# BioVapor, a 1-D Vapor Intrusion Model with Oxygen-limited Aerobic Biodegradation

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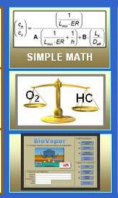
## Conceptual Model

### What is BioVapor?

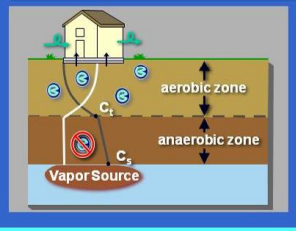
| | |
|---|---|
| *1-D Analytical Model* | Version of Johnson & Ettinger vapor intrusion model modified to include aerobic biodegradation (DeVaull, 2007). |
| *Oxygen Mass Balance* | Uses iterative calculation method to account for limited availability of oxygen in vadose zone. |
| *User-Friendly* | Simple interface intended to facilitate use by wide range of environmental professionals. |




***KEY POINT:***

**Free, easy-to-use vapor intrusion model that accounts for oxygen-limited aerobic vapor intrusion.**

### BioVapor: Conceptual Model




3. Advection, diffusion, and dilution through building foundation
2. Diffusion & 1st order biodegradation in aerobic zone
1. Diffusion only in anaerobic zone

### BioVapor: Oxygen Mass Balance

**Iterative Calculation Method**

**Calculate Oxygen Demand:**
- depth of aerobic zone
- HC vapor concentration
- 1st order biodegradation

$O_2$ demand = *supply?*

No → Increase or decrease depth of aerobic zone

Yes → Final Model Solution

***KEY POINT:***

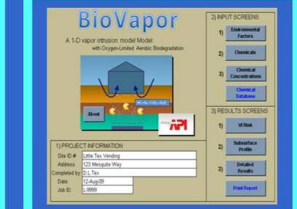
**Calculations are cheap & quick**

## Model Inputs

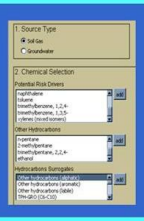
### Environmental Factors

### Oxygen Boundary Condition

| | |
|---|---|
| *Open Soil: (Constant $O_2$ Conc.)* | Constant oxygen concentration at top of vadose zone:<br>- 21% oxygen in dirt crawl space<br>- Measured oxygen concentration below solid foundation |
| *Solid Foundation: (Constant Air Flow)* | Constant oxygen flux across top of vadose zone:<br>- Air flow from atmosphere to below building foundation |
| *Fixed Aerobic Depth* | User-specified depth of aerobic zone:<br>- Based on measured vertical profile in vadose zone<br>- No O2 mass balance |

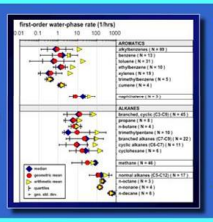




### Chemicals



| | |
|---|---|
| Risk Drivers: | Vadose zone transport/oxygen demand and indoor concentration/risk. |
| Other Hydrocarbons: | Only vadose zone transport /oxygen demand<br>- Not considered risk drivers<br>- No well accepted tox. values |
| Hydrocarbon Surrogates: | Only vadose zone transport /oxygen demand<br>- One surrogate can represent multiple hydrocarbons |

### Biodegradation Rates

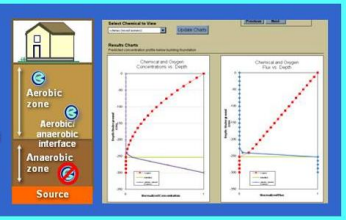



- Petroleum rapidly biodegrades in vadose zone with oxygen
- Geometric mean first-order rates:
  - BTEX = 0.79 /hr
  - Aliphatics = 71 /hr (DeVaull, 2007)
- Biodegradation occurs in pore water
- User can edit default biodegradation rates

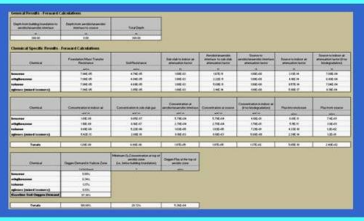
## Model Outputs

### Vapor Intrusion Risk Results

### Vadose Zone Vertical Profile




### Detailed Results




### Acknowledgements

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- **BioVapor Software Interface:** Paul Newberry, GSI Environmental
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**Reference:**

DeVaull, G.E. 2007. Indoor Vapor Intrusion with Oxygen-Limited Biodegradation for a Subsurface Gasoline Source, ES & T Vol. 41; p.3241 – 3248.



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