

## Development of a System for *in situ* Determination of Chlorinated Hydrocarbons in Groundwater

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## Introduction

- Groundwater monitoring:
  1. Determination of water quality and chemistry of the region
  2. Determination of groundwater contamination
    - chemicals (heavy metals, organic solvents, mineral oils, pesticides and fertilizers and microbiological contaminants)

## Introduction

### Volatile Organic Compounds (VOCs)

- Chlorinated solvents - DNAPLs ( $C_2HCl_3$ ,  $C_2Cl_4$ , VC) are among most frequently identified contaminants
- BTEX – LNAPLs (benzene, toluene, ethylbenzene, xylene) released by petroleum products
- Sources:
  - Stored fuels (gasoline, diesel, heating oil)
  - Solvents from dry-cleaners
  - Industrial solvents
  - Wood preservatives (creosote)

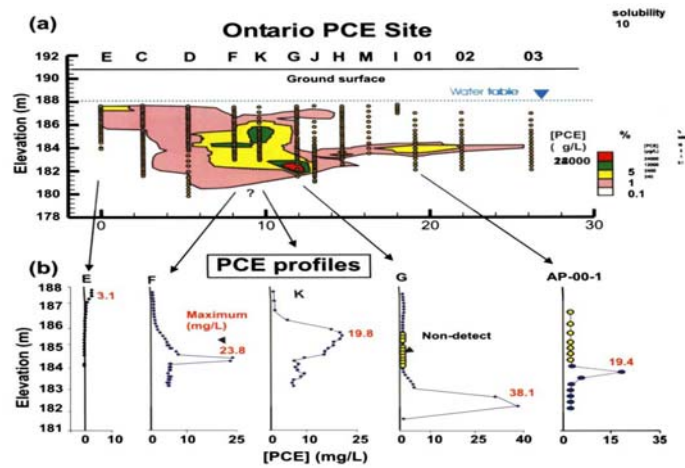
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## Why an *in situ* determination of VOCs?

	Laboratory techniques	On – site analysis
Accuracy	+	-
Sensitivity	+	+/-
Selectivity	+	+/-
Precision	+	+/-
Time	-	+
Cost	-	+/-
Space	-	+
Direct availability of data	-	+

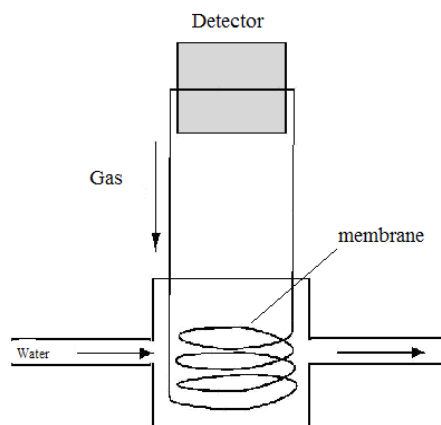
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# Why an *in situ* determination of VOCs?



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Martin A. Guilbeault *et al.* 2005

## Method

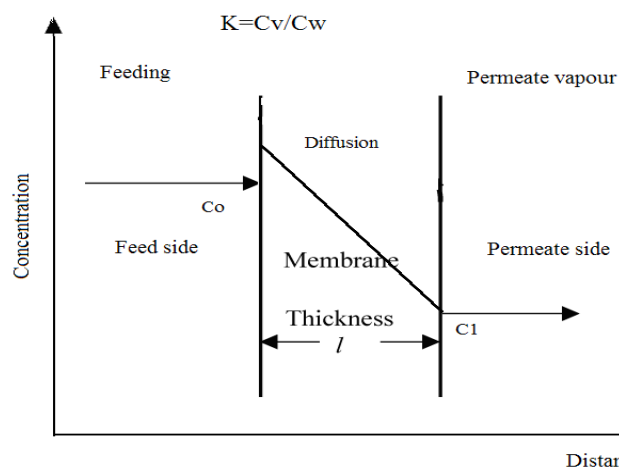


## Study approach

- Laboratory studies
  - testing permeability of different polymeric membranes
  - testing sensitivity of different detectors
- Construction of field prototype
- On – site testing

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## Principle



Process and concentration profile during analyte permeation through a non porous membrane

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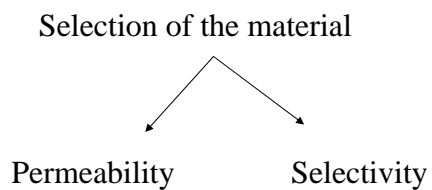
## Fick's law

$$F = A \cdot D \cdot \frac{C_{\text{mbout}} - C_{\text{mbin}}}{d} = A \cdot D \cdot K_p \cdot \frac{C_{\text{gasout}} - C_{\text{gasin}}}{d}$$

- D diffusion coefficient ( $L^2/T$ )  
Kp partition coefficient  
A area across with diffusion takes place ( $L^2$ )  
d thickness of tubing wall (L)

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## Laboratory Experimental



A series of material

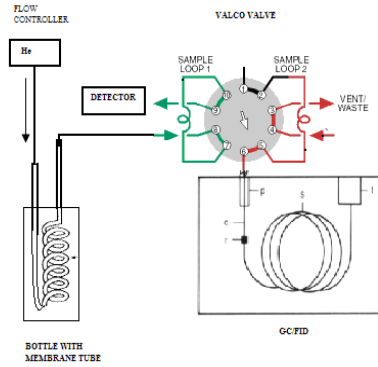
- Silicone rubber
- Polyethylene
- ...

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# Laboratory Experimental

- Experimental set up

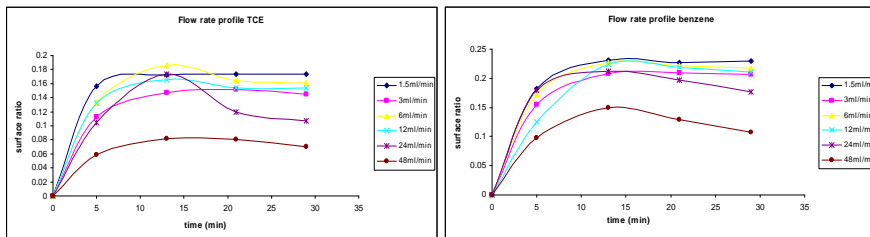
- A) Vapour-vapour separation
- B) Water-vapour separation



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# Vapour – vapour separation

- Trichloroethylene and benzene concentrations at outlet of silicone rubber tube for different flow rates analysed by GC/FID



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## Detector

- PID: the typical detector for field screening of VOCs  
Disadvantage of no discrimination between halogenated and non-halogenated species
- X-Wand™ HVOC screening device: Heated diode sensor selective to halogens
- NDIR (Non-dispersive IR) detector: pyroelectric sensor

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## Conclusions

- Silicone rubber as a non porous hydrophobic membrane shows a good permeability for hydrocarbons, BTEX and chlorinated solvents
- Low levels of trichloroethylene (3 -5 ug/L) can be measured with the X-Wand detector
- Combination of extraction with silicone tubes and detection with heated diode detector promising approach for selective on-site measurement of chlorinated hydrocarbons

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## References

- Fetter, C.W., *Applied Hydrogeology*, 4th edition, 2001, Pearson Education
- Guilbeault, M. A., Parker, B. L., Cherry, J. A., *Mass and Flux Distributions from DNAPL Zones in Sandy Aquifers*, *Groundwater*, 43, 1, 2005, 70-86
- Schwarzenbach, R. P., Gschwend, P. M., Imboden, D. M., *Environmental Organic Chemistry*, 2nd edition, Wiley – Interscience, 2003
- *X-Wand HVOC Analyzer's Operation manual*, Bacharach, 2007

Thank you for your attention!