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O&G Development:

Emissions, Exposures, and Potential Community Health Implications

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RHP Risk Management

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Credentials

- PhD, SM in Toxicology (MIT)
- Fellow Academy of Toxicological Sciences (ATS)

Experience

- > 40 years as a toxicologist, including assessing potential health risks from inhaled pollutants

Publications

- >3 dozen peer-reviewed scientific papers, book chapters, or reports
- Editor, 2 scientific books
- Member of advisory committees to US EPA, WHO

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Hazard vs. Risk

HAZARD

The **potential** to cause harm.

Inherent in the substance, situation, or activity.

VS.

RISK

The **chance** of harm occurring.

Depends on exposure and severity.

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It's What's Inside That Counts!

- O&G "emissions" include many chemicals at different concentrations
  - Flaring: Hydrocarbons (methane, ethane, propane, butane, ethylene); trace chemicals: (propylene, hexane, and various butene isomers).

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Composite Natural Gas Profile

Compound	SPECIATE ID	DRE Range			
		> 0.98	0.95 - 0.98	0.8 - 0.95	< 0.8
		Weight(%)			
Formaldehyde	465	3.910	2.710	2.220	1.250
Methanol	531	0.169	0.126	0.136	0.119
Acetaldehyde	279	2.600	1.720	1.320	0.678
Acetylene	282	5.290	4.100	3.910	2.150
Ethylene	452	2.600	1.860	1.620	0.916
Methane	529	59.300	62.200	63.100	65.900
Ethane	438	9.570	10.000	10.200	10.600
Propane	671	7.320	7.660	7.770	8.130
Butane	592	4.880	5.110	5.180	5.420
Pentane	605	2.440	2.550	2.590	2.710
Hexane	601	0.352	0.369	0.374	0.391
Benzene	302	0.075	0.079	0.080	0.083
Toluene	717	0.067	0.070	0.071	0.074
2,2,4-trimethylpentane	118	0.099	0.104	0.106	0.110
Ethylbenzene	449	0.004	0.004	0.005	0.005
Isomers of xylene	507	0.019	0.020	0.020	0.021
Isomers of hexane	2127	1.260	1.320	1.340	1.400

Weight percentage relative propylene

From Shah, Yarwood et al., 2017 using data from TCEQ (2010) flare study

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Toxicity of Emissions from Flare Event

- Most of the gases present in this example have low toxicity profiles (low hazard).
- Only a small proportion are associated with potential risk, and that is only if people are exposed at these concentrations (they are not).

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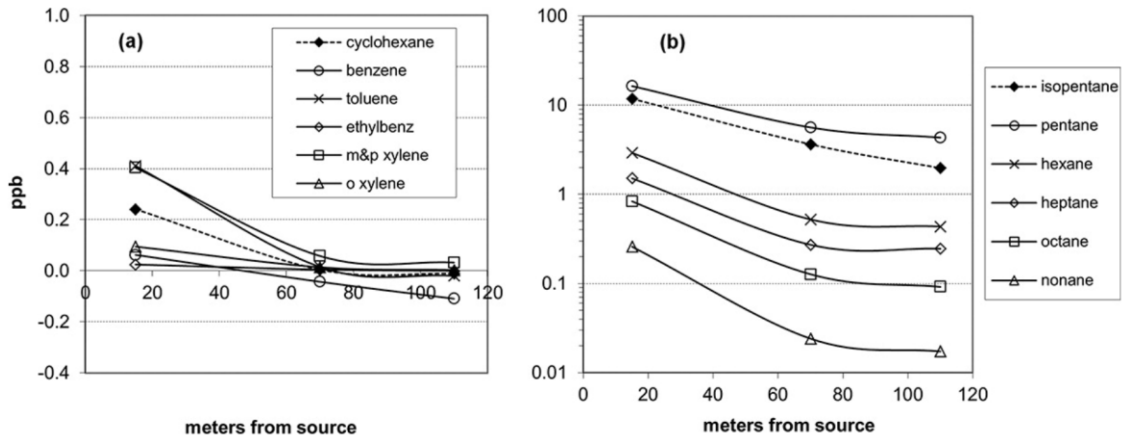
Dilution with Distance from Source

- Gas emissions dissipate with distance from sources

Figure 5. VOC gradient downwind of a well with condensate tank emissions. (a) Aromatics and cycloalkanes (linear scale); (b) aliphatic hydrocarbons (log scale). Concentrations are background subtracted 7-day averages for the week of May 13, 2010.



relative to alkanes. In addition, 1,3-butadiene does not show an appreciable

From Zielinska et al., 2014. *JAWMA* 64 (12): 1369–83. https://doi.org/10.1080/10962247.2014.954735.

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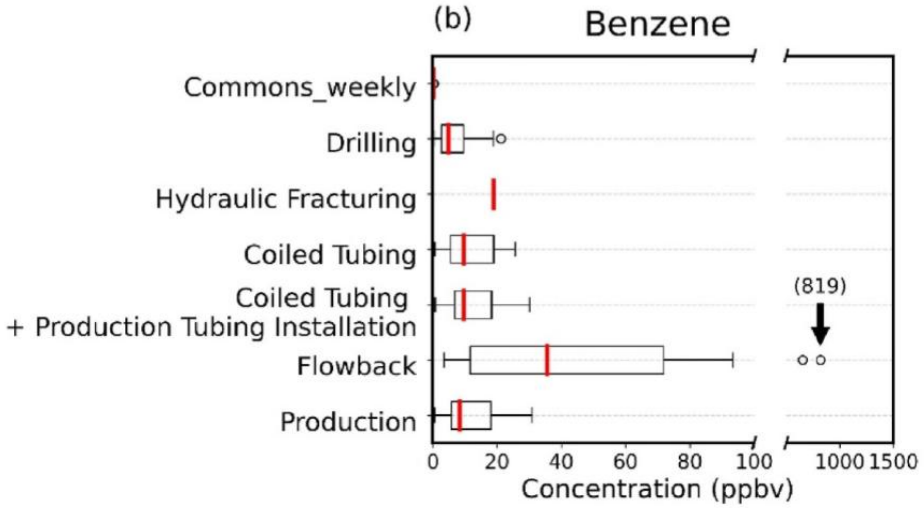
Emissions Vary with Phase of Development: Benzene

- Different development phases
  - Preproduction phases usually last weeks-to-months; production phase can last 30 years, dominate lifetime exposures
  - Emissions decrease further during production
- Emissions have decreased in more contemporary wells



From Ku et al., 2024. *Atmospheric Environment* 317 (January): 120187.

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Health Effects Considerations: Benzene

- Concentration matters! Exposure duration matters! Toxicity matters!
- Health benchmark values (IRIS, ATSDR, etc.) are **very conservative**. Exposure above these concentrations does not necessarily mean health effects are likely to occur.

Duration	Value
Cancer (lifetime exposure)	2.2×10^{-6} to 7.8×10^{-6} per µg/m^3 (EPA IRIS) 0.7×10^{-6} to 2.5×10^{-6} per ppb
Chronic noncancer (lifetime exposure; ≥ 1 yr exposure)	30 µg/m^3 (94 ppb) (EPA IRIS RfC) 6 µg/m^3 (19 ppb) (ATSDR MRL)
Intermediate noncancer (1-12-month exposure)	20 µg/m^3 (63 ppb) (ATSDR MRL)
Acute noncancer (≤1 month)	30 µg/m^3 (94 ppb) (ATSDR MRL)

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Evaluating Community Impacts: Epidemiological Studies

- **Observational studies** in human populations where exposure happens in an environment (e.g., people living near or working at O&G sites)
- Exact exposure is not always known
  - Sometimes must be estimated using surrogate measures
  - Other exposures, social factors sometimes but not always accounted for

Conclusion: Study limitations of O&G studies to date prevent concluding that exposures originating directly from O&G sites contribute to health outcomes.

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Evaluating Community Impacts: Risk Assessment Studies

Exposure estimates at different distances away from well sites, using measured or conservatively modelled concentrations

Compare exposure estimates to **conservative estimates of risks** set by authoritative bodies (USEPA, ATSDR)

If Hazard Quotient (HQ) ≤1.0, then no significant risks anticipated

For cancer, excess risk range of 1- to 100-in-a-million acceptable

Studies examined chronic (cancer and noncancer) and acute exposures; multiple HAPs.

Conclusion: Most studies only examined distances >½ mile from O&G sites → No significant risks.

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Conclusions

- Hazard ≠ Risk
- Most of the gasses visualized are nontoxic
- Concentrations of gases dissipate with distance from site
- Varies with development phase

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Conclusions

Concentration, duration of exposure is important in evaluating potential health impacts

Study limitations of O&G epidemiology studies to date prevent concluding that exposures originating from O&G sites contribute to health outcomes

Most risk assessment studies estimating exposure from O&G sites only examined distances >½ mile away → Conclude no significant risks

Setbacks are not needed for health risks from chemical exposures

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Thank you!

Questions?

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