Air Pollution Exposure and Risk Near Unconventional Natural Gas Drill Sites: Example from Garfield County, Colorado

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Roadmap

• Natural Gas Development in Colorado
  – Garfield County
• Air Pollution Exposures
  – Chemicals and data available
  – Exposure during well completions activities
• Risk Assessment
  – Risks methods and estimates
• Conclusions, Limitations and Research Needs
Oil and Gas Drilling in Colorado
Garfield County

• Classic western valley meteorology
  – Dry/arid: annual average precipitation ~18”, sunny 71% of the time
  – Wide within day temperature swings, classic morning valley breeze, evening mountain breeze
  – Elevation ranges from 4500-5500 ft on the valley floor to > 8000 feet
  – Increased well development near populated areas, such as in and around the town of Battlement Mesa
Air Pollution Data Available

- Ambient measurements for a wide range of VOCs
  - 24-hr average measurements, EPA certified lab/methods, 78 non-methane VOCs quantified
  - 163 samples used to characterize ambient air levels in natural gas development area between 2008-10
- Unique data used in this analysis: samples collected near wells during flowback/well completion processes
  - Twenty four samples collected during well completion at distances from 150 to 500 feet from the emission source
  - Used as part of the human health risk assessment of short term (subchronic) and longer term (chronic effects) cancer and non-cancer effects
Human Health Risk Assessment

• “Screening” Risk Estimates Using EPA methods
  – EPA Reference Concentrations (RfCs), inhalation unit risks, and other health-based guidelines when RfCs or cancer potency estimates not available
  – Exposure scenarios
  – Chronic and subchronic assessments of risk for nearby residents

• Quantitative Risk Assessment
  – Non Cancer (Systemic): Hazard Index
    • Ratio of estimated exposure to RfC and/or health-based guidance level
    • Index sums potential effects of multiple chemicals
    • Are these greater than 1?

  – Cancer: Lifetime Excess Cancer Risk, multiple chemicals
    • Are risks greater than 1 in a million?
    • Are risks greater than 1 in 10,000?
Exposure Scenarios

Site Specific Durations

- **Subchronic**: Short-term, “high exposure” well completion scenario, resident living near two wells under development, 20 months total
- **Chronic**: 30 year exposures to well production emissions/natural gas area emissions, noncancer and cancer risk estimates

Uncertainties

- Divided exposures into “near” and “far” from well pads based on citizen odor complaints
- EPA default options for “reasonable maximum exposure”, e.g.,
  - *Exposure Frequency/Duration*: 350 days/per year, 24 hours/day, 70 year lifetime
  - *Upper bound of mean concentration estimates for the various air toxics*
Hazard Indices by Duration of Exposure and Distance from Source

Level above which health effects may occur

Exposure Scenario

Colorado School of PUBLIC HEALTH
Hazard Indices by Health Endpoint: Near Wells, 20 Month Exposure Scenario

![Bar Chart]

- Neurological Effects: 4
- Respiratory Effects: 2
- Hematological Effects: 3
- Developmental Effects: 1

End Points
Non-Cancer Risk Drivers

- Trimethylbenzenes: 50%
- Alkanes: 26%
- Xylenes: 15%
- Benzene: 5%
- Others: 3%
Cancer Risk Summary

- Range from 6 to 10 in a million for a 30 year chronic exposure (normalized to 70 years)
- Benzene and ethylbenzene are the main risk drivers
- Slightly above 1 in a million risk, but below levels where remediation typically occurs.
- Overall concentrations similar or higher than many urban areas
Risk Assessment Summary

• Residents living near well completion activities potentially exposed to substantial levels of air toxics
• Estimated cancer risks and chronic non-cancer hazard indices are greater for residents living nearest the well pads, but are within generally acceptable range.
• Subchronic non-cancer cumulative and endpoint specific hazard indices are greater than one for residents living near well pads.
Uncertainties and Limitations

• Small sample size: limited data exists on emission around well completion sites
• Non-methane pollutant emissions appear to vary substantially by field type, number of well heads, completion process, and controls in place
• Limited suite of volatile compounds explored, but not other primary or secondary pollutants (e.g., aldehydes, diesel exhaust, ozone, PM, etc.)
• These data do not tell us how far is far enough nor how close is too close to well development sites
Conclusions

• Short term exposures for nearby residents are potentially in the range of health concern
  – Much is dependent on distance, local meteorology and topography

• Prevention strategies should be directed at minimizing exposures during well completion activities to reduce potential subchronic non-cancer risks
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