Boom or Bust?
Measuring exposures and health risks from oil and gas related chemicals

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Senior Toxicologist
"The oldest and strongest emotion of mankind is fear, and the oldest and strongest kind of fear is fear of the unknown"

— H.P. Lovecraft, author
OUTLINE

- Health risks do not need to be unknown, they can be measured
- Start with why: assessing risk should be fit for purpose
- Just because a chemical is detected does not mean that it is “toxic” in the amount detected
- Not all data are created equal!

Addressing health risk concerns can be a “boom”, not a “bust”
START WITH WHY
Prop 181

“Can regulate to minimize adverse impacts to public safety, health, welfare”

- What will you determine is adverse?
- How will you determine this?
- What actions will you take from the information?
  - Setbacks? BMPs? Air monitoring?
“Risk assessment .. is not an end in itself but a means to develop policies that make the best use of resources to protect the health of the public and of ecosystems”
-(National Academy of Sciences 2009, 240)
WHAT IS RISK?

HAZARD

The inherent ability of a chemical cause harm

EXPOSURE

Contact between a chemical and a person

RISK

The possibility of a harm arising from exposure to a chemical, *under specific conditions*. 
MEASURING HAZARD

HAZARD

EXPOSURE

RISK
Hazardous air pollution
At every stage in oil and gas extraction, toxic chemicals are released into the air.

Chemicals released
- Polymeric organic matter (POMs)
- Naphthalene
- Phenanthrene
- Fluorene
- Indene
- Dibenzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Chrysene
- Acenaphthylene

Health effects
- Carcinogenic
- Bone marrow damage
- Damage to immune system
- Blood disorders
- Damage to liver
- Pulmonary damage
- Damage to brain, kidneys, and developing fetus
- Skin/respiratory irritant

Source: Annual Review of Public Health, Canadian Metabolomics Conference, Getty Images

WHAT’S MISSING?
EXPOSURE

Denver Post, 4/7/19
HOW ARE “SAFE” LEVELS ESTIMATED?

Just because a chemical is detected does not mean that it is “toxic” in the amount detected.

A scientist must estimate the relationship between exposure concentration and health effects before they can make conclusions.
HOW ARE “SAFE” LEVELS ESTIMATED?

100-1000 times lower than where “adverse toxicity” is observed.
### WHAT EXPOSURE GUIDELINES SHOULD BE USED?

**Reference Concentration (RfC)**

**Minimal Risk Levels (MRLs)**

**Acute Exposure Guideline Levels (AEGLs)**

**Worker Exposure Guidelines**

Exposure guidelines are developed for different exposure scenarios, different levels of protectiveness.

<table>
<thead>
<tr>
<th>Classification</th>
<th>18-Minute</th>
<th>30-Minute</th>
<th>1-Hour</th>
<th>4-Hour</th>
<th>8-Hour</th>
<th>Endpoint (Reference)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEGL-1 (Non-irritating)</td>
<td>130 (420)</td>
<td>73 (240)</td>
<td>52 (170)</td>
<td>18 (58)</td>
<td>9.0 (29)</td>
<td>Highest level without AEGL-1 effect in humans. 110 ppm for 2h no subjective symptoms (Shih et al., 1950)</td>
</tr>
<tr>
<td>AEGL-2 (Irritating)</td>
<td>1100 (3600)</td>
<td>800 (2600)</td>
<td>400 (1300)</td>
<td>200 (650)</td>
<td>990 (3300)</td>
<td>Highest level without AEGL-2 effect (CNS depression, i.e. reduced activity in animals). 400 ppm for 4h. Molnar et al., 1986.</td>
</tr>
<tr>
<td>AEGL-3 (Severe)</td>
<td>5600 (18,000)</td>
<td>4000 (13,000)</td>
<td>2000 (6500)</td>
<td>990 (3300)</td>
<td>Highest reliable NOEL for mortality in rats. 5940 ppm for 4h. Molnar et al., 1986.</td>
<td></td>
</tr>
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MEASURING EXPOSURE

HAZARD

EXPOSURE

RISK
EXPOSURE FACTORS

✓ Amount – how much?

✓ Duration – how long?
  ▪ Short-term
  ▪ Long term

✓ Frequency - how often?
  ▪ Once
  ▪ Intermittent
  ▪ Constant
**Source Data**

**Source**

- **Emissions**
- **Fenceline Air**

**Pros**
- When used with models, can predict a large range of different exposure scenarios and predictions of risks

**Cons**
- Cannot provide direct, measured exposure data

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PROS

- When used with models, can predict a large range of different exposure scenarios and predictions of risks

CONS

- Cannot provide direct, measured exposure data

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**Emission Rates**

**Meteorological Data**

**Air Concentrations**


http://www.aqsllc.net/services/air-dispersion-modeling
<table>
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<th><strong>COMMUNITY AIR</strong></th>
<th><strong>PROS</strong></th>
<th><strong>CONS</strong></th>
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<td>✔ Provide an estimate of exposure in communities without models</td>
<td>✔ data are only as good as the study design!!!!!</td>
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<td>✔ Can determine the source of exposure</td>
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**PROS**
- Provide an estimate of exposure in communities without models
- Can determine the source of exposure
- Measurements and analytical methods well established
- Can be directly compared to exposure guideline values

**CONS**
- Data are only as good as the study design!!!!!
BIOMONITORING

PROS

- Direct evidence a person was exposed
- Can be useful *if* combined with other pieces of information:
  - external measurements
  - pharmacokinetic models
  - epidemiology studies
  - Cluster of health effects in a population

CONS

- Cannot directly provide information on:
  - source
  - exposure
  - health risks
- Feasibility (cost, time, sufficient # people, invasive, methods)
- Risk communication
BIOMONITORING CHALLENGES

✓ Interpreting data to characterize exposure

- Sources?
- Activities?
- Weather?
- Timing?

Multiple Sources

External Exposure

Internal Exposure (DOSE)

15 ng/ml Benzene

Difficult to identify and control exposure if you can’t answer these questions
Most exposure guideline values are derived to compare to measured external exposure levels, not internal.
Measurements of benzene in blood

- Why is there benzene in my blood?
- What is my health risk?
- Where did it come from?
Why is there benzene in my blood?

- Benzene can come from many non oil and gas sources
- Can be detected in the general population
What is my health risk?

MEASURED ENVIRONMENTAL EXPOSURE

RISK = \frac{\text{EXPOSURE GUIDELINE VALUE}}{\text{EXPOSURE EXPOSURE}}

- What’s the environmental exposure?
- What exposure guideline value do you use if you don’t know the exposure scenario?
CASE STUDY

Where did it come from?

No clue! You have to collect environmental data!

Multiple Sources → External Exposure
Multiple Sources → Internal Exposure (DOSE)
Multiple Sources

Pharmacokinetic Models
CASE STUDY

Compare apples to apples

Predicted blood levels of equivalent air measurements
Where do you go from here?

Biomonitoring uncertainty at all levels

- Methods used to collect the samples
- Analytical methods
- Exposure history
- Sources of exposure
- Extrapolating from an internal dose to an external exposure

Can become a risk communication and public health decision making nightmare!
“Compared with measures of contaminants in air, water, or food, biomonitoring results are intrinsically associated with a person and thereby have far greater potential to generate concern and action, for good or ill”

“The social and political climate in which the new technology of biomonitoring has emerged is itself volatile; contentious and potentially fractious policy debates and litigation surround the field and render it likely that studies will be conducted or interpreted to meet the agendas of specific parties unless great care is taken to establish uniformly agreed on scientific standards against which any study can be transparently judged. “

WHAT SHOULD YOU MEASURE?

Source

Emissions

Fenceline Air

External

Community Air

Inhaled Amount

Internal

Amount In Body
HEALTH RISK FOR DECISION MAKING

Health Risk vs.

PUBLIC HEALTH DECISION MAKING

- Health Risk
- Legislative Mandates
- Social Concerns
- Economic Concerns
CONCLUSIONS

- Health risks do not need to be unknown, they can be measured
- Start with why: assessing risk should be fit for purpose
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Addressing health risk concerns can be a “boom”, not a “bust”
Thank you!
Questions?
**Key Concepts of Risk Assessment**

There is no risk if there is no exposure.

Detecting a chemical in the air or in the body does not equate to risk.

Risk is a function of exposure and the chemical hazard.

A scientist must know or estimate the relationship between exposure concentration and health effects before they can make conclusions.