Acetylene	ND	ND	25000 ^T	2500 ^T
Ammonia	19.79	9.87	30000 ^I	717 ^I
Benzene	0.99	0.29	9 ^A	9 ^I
Butene	0.97	0.31	27000 ^T	2300 ^T
Cyclohexane	0.98	0.28	1000 ^I	1743 ^I
Cyclopentane	0.98	0.25	5900 ^T	120 ^T
Ethane	17.85	2.13	NA	NA
Ethylbenzene	0.96	0.28	5000 ^A	230 ^I
Ethylene	0.89	0.36	500000 ^T	5300 ^T
Hexene	ND	ND	NA	NA
Isobutane	1.50	0.38	33000 ^T	10000 ^T
Isopentane	2.16	0.34	8100 ^T	8000 ^T
Isoprene	0.99	0.30	20 ^T	2 ^T
m/p-Xylenes	0.97	0.29	1700 ^A	23 ^I
m-Diethylbenzene	0.96	0.18	460 ^T	46 ^T
Methane	2740.00	2110	NA	NA
Methylcyclohexane	1.00	0.30	4000 ^T	400 ^T
Methylcyclopentane	ND	ND	750 ^T	75 ^T
m-Ethyltoluene	0.99	0.21	250 ^T	25 ^T
n-Butane	5.28	0.53	92000 ^T	10000 ^T
n-Decane	0.98	0.26	1750 ^T	175 ^T
n-Dodecane	0.10	0.04	1700 ^D	38 ^R
n-Heptane	0.97	0.27	8300 ^T	2200 ^T
n-Hexane	0.99	0.35	1700 ^T	198 ^I
n-Octane	0.98	0.27	4100 ^T	75 ^T
n-Nonane	0.96	0.27	3000 ^T	38 ^P
n-Pentane	1.38	0.30	68000 ^T	8000 ^T
n-Propylbenzene	0.87	0.24	510 ^T	203 ^P
n-Undecane	0.57	0.09	550 ^T	55 ^T
o-Ethyltoluene	0.92	0.19	250 ^T	25 ^T
o-Xylene	0.93	0.29	1700 ^A	23 ^I
p-Diethylbenzene	0.98	0.26	460 ^T	46 ^T
p-Ethyltoluene	0.97	0.31	250 ^T	25 ^T
Pentene	0.99	0.35	12000 ^T	560 ^T
Propane	9.07	1.13	68000 ^T	8000 ^T
Propylene	0.92	0.30	NA	1743 ^C
Styrene	0.95	0.10	5000 ^A	235 ^I
Toluene	0.92	0.26	2000 ^A	1327 ^I

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); D = DOE (Department of Energy Temporary Emergency Exposure Limit); R = Read Across; NA = no health value available; ND = not detected (i.e. concentration below instrument detection limit)

Figure 1. (A) Short-term and (B) long-term risk estimates (hazard quotients - HQ) for individual and combined (“All”) VOCs for non-cancer effects. *If HQ is less than 1, no further evaluation is necessary and it can be concluded that potential for harmful health effects from the exposures measured in this study is low, even for sensitive populations. If HQ is greater than 1, further evaluation is conducted.*

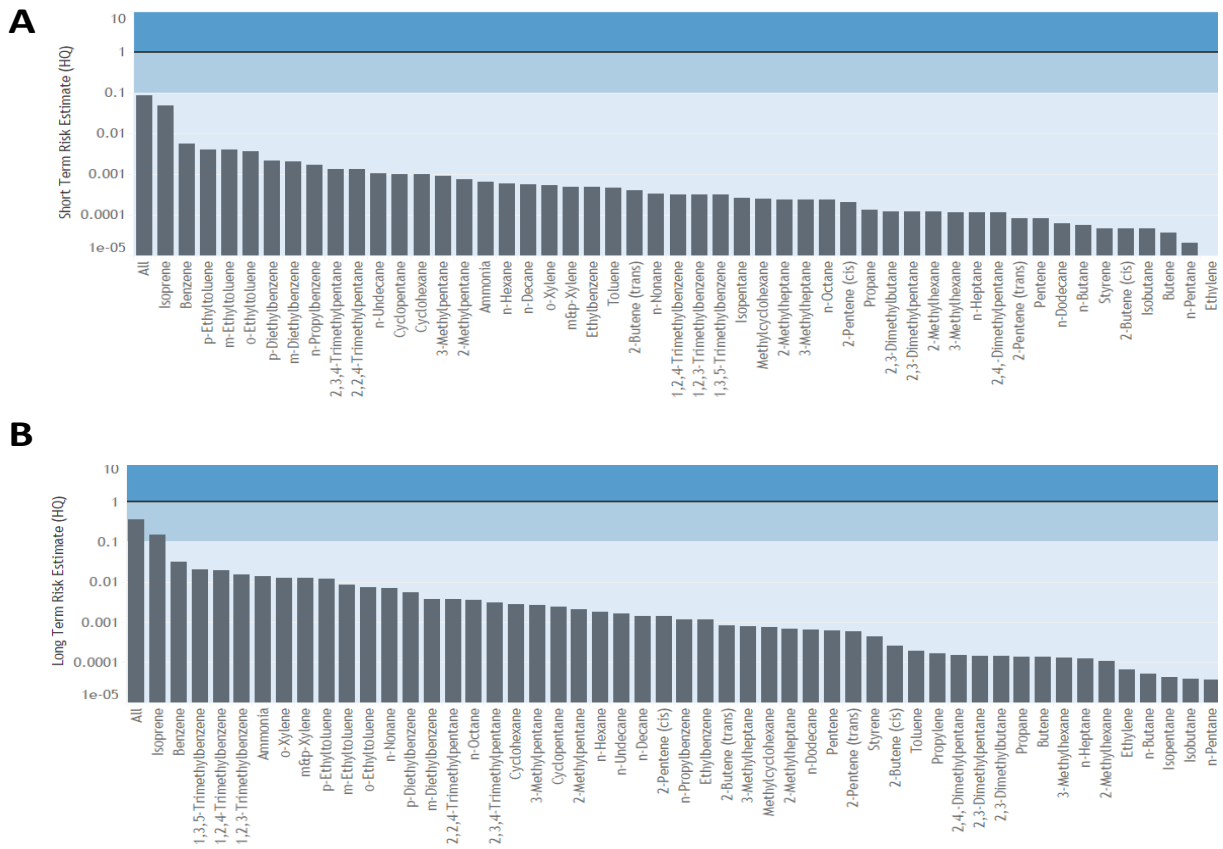


Table 2. Summary of average air measurements collected in the investigation compared to lowest VOC concentration at each risk level within the generally “acceptable”¹ risk range (1x10⁻⁴ to 1x10⁻⁶).

Substance	Average Air Measurement (ppb)	Cancer Risk Estimate		
		Air Concentration at 1x10 ⁻⁶ (ppb)	Air Concentration at 1x10 ⁻⁵ (ppb)	Air Concentration at 1x10 ⁻⁴ (ppb)
Benzene ²	0.29	0.041 ²	0.41 ²	4.1 ²
Ethylbenzene ³	0.28	0.092 ³	0.92 ³	9.2 ³

¹A one in a million cancer risk (1x10⁻⁶) is considered a minimal cancer risk. A one in ten thousand cancer risk (1x10⁻⁴) is considered the upper limit of the US EPA “acceptable” range.

²Determined using the US EPA inhalation unit risk of 7.8 x10⁻⁶ per µg/m³.

³Determined using the CalEPA inhalation unit risk of 2.5x10⁻⁶ per µg/m³.