Characterizing Emissions from Natural Gas Drilling and Well Completion Operations in Garfield County, CO

Study Fact Sheet

May 2018

Key Points

- **Increases in natural gas extraction activities in western Colorado have the potential to increase air emissions of methane and volatile organic compounds (VOCs).** Some VOCs are classified as air toxics and some can impact local air quality through increased ozone formation.
- Concentrations of VOCs in the vicinity of a wellpad depend upon the background VOC concentration, the rate of VOC emissions from activity on the pad, and the meteorological conditions that influence the transport and dispersion of VOCs downwind of the pad.
- Air emissions have not previously been well quantified during well drilling and completion activities. To fill this gap, **Colorado State University (CSU) worked with local stakeholders to design and conduct a study to accurately quantify VOC and methane emissions from drilling, fracking, and flowback operations in Garfield County.** 21 experiments were conducted from 2013-2015 and emission rates of 48 VOCs reported by activity type. The highest emissions of methane and most VOCs (e.g., benzene, toluene, ethane) were observed during flowback activities. Study data and findings were made available to the public in 2016.
- The Colorado Department of Public Health and Environment sponsored a potential human health risk assessment for those living or working near oil and gas operations, using emissions data from this study and a companion study conducted on the Front Range.

Garfield County emissions sampling (photo credit J. Ham)

Improved unconventional oil and natural gas extraction techniques have allowed access to previously untapped resources in areas such as the Piceance Basin of western Colorado. Observations of the air emission rates of methane and, especially, volatile organic compounds (VOCs) from these activities, especially well drilling and completions, are important but historically not well known. Without good information about air emissions, evaluating the effect of increased unconventional oil and natural gas recovery on local air quality and public health is extremely challenging.

Garfield County, Colorado and several industry partners funded this study to fill this critical knowledge gap concerning emissions of air toxics, ozone precursors, and methane. Emission rates from drilling, hydraulic fracturing (fracking), and flowback were measured. Direct measurement of emission rates allows public health and air quality impacts to be simulated for a range of future activity scenarios at any location of interest under a wide range of meteorological conditions.

How were stages of well development defined in this study?

- **Drilling:** This is the process of crushing or cutting rock to start and deepen the wellbore for oil and gas extraction. Horizontal drilling refers to wells drilled at an angle other than vertical so the well runs parallel to the oil and gas formation.
- **Hydraulic fracturing (fracking):** Small fissures are initiated in the well and enlarged by injecting water, sand, and chemicals down the wellbore at high pressure.
- **Flowback:** Following the fracking process, part of the fracking fluid injected into the well is recovered, along with produced water and hydrocarbons. Flowback is considered to continue until the well product is directed into marketing pipelines.

What are VOCs and why are they important?

- VOCs are carbon-based chemicals (volatile organic compounds) that easily evaporate into the air at ambient temperatures.
- Some VOCs are directly hazardous to human health (air toxics) and some contribute to degradation of local and regional air quality through production of ozone or other regulated pollutants.
- Natural gas is made up of 75-92% methane, 4-15% ethane, and the rest is composed of other VOCs, carbon dioxide, nitrogen and other trace gases. The composition can vary depending on the ratio of gas to oil, the geological formation, and other factors.

Measurement methods

A Tracer Ratio Method was used to determine emission rates of methane and VOCs. In this approach, the emission rate of the compound of interest is determined, relative to a known tracer release rate, using the background-corrected downwind concentration ratio. Acetylene (the tracer) was released near the main source of emission on the well-pad. Real-time methane and acetylene concentrations and 3-minute integrated whole air canister samples for VOCs were measured downwind. Upwind (background) acetylene, methane, and VOC concentrations were measured to account for the influence of upwind sources on the well-pad. The whole air sample canisters were analyzed for 48 VOCs using gas chromatography with flame ionization detection.

Graphic representation of a typical sampling setup

Summary of study results

Methane

Methane is a much more potent greenhouse gas than CO_2. The largest source of industrial methane emissions is from oil and natural gas activities.

Variable rates of methane emissions were measured during well drilling, fracking, and flowback. The highest emission rates were observed during flowback, despite the use of green completions. Median values are reported by activity type in the table at left.

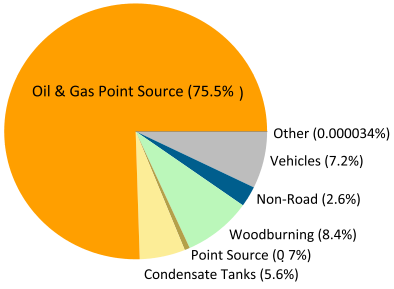
Median emission rates of methane

Operation Type	# of Sites	Median [g s^{-1}]
Drilling	5	2.0
Fracking	6	2.8
Flowback	6	40

Air Toxics

A variety of VOCs are active as air toxics and can act as carcinogens or be associated with neurotoxicity, hematological problems, or adverse respiratory effects. The U.S. Environmental Protection Agency, for example, has classified benzene as a human carcinogen and excess benzene exposure can result in blood disorders. Benzene has a variety of sources, including burning coal and oil, motor vehicle exhaust, industrial solvents, tobacco smoke, and oil and natural gas operations.

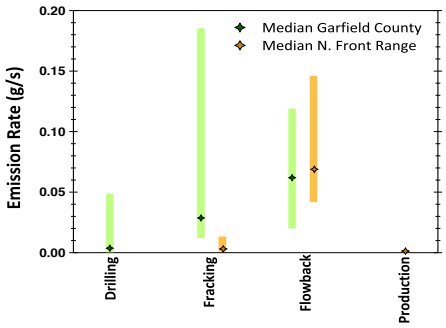
Garfield County 2011 benzene emission inventory by sector



Source: www.colorado.gov/airquality/inv_maps.aspx

The Colorado State 2011 emission inventory reports that about 75% of benzene emissions in Garfield County come from oil and gas point sources. We observed benzene emissions from drilling, fracking, and flowback operations in Garfield County. The highest median benzene emissions were observed during flowback (the range of data represents the 25th to 75th percentiles). A companion study, conducted in the Colorado North Front Range (NFR) on fracking, flowback, and production operations, exhibited lower benzene emissions from fracking and slightly higher emissions from flowback.

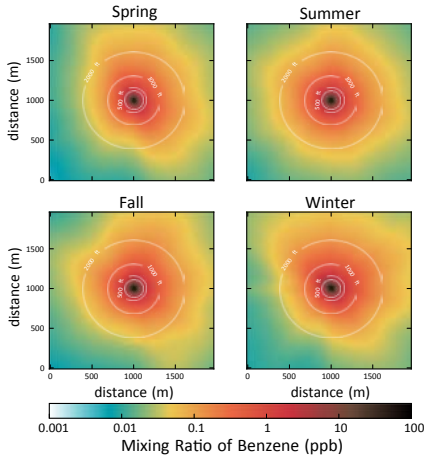
Benzene emissions by operation



Translating emission rates to understand potential impacts

How are emission rate data used?

Emission rates, local meteorology, and terrain information, can be used to simulate concentration fields surrounding a well-pad. U.S. EPA's AERMOD dispersion model was used to predict hourly VOC concentrations surrounding a well-pad for a period of one year. The figure at right shows average seasonal benzene concentration maps around a well-pad continuously emitting benzene at a high rate of 0.23 g/s, exceeding 75th percentile values observed for operations measured in Garfield County. Average benzene concentration increases generally do not exceed 1-3 ppbv at setback distances of 500 feet and decrease with additional distance; the Agency for Toxic Substances & Disease Registry's (ATSDR) Minimal Risk Level values for chronic and acute benzene exposure are 3 and 9 ppb, respectively.



Garfield County and North Front Range human health risk assessment study

Emission rates measured in the CSU studies in Garfield County and the North Front Range were used in a model-based exposure study, sponsored by the Colorado Department of Public Health and the Environment, to calculate potential human health risk from VOCs emitted from well drilling and completions and during long-term production.

For more information visit: www.garfield-county.com/air-quality/air-emissions-study.aspx
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