

# Toluene Biogenesis in Peatlands: Synthesis of Current Scientific Findings and a Recent Investigation in N. Alberta

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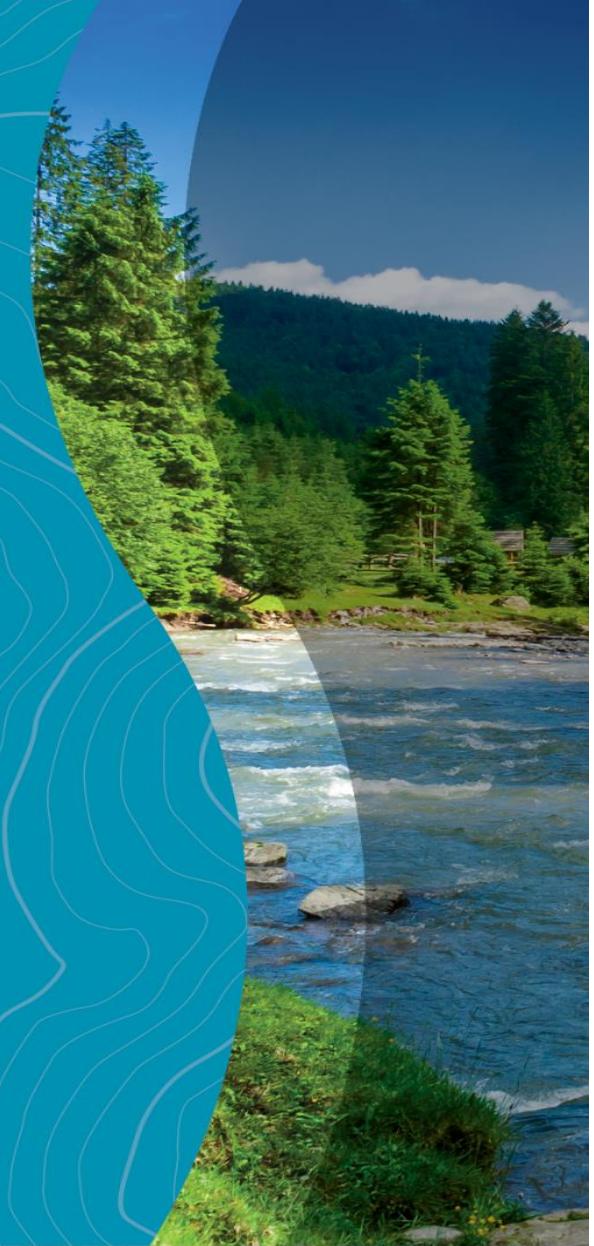
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# Overview

- **Introduction**
- **Methodology**
- **Results**
  - Literature Review
- **Discussion**
- **Recommendations/Best Practices**



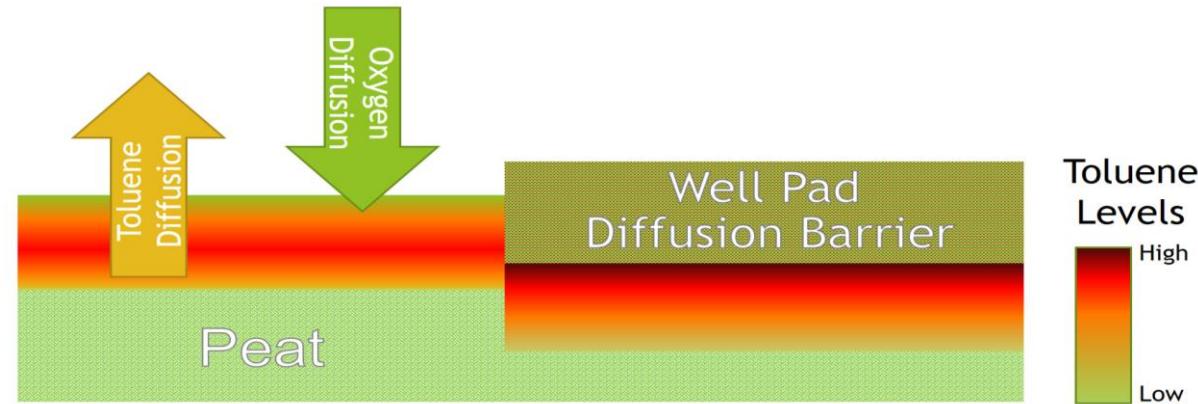
# Toluene Biogenesis in Peatlands

**Observed elevated toluene levels beneath the clay pad of abandoned well-sites**

## Evidence of biogenic production

- Anoxic hypolimnion of lakes in Germany (Juttner and Henatsch 1986; Juttner 1991)
- Microbe responsible identified (Fischer-Romero et al. 1996)

**Preliminary study found that toluene levels were higher and occurred at greater depths under well pads (capped) versus surrounding uncapped locations**



# Toluene Toxicity

## Adverse Health Effects

- rainbow trout (*Oncorhynchus mykiss*) @ 0.02 mg/L.
- leopard frog (*Rana pipiens*) and the northwestern salamander (*Ambystoma gracile*) @ 0.39 mg/L
- freshwater invertebrates like *Daphnia magna* LC50 @ 3.75 mg/L
- freshwater algae (*Selenastrum capricornutum*) @ 12.5 mg/L (CCME 1999, 2004)



# Methodology

- ▶ 6518 samples total
- ▶ Toluene data: 2049 samples
- ▶ Petrogenic impact: 413 samples
- ▶ Mineral soil: 1220 samples
- ▶ N=413 remaining samples, 249 with detailed salt data
  - ▶ 226 under clay pad, 190 outside



## Statistical methods

- ▶ Differences in analytes in capped and uncapped sites: Mann Whitney U
- ▶ Correlation between toluene and other analytes: Kendall's Tau
- ▶ Multivariate: Maximum Likelihood Estimation (MLE)  
Censored Regression Analysis

# Multivariate Analysis

Explanatory Variable	Coefficient	Standard Error	P-value
Intercept	4.89	1.48	<b>0.0009</b>
Cap	5.33	1.91	<b>0.005</b>
pH	-0.66	0.26	<b>0.01</b>
Cap*pH	-0.87	0.36	<b>0.02</b>
Depth Interval	-0.62	0.23	<b>0.007</b>
Frozen	-1.00	0.92	0.28
Bog	0.56	0.63	0.38



$$\Delta Toluene \left( \frac{mg}{kg} \right) / \Delta Cap = 5.33 - 0.87 \times (pH)$$



# Results

## Toluene Level Differences Between Capped and Uncapped Sites

- Capped and uncapped differences were only significant when considering multiple variables
  - PH is an important factor



# Results

## Relationship Between Sulphate and Toluene

- Significant negative correlation
- SO<sub>4</sub> significantly higher in capped sites
- Not a significant relationship in the MLE

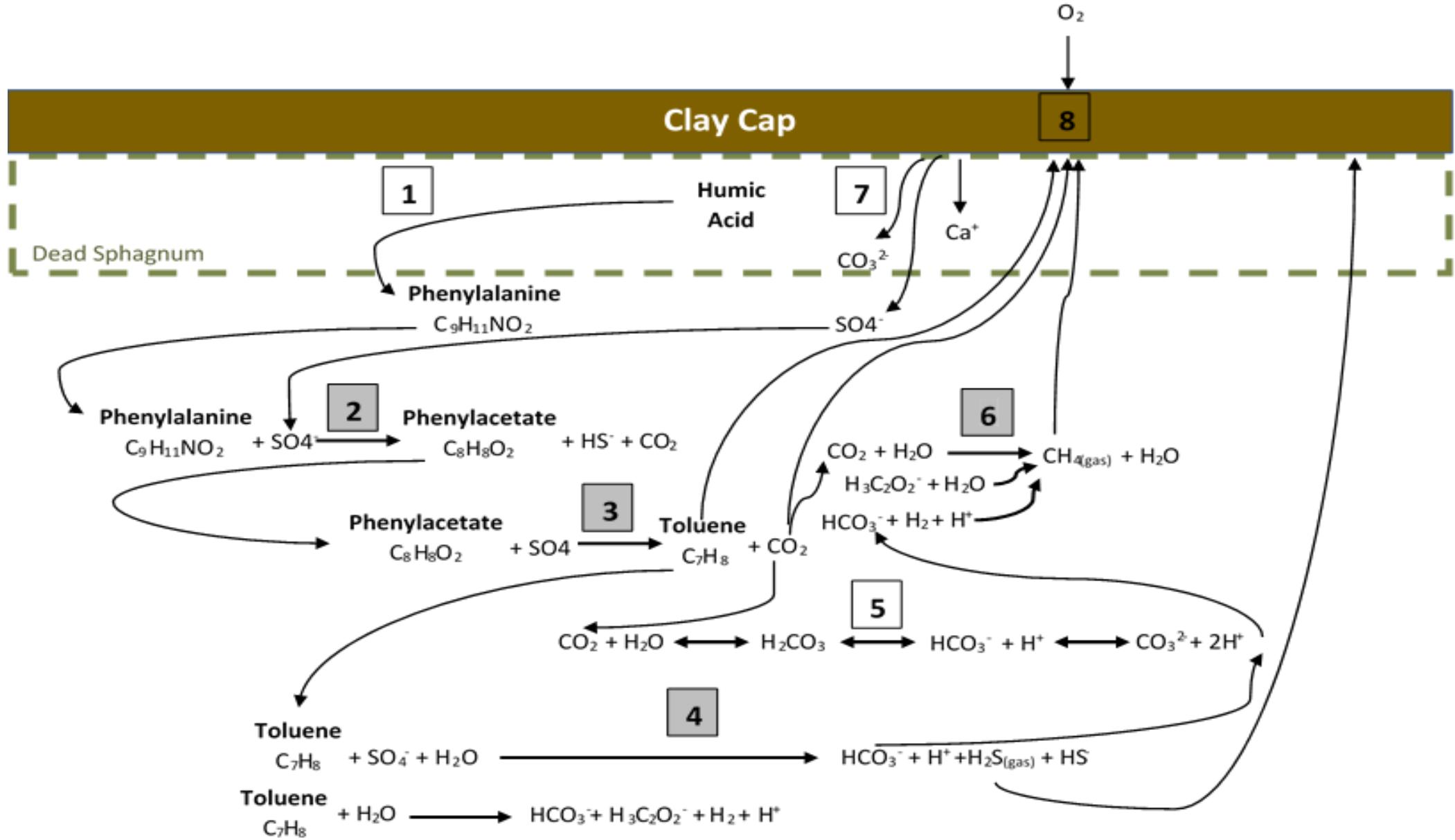


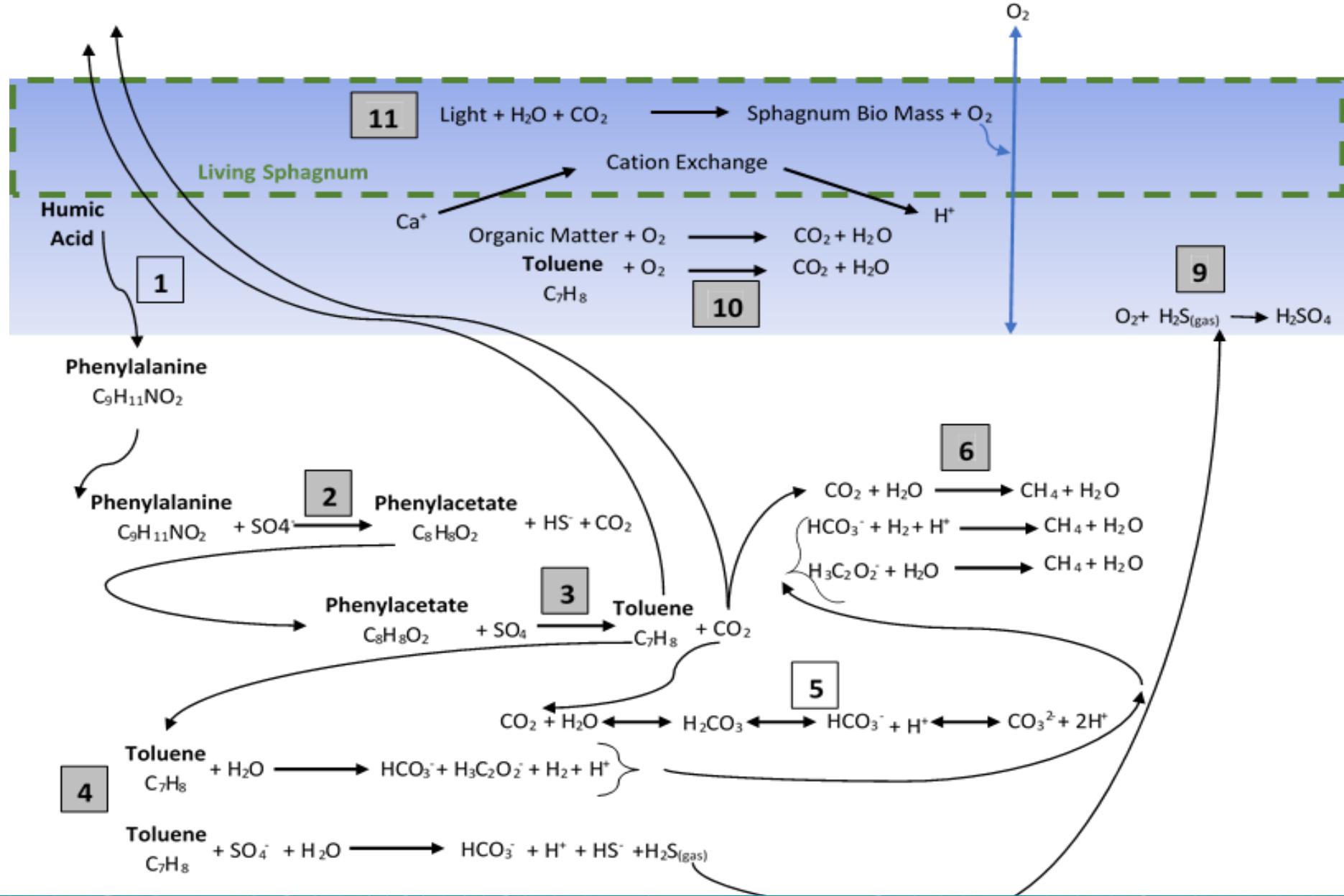
# Results

## Influence of other Measured Chemicals on Toluene Generation

- Significantly higher levels of salt ions and pH in the capped sites
- Salts not significant contributors to the MLE regression
- SO<sub>4</sub> only salt ion ID'd with role in lit review
- Strong relationship between pH and toluene







# Further Study

- Specifically with factors contributing to biogenesis and biodegradation
  - Sulphur, other nutrients electron acceptors
  - Possible remediation pathways
  - pH and toluene
- Fate and Transport (Gharedagloo and Price 2017)
- Removal of physical clay pad structure, total or partial?
- Revisit construction standards-When are clay pads actually needed?



# Best Practices

**Absence of Peatland based guidelines for remediation**

**Frozen sample complications**

**Sample location complications**



# Thank you!

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